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Countermeasures That Work:

A Highway Safety Countermeasure Guide For State Highway Safety Offices

U.S. Department of Transportation
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16. Abstract

The guide is a basic reference to assist State Highway Safety Offices (SHSOs) in selecting effective, evidence-based countermeasures for traffic safety problem areas. These areas are:

- Alcohol-Impaired Driving,
- Drug-Impaired Driving,
- Seat Belts and Child Restraints,
- Speeding and Speed Management,
- Distracted Driving,
- Motorcycle Safety,
- Young Drivers,
- Older Drivers,
- Pedestrian Safety,
- Bicycle Safety, and
- Drowsy Driving.

The guide:

- describes major countermeasure strategies and specific countermeasures that are relevant to SHSOs;
- summarizes strategy/countermeasure use, effectiveness, costs, and implementation time; and
- provides references to the most important research summaries and individual studies.

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Table of Acronyms and Abbreviations

AAAFTS	AAA Foundation for Traffic Safety
AAHPERD	American Alliance for Health, Physical Education, Recreation and Dance
AAMVA	American Association of Motor Vehicle Administrators
ADAS	advanced driver assistance systems
ALR	administrative license revocation
ALS	administrative license suspension
APIS	Alcohol Policy Information System
ARF	(FARS) Annual Report File
BAC	blood alcohol concentration, measured in grams per deciliter (g/dL)
BrAC	breath alcohol concentration, measured as grams per 210 liters of breath
CDC	Centers for Disease Control and Prevention
ChORUS	Clearinghouse for Older Road User Safety
CPS	child passenger safety
DADSS	Driver Alcohol Detection System for Safety
DRE	drug recognition expert
FARS	Fatality Analysis Reporting System
FMCSA	Federal Motor Carrier Safety Administration
GHSO	Governors Highway Safety Association
GDL	graduated driver licensing (laws)
IADLEST	International Association of Directors of Law Enforcement Standards and Training
IIHS	Insurance Institute for Highway Safety
MADD	Mothers Against Drunk Driving
MLDA	minimum legal drinking age (laws), also called MDLA-21
NASEM	National Academies of Sciences, Engineering, and Medicine
NCUTLO	National Committee on Uniform Traffic Laws and Ordinances
NCSL	National Conference of State Legislatures
NCHRP	National Cooperative Highway Research Program
NHTS	National Household Travel Survey
NIAAA	National Institute on Alcohol Abuse and Alcoholism
NOPUS	National Occupant Protection Use Survey
NSUBS	National Survey of the Use of Booster Seats
NTSB	National Transportation Safety Board
PBIC	Pedestrian and Bicycle Information Center
SFST	standardized field sobriety test
SRTS	Safe Routes to School
SSC	speed safety camera
TIRF	Traffic Injury Research Foundation
TRB	Transportation Research Board
VMT	vehicle miles traveled, usually expressed in millions

Preface to the 11th Edition, 2023

This edition of *Countermeasures That Work* was prepared by the University of North Carolina's Highway Safety Research Center. In addition to the authors, the following researchers contributed to this edition: Christine Gomola, Michael Vann, Stephen Heiny, Wesley Kumfer, and Michael Clamann. While this is the 11th edition of *Countermeasures That Work*, a digital version is now available at NHTSA.gov/Countermeasures where you can easily save and share information and countermeasures that you feel are most relevant. The first edition of *Countermeasures That Work* was prepared in 2005 by James H. Hedlund, Ph.D., of Highway Safety North, with the assistance of Barbara Harsha, executive director of the Governors Highway Safety Association. Additions and revisions have been made by James H. Hedlund of Highway Safety North and William A. Leaf of Preusser Research Group (2nd edition), UNC Highway Safety Research Center (3rd through 8th editions) and Battelle Memorial Institute (9th and 10th editions).

All chapters have been revised and updated for this edition. Information and research studies through May 31, 2020, have been reviewed and included as appropriate. Additionally, some research published after May 31, 2020, was included but a comprehensive review of the literature published after June 2020 was not completed. Data has been updated to include information from the 2021 FARS (Fatality Analysis Reporting System) Annual Report File (ARF). Updates to the guide are based only on published research. Unpublished programs and efforts are not included in this edition.

A significant change in the 11th Edition is the separation of the Alcohol- and Drug-Impaired Driving chapter of the previous editions into two distinct chapters, one focusing solely on alcohol-impaired driving and another on drug-impaired driving. As research into these topics has continued to evolve, it has become increasingly clear that, although intertwined, these two topic areas present unique challenges and varied countermeasures that warrant individual and nuanced discussion.

User Suggestions and Future Editions

The National Highway Traffic Safety Administration will update this guide biennially and may expand it with additional topic areas and countermeasures as appropriate. Users are invited to provide their suggestions and recommendations for the guide.

- How can it be improved, in form and content?
- Specific comments on information in the guide.
- Additional topic areas to include.
- Additional countermeasures to include for the current topic areas.
- Additional Key References to include.

Please send your suggestions and recommendations to:

Countermeasures That Work
National Highway Traffic Safety Administration
Office of Behavioral Safety Research, NPD-300
1200 New Jersey Avenue SE
Washington, DC 20590
or by email to NHTSA.Countermeasures@dot.gov

Purpose of the Guide

This guide is a basic reference to assist State Highway Safety Offices in selecting effective, science-based traffic safety countermeasures for major highway safety problem areas. The guide:

- describes major countermeasure strategies and specific countermeasures that are relevant to SHSOs;
- summarizes their use, effectiveness, costs, and implementation time; and
- provides references to the most important research summaries and individual studies.

The guide provides an overview for readers to familiarize themselves with the behavioral strategies and countermeasures in each topic area and provides resources for a deeper look at the topic. The guide is not intended to be a comprehensive list of countermeasures available for State use or a list of expectations for SHSO implementation. Inclusion in this guide does not mean that all costs associated with that countermeasure are allowable costs with NHTSA grant funds. For a description of an optimal State countermeasure program, SHSOs should refer to the *Uniform Guidelines for State Highway Safety Programs*, which delineate the principal components of each of the major program areas (NHTSA, n.d., the main web page and portal). States should identify problem areas through systematic data collection and analysis and are encouraged to continue to apply innovation in developing appropriate countermeasures. The evaluations summarized in this guide allow SHSOs to benefit from the experience and knowledge gained by others and to select countermeasure strategies that have either been proven to be effective or that have shown promise. States choosing to use innovative programs can contribute to the collective knowledge pool by carefully evaluating the effectiveness of their efforts and publishing the findings for the benefit of others.

How to Use the Guide

What's included:

The guide contains a chapter for each of the following major topic areas.

- Alcohol-Impaired Driving
- Drug-Impaired Driving
- Seat Belts and Child Restraints
- Speeding and Speed Management
- Distracted Driving
- Motorcycle Safety
- Young Drivers
- Older Drivers
- Pedestrian Safety
- Bicycle Safety
- Drowsy Driving

Each chapter begins with a brief overview of the topic, including emerging issues and some Key Resources. Next, a table lists the specific countermeasures included in the chapter and summarizes their effectiveness, costs, use, and implementation time. Effectiveness, cost, and time to implement can vary substantially from State to State and community to community. Costs for many countermeasures are difficult to measure, so the summary terms are very approximate. Each chapter sub-section may contain a list of "Key Resources," basically a list of recommended reading and resources. Each chapter concludes with a list of references for that chapter.

Countermeasure Effectiveness:

The effectiveness of any countermeasure can vary immensely from State to State or community to community. *What* is done is often less important than *how* it is done. The best countermeasure may have little effect if it is not implemented vigorously, publicized extensively, and funded appropriately. *The countermeasure effectiveness data presented in this guide probably shows the maximum effect that can be realized with high-quality implementation*. Many countermeasures have not been evaluated well, or at all, as noted in the effectiveness data. Additionally, some countermeasures found to be effective many years ago may not be as effective today. Effectiveness ratings are based primarily on demonstrated reductions in crashes; however, changes in behavior and knowledge are factored into the ratings when crash information is not available.

Countermeasure effectiveness is shown using a five-star rating system:

★★★★★	Demonstrated to be effective by several high-quality evaluations with consistent results.
★★★★	Demonstrated to be effective in certain situations.
★★★	Likely to be effective based on balance of evidence from high-quality evaluations.
★★	Limited evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.
★	No evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.

Additionally, some chapters include countermeasures under the heading "Approaches That Are Unproven or Need Further Evaluation." This section describes approaches that have been employed or recommended as countermeasures but, when used alone, the existing evaluation evidence does not support their usefulness or there is no evaluation evidence available and further research is needed. Though these approaches may not be effective when used alone, they may be useful when incorporated into comprehensive, multi-faceted programs. More detailed information can be found in previous editions of Countermeasures That Work. States, communities, and other organizations are encouraged to use 3-, 4-, or 5- star countermeasures. When implementing 1- and 2- star countermeasures or unrated approaches, they are encouraged to have the countermeasure evaluated in connection with its use.

What's not included:

Since the guide is intended as a tool for SHSO use, it does not include countermeasures for which SHSOs have little or no authority or responsibility. For example, the guide does not include vehicle- or roadway-based solutions. Also, it does not include countermeasures that are nearly universal in every State, such as .08 grams per deciliter blood alcohol concentration laws. While the guide does not include substantive detail of specific post-crash care related countermeasures from EMS or 911 services; these services are supported by SHSOs, traffic safety partners, and State Offices of EMS and 911. Guidance on these countermeasures is available at EMS.gov and 911.gov. Finally, the guide does not include administrative or management topics such as traffic safety data systems and analyses, program planning and assessments, State and community task forces, or comprehensive community traffic safety programs.

Disclaimers:

As with any attempt to summarize a large amount of sometimes-conflicting information, this guide is highly subjective. All statements, judgments, omissions, and errors are solely the responsibility of the authors and do not necessarily represent the views of NHTSA. Users who disagree with any statement or who wish to add information or key references are invited to send their comments and suggestions for future editions (see Preface for details). Although all web links in this guide are accurate at the time of publication, web links may change periodically. For broken links to NHTSA documents, search NHTSA's behavioral safety research reports at https://rosap.ntl.bts.gov/collection_nhtsa_bsr. For broken links to other reports or documents, refer to the website for the agency that produced the report.

New traffic safety programs are established, and research is conducted constantly. This report is not a comprehensive list of all research, current studies, or program information available on any countermeasure. Readers interested in any problem area or in specific countermeasures are urged to consult the references or contact NHTSA for up-to-date information.

Introduction

Countermeasures That Work is intended to be a reference guide for SHSOs to help select effective, science-based traffic safety countermeasures to address highway safety problem areas in their States. All countermeasures included in this guide aim to change human behavior in some way. Therefore, it is critical for SHSOs and others who use this guide to have a basic understanding of the science of human behavior.

"Human behavior" is a multidisciplinary field spanning public health, psychology, sociology, and other social sciences. These researchers endeavor to understand, explain, and even predict how humans will respond to their environment. SHSOs can learn from these other fields to improve the efficacy of their efforts. Programs or countermeasures that do not consider principles of human behavior are unlikely to be effective.

Updated Star Ratings

To help SHSOs differentiate between countermeasures that are more and less likely to be effective, the star rating system previously used for the one- and two-star countermeasures has been updated for this edition to include principles of human behavior. The rating system for the three-, four-, and five-star countermeasures did not change. One- and two-star countermeasures have the following updated definitions:

★★	Limited evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.
★	No evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.

In addition, many chapters now include a section called "Approaches That Are Unproven or Need Further Evaluation." This section includes approaches that have been employed or recommended as countermeasures but, when used alone, the existing evaluation evidence does not support their effectiveness or there is no evaluation evidence available and further research is needed. Though these approaches may not be effective when used alone, they may be useful when incorporated into comprehensive, multi-faceted programs. These approaches are included as they are often used or discussed by SHSOs. As with one- and two-star countermeasures, if an unrated approach is implemented, implementation and outcome evaluations are encouraged. Additional information on these approaches can be found in previous editions of *Countermeasures That Work*.

Why is it important to consider principles of human behavior when selecting countermeasures?

People are extraordinarily complex and often behave in seemingly inconsistent and unpredictable ways. Consequently, influencing or changing a behavior, which is the goal of most highway safety programs, is not a simple undertaking.

Over the past few decades, significant improvements have been made in many highway safety focus areas. Much of this improvement can be attributed to the four- and five-star countermeasures described in this guide. Many of the most successful countermeasures act by changing the physical or social environment to encourage the desired behavior. Environmental changes have the benefit of affecting the population as a whole, which is more efficient than trying to reach people individually. For example, universal motorcycle helmet laws affect all motorcyclists in a State by requiring helmet use. Similarly, graduated driver licensing affects all beginning young drivers in a State by restricting higher risk situations (e.g., nighttime driving) until they have experience in lower risk situations. High-visibility enforcement and publicized sobriety checkpoints change the environment by increasing the perceived risk of being caught in a community.

Education and awareness-raising campaigns are common approaches used to encourage behavior change. They are often seen as low-hanging fruits, easy, and low cost to implement but they rarely work in isolation. The goal of an awareness-raising campaign is to influence the attitudes, beliefs, or behavior of people through information and education. These campaigns often include communication strategies, such as press releases, press conferences, public service announcements, earned (free), paid, and social media, educational material like posters or brochures, and strategically placed logos or slogans. This strategy presumes that the audience lacks key information and that simply learning the information will be sufficient to change behavior.

For example, many States implement messaging around the topic of distracted driving. These messages range from general messaging around "paying attention" or "don't drive distracted" to more specific messaging around certain distracting behaviors (for example, messages discouraging texting while driving). However, data from the AAA Foundation for Traffic Safety demonstrates that the public already perceives driver distraction to be a serious traffic safety issue and yet still engages in those distracting activities. Ninety-six percent of those surveyed in 2020 said that using a cell phone to text or email while driving was extremely or very dangerous and yet 37% of respondents admitted to talking on the phone while driving during the past 30 days, 34% admitted to reading a text or email while driving, and 23% admitted to having manually typed or sent an email or text message (AAAFTS, 2021). In this case, the population already recognizes the dangers of distracted driving, but that information has not been sufficient to eliminate distracted behaviors. Therefore, information alone (as in a public awareness campaign) is not likely to have a large impact.

In this guide these types of strategies generally are in the "Approaches That Are Unproven or Need Further Evaluation" section because there is little evidence of their effectiveness when used alone. However, that is not to say that education and awareness campaigns do not have their place as part of a more comprehensive approach.

Before implementing any type of awareness-raising or educational messaging, it is important to ask 3 questions:

1. Does the audience lack this information?

   If the audience already knows the information being shared, additional efforts to "raise awareness" about the issue are unlikely to have any effect on behavior.

2. Is the information specific?

   General safety messages that tell people to "drive safely" or "be alert" are not specific enough to be meaningful to the audience.

3. Is it being used as part of a larger strategy for behavior change?

   Information alone rarely changes behavior.

It is also important for SHSOs to remember that behaviors and countermeasures don't exist in isolation. With the publication of the *National Roadway Safety Strategy*, the U.S. DOT (2022) officially adopted the Safe System Approach for transportation safety management in the United States. The Safe System Approach is a framework for transportation safety that centers human behavior and human physiology at the heart of any safety interventions. The six main principles of the Safe System Approach are that death and serious injury are unacceptable, humans make mistakes, humans are vulnerable, responsibility is shared, safety is proactive, and redundancy is crucial. Stakeholders should approach transportation safety proactively with the goal of creating redundancies in the system. The responsibility should be shared across disciplines and include science-based safety interventions that leverage safe vehicles, safe speeds, and safe roads to protect all road users and allow for safe travel (FHWA, 2020).

Additionally, SHSOs should carefully consider equity when selecting and implementing countermeasures. Behavioral countermeasures have relied heavily on enforcement efforts in the past. While these efforts have been credited with increasing compliance with traffic safety laws, they have historically been applied in a manner that has resulted in inequities and negative interactions with law enforcement (Johns Hopkins Center et al., n.d.; Road to Zero, n.d.). It is important to understand that not all communities will respond to countermeasures in a similar way and unintentional negative consequences can have long-term community impacts. The discussions of research results using variables of race, ethnicity, and national origin in this edition are based on the cited research and in some cases conflate race and ethnicity. Whenever possible, SHSOs should assess the anticipated and potential impacts of all potential countermeasures with an equity lens prior to implementation.

SHSOs are encouraged to consider both the Safe System Approach and equity when selecting countermeasures to influence behavior. Focusing only on the behaviors that influence crash outcomes fails to address the broader, systemic, and cultural forces that influence those behaviors such as local planning policies, licensure requirements, social norms, etc. (Dumbaugh et al., 2019). A truly Safe System-based approach considers how equitably applied behavioral interventions can interact with roadway designs and safe vehicle designs to guide road users to safe habits and seeks to shore up the transportation system so that when mistakes do occur, they will not result in death or serious injury.

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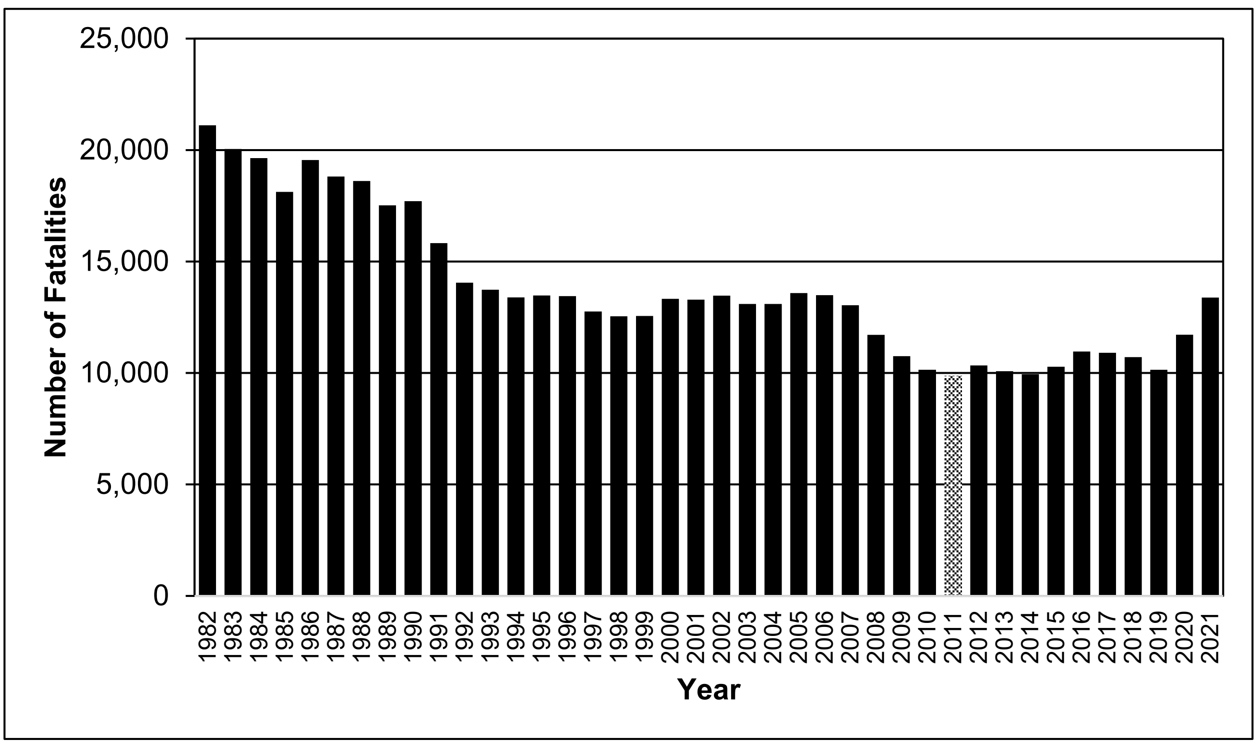
1. Alcohol-Impaired Driving

Overview

In 2021 there were 13,384 people killed in crashes involving alcohol-impaired drivers (defined as drivers or motorcycle riders with BACs of .08 g/dL or higher). This was an increase of 14.2% from the 11,718 fatalities in 2020 (National Center for Statistics and Analysis, 2023a). Fatalities in crashes involving alcohol-impaired drivers continue to represent almost one-third (31%) of the total motor vehicle fatalities in the United States. NHTSA's most recent *State Alcohol-Impaired-Driving Estimates Traffic Safety Facts* (NCSA, 2023c) contains additional national and State statistics pertaining to crashes involving alcohol.

Alcohol-impaired driving dropped steadily from the early 1980s to the mid-1990s. A study showed much of this decrease could be attributed to alcohol-related legislation (e.g., .08 BAC), administrative license revocation, and minimum drinking age laws) and to demographic trends (e.g., the aging of the population and the increased proportion of female drivers) (Dang, 2008). However, during this period there also was substantial public attention to the issue of alcohol-impaired driving, including the growth of grassroots organizations such as Mothers Against Drunk Driving and Remove Intoxicated Drivers, increased Federal programs and funding, State task forces, and increased enforcement and intensive publicity, all which combined to address this critical traffic safety problem.

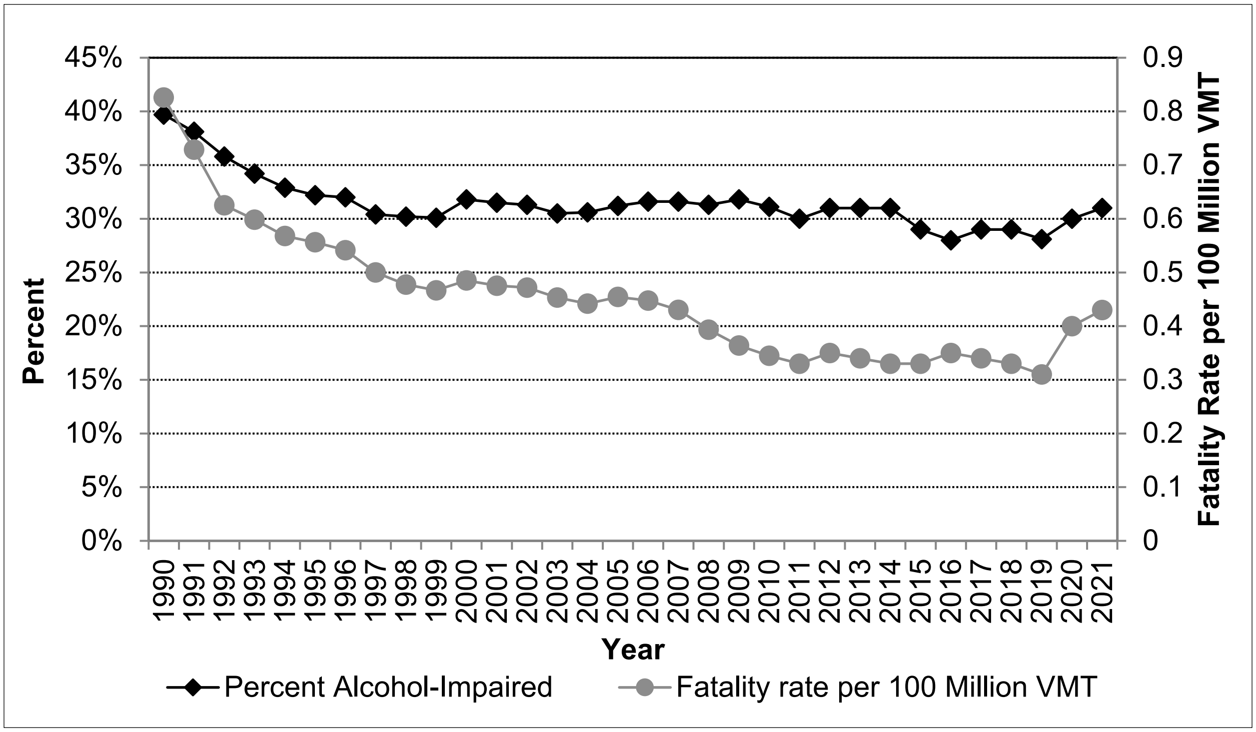
As shown in the figure below, alcohol-impaired-driving fatalities decreased 53% from 1982 to 2011. However, fatalities increased 36% from 2011 to 2021, due in part to a noticeable rise in alcohol-impaired-driving fatalities during 2020 and 2021 and the COVID-19 pandemic.



Source: NHTSA (1982 to 2023)

Figure 1-1. U.S. Alcohol-Impaired Driving Fatalities

As shown in the next chart, the *rate* of alcohol-impaired-driving fatalities, based on VMT, has declined noticeably over the last 3 decades. However, the percentages of fatalities in the United States that involve alcohol-impaired driving has decreased only slightly during this time.



Source: NHTSA (1990 to 2021), NCSA (2023a)

Figure 1-2. Percentages of U.S. Driving Fatalities Who Were Alcohol-Impaired and Alcohol-Impaired Fatality Rate by VMT

Understanding the Problem

According to the CDC (2018), about half (53%) of U.S. adults can be considered "regular" drinkers; that is, they have consumed at least 12 drinks during the previous year. An estimated 147 million trips are made annually by drivers with BACs of .08 g/dL or higher (Barry et al., 2022). The 2013-2014 National Roadside Survey found 8.3% of drivers on weekend nights have positive BACs, while 1.5% have BACs of .08 g/dL or higher (Berning et al., 2015). This represents a significant reduction from 2007, when 12.4% of drivers had positive BACs and 2.2% had BACs of .08 g/dL or higher. The percentage of drivers drinking on weekend nights has fallen dramatically since the first National Roadside Survey in 1973, which found that 35.9% of drivers had positive BACs and 7.5% of drivers had BACs of .08 g/dL or higher (Berning et al., 2015).

An AAAFTS survey of 2,725 U.S. residents conducted in 2020 found 94% believed it is extremely or very dangerous to drive after drinking enough alcohol to be over the legal limit. Nonetheless, 6% reported having done so within the past 30 days (AAAFTS, 2021). Seven percent of people reported having ridden with a drinking driver in the past 12 months (Fan et al., 2019).

Alcohol-impaired drivers include both drinkers who may occasionally drive after drinking too much, as well as persistent offenders who regularly drive while impaired. Impaired drivers may be considered “high risk” if they have high BACs, prior convictions, or alcohol use problems. For example, among drivers involved in fatal crashes during 2021 with positive BACs (.01 g/dL or higher), over half (55%) had BACs at or above .15 g/dL (NCSA, 2023a). Additionally, one-quarter of all drivers arrested for impaired driving and 30% of drivers convicted of impaired driving have had prior DWI convictions (Warren-Kigenyi & Coleman, 2014). In 2021 some 7% of drivers involved in fatal motor vehicle crashes with BACs of .08 g/dL or above had been convicted of DWI in the past 5 years, compared to 2% of sober drivers (NCSA, 2023a).

Other characteristics of drivers in alcohol-related fatal crashes include the following (NCSA, 2023a):

- Sex: There are about four male alcohol-impaired drivers in fatal crashes for every female alcohol-impaired driver.
- Age: Drivers 21 to 24 and 35 to 44 have the highest percentages (27% each) of alcohol impairment in fatal crashes of any age group.
- Vehicle type: Motorcycle riders have a higher percentage (28%) of alcohol impairment in fatal crashes than drivers of passenger cars (24%), light trucks (20%) or large trucks (3%).
- Restraint use: Among passenger vehicle drivers who were alcohol-impaired and killed in crashes, 65% were unrestrained.

Alcohol impairment among drivers involved in fatal crashes is nearly three times higher at night than during the day (NCSA, 2023a). Alcohol involvement is also much higher in fatal crashes on weekends (28%) than on weekdays (16%). Thirty-three percent of all drivers involved in single-vehicle fatal crashes are alcohol-impaired, compared to 14% in multivehicle fatal crashes. A substantial proportion of pedestrians killed in crashes also have high BACs—almost than one-third (30%) of fatally injured pedestrians have BACs of .08 g/dL or higher (NCSA, 2023b). These pedestrians tend to be older males, and the crashes typically occur on weekend nights at non-intersection locations (Hezaveh & Cherry, 2018). In addition, Blomberg et al. (2019) found that people with prior alcohol-related driving offenses may be at greater risk for being killed as high-BAC pedestrians than those without prior alcohol offenses.

Alcohol-impaired driving fatalities are affected by several external factors including geography, urbanization, road structure and conditions, and economic activity, as well as by a State’s laws and programs. For these reasons both the current level of alcohol-impaired driving and the progress in reducing alcohol-impaired driving vary greatly from State to State. For example, comparing all 50 States and the District of Columbia, the proportion of traffic fatalities involving drivers with BACs of .08 g/dL or higher in 2021 ranged from 20% in the lowest State, Mississippi, to 44% in the highest, Montana (NCSA, 2023a).

Four basic strategies are used to reduce impaired driving crashes and driving under the influence.

- *Deterrence:* Enact, publicize, enforce, and adjudicate laws prohibiting impaired driving so people choose not to drive impaired.
- *Prevention:* Reduce drinking and keep impaired drivers from driving.

- *Communications and outreach:* Inform the public of the dangers of impaired driving and establish positive social norms that make driving while impaired unacceptable.
- *Alcohol treatment:* Reduce alcohol dependency or addiction among drivers.

Deterrence is key

Deterrence works by changing behavior through the fear of apprehension and punishment. If drivers believe impaired driving is likely to be detected and impaired drivers are likely to be arrested, convicted, and punished, many will not drive while impaired by alcohol. This strategy, called *general deterrence*, influences the general driving public. An example of general deterrence would be well-publicized and highly visible enforcement activities, such as sobriety checkpoints. In contrast, *specific deterrence* refers to efforts to influence drivers who have been arrested for impaired driving so they will not continue to drive while impaired by alcohol. An example of this approach would include ignition interlocks or vehicle sanctions for DWI offenders.

Deterrence works when consequences are swift, sure, and severe (with swift and sure being more important in affecting behavior than severe). Deterrence, however, is far from straightforward, and complexities can limit the success of deterrence measures. For instance:

- Detecting impaired drivers is difficult. Law enforcement agencies have limited resources and officers must observe a traffic violation or other aberrant behavior before they can stop a motorist for an investigation of impaired driving (except at checkpoints). There are times when a stop is for something completely unrelated, but the stop may turn into an impaired-driving investigation if indicators are present once the officer and driver are face to face.
- Conviction also may be difficult. DWI laws are complicated, the evidence needed to define and demonstrate impairment is complex, and judges and juries may not choose to impose specified penalties if they believe the penalties are too severe.
- The DWI control system is complex. There are many opportunities for breakdowns in the system that allow impaired drivers to avoid penalties and screening/assessment to address the underlying causes of substance use misuse.

A State's DWI control system consists of its DWI laws and the enforcement, prosecution, adjudication, and offender monitoring policies and programs to support the laws. In this system, the operations of each component affect all the other components. Each new policy, law, or program affects operations throughout the system, sometimes in ways that are not anticipated. This guide documents 23 specific impaired-driving countermeasures in three groups: (1) legislation and licensing, (2) enforcement, and (3) other strategies for behavior change. But the overall DWI control system, including its management and leadership, is more important than any individual countermeasure.

Studies have highlighted the key characteristics of an efficient and effective DWI control system (Hedlund & McCartt, 2002; Robertson & Simpson, 2002):

- Training and education for law enforcement, prosecutors, judges, and probation officers.
- Record systems that are accurate, up-to-date, easily accessible, and able to track each DWI offender from arrest through the completion of all sentence requirements.

- Adequate resources for staff, facilities, training, equipment, and new technology.
- Coordination and cooperation within and across all components.

A few of the countermeasures discussed in this chapter, such as BAC test refusal penalties, alcohol-impaired-driving law review, and DWI courts are directed at improving DWI system operations. In some instances, the most important action that SHSOs can take to reduce alcohol-impaired driving is to review and improve DWI control system operations, perhaps using a State DWI task force or a State impaired-driving program assessment.

Ulmer et al. (1999) investigated why some States reduced alcohol-related traffic fatalities more than others. They concluded that there is no “silver bullet,” i.e., no single critical law, enforcement practice, or communications strategy. Once a State has effective laws, HVE, and substantial communications and outreach to support them, the critical factors are strong leadership, a commitment to reducing impaired driving, and adequate funding. Although 2 decades have passed, the basic findings are still applicable. SHSOs should keep this in mind as they consider the specific countermeasures in this chapter.

Many other traffic safety countermeasures help reduce impaired-driving-related crashes and casualties but are not discussed in this chapter. For example, improved vehicle structures and centerline rumble strips and barriers may reduce the likelihood of crashes or injuries sustained by impaired drivers. Additionally, higher alcohol taxes and reduced/limited alcohol sales/outlets can affect alcohol-impaired driving and crashes. These types of countermeasures are not included in this chapter as SHSOs have little or no authority or responsibility for them.

Data/Surveillance

Accurate data about alcohol-impaired driving is critical for monitoring trends and for developing and evaluating effective programs to address the problem. All States and the District of Columbia report BACs for drivers in fatal crashes to NHTSA’s Fatality Analysis Reporting System. Each State has its own laws and guidelines for BAC testing, and the reporting levels vary from State to State. In 2021 BAC test results were known for 38% of all drivers involved in fatal crashes, including 59% of drivers who were killed and 21% of surviving drivers (NCSA, 2023c). Known BAC test results were highest in South Dakota (81%) and lowest in Mississippi (9%). Testing rates have decreased over the past decade. In 2012 BAC test results were known for 52% of all drivers involved in fatal crashes, including 75% of drivers who were killed and 31% of surviving drivers (NCSA, 2023c).

Casanova et al. (2012) examined State practices for BAC testing and reporting in fatal crashes. At that time, 25 U.S. States required testing for all (or nearly all) fatally injured drivers. In the remaining States, law enforcement officers need probable cause to request BAC tests. Testing rates were approximately 15% higher, on average, in mandatory testing States. However, some probable-cause States tested over 80% of fatally injured drivers. Hence, laws by themselves do not guarantee high testing rates—a State’s practices and procedures can be just as important for achieving high rates.

Casanova et al. (2012) also conducted case studies of 9 States that have maintained high BAC testing rates or improved their rates substantially. The report described how these States overcame obstacles and used creative strategies to increase testing rates. Overall, factors associated with high testing rates included clear responsibility and policy, standard procedures, inter-agency cooperation, dedicated staff, and strong BAC laws.

For an overview of available data sources on alcohol-impaired driving, data gaps and barriers, data access, and future data and surveillance needs, see the National Academies of Sciences, Engineering, and Medicine's *Getting to Zero Alcohol-Impaired Driving Fatalities: A Comprehensive Approach to a Persistent Problem* (Teutsch et al., 2018).

Emerging Issues

Vehicular technologies may be helpful in detecting or preventing impaired driving. A 2021 study estimated that if alcohol detection technology were added to all new vehicles, up to 9,000 lives could be saved each year (Farmer, 2021). NHTSA has studied the feasibility of using vehicle-based sensors to detect alcohol-related impairment in drivers (Lee et al., 2010). The Driver Alcohol Detection System for Safety program is a collaborative research partnership between the automotive industry and NHTSA to assess and develop alcohol-detection technologies to prevent vehicles from being driven when a driver's BAC is at or exceeds the legal limit of .08 g/dL (as of December 30, 2018, Utah's BAC per se limit is .05 g/dL). Some technologies can passively detect alcohol in the breath of the driver; other technologies use a touch pad to measure alcohol concentration in the driver's skin tissue. In 2019 Maryland joined Virginia to pilot the DADSS program in selected fleet vehicles. More information is available from DADSS (2021) and NASEM (Teutsch et al., 2018).

The public generally supports using alcohol detection technology to prevent alcohol-impaired driving. In one nationally representative survey from 2010, some 64% of respondents said that having advanced alcohol detection technology in all vehicles was a "good" or "very good" idea (McCartt, Wells, & Teoh, 2010). The technology was supported even among those who admitted to driving at or above the legal limit. In the AAA Foundation survey, 70% of respondents supported requiring all new cars to have built-in technology that will not allow a vehicle to start if the driver's alcohol level is over the legal limit (AAAFTS, 2021).

Key Resources

For comprehensive overviews of alcohol-impaired driving, see the following.

- National Highway Traffic Safety Administration: *Alcohol and Highway Safety 2006: A Review of the State of Knowledge* (Voas & Lacey, 2011).
- National Cooperative Highway Research Program (NCHRP): *A Guide for Reducing Alcohol-Related Collisions* (Goodwin et al., 2005).
- "A Consensus Study Report" of the National Academies of Sciences, Engineering, and Medicine (NASEM): *Getting to Zero Alcohol-impaired Driving Fatalities: A Comprehensive Approach to a Persistent Problem* (Teutsch et al., 2018).

For more information about impaired-driving countermeasures, see:

- Transportation Research Board's Alcohol, Other Drugs, and Transportation Committee's e-Circular, *Countermeasures to Address Impaired Driving Offenders: Toward an Integrated Model* (TRB, 2013).

- Centers for Disease Control and Prevention: *The Community Guide: Motor Vehicle Injury* (CDC, 2021).
- *Approaches for Reducing Alcohol-Impaired Driving: Evidence-Based Legislation, Law Enforcement Strategies, Sanctions, and Alcohol-Control Policies* (Fell, 2019a)
- *DWI History of Fatally Injured Pedestrians* (Blomberg et al., 2019).

For alcohol-impaired-driving laws, see the following.

- National Conference of State Legislatures: *Drunken/Impaired Driving* (NCSL, 2021).
- National Highway Traffic Safety Administration: *Digest of Impaired Driving and Selected Beverage Control Laws* (NHTSA, 2017).

For approaches to dealing with persistent DWI offenders, see the following.

- Traffic Injury Research Foundation (TIRF): *The Persistent DWI Offender: Policy & Practical Considerations* (TIRF, 2018).

Alcohol-Impaired-Driving Countermeasures

Legislation and Licensing

Countermeasure	Effectiveness	Cost	Use	Time
Administrative License Revocation or Suspension (ALR/ALS)	★★★★★	$$$	High	Medium
Minimum Drinking Age 21 Laws	★★★★★	$$$	High	Short
Open Container Laws	★★★★★	$	High	Short
Lower BAC Limits	★★★★	$	Low	Short
High-BAC Sanctions	★★★	$	Medium	Short
BAC Test Refusal Penalties	★★★	$	Unknown	Short
Alcohol-Impaired-Driving Law Review	★★★	$$	Unknown	Medium

Enforcement

Countermeasure	Effectiveness	Cost	Use	Time
Publicized Sobriety Checkpoints	★★★★★	$$$	Medium	Short
High-Visibility Saturation Patrols	★★★★	$$	High	Short
Alcohol Measurement Devices	★★★★	$$	High	Short
Integrated Enforcement	★★★	$	Unknown	Short
Alcohol Vendor Compliance Checks	★★★	$$	Unknown	Short
Zero-Tolerance Law Enforcement	★★★	$	Unknown	Short

Other Strategies for Behavior Change

Countermeasure	Effectiveness	Cost	Use	Time
Alcohol Ignition Interlocks	★★★★★	$$	Medium	Medium
Alcohol Problem Assessment and Treatment	★★★★★	Varies	High	Varies
Alcohol Screening and Brief Intervention	★★★★★	$$	Medium	Short
Vehicle and License Plate Sanctions	★★★★	Varies	Medium	Short
DWI Offender Monitoring	★★★★	$$$	Unknown	Varies
DWI Courts	★★★★	$$$	Low	Medium

Countermeasure	Effectiveness	Cost	Use	Time
Limits on Diversion & Plea Agreements	★★★	$	Medium	Short
Alternative Transportation	★★★	$$	Unknown	Short
Mass-Media Campaigns	★★	$$$	High	Medium
Court Monitoring	★★	$	Low	Short

Approaches That Are Unproven or Need Further Evaluation

Countermeasure
Responsible Beverage Service
Sanctions
Designated Drivers
Youth Programs

Effectiveness:

★★★★★	Demonstrated to be effective by several high-quality evaluations with consistent results.
★★★★	Demonstrated to be effective in certain situations.
★★★	Likely to be effective based on balance of evidence from high-quality evaluations.
★★	Limited evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.
★	No evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.

Cost to implement:

$$$	Requires extensive new facilities, staff, equipment, or publicity, or makes heavy demands on current resources.
$$	Requires some additional staff time, equipment, facilities, and/or publicity.
$	Can be implemented with current staff, perhaps with training; limited costs for equipment or facilities.

These estimates do not include the costs of enacting legislation or establishing policies.

Use:

High	More than two-thirds of the States, or a substantial majority of communities
Medium	One-third to two-thirds of the States or communities
Low	Less than one-third of the States or communities
Unknown	Data not available

Time to implement:

Long	More than 1 year
Medium	More than 3 months but less than 1 year
Short	3 months or less

These estimates do not include the time required to enact legislation or establish policies.

Legislation and Licensing

Administrative License Revocation or Suspension

Effectiveness: ★★★★★	**Cost:** $$$	**Use:** High	**Time:** Medium

Administrative license suspension laws allow law enforcement and driver licensing authorities to suspend a driver's license if the driver fails or refuses to take a BAC test. Administrative license revocation laws are similar, except the offender must re-apply for a license once the suspension period ends. Usually, the arresting officer takes the license at the time a driver fails or refuses a BAC test. The driver typically receives a temporary license that allows time to make other transportation arrangements and to request and receive an administrative hearing or review. From a NHTSA review (2008a), in most jurisdictions at that time, an offender could obtain an occupational or hardship license during part or all the revocation or suspension period. NHTSA recommends that ALR laws include a minimum license suspension of 90 days (NHTSA, 2006a). The National Committee on Uniform Traffic Laws and Ordinances (NCUTLO, 2000) has a model ALR law.

ALR and ALS laws provide for swift and certain penalties for DWI rather than the lengthy and uncertain outcomes of criminal courts. They also protect the driving public by removing some DWI offenders from the road (but see the discussion of driving with a suspended license, under "other considerations"). The NCHRP Report 500 guide on reducing impaired-driving (Goodwin et al., 2005) and NHTSA's *Traffic Safety Facts* on ALR (NHTSA, 2008a) have more information about ALR laws.

Use:

As of July 2020 there were 48 States and the District of Columbia that had some form of ALR or ALS law for a first offense (GHSA, 2020). Thirty-nine States had minimum license suspensions of at least 90 days, as recommended by NHTSA.

Effectiveness:

Many State ALR and ALS laws have been in place for decades, and much of the research examining the effectiveness of these laws is now dated. For example, a summary of 12 evaluations through 1991 found ALR and ALS laws reduced crashes of different types by an average of 13% (Wagenaar et al., 2000). A more recent study examining the long-term effects of license suspension policies across the United States concluded that ALR reduces alcohol-related fatal crash involvement by 5%, saving an estimated 800 lives each year (Wagenaar & Maldonado-Molina, 2007). Similarly, Fell and Scherer (2017) found States with ALS laws have lower rates of drinking drivers in fatal crashes, especially when suspensions are 91 days or longer. See DeYoung (2013a) for a review of the research on the effectiveness of ALR/ALS laws.

Drivers are less likely to commit offenses when they believe sanctions will be certain and swift (Nagin & Pogarsky, 2006; Wright, 2010). A study in Ontario, Canada, found a 17% decrease in fatalities and injuries after enactment of a law that required immediate roadside license suspensions for drivers with BACs from .05 to .08 g/dL, which was in addition to existing sanctions for BACs above .08 g/dL (Byrne, Ma, Mann, & Elzohairy, 2016). A companion study of the same law found that an immediate 7-day impoundment of drivers' vehicles reduced recidivism occurring within the following 3-month period by 29% (Byrne, Ma, & Elzohairy, 2016). The Ontario study suggests that swift and certain administrative sanctions—such as ALS and vehicle impoundment—can be highly effective in reducing alcohol impaired-driving crashes and fatalities, and in reducing further impaired driving by DWI offenders.

Costs:

ALR/ALS laws require funds to design, implement, and operate a system to record and process administrative license actions. In addition, a system of administrative hearing officers must be established and maintained. Some States have recovered ALR or ALS system costs through offender fees (Century Council, 2008; NHTSA, 2008a).

Time to implement:

Designing and implementing the system and recruiting and training administrative hearing officers takes 6 to 12 months.

Other considerations:

- *Two-track system:* Under ALR or ALS laws, drivers face both administrative and criminal actions for DWI. The two systems operate independently. Drivers whose licenses have been suspended or revoked administratively still may face criminal actions that also may include license suspension or revocation.
- *Driving with a suspended license:* Some DWI offenders continue to drive on occasion with suspended or revoked licenses (Lenton et al., 2010; McCartt et al., 2002). For strategies to reduce driving with a suspended or revoked license, see Neuman et al. (2003).
- *Delaying license reinstatement:* Many DWI offenders do not reinstate their licenses when they are eligible to do so. A study by Voas, Tippetts and McKnight (2010) found that at that time, about half (49%) of DWI offenders delay license reinstatement for at least a year, while 30% delay reinstatement for 5 years or more. Offenders who delay reinstatement were more likely to recidivate than those who have their licenses restored. This suggests it may be important to encourage DWI offenders to reinstate their licenses once eligible, but with appropriate controls such as ignition interlocks and close monitoring.
- *Hearings:* An effective ALR system will restrict administrative hearings to the relevant facts: that the arresting officer had probable cause to stop the vehicle and require a breath alcohol concentration test and that the driver refused or failed the test. Such a system will reduce the number of hearings requested, reduce the time required for each hearing, and minimize the number of licenses that are reinstated. When an administrative hearing is not restricted in this way, it can serve as an opportunity for the defense attorney to question the arresting officer about many aspects of the DWI case. This may reduce the chance of a criminal DWI conviction (Hedlund & McCartt, 2002). Officers often spend substantial time appearing in person at ALR hearings, and a case may be dismissed if an officer fails to appear. Some States use telephonic hearings to solve these problems (Wiliszowski et al., 2003).

Minimum Legal Drinking Age 21 Laws

Effectiveness: ★★★★★	**Cost:** $$$	**Use:** High	**Time:** Short

The primary strategy to reduce underage drinking, as well as drinking and driving, has been restricting access to alcohol via minimum purchase age laws. Since July 1988 the minimum legal drinking age has been 21 in all States. There is strong evidence that MLDA-21 laws reduce drinking, driving after drinking, and alcohol-related crashes and injuries among youth (McCartt, Hellinga, & Kirley, 2010; Shults et al., 2001; Wagenaar & Toomey, 2002). In fact, MLDA-21 laws reduced youth drinking and driving more than youth drinking alone (using the measurements of self-reporting and testing of impaired drivers in fatal crashes) (McCartt, Hellinga, & Kirley, 2010). Drinking and driving has become less socially acceptable among youth, and more youth have separated their drinking from their driving (Hedlund et al., 2001).

MLDA-21 law enforcement can take several forms:

- *Actions directed at alcohol vendors*: compliance checks to verify that vendors will not sell to youth, dram shop liability laws, or responsible beverage service training laws.
- *Actions directed at youth*: "use and lose" laws that confiscate the driver's license of an underage drinker, "Cops in Shops" directed at underage alcohol purchasers, law enforcement "party patrols" using party dispersal techniques, and penalties for using false identification.
- *Actions directed at adults*: beer keg registration laws, enforcement of laws prohibiting purchasing alcohol for youth, shoulder tap operations (in which decoy minors ask adults to purchase alcohol for them and if the adult complies, the adult is cited or arrested), and programs to penalize parents who provide alcohol to youth at parties.

Fell et al. (2016) found that nine laws that support enforcement of the MLDA-21 law significantly decreased fatal crash ratios of drinking to nondrinking drivers under 21. The laws are: (1) possession of alcohol, (2) purchase of alcohol, (3) use alcohol and lose your license, (4) zero-tolerance .02 BAC limit for underage, (5) age of bartender as 21 or older, (6) State responsible beverage service program, (7) fake identification support provisions for retailers, (8) dram shop liability, and (9) social host civil liability. The study estimated that combined, the nine MLDA-21 support laws save approximately 1,355 lives each year; however, only 5 States have enacted all nine laws. While these enforcement strategies have been used frequently, few have been evaluated.

The implementation of MLDA-21 laws for alcohol vendors, adults, and youth differs substantially from State to State. See the Alcohol Policy Information System for State-by-State summaries of some of the key provisions (APIS, 2021).

Use:

The minimum age to purchase alcohol is 21 years old in all 50 States and the District of Columbia.

Effectiveness:

Several reviews point to the effectiveness of MLDA-21 laws. Shults et al. (2001) identified 33 published studies examining the effects of changing the legal drinking age. Overall, changes to the MLDA affected alcohol-related crashes by 10% to 16%, with crashes decreasing when the

MLDA was raised, and increasing when it was lowered. Wagenaar and Toomey (2002) reviewed 79 high-quality studies examining the relationship between the MLDA and crashes. Of these studies, 58% found fewer crashes associated with a higher MLDA, whereas none found fewer crashes associated with a lower MLDA. These findings prompted McCartt, Hellinga, and Kirley (2010) to conclude: "The highway safety benefits of MLDA-21 have been proven, and the cause-and-effect relationship between MLDA and highway crashes is clear. Deaths go up when the drinking age is lowered, and they go down when it is raised" (p. 180). NHTSA estimates that MLDA-21 laws have saved 31,959 lives since 1975 and an estimated 538 lives in 2017 alone (NCSA, 2019, 2022).

Costs:

Costs may be associated with training needed for enforcement of MLDA-21 laws. (See Countermeasures on Zero Tolerance Law Enforcement and Alcohol Vender Compliance Checks.)

Time to implement:

MLDA-21 laws can be implemented as soon as appropriate legislation is enacted.

Other considerations:

- *Repealing MLDA-21 laws:* From 2007 to 2010 six States introduced legislation allowing at least some people under 21 to purchase and consume certain types of alcoholic beverages (McCartt, Hellinga, & Kirley, 2010). None of these bills passed. There has been more research on the MLDA than perhaps any other alcohol-control policy (Wechsler & Nelson, 2010). Most traffic safety experts have concluded that MLDA-21 laws are effective, and they recommend strengthening enforcement of MLDA-21 laws and establishing policies to support them. For further discussion of this issue, see Wechsler and Nelson (2010) and McCartt, Hellinga, and Kirley (2010).
- *"Use and lose" laws:* These laws allow confiscation of the driver's license or postpone licensure for a period of time for youth who violate a State's MLDA-21 law. Ulmer et al. (2001) investigated "use and lose" law implementation and effects in Pennsylvania. License suspensions for violations of MLDA-21 appeared to reduce subsequent traffic violations and crashes. In a national study, Fell et al. (2009) found "use and lose" laws were associated with a 5% decrease in fatal crashes among underage drivers. The study estimated that 165 lives would be saved each year if all States had these laws. "Use and lose" laws can be implemented quickly and inexpensively once enacted. To be effective, they should be publicized extensively. As of January 2021, there were 28 States and the District of Columbia that had mandatory "use and lose" laws and another 10 States had "use and lose" authority that may be applied in varying circumstances (APIS, 2021).
- *Keg registration laws:* These laws link beer keg purchasers to an identification number on the keg, which provides a method of identifying adults who supply beer to parties attended by youth. As of 2021 there were 16 States that had mandatory keg registration laws (APIS, 2021), down from 30 in 2018. Utah only permits the sale of kegs to authorized beer retailers to dispense beer on draft for consumption on the beer retailer's premises. In a study on the effectiveness of these laws, keg registration was shown to be associated with reduced traffic fatality rates in 97 U.S. communities (Cohen et al., 2001).

However, the authors could not conclude that keg registration *caused* the lower fatality rates. A study by Fell et al. (2015) found that keg registration laws were associated with decreases in per-capita beer consumption but increases in the ratio of drinking to sober underage drivers involved in fatal crashes.

- *Social Host Liability:* Under social host laws, adults who host underage drinking parties (specific laws), or who allow underage drinking to occur on their property (general laws), can be held accountable if a young person is subsequently involved in a crash. This liability might discourage adults (parents, older siblings, and friends) from purchasing alcohol for underage people or hosting an underage party. Conducting source investigations, in which law enforcement teams identify the providers of the alcohol, can be resource intensive and time consuming (Curtis & Ramirez, 2011). Moreover, the few research studies that have examined the effect of social host liability laws have obtained conflicting findings (Voas & Lacey, 2011). Nonetheless, comprehensive and well-publicized efforts to hold providers accountable appear to be promising. Social host laws, and their accompanying penalties, vary from State to State. A description of each State's social host laws may be found in NHTSA's *Digest of Impaired Driving and Selected Beverage Control Laws* (NHTSA, 2017). Another resource is available from the APIS (2021).
- *Underage Drinking Tip line:* In 2006 Kansas launched a statewide underage drinking tip line: 866-MustB21 and Pennsylvania uses 1-888-UNDER21. The toll-free tip lines operate 24 hours a day, 7 days a week, for people to report parties involving underage drinking, plans to purchase alcohol for underage people, and willingness of retailers to sell alcohol to underage people. The effect of the tip lines has not been evaluated. Kansas pays about $200 a month for this service and no data on the number of calls, responses, etc., are available. Nebraska introduced a statewide underage drinking tip line in 2009, using the same phone number as Kansas. New York, Texas, and Iowa, have since implemented underage drinking tip lines.
- *Comprehensive community programs:* Community programs focus on changing the local environment to prevent alcohol misuse through changes in ordinances and norms, incorporating discrete counseling and prevention programs, or combinations of such strategies (Fagan et al., 2011). Several comprehensive community initiatives have reduced youth drinking and alcohol-related problems (Fagan et al., 2011; Hingson et al., 2004; Shults et al., 2009). These initiatives typically bring together schools, health departments, and law enforcement, with alcohol sellers, parents, youth, and citizen organizations (Fagan et al., 2011). They may include school-based programs, law enforcement, media, and other intervention strategies. They require strong leadership and organization. They may take many months to plan and implement. Successful community initiatives are centered around data-driven practices and evidence-based measures, making the careful monitoring of program processes necessary to ensure quality outcomes. One example is a campaign conducted in Huntington, West Virginia, that included checkpoints to look for violations of the MLDA-21 law, checks of alcohol outlets to reduce sales to minors, and publicity for program activities. Roadside surveys conducted before and during the program showed a 93% drop in 16- to 20-year-old drivers having BACs greater than .05 g/dL (Insurance Institute for Highway Safety, 2008). Another promising program is Oregon's Reducing Youth Access to Alcohol. The

program involves community mobilization including "reward and reminder" visits (where vendors receive rewards if they decline to sell alcohol to a minor), regular compliance checks, enforcement of minor in possession laws, and media advocacy. The program was effective in reducing the sale of alcohol to minors: successful purchase attempts by minors dropped from 24% before the program to 5% afterwards. Additionally, the individual communities with the strongest programs also experienced reductions in underage drinking (Flewelling et al., 2013). For more examples of community programs, see: *An Impact Evaluation of Underage Drinking Prevention Projects* (Lacey et al., 2004).

Open Container Laws

Effectiveness: ★★★★★	**Cost:** $	**Use:** High	**Time:** Short

Open container laws prohibit the possession of any open alcoholic beverage container and the consumption of any alcoholic beverage by motor vehicle drivers or passengers. These laws typically exempt passengers in buses, taxis, and the living quarters of mobile homes.

In 1998 Congress required States to enact open container laws or have a portion of their Federal-aid highway construction funds redirected to alcohol-impaired driving or hazard elimination activities (NHTSA, 2008b). To comply, State open container laws must:

- Prohibit possession of alcoholic beverage containers and consumption of alcohol in motor vehicles;
- Cover the entire passenger area;
- Apply to all types of alcoholic beverages;
- Apply to all vehicle occupants;
- Apply to all vehicles on public highways; and
- Provide for primary enforcement of the law.

Survey data in both law and no-law States show strong public support for open container laws (NHTSA, 2008b).

Use:

As of October 2022 there were 38 States and the District of Columbia that had open container laws that complied with the Federal requirements (FHWA, 2022).

Effectiveness:

A study of 4 States that enacted laws in 1999 found the proportion of alcohol-involved fatal crashes appeared to decline in 3 of the 4 States during the first 6 months after the laws were implemented, but the declines were not statistically significant (Stuster et al., 2002). In general, the proportion of alcohol-involved fatal crashes was higher in States with no open container laws than in States with laws. Open container laws are associated with fewer alcohol-related fatalities (Ying et al., 2013; Whetten-Goldstein et al., 2000).

Active enforcement of open container laws is important for open container laws to be effective. In one study self-reported impaired driving was 17.5% lower in States that actively enforced open container laws compared with States that did not (Lenk et al., 2016).

Costs:

Open container laws require funds to train law enforcement officers and to implement enforcement.

Time to implement:

Open container laws can be implemented as soon as appropriate legislation is enacted.

Lower BAC Limits

Effectiveness: ★★★★	**Cost:** $	**Use:** Low	**Time:** Short

Laboratory studies show impairment in driving ability begins at levels below .08 g/dL BAC (i.e., Moskowitz et al., 2000). The National Transportation Safety Board (2013) is one organization that has recommended a BAC of .05 g/dL or lower for all drivers. Consequently, many countries, and some U.S. jurisdictions, impose penalties for drivers who have BACs of .05 g/dL or higher. From a recent survey, 53% of drivers in the United States supported lowering the BAC limit for all drivers from .08 to .05 g/dL (AAAFTS, 2021).

All States have BAC limits of .02 g/dL or lower for drivers under 21 (NIAAA, 2022a). These laws reinforce MLDA laws prohibiting people under 21 from purchasing or possessing alcohol in public. Additionally, some States set BAC limits of .02 or .04 g/dL for people convicted of DWI, to emphasize that they should not be driving after drinking.

Use:

All States have an illegal per se BAC limit of .08 g/dL with the exception of Utah, which enacted a .05 g/dL law that went into effect on December 30, 2018. Colorado and New York both have driving while ability impaired laws (impairment at a BAC lower than .08 g/dL) and West Virginia may revoke a license at a BAC above .05 g/dL. As of November 2016 four States, Nebraska, North Carolina, Vermont, and Virginia, have lower BAC limits for people convicted of DWI (NCSL, 2016a).

Effectiveness:

A NHTSA study evaluated the impact of Utah's .05 g/dL per se law (Thomas et al., 2022). The study showed reductions in fatal crashes and overall numbers of people killed in 2019 (the first year the .05 law was in effect) compared to 2016 (the last full year before the law was passed). In 2019, despite increased VMT Utah recorded 225 fatal crashes and 248 fatalities, which is lower than the 259 fatal crashes and 281 fatalities for 2016. When VMT is considered, the fatal crash rate reduction from 2016 to 2019 in Utah was 19.8%, and the fatality rate reduction was 18.3%. In comparison the rest of the United States showed a 5.6% fatal crash rate reduction and 5.9% fatality rate reduction during the same time. Neighboring Arizona, Colorado, and Nevada did not show the same levels of improvement in fatal crash and fatality rates as Utah. In telephone surveys conducted of the general public in Utah, there was increased awareness for the .05 limit among drinkers, After the BAC limit was lowered, some drinkers reported making sure alternative transportation was available when drinking away from home. As there is sometimes concern that a lower limit will negatively affect a State's hospitality industry, the study examined alcohol sales. These sales in Utah from 2012 to 2018 increased, and the trend continued through Fiscal Year 2020, after the law was in effect. Similar patterns were observed for sales tax revenues from restaurants, rental car, hotel, and resort sales, as well as air travel to Utah and visitors to State and National parks.

Evaluations from other countries suggest lower BAC limits reduce alcohol-impaired driving and crashes (NHTSA, 2003). For example, a law introduced in British Columbia, Canada, in 2010 included an administrative 3-day license suspension and possible vehicle impoundment for drivers with BACs from .05 to .08 g/dL. The law was intended to maximize deterrence by increasing the certainty and swiftness of sanctions. In the year after the law took effect, there was a 40% decrease in alcohol-related fatal crashes (Macdonald et al., 2013). Moreover, roadside surveys revealed a 44% decrease in drivers with BACs of .05 g/dL or higher, and a 59% decrease in drivers with BACs over .08 g/dL (Beirness & Beasley, 2014). In 2008 Brazil lowered the BAC limit from .06 g/dL to .02 g/dL for all motorists. Violations result in suspensions of driving privileges. Roadside surveys conducted before and after the law change found a 45% decrease in drivers with a positive BAC (Campos et al., 2013).

Not all jurisdictions that have lowered their BAC limits have seen subsequent reductions in crashes. For example, in 2014 Scotland lowered the BAC limit for all drivers from .08 g/dL to .05 g/dL. Although alcohol consumption in bars and restaurants decreased, there was no change in traffic crashes, injuries, or fatalities (Haghpanahan et al., 2019). The researchers noted that no special enforcement took place after the BAC limit was lowered. In sum, the available evidence suggests lowering the illegal *per se* limit to .05 g/dL for all drivers can reduce alcohol-related crashes and fatalities, but publicizing and enforcing the lower BAC limit may be important.

Several studies have also examined lower BAC limits specifically for DWI offenders. In 1988 Maine established a .05 g/dL BAC limit for 1 year after a first DWI offense and for 10 years after a subsequent offense. Violators received an administrative license suspension. In 1995 this BAC limit was further lowered to .00 g/dL. Hingson et al. (1998) evaluated the 1988 law and concluded that it reduced the proportion of fatal crashes that involved repeat offenders by 25%. Jones and Rodriguez-Iglesias (2004) evaluated the overall effects of both laws, using data from 1988 to 2001. They also concluded that the laws contributed to a reduction in the proportion of repeat offenders in fatal crashes, primarily due to a reduction in drivers at BACs of .10 g/dL and higher.

Costs:

Implementation and operation costs are minimal. Jones and Rodriguez-Iglesias (2004) found that Maine's laws had little or no cost effect on the operations of the DWI control system. Overall, the burden on the court system will be lessened if penalties are administrative, rather than criminal (as was the case in British Columbia).

Time to implement:

Lower BAC limit laws can be implemented as soon as legislation is enacted.

High-BAC Sanctions

Effectiveness: ★★★	**Cost:** $	**Use:** Medium	**Time:** Short

Almost all States increase the penalties for the standard impaired-driving (DWI) offense for repeat offenders. Some States also have enhanced sanctions for drivers with high BACs, typically above .15 g/dL. In 2021 two-thirds (67%) of alcohol-impaired-driving fatalities were in crashes that each involved at least one driver with a BAC of .15 g/dL or higher (NCSA, 2023a).

High-BAC sanctions are based on the observation that many high-BAC drivers are habitual impaired-driving offenders, even though they may not have records of previous arrests and convictions. Moreover, drivers with high BACs put themselves and other road users at even greater risk; over half (55%) of the drivers with positive BACs involved in fatal crashes in 2021 had BACs of .15 g/dL or greater (NCSA, 2023a). Enhanced sanctions for high-BAC drivers vary by State and may include mandatory assessment and treatment for alcohol misuse problems, close monitoring or home confinement, installation of an ignition interlock, and vehicle or license plate sanctions. NHTSA recommends sanctions for first-time offenders with high BACs be comparable to those for repeat offenders (NHTSA, 2008c).

Use:

As of March 2023 all States except Alaska, Arkansas, Connecticut, Hawaii, Mississippi, and Vermont had increased penalties for drivers with high BACs (GHSA, 2023). The definition of high BAC ranges from .10 to .20 g/dL, but the most common is .15 g/dL (23 States). Additionally, some States have several levels of high BACs, with sanctions escalating with increasing BACs. See the National Conference of State Legislatures (2016a) for more information about State penalties for high BACs.

Effectiveness:

In the only evaluation of high-BAC sanctions to date, McCartt and Northrup (2003, 2004) examined Minnesota's high-BAC law that included administrative license impoundment and more severe post-conviction penalties for drivers with BACs of .20 g/dL or higher. The one-year recidivism rate was significantly lower for the high-BAC offenders compared to those with BACs from .17 and .19 g/dL (who also had relatively high BACs but were not subject to the enhanced sanctions). This suggests the sanctions were successful at preventing future impaired driving. However, the researchers did not examine the effect of high-BAC laws on alcohol-impaired-driving crashes or fatalities.

Costs:

In the short run, high-BAC sanctions may produce increased costs for interlocks, treatment, and other sanctions. Over a longer period, if high-BAC sanctions reduce recidivism and deter alcohol-impaired driving, then costs will decrease.

Time to implement:

High-BAC sanctions can be implemented as soon as appropriate legislation is enacted.

Other considerations:

- *Test refusal:* High-BAC sanctions may encourage some drivers to refuse an officer's request for a BAC test unless the penalties for test refusal are at least as severe as the high-BAC penalties. See the next countermeasure on BAC test refusal penalties for more information.

- *Child endangerment laws:* Like high-BAC laws, child endangerment laws recognize there are certain instances where impaired drivers pose extreme risk to others. In 2019 there were 204 children 14 or younger (19% of all child fatalities) who were killed in alcohol-impaired-driving crashes (NCSA, 2023a). Of those, 109 were occupants of vehicles with drivers who had BACs of .08 g/dL or higher. Child endangerment laws create a separate offense or enhance DWI penalties for impaired drivers who carry children. As of 2018 there were 46 States and the District of Columbia that had separate or higher penalties for impaired drivers who have children in their vehicles (Mothers Against Drunk Driving, 2018). Unfortunately, research suggests child endangerment laws do not reduce fatalities among young passengers (Kelley-Baker & Romano, 2016). Reasons for the lack of effectiveness include inadequate publicity, issues with enforcement, and inconsistently applied sanctions by the court system.

BAC Test Refusal Penalties

Effectiveness: ★★★	**Cost:** $	**Use:** Unknown	**Time:** Short

All States have implied consent laws stipulating that drivers implicitly consent to be breath tested if they are suspected of impaired driving (Shinkle et al., 2019; NHTSA, 2017). However, some drivers refuse to provide breath or blood samples for BAC tests. Although the data is a decade old, researchers found approximately one in four drivers arrested for DWI refused the BAC test, a figure that ranged from 1% to 82% depending on the State (Jones & Nichols, 2012; Namuswe et al., 2014). A driver's BAC is a critical piece of evidence in an alcohol-impaired-driving case. The absence of a BAC test can make it more difficult to convict the impaired driver.

All States except Wyoming have established separate penalties for BAC test refusal for all drivers, typically involving administrative license revocation or suspension (Foundation for Advancing Alcohol Responsibility, n.d.). If the penalties for refusal are less severe than the penalties for failing the test, many drivers will refuse. The model DWI code sets a more severe penalty for test refusal than for test failure (NCUTLO, 2000).

Reduced test refusal rates will help the overall DWI control system by providing better BAC evidence. Having driver BACs may increase DWI and high-BAC DWI convictions, increase the likelihood that prior DWI offenses will be properly identified, and provide the courts with better evidence for offender alcohol assessment and treatment. For a thorough discussion of issues related to BAC test refusal, see NHTSA's 2008 *Refusal of Intoxication Testing: A Report to Congress* (Berning et al., 2008). See also Voas et al. (2009) for a history of implied consent laws in the United States and a review of the research on breath test refusal.

Use:

The relative penalties in each State for failing and refusing a BAC test cannot be categorized in a straightforward manner due to the complexity of State alcohol-impaired-driving laws and the differences in how these laws are prosecuted and adjudicated. All States except Wyoming impose administrative sanctions for test refusal. As of June 2018 BAC test refusal was a criminal offense in at least 12 States (Teigen, 2018). See NHTSA's *Digest of Impaired Driving and Selected Beverage Control Laws* (2017) for more detail on each State's laws.

Effectiveness:

Zwicker et al. (2005) found that test refusal rates appear to be lower in States where the consequences of test refusal are greater than the consequences of test failure. No study has examined whether stronger test refusal penalties are associated with reduced alcohol-impaired crashes.

Costs:

The cost for BAC test refusal penalties depends on the number of offenders detected and the fines and other penalties applied to them.

Time to implement:

Increased BAC test refusal penalties can be implemented as soon as appropriate legislation is enacted.

Other considerations:

- *Criminalizing test refusal:* Criminalizing test refusal may reduce refusal rates and increase the likelihood of convictions for DWI (Jones & Nichols, 2012). It also ensures the drivers will be identified as repeat offenders upon subsequent arrests. The U.S. Supreme Court decision *Birchfield v. North Dakota* upheld the ability of States to criminalize refusal for breath testing, but not for warrantless blood tests. The implications of the *Birchfield* decision are described in Lemons and Birst (2016).
- *Warrants:* To reduce breath test refusals and increase the number of drivers successfully prosecuted for DWI, some States issue warrants for drivers who refuse to provide breath tests. Issued by a judge or magistrate, the warrant requires the driver to provide a blood sample, by force if necessary. One study reviewed how warrants are used in Arizona, Michigan, Oregon, and Utah (Hedlund & Beirness, 2007). The study found that warrants may successfully reduce breath test refusals and result in more pleas, fewer trials, and more convictions. Although warrants require additional time for law enforcement, officers report the chemical evidence obtained from the warrant are of great value and worth the effort to obtain (Haire et al., 2011). Note that following the *Birchfield v. North Dakota* Supreme Court decision, warrants are required for blood tests unless there are exigent circumstances (see Lemons & Birst, 2016). The U.S. Supreme Court decision in *Mitchell v. Wisconsin* (2019) ruled that police may order a blood draw without a warrant from an unconscious person suspected of impaired driving.

Alcohol-Impaired-Driving Law Review

Effectiveness: ★★★	**Cost:** $$	**Use:** Unknown	**Time:** Medium

Alcohol-impaired-driving laws are extremely complex. They may be difficult to understand, enforce, prosecute, and adjudicate, with many loopholes and inconsistencies. In many States, a thorough review and revision would produce a system of laws that would be far simpler and more understandable, efficient, and effective.

DWI laws have evolved over the years to incorporate new definitions of the offense of driving while impaired (illegal per se laws), new technology and methods for determining impairment (e.g., BAC tests, Standardized Field Sobriety Tests [SFSTs]), and new sentencing and monitoring alternatives (e.g., electronic monitoring, alcohol ignition interlocks). Many States modified their laws to incorporate these ideas without reviewing their effect on the overall DWI system. The result is often an inconsistent patchwork. Robertson and Simpson (2002) summarized the opinions of hundreds of law enforcement officers, prosecutors, judges, and probation officials across the country: "Professionals unanimously support the simplification and streamlining of existing DWI statutes" (p. 18). Before it disbanded, the NCUTLO (2000) prepared a model DWI law, which has been incorporated into the Uniform Vehicle Code. It addressed BAC testing, BAC test refusals, higher penalties for high-BAC drivers, ALR hearing procedures, and many other issues. States can use the NCUTLO model as a reference in reviewing their own laws. In addition, the TIRF has a guidebook (Robertson et al., 2007) to assist policymakers in leading a strategic review of DWI systems, with the goal of streamlining systems and closing loopholes. NHTSA also has created several guidebooks, including one to assist States in establishing impaired-driving statewide task forces to review key legislation and improve current DWI systems (Fell & Langston, 2009), and another to assist officials and the general public in establishing task forces at local or regional levels (Fell, Fisher, & McKnight, 2011).

At a State's request NHTSA will facilitate an Impaired-Driving Program Assessment to evaluate the State's impaired-driving system and to make recommendations for strengthening its programs, policies, and practices. NHTSA and the State's Highway Safety Office assemble an assessment team comprised of national and State experts in impaired driving. The team interviews representatives from agencies across the State, and reviews local data to document the strengths and weaknesses of the State's impaired-driving system. The team provides the State with written recommendations on actions to improve the impaired-driving system.

Use:

It is unknown how many States have conducted reviews of their overall impaired-driving system. Several States work with NHTSA each year in conducting assessments.

Effectiveness:

To date there is no information on the impact of law reviews in reducing alcohol-impaired crashes. The effect of a law review will depend on the extent of inconsistencies and inefficiencies in a State's current laws. A law review can be an important action a State takes to address its alcohol-impaired-driving problem, because a thorough law review will examine the function of the entire DWI control system and will identify problem areas. The effect of a law review should be a more efficient and effective DWI control system.

Some States that have incorporated assessments into their programs have experienced declines in impaired-driving fatality rates. Coleman and Mizenko (2018) reported case studies of three States—New Mexico, Oklahoma, and Washington—that implemented an impaired-driving leadership model. Key elements of the leadership model included conducting an impaired-driving assessment, developing an impaired-driving strategic plan, assembling a leadership team, providing authority to the team, and garnering support of the State's governor. After implementing the leadership model, all 3 States showed reductions in impaired-driving fatality rates per 100 million VMT. Although encouraging, these reductions may also reflect factors or trends in each State beyond just the leadership model. See Coleman and Mizenko (2018) for more information about the leadership model, including lessons learned and recommendations for other States.

Costs:

The review will require substantial staff time. Implementation costs will depend on the extent to which the laws are changed.

Time to implement:

It can take considerable time to identify qualified stakeholders and establish a task force to conduct the law review.

Enforcement

Publicized Sobriety Checkpoints

Effectiveness: ★★★★★	**Cost:** $$$	**Use:** Medium	**Time:** Short

At sobriety checkpoints, law enforcement officers stop vehicles at predetermined locations to investigate whether drivers are impaired. They either stop every vehicle or stop vehicles at some regular interval, such as every third or tenth vehicle. Although sobriety checkpoints remove impaired drivers from road, the primary purpose of checkpoints is to deter driving after drinking among the general population by increasing the perceived risk of being caught and arrested. To do this, checkpoints must be highly visible, publicized extensively, and conducted regularly, as part of an ongoing sobriety checkpoint program. Fell et al. (2004) provide an overview of checkpoint operations, use, effectiveness, and issues. See Fell, McKnight, and Auld-Owens (2013) for a detailed description of 6 HVE programs in the United States, including enforcement strategies, visibility elements, use of media, funding, and many other issues. NHTSA (2021a) provides resources and further details on HVE.

The public generally supports sobriety checkpoints. In a representative survey of 2,000 U.S. drivers, two-thirds (65%) were in favor of conducting sobriety checkpoints at least monthly (Fell, 2019b).

Use:

Thirty-eight States and the District of Columbia permit sobriety checkpoints as part of their impaired-driving enforcement, but they vary how regularly they are conducted (FAAR, 2022). Some States prohibit the use of checkpoints. Erickson et al. (2015) conducted a survey of 48 State patrol agencies and 1,082 local law enforcement agencies across the United States about their enforcement activities during 2010 and 2011. In those States where checkpoints were permitted by State law, 97% of State patrol agencies and 55% of local law enforcement agencies reported conducting sobriety checkpoints. In a separate survey of the State Highway Safety Offices, 11 out of 50 reported checkpoints were conducted on a weekly basis somewhere in their States (Fell et al., 2003). The main reasons cited for not using checkpoints more frequently were lack of law enforcement personnel and lack of funding. See the Cost section below for possible solutions to these issues.

Effectiveness:

The CDC's systematic review of 15 high-quality studies found that checkpoints reduce alcohol-related fatal crashes by 9% (Bergen et al., 2014). Similarly, a meta-analysis found checkpoints reduce alcohol-related crashes by 17%, and all crashes by 10 to 15% (Erke et al., 2009). Publicized sobriety checkpoint programs are proven effective in reducing alcohol-related crashes among high-risk populations including males and drivers 21 to 34 years old (Bergen et al., 2014).

Research suggests that high-visibility sobriety checkpoints deter drinking and driving in a community for approximately one week. A study of sobriety checkpoints in Los Angeles, California from 2013 to 2017 found fewer alcohol-related crashes during the week after DWI enforcement took place, but effects did not persist beyond one week (Morrison et al., 2019). Consequently, sobriety checkpoints need to take place regularly in a community—ideally on a weekly basis. In addition to numerous checkpoints or other highly visible impaired-driving enforcement operations, intensive publicity of the enforcement activities is critical, including paid advertising (Fell, Langston, et al., 2008). Programs with lower levels of enforcement and publicity do not demonstrate reduced crashes or fatalities. See also NHTSA's Strategic Evaluation States initiative (NHTSA, 2007; Syner et al., 2008), NHTSA's evaluation of *Checkpoint Strikeforce* program (Lacey et al., 2008), and evaluation of the national Labor Day holiday campaign: *Drunk Driving. Over the Limit. Under Arrest* (Solomon et al., 2008).

Costs:

The main costs are for law enforcement time and for publicity. A typical checkpoint using 15 or more officers can cost $5,000 to $7,000 (Robertson & Holmes, 2011). However, law enforcement costs can be reduced by operating checkpoints with smaller teams of 3 to 5 officers (NHTSA, 2006b; Stuster & Blowers, 1995). Law enforcement agencies in two rural West Virginia counties were able to sustain a year-long program of weekly low-staff checkpoints. The proportion of nighttime drivers with BACs of .05 g/dL and higher was 70% lower in these counties compared to drivers in comparison counties that did not operate additional checkpoints (Lacey et al., 2006). These smaller checkpoints can be conducted for as little as $500 to $1,500 (Maistros et al., 2014). NHTSA has a guidebook available to assist law enforcement agencies in planning, operating, and evaluating low-staff sobriety checkpoints (NHTSA, 2006b). Another possible solution is to combine resources with other agencies. A survey by Eichelberger and McCartt (2016) found that 40% of agencies that conducted checkpoints reported pooling resources with other law enforcement agencies.

Checkpoint publicity can be costly if paid media is used. For the *Checkpoint Strikeforce* program, paid media budgets ranged from $25,000 in West Virginia to $433,000 in Maryland (Fell, McKnight, & Auld-Owens, 2013). Publicity for checkpoints should also include earned and social media. Other, less-costly elements to increase visibility of enforcement include electronic message boards, pop-up road signs, specially marked squads, and other tools (NHTSA, 2021a).

Time to implement:

Sobriety checkpoints can be implemented very quickly if officers are trained in detecting impaired drivers, SFSTs, and checkpoint operational procedures.

Other considerations:

- *Legality:* Checkpoints are not conducted in 13 States. In 10 of these -- Idaho, Michigan, Minnesota, Montana, Oregon, Rhode Island, Texas, Washington, Wisconsin, and Wyoming -- checkpoints are prohibited by State law, State constitution, or interpretation of the State law (FAAR, 2022). In Missouri checkpoints are authorized by law but the State budget prohibits funding checkpoint activities. States where checkpoints are not permitted may use other enforcement strategies such as saturation patrols (see the next countermeasure).
- *Visibility:* To deter alcohol-impaired driving among the general public, checkpoints must be highly visible and publicized extensively. Communication and enforcement plans should be coordinated. Messages should clearly and unambiguously support enforcement. Paid media may be necessary to complement news stories and other earned media, especially in a continuing checkpoint program. See Fell, McKnight, & Auld-Owens (2013) for additional recommendations concerning checkpoint visibility.

- *Combining checkpoints with other activities:* To enhance the visibility of their law enforcement operations, some jurisdictions combine checkpoints with other activities such as saturation patrols and enforcement of open container laws. For example, some law enforcement agencies conduct both checkpoints and saturation patrols during the same weekend. Others alternate checkpoints and saturation patrols on different weekends as part of a larger publicized impaired-driving enforcement effort. According to one study, the prevalence of self-reported alcohol-impaired driving was lower in States that combined sobriety checkpoints, saturation patrols, and enforcement of open container laws compared to States that only did one of these (Sanem et al., 2015).
- *Flexible Checkpoints:* Another easy-to-implement and cost-effective strategy to leverage the benefits of traditional checkpoint campaigns is to implement flexible or "phantom" checkpoints. This strategy involves staging checkpoints, but not actually stopping drivers. Signs, law enforcement vehicles, and other indicators of checkpoint activity are parked next to the road suggesting that DWI enforcement is about to begin. The "checkpoint" is then moved to several locations over the course of the evening. The primary objective is deterrence—flexible checkpoints raise the visibility of enforcement activity and increase the perception among the general public that drinking drivers will be caught. An advantage is that only a few officers or auxiliary personnel are required to conduct this activity. Although evaluation studies are needed, law enforcement agencies that have tried flexible checkpoints consider this to be a useful and economic strategy (Lacey et al., 2017). Overall, flexible checkpoints are a versatile, low-cost tool that even small agencies can use to enhance and increase the visibility of their DWI enforcement efforts.
- *Standardized Field Sobriety Tests:* Officers have used SFSTs for more than 40 years[1] to identify impaired drivers. The SFST is a three-test battery—the horizontal gaze nystagmus test, the walk-and-turn test, and the one-leg-stand test. Research shows the combined components of the SFST are 91% accurate in identifying drivers with BACs at or above .08 g/dL (Stuster & Burns, 1998). NHTSA strongly supports all officers working traffic enforcement be SFST-trained. Some localities require officers have SFST refresher training before participating in such activities. Officers with SFST or ARIDE training should be able to identify impairment by alcohol or other substances in the field or at checkpoints. Drug recognition experts (DREs) can supplement sobriety checkpoints to detect drivers who are impaired with substances other than alcohol. DREs typically some in after an arrest for impaired driving has been made. SHSOs may request an SFST assessment (or with a DRE module or a stand-alone DRE assessment) that examines a State's DRE program.

[1] NHTSA's first report on the subject, *Development and Field Test of Psychophysical Tests for DWI Arrest*, by Tharp, Burns, and Moskowitz, Report No. DOT HS 805 864, was published in March 1981.

High-Visibility Saturation Patrols

Effectiveness: ★★★★	**Cost:** $$	**Use:** High	**Time:** Short

A saturation patrol (also called a blanket patrol or dedicated DWI patrol) consists of a large number of law enforcement officers patrolling a specific area looking for impaired drivers. These patrols usually take place at times and locations where impaired-driving crashes commonly occur. Like publicized sobriety checkpoint programs, the primary purpose of publicized saturation patrol programs is to deter driving after drinking by increasing the perceived risk of arrest. To do this, saturation patrols should be publicized extensively and conducted regularly, as part of an ongoing program. NHTSA provides resources on HVE at www.nhtsa.gov/enforcement-justice-services/high-visibility-enforcement-hve-toolkit (NHTSA, 2021a). NHTSA strongly recommends that officers conducting these activities be trained in SFST.

Use:

Saturation patrols are a widely used approach to address alcohol-impaired driving. A national survey reported that 63% of local law enforcement agencies and 96% of State patrol agencies reported conducting saturation patrols (Erickson et al., 2015).

Effectiveness:

Few studies have examined the effectiveness of saturation patrols separate from other efforts (e.g., sobriety checkpoints). Sobriety checkpoints are prohibited by State law in Michigan. A statewide campaign was conducted from 2002 to 2004 that included weekly saturation patrols, an extensive public information campaign including paid media, and community partnerships. Alcohol-related fatalities per 100 million VMT decreased 18% following the campaign, and the percentage of fatal crashes involving alcohol-impaired drivers decreased somewhat relative to neighboring States (Fell, Langston, et al., 2008). Although more research is needed, the experience of Michigan suggests that saturation patrols can be effective in reducing alcohol-related fatal crashes when accompanied by extensive publicity.

Costs:

The main costs are for law enforcement time and for publicity. Saturation patrol operations are quite flexible in both the number of officers required and the time that each officer participates in the patrol. As with sobriety checkpoints, publicity can be costly if paid media is used.

Time to implement:

Saturation patrols can be implemented within 3 months if officers are trained in detecting impaired drivers and in SFST. See the NHTSA HVE toolkit for implementation information (www.nhtsa.gov/enforcement-justice-services/high-visibility-enforcement-hve-toolkit).

Other considerations:

- *Legality:* Saturation patrols are legal in all jurisdictions.
- *Publicity:* As with sobriety checkpoints, saturation patrols should be highly visible and publicized extensively to be effective in deterring impaired driving. Communication and enforcement plans should be coordinated. Messages should clearly and unambiguously support enforcement. Paid media may be necessary to complement social media, news stories and other earned media, especially in a continuing saturation patrol program (Goodwin et al., 2005).

Alcohol Measurement Devices

Effectiveness: ★★★★	**Cost:** $$	**Use:** High	**Time:** Short

Alcohol measurement devices are stationary or portable alcohol sensors used to measure a driver's BrAC. Law enforcement officers typically use these devices in the field to help establish probable cause for a DWI arrest. The driver blows into a mouthpiece and the device displays a numerical BrAC, such as .12 g/dL.[2] Alcohol measurement devices are reliable and effective tools to aid law enforcement officers in detecting alcohol (NHTSA, 2021b).

There are two main categories of breath test devices used by law enforcement: evidential breath test devices (EBTs) and preliminary breath test devices (PBTs). PBTs, also known as screeners, are hand-held devices used at the roadside by officers in their investigation to determine if there is probable cause for an arrest. EBTs are State-approved, conform to established specifications, and can be portable or stationary. The results from EBTs can be used as evidence in court.

NHTSA conducts independent testing of devices and provides a "Conforming Products List" of alcohol screening (PBT), alcohol testing (EBT), and calibration units for these devices. Devices included on NHTSA's Conforming Products Lists are eligible for purchase using Federal funds (NHTSA, 2021b).

Other tools for law enforcement are passive alcohol sensors (PASs). These are usually integrated into flashlights or clipboards and measure alcohol presence in the air where the drivers are breathing. They are particularly useful in situations such as checkpoints where officers need to screen drivers quickly. The breath test device displays a BrAC range, such as a red light for any BAC at or above .08 g/dL. The PAS can be used without the driver's knowledge and without any probable cause because the PAS is considered "an extension of the officer's nose" and records information that is "in plain view" (Preusser, 2000). A PAS report of alcohol presence may give the officer reasonable suspicion to request further examination with SFSTs or an alcohol measurement device.

Several PAS models are available commercially. They generally are reliable and effective at detecting alcohol in the ambient air. In one study, both breath samples and PAS measures were obtained from over 12,000 drivers. Results showed that a PAS score was a strong predictor of a driver's BAC status, leading to the conclusion that "the PAS can be an effective tool for officers when deciding whether to initiate a DWI investigation" (Voas et al., 2006). NHTSA does not test PAS devices.

Use:

In most States screening devices can be used in an officer's investigation for probable cause for arrest; they are rarely used as evidence in court. One exception is California, which allows PBT results as evidence of presence of alcohol (Nesci, 2015). California officers can use PBT evidence to enforce zero-tolerance laws for drivers under 21; an officer at the roadside can issue a citation and seize the driver's license (Ferguson et al., 2000). EBTs are commonly used to provide evidence of alcohol impairment that is presented in court.

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[2] BrACs are normally recorded in units of grams per 210 liters of breath, but are "converted" to grams per deciliter, g/dL, simply to keep the terminology standardized and equivalent to blood tests.

Little data are available on how frequently PAS units are used. In a nationwide survey of law enforcement agencies, less than a quarter reported using PAS equipment to improve detection of alcohol-impaired drivers (Eichelberger & McCartt, 2016).

Effectiveness:

Law enforcement officers generally agree that breath test devices are useful. Sixty-nine percent of the 2,731 law enforcement officers surveyed by Simpson and Robertson (2001) supported greater breath test devices availability and use. Breath test devices are especially valuable for two classes of drivers who may appear to perform normally on many tasks: drivers with high tolerance to alcohol (Simpson & Robertson, 2001) and drivers under 21 who may be in violation of zero-tolerance laws (Ferguson et al., 2000). A breath test device also can be useful at crash scenes where a driver is injured and unable to perform an SFST. There is some evidence that breath test devices use increases DWI arrests and reduces alcohol-involved fatal crashes (Century Council, 2008).

The PAS is especially effective at detecting impaired drivers at checkpoints, where officers must screen drivers quickly with little or no opportunity to observe the drivers on the road. Evaluations show that officers using PAS devices at checkpoints can detect 50% more drivers at BACs of .10 g/dL or higher than officers not using PAS (Century Council, 2008; Farmer et al., 1999; Fell et al., 2004; Voas, 2008). The PAS appears to be especially effective in assisting officers who rarely make arrests for DWI (Fell, Compton, & Voas, 2008).

Costs:

Breath test devices cost $200 to $2,000 a piece, with PBTs typically costing $300 to $700. Many law enforcement departments have only a limited number of breath test devices and most patrol officers do not have regular access to them. Officers surveyed by Simpson and Robertson (2001) estimated that three-fourths of all DWI arrests occur on routine patrols, so DWI detection would be substantially improved if every patrol officer had a breath test device.

Time to implement:

Breath test devices and PAS units can be used as soon as they are purchased, and officers are trained in their use and maintenance. Breath test devices instruments must also have regular calibration checks. Most law enforcement agencies have the facilities to conduct these checks.

Other considerations:

- *The "one test" rule:* Some State statutes allow only one chemical BrAC/BAC test can be obtained from a driver arrested for DWI. In these cases, the State would rather the test be an evidential device rather than a screening device.
- *Other drugs:* PBT, EBT, and PAS devices are designed strictly for identifying alcohol and cannot detect the presence of drugs other than alcohol.
- *Acceptance of PAS by law enforcement:* Some officers reportedly dislike using the PAS. Common reasons for not using PASs are they require officers to be closer to a driver than they consider safe, and they require officers to attend to the device as well as the driver (Preusser, 2000; Eichelberger & McCartt, 2016). Other officers believe they can detect the odor of alcohol accurately without assistance from PASs (Preusser, 2000).

- *Calibrating Breath Alcohol Testing Devices:* Calibration is a crucial element of any successful Alcohol Breath Testing Program to ensure the proper use, care, and accuracy of breath testing devices. Breath alcohol devices are required to have quality assurance plans that specify the inspection, maintenance, calibration requirements, and intervals of recalibration. Calibrating Units aid in this process by providing known concentrations of ethanol vapor for the calibration checks of instruments that measure breath alcohol. Owners of the devices must also maintain records of the inspection, maintenance, and calibration activities performed on the devices. Calibration is carried out by either the device's manufacturer or a maintenance representative, certified by the manufacturer, a State health agency, or other appropriate State agency.

Integrated Enforcement

Effectiveness: ★★★	**Cost:** $	**Use:** Unknown	**Time:** Short

Impaired drivers are detected and arrested through regular traffic enforcement and crash investigations as well as through special impaired-driving checkpoints and saturation patrols. Special enforcement activities directed primarily at other offenses such as speeding or seat belt nonuse, offer an additional opportunity to detect impaired drivers, especially at night, as impaired drivers often speed or fail to wear seat belts. However, when conducting special enforcement activities for other offenses, such as speeding and seat belt nonuse, it is important to maintain the enforcement focus on those offenses.

Use:

There is no data on how frequently integrated enforcement methods are used.

Effectiveness:

The *More Cops, More Stops* program was conducted in six phases from 2011 to 2013 in cities in Oklahoma and Tennessee. The program aimed at HVE of impaired driving, seat belt, and speeding laws (Nichols et al., 2016). A small, statistically significant decline was observed in the percentage of impaired drivers with BACs > .00 g/dL and BAC ≥ .08 g/dL in Nashville during the enforcement period; declines were greater when checkpoints were used. However, there was not enough evidence to suggest that *More Cops, More Stops* enhanced outcomes over those of other ongoing campaigns such as *Drive Sober Or Get Pulled Over*. Instead, the complex focus of the high-visibility campaign and the demands on law enforcement to enforce three traffic safety issues together may have led to no more than modest benefits. Other studies have also produced mixed results. Jones et al. (1995) conducted a three-site evaluation of integrated impaired driving, speed, and seat belt use enforcement. Sites that combined high publicity with increased enforcement reduced crashes likely to involve alcohol (such as single-vehicle nighttime crashes) by 10% to 35%. They concluded that the results were encouraging, but not definitive. The *Massachusetts Saving Lives* comprehensive programs in six communities used integrated enforcement methods. The programs reduced fatal crashes involving alcohol by 42% (Hingson et al., 1996). About half the speeding drivers detected through these enforcement activities had been drinking and about half the impaired drivers were speeding. See also Voas and Lacey (2011), Goodwin et al. (2005), and Stuster (2000).

Costs:

As with other enforcement strategies, the primary costs are for law enforcement time and for publicity.

Time to implement:

Impaired driving can be integrated into other enforcement activities within 3 months if officers are trained in detecting impaired drivers and in SFST.

Other considerations:

- *Publicity:* Integrated enforcement activities should be publicized extensively to be effective in deterring impaired driving and other traffic offenses. Paid media may be necessary to complement news stories and other earned media, especially in an ongoing program (Goodwin et al., 2005).

- *Priorities:* Integrated enforcement activities send a message to the public and to law enforcement officers alike that traffic safety is not a single-issue activity.
- *Resident reporting programs:* Some jurisdictions have dedicated programs where drivers can call to report suspected impaired drivers. Such programs can generate support for law enforcement efforts and increase the perception in the community that impaired drivers will be caught. A study of a grassroots DWI witness reward program in Stockton, California, found a significant decrease in alcohol-related injury/fatality crashes following the program, relative to six comparison communities (Van Vleck & Brinkley, 2009). Mothers Against Drunk Driving Canada launched a program in 2007 called *Campaign 911* to encourage the general public to report impaired drivers. Calls to 911 increased sharply after the program was implemented, as did the number of vehicles stopped and the number of criminal charges issued (Solomon & Chamberlain, 2013). The effect of the program on crashes was not examined. NHTSA offers a manual for law enforcement agencies and local organizations that are interested in establishing a DWI reporting program in their communities (Kelley-Baker et al., 2006, 2008).

Alcohol Vendor Compliance Checks

Effectiveness: ★★★	**Cost:** $$	**Use:** Unknown	**Time:** Short

In all 50 States alcohol venders are required to verify the age of young customers to be sure they are at least 21 years old. Several past studies suggest young people could obtain alcohol without much difficulty. Across various studies, young buyers successfully purchased alcohol in 44% to 97% of attempts without showing identification (Goodwin et al., 2005). To reduce the likelihood that alcohol vendors sell alcohol to underage people, law enforcement officers can conduct frequent compliance checks.

In a compliance check or "sting," law enforcement officers watch as underage people attempt to purchase alcohol and cite the server or vendor for an MLDA-21 violation if a sale is made. Vendors can include on premise retailers (bars and restaurants) or off-premises outlets (convenience stores or liquor stores). Currently, online sales of alcohol are not well regulated, and vendors' age verification practices may not be stringent. In a 2011 study in North Carolina, 45% of online alcohol orders placed by underage students were delivered; 23% of these orders did not require age verification. Even when age verification procedures were used, they often failed to identify the purchaser as a minor (Williams & Ribisl, 2012).

An effective compliance check program works primarily through deterrence. The goal is to increase the perception among vendors they will be caught if they sell alcohol to underage people. To maximize deterrence, compliance checks should be:

- Conducted frequently and be unpredictable. Vendors should know that compliance checks are taking place, but should not know exactly when they will occur.
- Conducted at all vendors, not just a sample of vendors in the community. One study showed the benefits of compliance checks did not generalize to vendors who were not checked (Wagenaar et al., 2005).
- Well-publicized among vendors and the community at large. This will discourage young people from trying to obtain alcohol, and encourage vendors to put policies and procedures in place that prevent the sale of alcohol to underage customers.
- Sustained over time. The effects of compliance checks decay over a few months, so an ongoing program is needed to maintain deterrence (Wagenaar et al., 2005).

A useful resource on how to conduct compliance checks is the Alcohol Epidemiology Program's *Alcohol Compliance Checks: A Procedures Manual for Enforcing Alcohol Age-of-Sale Laws* (AEP, 2013).

Use:

As of January 2022 there were 45 States and the District of Columbia that prohibit minors from purchasing or attempting to purchase alcohol (APIS, 2022). Twenty-five States allow people under age 21 to purchase alcohol for law enforcement purposes such as merchant compliance checks. Although many jurisdictions conduct compliance checks of alcohol retailers at least occasionally, few jurisdictions do so frequently or regularly. One national survey conducted in 2010-2011 found that only 35% of local law enforcement agencies and 67% of State agencies (e.g., alcohol beverage control) reported conducting compliance checks (Erickson et al., 2014).

Among agencies that did conduct checks, less than 10% reported checking all alcohol establishments at least 3 or 4 times a year.

Effectiveness:

Several studies document that well-publicized and vigorous compliance checks reduce alcohol sales to youth. For example, a review of 8 high-quality studies found that compliance checks reduced sales to underage people by an average of 42% (Elder et al., 2007). The effect of compliance checks on motor vehicle crashes has not been studied. In San Diego County, annual DUI citation data (2000 to 2013) were analyzed and the results suggested that retail beverage service laws (which prevent alcohol sales and service to minors including compliance checks) and social host laws (which prohibit hosting underage drinking) contributed to lower underage DUI rates (-25% and -32.1%) (Scherer et al., 2018).

Costs:

Compliance checks require time from law enforcement. These costs can be supported, in part, through alcohol license fees or fines collected from non-compliant vendors.

Time to implement:

Compliance checks can be implemented within 3 months if officers are trained in proper compliance check procedures. Training typically takes less than a week.

Other considerations:

- *Penalties for violations:* To increase the likelihood that penalties will be quickly and consistently enforced, Goodwin et al. (2005) recommend that all penalties for violations should be administrative in nature. Also, the penalties must be substantial enough to deter alcohol vendors from selling to underage people. Some States employ graduated penalties for vendors who fail compliance checks, where both fines and suspension periods increase with each violation (Goodwin et al., 2005).

Zero-Tolerance Law Enforcement

Effectiveness: ★★★	**Cost:** $	**Use:** Unknown	**Time:** Short

Zero-tolerance laws set a maximum BAC of less than .02 g/dL for drivers under 21 years old. Violators have their driver's licenses suspended or revoked. There is strong evidence that zero-tolerance laws reduce alcohol-related crashes and injuries (Voas & Lacey, 2011; Goodwin et al., 2005; Shults et al., 2001). Fell et al. (2009) estimate that zero-tolerance laws save 159 lives each year.

However, enforcement and publicity for zero-tolerance laws appears to be rare (Hedlund et al., 2001; Voas & Lacey, 2011). Studies have found that young drivers are not arrested in proportion to their involvement in alcohol-related crashes (Hingson et al., 2004). One exception is Washington State, where a study found that arrests for alcohol violations among 16- to 20-year-old drivers increased by about 50% after the zero-tolerance law went into effect (McCartt et al., 2007). Enforcement may have been greater in Washington because the law allows officers to request a test for alcohol based on suspicion of either a DWI or zero-tolerance offense. In other States where drivers can only be tested if DWI is suspected, zero-tolerance laws may be more difficult to enforce.

Use:

Zero-tolerance laws have been in effect in all States since 1998. The degree to which zero-tolerance laws are enforced in States is unknown.

Effectiveness:

An early study in Maryland found that alcohol-involved crashes for drivers under 21 dropped by 21% in six counties after the zero-tolerance law was implemented. After the law was publicized extensively, these crashes dropped by an additional 30% (Blomberg, 1992). No other studies have examined the effect of increasing enforcement and publicity for an existing zero-tolerance law. Lacey et al. (2000) documented how zero-tolerance laws are administered and enforced in 4 States. Highly publicized enforcement has proven effective in increasing compliance with many traffic safety laws and reducing crashes and injuries: see for example countermeasure on publicized sobriety checkpoints and Short-Term, High-Visibility Seat Belt Law Enforcement. A review of the impact of impaired-driving laws on alcohol-related fatalities from 1980 to 2009 found the zero-tolerance law to have the most impact with an estimate of 19 to 29 lives saved in 2012 (Ying et al., 2013). The study also found that areas with historically high impaired-driving fatalities may need *ex-post* regulations, such as the zero-tolerance and other penalizing laws, to reverse the trend. This contrasts with other locations that can show improvements with preventative regulations such as the MLDA and open container laws.

Costs:

Zero-tolerance laws can be enforced during regular patrols or during special patrols directed at times and areas when young, impaired drivers may be present. Enforcement will require moderate costs for appropriate training, publicity, and perhaps equipment (see Other considerations).

Time to implement:

Enforcement programs can be implemented within 3 or 4 months, as soon as appropriate training, publicity, and equipment are in place.

Other considerations:

- *Zero-tolerance-law provisions:* Zero-tolerance laws are far easier to enforce if the offense is an administrative rather than criminal violation as an administrative license suspension can be implemented without a court conviction, and if law enforcement officers can use PBTs (preliminary breath test devices) at the roadside to determine if the law has been violated and, if so, to seize the driver's license (Jones & Lacey, 2001). Some State laws require the same probable cause as for a standard DWI arrest, or even require a full DWI arrest, before a BAC test for a zero-tolerance-law violation can be administered. In these States, the zero-tolerance law is not enforced independently of the standard DWI law, and in fact young drivers may not be aware of the zero-tolerance law (Hingson et al., 2004).
- *PBT and PAS:* Preliminary breath test devices are important for effective and efficient enforcement in States that allow PBT use for zero-tolerance laws. A passive alcohol sensor (PAS) can help officers detect violators who have consumed alcohol. See countermeasures Alcohol Measurement Devices.
- *Holding juveniles in custody:* A complication of enforcing zero-tolerance laws is issues related to holding young offenders once they are taken into custody. NHTSA helped produce an implementation guide for developing a juvenile holdover program (NHTSA, 2001).

Other Strategies for Behavior Change

Alcohol Ignition Interlocks

Effectiveness: ★★★★★	**Cost:** $$	**Use:** Medium	**Time:** Medium

An alcohol ignition interlock prevents a vehicle from starting or being operated unless the driver provides a breath sample with a BrAC lower than a pre-set level, usually .02. Interlocks typically are used as a condition of probation for DWI offenders, to prevent them from driving while impaired by alcohol after their driver's licenses have been reinstated.

Interlocks are highly effective in allowing a vehicle to be operated by sober drivers, but not by alcohol-impaired drivers. A post-start retest is meant to prevent an offender from having someone else who has not been drinking start the car for them or from drinking while driving. A data recorder logs the driver's BrAC at each test and can be used by probation officers to monitor the offender's drinking and driving behavior. Marques and Voas (2010) provided an overview of interlock use, effectiveness, operational considerations, and program management issues. Marques (2005), Beirness and Robertson (2005), and Robertson et al. (2006) summarized interlock programs in the United States and other countries and discussed typical problems and solutions. See also Brunson and Knighten (2005), Neuman et al. (2003), and proceedings from the 11th Annual International Alcohol Interlock Symposium (Robertson et al., 2011).

NHTSA offers an ignition interlock toolkit to assist policymakers, highway safety professionals, and advocates (Mayer, 2014). In addition, NHTSA has published a report, *Case Studies of Ignition Interlock Programs*, featuring State ignition interlock programs (Fieldler et al., 2012); an *Evaluation of State Ignition Interlock Programs: Interlock Use Analysis From 28 States 2006-2011* (Casanova-Powell et al., 2015); and *Interlock Data Utilization* (Taylor et al., 2017). NHTSA has created model guidelines to assist States in developing and implementing highly effective interlock programs based on successful practices in the United States and other countries (NHTSA, 2013). Information on States' legislation, program funding, data collection and management, interlock technology, and driver compliance can be found at https://aic.tirf.ca/alcohol-interlock-program-inventory/

Use:

All 50 States and the District of Columbia allow interlocks to be used for some DWI offenders. In 34 States and the District of Columbia, interlocks are mandatory for all convicted offenders, including first offenders (Robertson et al., 2022). In 14 States interlocks are mandatory for certain offenders, such as high BAC and repeat offenders. Presently, interlocks are discretionary in North Dakota and South Dakota.

Despite widespread laws a relatively small percentage of eligible offenders have an interlock installed. In a 2019 survey of ignition interlock providers, Robertson et al. (2022) found that 15% of those arrested for DWI had an interlock installed on their vehicle, and 42% of those convicted had an interlock. Although these percentages have increased somewhat over time, the installation rate among eligible offenders remains relatively low.

Use of interlocks is higher when they are required rather than optional. California conducted a pilot program in which interlocks were required in four counties. Interlock use was higher in the four pilot counties that required interlocks for DWI offenders (42.4%) than in non-pilot counties (4.3%) (Chapman et al., 2015). Additionally, use of interlocks is substantially higher when they are required as a prerequisite to license reinstatement. For example, among DWI offenders in Florida who were subject to the State's interlock requirement, 93% installed interlocks once they qualified for reinstatement (Voas, Tippetts, Fisher, & Grosz, 2010). Similarly, a study in Washington State found interlock installations increased and recidivism decreased when interlocks were required for all offenders and offenders were allowed to install an interlock in lieu of license suspension (McCartt et al., 2018). Finally, use of interlocks is higher when interlocks are offered as an alternative to more restrictive sanctions, such as home confinement via electronic monitoring (Roth et al., 2009).

Effectiveness:

A review of 15 studies of interlock effectiveness found that offenders who had interlocks installed in their vehicles had arrest recidivism rates that were 75% lower than drivers who did not have interlocks installed (Elder et al., 2011; see also Government Accountability Office [GAO], 2014). Findings were similar for first offenders and repeat offenders. After interlocks were removed, however, the effects largely disappear, with interlock and comparison drivers having similar recidivism rates.

Studies have also demonstrated that interlocks reduce alcohol-related crashes and fatalities while they are installed in vehicles (Elder et al., 2011; Kaufman & Wiebe, 2016; McGinty et al., 2017; Teoh et al., 2021; Vanlaar et al., 2017). For example, Teoh et al. (2021) found that States that require interlocks for all DWI offenders had 26% fewer alcohol-involved fatal crashes than States with no interlock laws. Similarly, States that require interlocks for repeat offenders and high-BAC offenders had 20% fewer alcohol-involved fatal crashes. The authors concluded that ignition interlock laws are effective at reducing the number of impaired drivers in fatal crashes, especially when those laws cover all DWI offenders. Studies estimate that 2,600 lives could be saved each year if every State required interlocks for all DWI offenders (Kaufman & Wiebe, 2016).

Interlocks stop motorists impaired by alcohol from driving while they are installed, but unless motorists change their attitudes and behaviors, they may simply continue driving impaired once the interlock is removed. Florida passed legislation in 2008 to address this problem by mandating treatment for DUI offenders in interlock programs who commit 4 or more interlock violations. These offenders are required to attend 8 to 12 weeks of treatment from certified substance abuse counselors/programs, which includes an individualized treatment plan involving individual or group therapy. A study of Florida's law found that offenders who received treatment in addition to the interlock had one-third lower DWI recidivism once the interlock was removed compared to offenders who had the interlock only (Voas et al., 2016).

Costs:

Cost is frequently cited as a barrier to greater use of interlocks. Offenders are typically required to pay the costs for installing, calibrating, monitoring, and removing interlocks. However, a growing number of States have indigent funds to reduce the costs for low-income offenders. A recent study found two-thirds of States offer financial support to interlock program participants who need it (Robertson et al., 2017). The study also found that less than 10% of offenders typically use these indigent funds. Alabama, Delaware, and Connecticut enacted legislation to expand their ignition interlock indigent programs in 2018 (NCSL, 2019).

Time to implement:

Interlock programs may require enabling legislation. Once authorized, interlock programs require 4 to 6 months to implement a network of interlock providers.

Other considerations:

- *Barriers to use:* Interlocks have demonstrated their effectiveness in controlling impaired driving while they are installed. Considering this success, their limited use may be due to several factors, such as lengthy license suspension periods, offenders who delay license reinstatement, judges who lack confidence in the interlock technology or who fail to enforce "mandatory" interlock requirements, interlock costs, and localities that lack enough interlock providers. In a survey of DWI offenders who chose not to use an interlock (when it was optional), the main reasons cited were interlock costs and stigma from being perceived as a problem drinker (Forsman & Wallhagan, 2019). To increase the number of offenders who drive interlock-equipped vehicles, some States have made the alternatives to interlocks more undesirable. For example, pilot programs in Indiana and New Mexico found that roughly two-thirds of offenders chose to have interlocks installed when the alternative was house arrest with electronic alcohol monitoring or jail (Marques et al., 2010; Voas et al., 2001). Other States such as Arkansas, Colorado, Maine, Mississippi and Nebraska allow offenders to shorten (or eliminate) the license suspension period if they are willing to operate an interlock-installed vehicle. An evaluation of such a law in Ontario found that a reduced suspension program increased installation rates from 45% to 70% among eligible first-time offenders (Ma et al., 2016). For a discussion of barriers to interlock use, see Beirness and Marques (2004), Beirness et al. (2008), Beirness and Robertson (2005), and Neuman et al. (2003). For a discussion on how States have successfully overcome obstacles encountered with interlock programs, see Casanova-Powell et al. (2015).
- *Compliance with interlocks:* Some offenders have relatively high rates of breath test failures and other violations, typically near the beginning of their participation in an interlock program (Vanlaar et al., 2013; Vanlaar et al., 2010). Research shows that offenders with breath test failures have higher rates of reoffending once the interlock is removed compared to those with a "clean" record (Bailey et al., 2018; Le et al., 2019). Presently, few jurisdictions use the compliance data collected by interlocks to identify offenders who may be at high risk for recidivism (Taylor et al., 2017). The data could also be used to require an extension of the interlock period for those with poor compliance, or even to inform treatment options (Marques et al., 2010). Better coordination between interlock programs and treatment providers might help reduce recidivism once interlocks are removed (Taylor et al., 2017).
- To improve compliance with interlocks, it is important to closely monitor offenders during their participation in an interlock program. One study found that offenders who were closely monitored (e.g., their data were reviewed weekly, and they received letters documenting their progress) had fewer initial breath test failures and other indicators of non-compliance than offenders who received standard monitoring through the State licensing office (Zador et al., 2011). Similarly, an in-depth study of 3 State interlock programs found non-compliance was highest in the State with less consistent monitoring practices (California) than in the 2 States (Florida and Texas) with stronger monitoring

practices (Vanlaar et al., 2013). As of May 2019 22 States require interlock devices that are equipped with cameras to ensure that the people using the interlocks are the drivers (NCSL, 2019). Additionally, monitoring the number of miles driven on an interlock vehicle can prevent an offender from circumventing the device by driving another vehicle. Some States set vehicle usage criteria for the number of miles the offender will likely be driving per week while the interlock is installed. If the mileage on the interlock-equipped vehicle is unexpectedly low, further sanctions can be put in place (Mayer, 2014).

- *First-time offenders:* There are special issues concerning interlocks and first-time offenders. Historically, interlock programs were mandatory for repeat offenders and voluntary for first-time offenders (Robertson et al., 2010). In many jurisdictions first-time offenders are not monitored by the court system. Consequently, it can be difficult to respond to violations and to ensure that first-time offenders participate, install the devices, and complete the interlock program. Despite challenges in closely monitoring first-time offenders, evidence suggests interlocks effectively reduce recidivism among this group while the interlock is installed (Marques et al., 2010; McCartt et al., 2013; McCartt et al., 2018). For more information about issues in implementing interlock programs with first-time offenders, see Robertson et al. (2010).
- *Rural areas:* For offenders living in rural areas, access to an interlock service provider may be problematic (Cheesman et al., 2014). Interlock service providers may be limited or non-existent in rural jurisdictions, requiring offenders to drive long distances to get an interlock installed or serviced. To improve the availability of interlocks, States can require vendors to provide service to rural areas as a prerequisite for obtaining a contract with the State (Mayer, 2014).
- *Public support:* There is strong support among the general public for ignition interlocks. In national surveys, approximately 80% of respondents support requiring interlocks for drivers convicted of DWI, including first offenders (AAAFTS, 2018; McCartt, Wells, & Teoh, 2010). Moreover, about 65% of respondents favored having alcohol detection technology in *all* new vehicles. The general public also believes strongly that interlocks work. In a NHTSA survey, respondents were asked about the effectiveness of eight strategies to reduce or prevent impaired driving. Interlocks ranked highest in the percentage who rated the strategy "very effective" (63%) (Moulton et al., 2010).
- *General deterrence:* The implementation of ignition interlock programs targeting DWI offenders does not seem to produce a general deterrence effect among the broader driving population. An evaluation of general deterrence was conducted in California by comparing recidivism rates in four counties that participated in a pilot program involving mandatory interlock installation to recidivism rates in all other California counties (Chapman et al., 2015). The study found that mandatory interlock installation was ineffective at reducing county-wide DWI recidivism below those of the comparison counties. This lack of difference in conviction rates held for drivers with one, two, or three or more prior DWI convictions. Note that this study did not track local advertising of the program in the four pilot counties, so it is unknown if the absence of a general deterrence effect was affected by the level of outreach effort.

Alcohol Problem Assessment and Treatment

Effectiveness: ★★★★★	**Cost:** Varies	**Use:** High	**Time:** Varies

It is widely recognized that many DWI first offenders and most repeat offenders are dependent on alcohol or have alcohol misuse problems (White & Gasperin, 2007). They likely will continue to drink and drive unless their alcohol misuse problems are addressed. A DWI arrest provides an opportunity to identify offenders with alcohol misuse problems and to refer them to treatment as appropriate. However, treatment should not be provided in lieu of other sanctions or as part of a plea bargain or diversion program that eliminates the record of a DWI offense.

Alcohol problem assessment can take many forms, from a brief paper-and-pencil questionnaire to a detailed interview with a treatment professional. Alcohol treatment can be even more varied, ranging from classroom alcohol education programs to long-term inpatient facilities. For brief overviews of alcohol assessment and treatment programs and further references see Century Council and National Association of State Judicial Educators (2008), Dill and Wells-Parker (2006), Goodwin et al. (2005), Robertson et al. (2008), and Voas and Lacey (2011).

Part of the assessment process is determining the likelihood that an offender will continue to drive impaired. Under a cooperative agreement with NHTSA, the American Probation and Parole Association developed a screening tool—the Impaired Driving Assessment—to determine an offender's risk of recidivism and to help determine the most appropriate and effective community supervision program to reduce that risk (Lowe, 2014). Pilot testing of the IDA revealed that probation failure is commonly associated with extensive prior legal histories, mental health problems, and higher levels of alcohol/drug use.

Use:

All States have provisions under State law for alcohol treatment for DWI offenders (NHTSA, 2017). However, the nature of the treatment—and to whom it applies—varies greatly. Some States mandate treatment, especially for repeat offenders, but usually treatment requirements are at the court's discretion.

Effectiveness:

Even the best of the many assessment instruments currently in use is subject to error. Chang et al. (2002) found that none of the assessment instruments studied correctly identified more than 70% of offenders who were likely to recidivate. However, the assessment process itself can have therapeutic benefits. See the countermeasure on Alcohol Screening and Brief Interventions.

Wells-Parker et al. (1995) reviewed studies evaluating treatment effectiveness. They found that, on average, treatment then reduced DWI recidivism and alcohol-related crashes by 7% to 9%. Treatment appears to be most effective when combined with other sanctions and when offenders are monitored closely to assure that both treatment and sanction requirements are met (Century Council, 2008; Dill & Wells-Parker, 2006).

Costs:

Treatment expenses vary widely depending on program type. However, several studies suggest alcohol abuse treatment can be cost effective (UKATT Research Team, 2005). For example, a study from California found every dollar spent on treatment potentially saved taxpayers up to $7

(Gerstein et al., 1994). Offenders may bear some of the costs of both assessment and treatment, though provisions must be made for indigent offenders.

Time to implement:

Implementation time varies depending on program type. The simplest can be implemented in several months, while others may take years.

Other considerations:

- *Treatment options:* There are many effective treatment options for alcohol misuse problems including cognitive-behavioral therapy, group counseling, pharmacological interventions (e.g., naltrexone, acamprosate), and brief interventions. It is important that treatment be tailored to the person and be age appropriate. Also, combining therapies can result in better outcomes because DWI offenders usually have a range of diverse and complex problems (Dill & Wells-Parker, 2006).
- *DWI courts:* Alcohol problem assessment and treatment are an integral part of DWI courts. In addition, a DWI court can sanction offenders who fail to complete assigned treatment programs. For more information, see the countermeasure on DWI courts.
- *Other mental health issues:* Alcohol assessment and treatment provide an opportunity to address other problems that may underlie or contribute to problems with alcohol. One study found that more than 60% of DWI repeat offenders have experienced other psychiatric disorders in addition to alcohol-related problems, such as post-traumatic stress disorder, anxiety disorders, and bipolar disorder (Shaffer et al., 2007). This is substantially higher than the rate of about 30% for the general population.

Alcohol Screening and Brief Intervention

Effectiveness: ★★★★★	**Cost:** $$	**Use:** Medium	**Time:** Short

Alcohol screening uses a few questions to estimate the level and severity of alcohol use and to determine whether a person may be at risk of alcohol misuse or dependence (Substance Abuse and Mental Health Services Administration [SAMHSA], 2015). Brief interventions are short, one-time encounters with people who may be at risk of alcohol-related injuries or other health problems. Brief interventions focus on awareness of the problem and motivation toward behavior change. The combination of alcohol screening and brief intervention is most common with injured patients in emergency departments or trauma centers. Patients are screened for alcohol misuse problems and, if appropriate, are counseled on how alcohol can affect injury risk and overall health. Patients also may be referred to a follow-up alcohol treatment program. Brief interventions take advantage of a "teachable moment" when a patient can be shown that alcohol use can have serious health consequences.

Higgins-Biddle and Dilonardo (2013) and Dill et al. (2004) provide a summary of alcohol screening and brief intervention studies. Also, NHTSA and the American Public Health Association (APHA) have produced an alcohol and brief intervention guide for public health practitioners (Guard & Rosenblum, 2008). Finally, NHTSA offers a toolkit to assist in conducting screening and brief intervention on college campuses (Quinn-Zobeck, 2007).

Use:

Approximately one-half of trauma centers screen patients for alcohol misuse problems and one-third use some form of brief intervention (Goodwin et al., 2005; Schermer et al., 2003). Alcohol screening and brief interventions also are used in colleges, primary care medical facilities, and social service settings (Goodwin et al., 2005). Brief interventions have also been used to reduce DWI among young adults and adolescents (Tanner-Smith & Lipsey, 2015).

Effectiveness:

Many studies show that alcohol screening and brief interventions in medical facilities can increase the likelihood of treatment referrals for alcohol misuse and reduce self-reported driving after drinking (D'Onofrio & Degutis, 2002; Moyer et al., 2002; Runge et al., 2002; Wilk et al., 1997). Dill et al. (2004) reviewed nine studies that evaluated alcohol screening and brief intervention effects on relevant outcomes, such as personal alcohol use and motor vehicle collision injuries. These studies generally found that alcohol screening and brief interventions reduced both drinking and alcohol-related traffic crashes and injuries. Brief interventions appear more effective with some populations than others. For example, patients with alcohol use disorder may need to be referred to a more intensive treatment plan (Teutsch et al., 2018).

Costs:

Alcohol screening and brief interventions in medical facilities require people with special training to administer the intervention. However, several studies show the intervention is cost effective, and substantially reduces future health care costs (e.g., hospital and emergency room visits) (Guard & Rosenblum, 2008).

Time to implement:

Procedures for alcohol screening and brief interventions are readily available from APHA (Guard & Rosenblum, 2008), the American College of Emergency Physicians (ACEP, 2006), and the National Institute on Alcohol Abuse and Alcoholism (NIAAA, 2005), and can be implemented as soon as staff is identified and trained.

Other considerations:

- *Alcohol exclusion laws:* An alcohol exclusion law (Uniform Accident and Sickness Policy Provision Law or UPPL) allows insurance companies to deny payment to hospitals for treating patients who are injured while impaired by alcohol or a non-prescription drug (NHTSA, 2008d). These laws may cause hospitals to be reluctant to determine the BACs of injured drivers and may limit the use of alcohol screening (although screening does not measure the patient's BAC). The National Institute on Alcohol and Alcoholism maintains a list of States that permit or prohibit alcohol exclusion (NIAAA, 2022b).

Vehicle and License Plate Sanctions

Effectiveness: ★★★★	**Cost:** Varies	**Use:** Medium	**Time:** Short

Many States have implemented sanctions affecting a DWI offender's license plate or vehicle. These sanctions are intended to prevent the offender from driving the vehicle while the sanctions are in effect, and to deter impaired driving by the general public. Vehicle and plate sanctions include:

- Special license plates for drivers whose licenses have been revoked or suspended. The plates allow family members and other people to drive the offender's vehicle but permit law enforcement to stop the vehicle to verify that the driver is properly licensed.
- License plate impoundment. Officers seize and impound or destroy the license plate.
- Vehicle immobilization. Vehicles are immobilized on the offender's property with a "boot" or "club."
- Vehicle impoundment. Vehicles are stored in a public impound lot.
- Vehicle forfeiture. Vehicles are confiscated and sold at auction.

NHTSA (2008e), DeYoung (2013b), and Voas et al. (2004) give an overview of vehicle and license plate sanctions and are the basic references for the information provided below. See also Brunson and Knighten (2005), and Neuman et al. (2003). All vehicle and license plate sanctions require at least several months to implement.

Use, effectiveness, and costs:

- *Special license plates:* Special license plates are permitted in Georgia, Iowa, Minnesota, Ohio, and Oregon (NCSL, 2016b). Ohio requires special plates for all first-time offenders with BACs of .17 g/dL and above and for all repeat offenders. Effectiveness and costs have not been evaluated in any State. In the 1990s Oregon and Washington adopted a version of this strategy by allowing arresting officers to place a "zebra stripe" sticker on the license plate at the time of arrest. Oregon's program proved effective in reducing DWI recidivism, but Washington's did not. Use has been discontinued in both States (Neuman et al., 2003; NHTSA, 2008e).
- *License plate impoundment:* License plate impoundment is used in at least 9 States (NHTSA, 2017). In Minnesota license plate impoundment administered by the arresting officer was shown to reduce both recidivism and driving with a suspended license, especially among the youngest offenders (Leaf & Preusser, 2011; Rogers, 1994). As plate impoundment does not involve the courts, it occurs quickly, consistently, and efficiently (Neuman et al., 2003; NHTSA, 2008e; NTSB, 2000).
- *Vehicle immobilization*: Laws in 12 States allow vehicle immobilization (NHTSA, 2017). An evaluation in Ohio found that immobilization reduced recidivism (Voas et al., 1998). Costs are minimal compared to impoundment or forfeiture (Neuman et al., 2003; NTSB, 2000).
- *Vehicle impoundment:* From the last available information in 2017 there were 13 States and the District of Columbia that allow for vehicle impoundment and some use it extensively (NHTSA, 2017). The strategy is costly, and owners may abandon low-value

vehicles rather than pay substantial storage costs (Neuman et al., 2003; NTSB, 2000). Towing fees are often considerable, and storage fees can range from $18 to $95 per day (City of Columbus, 2019; San Jose Police Department, 2018). In California impoundment programs are administered largely by towing contractors and supported by fees paid when drivers reclaim their vehicles or by the sale of unclaimed vehicles. An evaluation of California's impoundment law found both first-time and repeat offenders whose vehicles were impounded had fewer subsequent arrests for driving with a suspended license and fewer crashes (DeYoung, 1997). In 2010 Ontario introduced 7-day vehicle impoundment for drivers with BACs over .08 g/dL or who refused the BAC test. The measure was associated with a 29% reduction in DWI re-offenses occurring within 3 months of the end of license suspension (Byrne, Ma, & Elzohairy, 2016). However, two-follow up studies found that vehicle impoundment programs in Canada have not reduced alcohol-related crashes or fatalities among the general driving population (Byrne, Ma, Mann & Elzohairy, 2016; Smith et al., 2019). This suggests vehicle impoundment is effective at specific deterrence—that is, discouraging offenders from re-offending—but has little general deterrence effect.

- *Vehicle forfeiture:* Twenty-nine States have provisions allowing vehicle forfeiture for impaired driving or driving with a suspended license (NHTSA, 2017); however, there is little information on its use or effectiveness. Vehicle forfeiture programs must pay storage costs until the vehicles are sold or otherwise disposed (Neuman et al., 2003; NTSB, 2000).

Time to implement:

Vehicle and license plate sanctions can be implemented as soon as appropriate legislation is enacted.

Other considerations:

- *To whom are vehicle sanctions applied:* Most vehicle sanctions have been applied to repeat offenders rather than first offenders, although some States also apply vehicle sanctions to high-BAC first offenders (e.g., BACs of .15 g/dL or higher). If someone other than the offender owns the vehicle, a State should consider requiring the vehicle owner to sign an affidavit stating the owner will not allow the offender to drive the vehicle while the suspension is in effect (NHTSA, 2008e).
- *Administrative issues:* All license plate and vehicle sanctions require an administrative structure to process the license plates or vehicles. Laws should permit officers to impound vehicles or license plates at the time of arrest so offenders do not have the opportunity to transfer vehicle ownership (NHTSA, 2008e).

DWI Offender Monitoring

Effectiveness: ★★★★	**Cost:** $$$	**Use:** Unknown	**Time:** Varies

The most successful methods for controlling convicted DWI offenders and reducing recidivism have the common feature that they monitor offenders closely. Note that while these methods monitor sobriety, they do not actually prevent someone from drinking and/or driving the vehicle. Close monitoring can be accomplished at various levels and in various ways, including a formal intensive supervision program, home confinement with electronic monitoring, and dedicated detention facilities. South Dakota's 24/7 Sobriety Project is one example of an intensive supervision program. Participants are prohibited from using alcohol or drugs as a condition of remaining in the community and avoiding incarceration. The program includes twice daily alcohol breath testing, transdermal devices that monitor for alcohol consumption, and random drug testing. If an offender tests positive for alcohol or drugs, they are taken into custody and appear before a judge within 24 hours. The goal is to ensure that consequences for violations are swift and certain.

For overviews of DWI offender monitoring and further references, see Century Council and National Association of State Judicial Educators (2008) and Goodwin et al. (2005). See also Wiliszowski et al. (2011) for more information about intensive supervision programs and descriptions of 8 different programs, and Fisher et al. (2013) for additional details about South Dakota's 24/7 Sobriety Project. Information about transdermal alcohol monitoring, including 6 case studies, can be found in McKnight et al. (2012). DWI courts and alcohol ignition interlocks, discussed elsewhere in this chapter, also assist in monitoring offenders closely. Finally, guidelines for community supervision of DWI offenders are available from NHTSA (Dunlap et al., 2008).

Use:

The most commonly used transdermal device is SCRAM (secure continuous remote alcohol monitoring). In 2011 approximately 50,000 people were being monitored with SCRAM devices in the United States, roughly two-thirds of whom were DWI offenders (Fell & McKnight, 2013). Forty-nine States have used the SCRAM device with at least some offenders, and 34 States have used the device with more than 1,000 offenders (Fell & McKnight, 2013).

Presently, 24/7 sobriety monitoring programs or pilot programs are active in 14 States including Alaska, Florida, Hawaii, Idaho, Iowa, Montana, Nebraska, Nevada, North Dakota, South Dakota, Utah, Washington, Wisconsin, and Wyoming (Bloch et al., 2020).

Effectiveness:

Intensive supervision programs, home confinement with electronic monitoring, and dedicated detention facilities all have been evaluated in individual settings and show substantial reductions in DWI recidivism. Studies examining the effectiveness of the 24/7 Sobriety Program implemented in North and South Dakota have found reductions in recidivism among DWI offenders enrolled in the program. In South Dakota implementation of the 24/7 Sobriety Program resulted in a 12% decrease in repeat DWI arrests and a 4% decrease in collisions by participants (Kilmer et al., 2013). Findings were similar in North Dakota, where the program reduced crashes and DUI arrests (Kubas et al., 2016). Continued enrollment in the North Dakota program was associated with significant decreases in recidivism after 60 days (29.7%), 1 year (34.2%), and 2 years (39.5%) (Kubas et al., 2017). In other studies recidivism was reduced by one-half in intensive supervision programs in Oregon (Lapham et al., 2006) and Connecticut (Barta et al., 2017), and by one-third in an electronic monitoring program in Los Angeles County, California (Brunson & Knighten, 2005; Jones et al., 1996).

A study examined the effectiveness of intensive supervision programs in Nebraska and Wisconsin. These programs used SCRAM to provide continuous monitoring of sobriety for drivers that had alcohol-related offenses (Tison et al., 2015). Offenders assigned to SCRAM were matched to a control group of comparable offenders that were not assigned to SCRAM. Recidivism, measured as re-arrests for an alcohol offense, was virtually nonexistent for those on SCRAM, and the SCRAM offenders who did recidivate once the device was removed remained compliant longer than offenders in the control group (360 versus 271 days in Wisconsin and 458 versus 333 days in Nebraska).

Costs:

All close monitoring programs are more expensive than the standard high-caseload and low-contact probation, but less expensive than jail. Offenders in 24/7 programs typically pay $4 per day for breath testing, while electronic monitoring fees typically range from $5 to $10 per day (Fell & McKnight, 2013). SCRAM Systems' *24/7 Sobriety Program Implementation Guide* suggests a $2 fee per day for on-site breath testing and a $6 fee per day for remote electronic alcohol monitoring for participants (SCRAM Systems, 2018). A goal of 24/7 programs is to be self-sufficient (i.e., entirely funded by offenders). New Mexico estimated that intensive supervision costs $2,500 per offender per year compared to $27,500 per offender per year for jail (Century Councils, 2008). Dedicated detention facility costs can approach jail costs: $37 per day in a Baltimore County dedicated detention facility compared to $45 per day for jail. Offenders may bear some program costs, especially for the less expensive alternatives.

Time to implement:

All close monitoring programs require many months to plan and implement. Dedicated facilities require years to plan and build.

DWI Courts

Effectiveness: ★★★★	**Cost:** $$$	**Use:** Low	**Time:** Medium

Based on the drug court model, DWI courts are specialized courts dedicated to changing the behavior of DWI offenders through intensive supervision and treatment. A dedicated DWI court provides a systematic and coordinated approach to prosecuting, sentencing, monitoring, and treating DWI offenders. Prosecutors and judges in DWI courts specialize in DWI cases. A DWI court's underlying goal is to change offenders' behavior by identifying and treating their alcohol misuse problems and by holding offenders accountable for their actions. DWI courts are usually targeted towards the enrollment, treatment, and supervision of drivers with prior DWI offenses or those with BACs of .15 g/dL or higher (Teutsch et al., 2018; NHTSA, 2016). DWI courts have greater success in changing driver behaviors compared to traditional court processes and sanctions and can be a particularly useful countermeasure for high-risk offenders.

Intensive supervision is a key component of DWI courts. Probation officers monitor offenders closely and report any probation infraction to the judge immediately for prompt action. Infractions include failure to appear at court, testing positive on an alcohol or drug test, and not participating in the court ordered treatment sessions (NHTSA, 2016). Restrictions and monitoring are gradually relaxed as offenders demonstrate responsible behavior. The frequency of court appearance is higher at the beginning of the DWI programs, usually one or more times a week, and then it varies as participants progress to the next phases. In addition, participants are required to submit random alcohol and drug tests several times once the program begins. Most programs also reward participants (e.g., verbal or small token acknowledgement, reduction in sanctions) as they complete a phase of the program, meet treatment requirements, maintain sobriety, and comply with appointments.

A DWI court can reduce recidivism because judge, prosecutor, probation staff, and treatment staff work together as a team to assure that alcohol treatment and other sentencing requirements are satisfied for offenders on an individual basis. Treatment programs typically involve relapse prevention, counseling, support groups, drug education, and mental health programs for participants with co-occurring disorders. Most programs (75%) rely on treatment providers operating separately from court (NHTSA, 2016).

See Brunson and Knighten (2005) and Goodwin et al. (2005) for comprehensive overviews of DWI courts. The National Center for DWI Courts (NCDC, 2011) summarized 10 guiding principles for States implementing DWI courts. The guide also outlines recommendations for assessing and establishing plans for treatment, evaluation, stakeholder collaboration, and sustainability of the program.

Use:

As of May 2020 the National Drug Court Resource Center (2021) reported 269 designated DWI courts in 31 States, a slight drop from the 278 courts in 34 States in 2018. In addition there were 186 hybrid DWI/drug courts in 15 States, which are drug courts that also take DWI offenders. States with the most designated DWI courts include Michigan (32), Missouri (23), Georgia (20), Wisconsin (19), Texas (18), Colorado (16) and Minnesota (15).

In collaboration with the National Center for DWI Courts, NHTSA (2016) conducted an online survey with DWI courts and DWI/drug courts to obtain specific information about how the courts were being operated. A total of 105 DWI and DWI/drug courts responded to the survey in its entirety. Of the programs that responded, 44% indicated they serve primarily rural areas, 33% serve primarily urban areas, and 22% serve primarily suburban areas. Respondents indicated a range in the number of DWI participants currently active in their programs from fewer than 10 to more than 200.

Effectiveness:

Marlowe et al.'s 2009 systematic review found that DWI courts appear to be effective at reducing recidivism, although the available studies had too many shortcomings to draw definitive conclusions. A meta-analysis of 28 studies suggests DWI courts reduce recidivism among DWI offenders by approximately 50% compared to traditional court programs (Mitchell et al., 2012). However, the authors note that more rigorous evaluations of DWI courts are still needed.

Some program evaluations show that DWI courts are successful. Low DWI recidivism rates have been found for graduates of DWI courts in Athens, Georgia; Maricopa County, Arizona; Los Angeles County, California; and elsewhere (Marlowe et al., 2009). One study in Michigan found that DWI court participants were 19 times less likely to be rearrested for DWI within 2 years than a comparison group of offenders who were in traditional probation (Michigan Supreme Court & NPC Research, 2008). Another study of three DWI courts in Georgia found that offenders who graduated from the court program had a 9% recidivism rate within the next 4 years, compared to a 24% recidivism rate for a comparison group of offenders processed in traditional courts (Fell, Tippetts, & Langston, 2011). A study of DWI and hybrid DWI/drug courts in North Carolina found that participants who graduated from the court program were less likely to be rearrested or convicted on DWI charges than others who did not participate in the court program. Hybrid courts were less effective than DWI courts when participant re-arrests were compared. The study reported that while either court program was generally effective, only 1% of those convicted of DWI offenses were being referred to these courts (Sloan et al., 2016).

Costs:

According to the meta-analysis conducted by Mitchell et al. (2012), the cost of DWI courts is lower than standard probation. A cost-benefit analysis conducted by the Department of Justice in 2014 estimated a generalized Criminal Justice System cost component based on interviews with 20 drug courts (Downey & Roman, 2014). The cost estimate amounted to $4,869 for drug court participants, which was lower than the estimated cost of $5,863 for the "status quo" approach. An analysis of the Anne Arundel County, Maryland, criminal justice system reported that the per-person cost over the 2-year program for DUI court graduates was $3,143. This was an average savings of $5,873 compared to people with DUI offenses who choose not to enroll in the DUI court program (NPC Research, 2009). The results of these evaluations indicate that while DWI courts provide more intensive and expensive services than standard probation, they still cost less to administer due to the shortened time required for supervising participants and the reduced use of incarceration (Harron & Kavanaugh, 2015). Traditionally, the majority of DWI court programs are funded mostly through State grants and fees imposed on the client for the payment of ignition interlocks, treatments, and fines. Federal, municipal and nonprofit grant funding sources are less predominant. Overall, less than half of the DWI courts have a sustainability plan for a long-term DWI court program (NHTSA, 2016).

Time to implement:

DWI courts can be implemented 4 to 6 months after the participating organizations agree on the program structure if enough trained prosecutors, judges, probation officers, and treatment providers are available. Otherwise, planning and implementation may require a year or more.

Other considerations:

- *Traffic Safety Resource Prosecutors:* DWI cases can be highly complex and difficult to prosecute, yet they are often assigned to the least experienced prosecutors. In one survey, about half of prosecutors and judges said the training and education they received prior to assuming their position was inadequate for preparing them to prosecute and preside over DWI cases (Robertson & Simpson, 2002). Traffic safety resource prosecutors (TSRPs) are professionals with prosecutorial experience who specialize in the prosecution of traffic crimes, and DWI cases in particular. They provide training, education, and technical support to prosecutors and law enforcement agencies within their States. The National District Attorneys Association (NDAA) provides resources for prosecuting drug-impaired drivers that are available at the National Traffic Law Center (NDAA, 2021b). The NDAA also provides TSRP training webinars and resources (NDAA, 2021a). NHTSA has also developed a manual to assist new TSRPs (Robertson et al., 2016).
- *Judicial Outreach Liaisons (JOLs):* These are current or former judges experienced in adjudicating DWI cases. Many JOLs have presided over DWI or drug courts. JOLs function as peer-to-peer educators, writers, consultants and liaisons, to share the latest research with the judges of their region or State. NHTSA has developed guidelines for creating State JOLs (Axel et al., 2019).

Limits on Diversion and Plea Agreements

Effectiveness: ★★★	**Cost:** $	**Use:** Medium	**Time:** Short

Diversion programs defer sentencing while a DWI offender participates in some form of alcohol education or treatment. In many States, charges are dropped, or the offender's DWI record is erased if the education or treatment is completed satisfactorily. A survey of prosecutors found that of defendants who plead guilty, 67% negotiated a plea agreement resulting in a reduced penalty (Robertson & Simpson, 2002). Negotiated plea agreements are a necessary part of efficient and effective DWI prosecution and adjudication. However, plea agreements in some States allow offenders to eliminate any record of a DWI offense and to have their penalties reduced or eliminated. Offenders pleading guilty to lesser offenses are of concern to prosecutors, judiciary, and advocacy groups because avoiding the original DWI charge results in no conviction records for the offender (Walden & Walden, 2011). However, deferred adjudication provides other sentencing options but keeps convictions on record temporarily. Thus, in the case of a second offense, sanctions can still be increased as long as the deferred conviction is still in the record.

Effective DWI control systems can use a variety of adjudication and sanction methods and requirements. The key feature is that an alcohol-related offense must be retained on the offender's record (Hedlund & McCartt, 2002; Goodwin et al., 2005; NTSB, 2000; Robertson & Simpson, 2002). Otherwise, offenders who recidivate will receive less severe penalties than if the original charge had been retained on their record.

Use:

As of 2006 there were 33 States that provided for diversion programs in State law or statewide practice. Local courts and judges in some additional States also offer diversion programs (NHTSA, 2006c). The Century Council and National Association of State Judicial Educators (2008) documented diversion programs restrictions in several States. As of December 2015 there were 15 States that had laws limiting plea agreements in certain cases (NHTSA, 2017). Louisiana and West Virginia recently passed laws limiting the ability for an offender to have a DWI charge removed from their criminal record (Bloch et al., 2020).

Effectiveness:

The evidence for the effectiveness of diversion programs has been mixed (Voas & Fisher, 2001). Although a few studies have shown diversion programs reduce recidivism, others have shown no benefits. However, there is substantial anecdotal evidence that diversion programs, by eliminating the offense from the offender's record, allow repeat offenders to avoid being identified (Hedlund & McCartt, 2002). Eliminating or establishing limits on diversion programs should remove a major loophole in the DWI control system.

Wagenaar et al. (2000) reviewed 52 studies of plea agreement restrictions applied in combination with other DWI control policies and found an average reduction of 11% across various outcome measures such as rates of crashes/fatalities/injuries, alcohol-involved crashes, and roadside BACs. However, the effects of plea agreement restrictions by themselves cannot be determined in these studies. The only direct study of plea agreement restrictions was completed over 20 years ago (Surla & Koons, 1989; NTSB, 2000). It found that plea agreement restrictions reduced recidivism in all three study communities.

Costs:

Costs for eliminating/limiting diversion programs can be determined by comparing the per-offender costs of the diversion program and the non-diversion sanctions. Similarly, costs for restricting plea agreements will depend on the relative costs of sanctions with and without the plea agreement restrictions. In addition, if plea agreements are restricted, some charges may be dismissed or some offenders may request a full trial, resulting in significant costs.

Time to implement:

Eliminating/limiting diversion programs and restricting plea agreements statewide may require changes to State DWI laws. Once legislation is enacted, policies and practices can be changed within 3 months. Individual prosecutor offices and courts may change local policies and practices without statewide legislation.

Alternative Transportation

Effectiveness: ★★★	**Cost:** $$	**Use:** Unknown	**Time:** Short

In NHTSA's 2007 National Roadside Survey, half (53%) of intoxicated drivers (BAC≥.08 g/dL) reported coming from a bar, restaurant, or a friend's house, and approximately 70% were driving home (Lacey et al., 2009). Having alternative transportation is important to reduce the need for intoxicated people to drive after drinking. Alternative transportation can include for-profit rideshare services, nonprofit safe ride programs, and public transportation such as subways or buses.

For-profit rideshare services are on-demand transportation providers that may be accessed through a mobile application. Rideshare services have expanded greatly over the past decade, accounting for up to 14% of VMT in some urban areas (Fehr & Peers, 2019). The largest rideshare service providers in the United States are Uber and Lyft, responsible for nearly all rideshare business (Blomberg Second Measure, 2022).

Nonprofit safe ride programs are free or charge a minimal fee and often operate in specific regions (e.g., near university campuses) or at specific times (e.g., weekends and holidays). Some will drive the drinker's car home along with the drinker. Safe ride programs are relatively inexpensive and easy for communities to implement. Although it can be difficult to measure the effectiveness of these programs, they can play a role in a community's efforts to reduce drinking and driving. For an overview, see Barrett et al. (2017), Decina et al. (2009), Fell et al. (2020), and Neuman et al. (2003).

Use:

In 2017 the TIRF surveyed a random, representative sample of American drivers 21 and older. Almost half (45%) of respondents said they were familiar with safe ride home programs (Wicklund et al., 2018). Of these, 78% said that safe ride home programs were available in their area, and 14% reported using these programs at least sometimes. One in five (19%) respondents said they had used a for-profit rideshare service after drinking alcohol. People living in urban areas (37%) were more likely to report having used a rideshare service than those living in suburban (21%) or rural (9%) areas. Additionally, use of rideshare services and safe ride home programs was more common among younger people than older people. Finally, 45% said public transportation was available in their area, and 22% reported using public transportation at least sometimes.

Effectiveness:

Fell et al. (2020) reviewed 125 studies of alternative transportation programs. The review found that well-implemented programs can reduce impaired driving. For example, a safe ride program called "Road Crew" that provided rides to drinkers in rural Wisconsin was successful in reducing alcohol-impaired driving, especially among young adults (Rothschild et al., 2006). Several studies suggest decreases in impaired driving arrests when rideshare services are first introduced in a community (Casanova Powell Consulting & Smith, 2020, 2021; Dills & Mulholland, 2018; MADD, 2015). With respect to *crashes*, the findings are mixed. A recent large-scale study examined hospitalizations for motor vehicle crashes after Uber was introduced in Houston in 2014 (Conner et al., 2021). There was a 24% reduction in people hospitalized on Friday and Saturday nights, but not at other times of day or days of the week. This suggests Uber may have reduced alcohol-related driving and crashes. The effect was limited to people under age 30. Other studies have found little to no positive impact of alternative transportation on crashes. In their review, Fell et al. (2020) conclude the most successful alternative transportation programs are accepted by the community, have high public awareness, are low cost or free, are available year round, and provide rides both to and from drinking venues.

Costs:

The major ride service program costs are for the rides that are provided. Short-term ride service programs can be operated largely with donated rides. Year-round programs need enough steady funding to accommodate demand (Neuman et al., 2003).

Time to implement:

Short-term ride service programs can be established and operated informally in a few weeks. Longer-term programs need to establish long-term strategies for funding and managing the program.

Mass Media Campaigns

Effectiveness: ★★	**Cost:** $$$	**Use:** High	**Time:** Medium

A mass media campaign consists of intensive communication and outreach activities regarding alcohol-impaired driving that use radio, television, print, social, and other mass media, both paid or earned. Mass media campaigns are a standard part of every State's effort to reduce alcohol-impaired driving. Some campaigns publicize a deterrence or prevention measure such as a change in a State's DWI laws or a checkpoint or other highly visible enforcement program. Others promote specific behaviors such as the use of designated drivers, illustrate how impaired driving can injure and kill, or simply urge the public not to drink and drive. Campaigns vary enormously in quality, size, duration, funding, and many other ways. Effective campaigns identify a specific target audience and communications goal and develop messages and delivery methods that are appropriate to—and effective for—the audience and goal (Williams, 2007).

Use:

Most States use some form of alcohol-impaired-driving mass media campaign every year. Mass media campaigns are an essential part of many deterrence and prevention countermeasures that depend on public knowledge to be effective.

Effectiveness:

Most mass media campaigns are not evaluated. Elder et al. (2004) studied the few available high-quality evaluations. The campaigns being evaluated were carefully planned, well- funded, well-executed, achieved high levels of audience exposure (usually by using paid advertising), had high-quality messages that were pre-tested for effectiveness, and were conducted in conjunction with other impaired-driving activities (usually enforcement). These mass media campaigns were associated with a 13% reduction in alcohol-related crashes. In general, mass media outreach works best when it is one part of a multifaceted campaign that includes HVE (see the enforcement countermeasures in this chapter). Levy et al. (2004) documented the costs and media strategy of a high-quality national media campaign and its effects on driver knowledge and awareness.

Broad campaigns may not be as effective as single-issue campaigns: the "More Cops More Stops" campaign covered impaired driving, seat belt use, and speeding enforcement and was deployed from November 2011 to August 2013 in Oklahoma and Tennessee as a standalone campaign, and in conjunction with specific enforcement campaigns (e.g., *Click It or Ticket* and *Drive Sober or Get Pulled Over*). The campaign evaluation used driver awareness surveys in program and control regions in addition to roadside BrAC data. Although there was a small but significant decline in the percentage of drivers with positive BrACs in the two tested program areas, overall there was not enough evidence to suggest that the *More Cops More Stops* campaign added to the impact of ongoing campaigns. Instead, the complex focus of the campaign may have exacerbated enforcement fatigue (Nichols et al., 2016).

Costs:

High-quality and effective mass media campaigns are expensive. Funds are needed for market research, design, pre-testing, and production. Paid advertising expenses depend on the media chosen and the media markets needed to reach the target audience.

Time to implement:
A high-quality mass media campaign will require at least 6 months to research, plan, produce, and distribute.

Other considerations:

- *Campaign quality:* Poor-quality or stand-alone campaigns that are not tied to program activities are unlikely to be effective. Similarly, although public service announcements are a relatively inexpensive way to deliver messages about impaired driving, they are likely to be aired infrequently, reach small audiences, miss the target audience, and have little or no effect. To be successful, mass media campaigns must be carefully pre-tested, communicate information not previously known, be long-term, and have substantial funding (Williams, 2007).
- *Comprehensive media strategy:* Mass media campaigns should be planned as part of an overall communications and outreach strategy that supports specific impaired-driving activities, such as enforcement.
- *Fear appeals:* A common approach in media campaigns is to provoke fear or anxiety by depicting the severe negative consequences of impaired driving (e.g., injuries/deaths; grieving family members). Although commonly used, the evidence suggests this approach can potentially *increase* undesirable behaviors (Wundersitz et al., 2010). For this reason, fear appeals should be used with caution and other types of approaches should be considered first, especially in media campaigns targeted at youth.
- *Social norms campaigns:* Social norms marketing campaigns are a more recent approach to reducing alcohol-related crashes. They are built on the premise that an individual's behavior is influenced by his or her perceptions of how most people behave. However, people often assume that unsafe behaviors (e.g., drinking and driving, seat belt nonuse) are more common than they actually are. By correcting these misperceptions, social norms programs encourage people to adopt the "norm," which is the safe behavior. A study in Montana demonstrated the potential effectiveness of this approach. Surveys of young adults 21 to 34 years old in Montana revealed that only 20% had driven in the previous month after consuming two or more alcoholic drinks, although more than 90% thought their peers had done so (Linkenbach & Perkins, 2005). Based on this finding, a paid media campaign was developed with the normative message, "MOST Montana Young Adults (4 out of 5) Don't Drink and Drive." By the end of the campaign, reported drunk driving among young adults in target counties decreased from 22.9% to 20.9%, while the percentage in non-targeted counties increased from 16.9% to 28.6%.
- *Social media:* NHTSA and most States have begun using social networking sites to reach the general public with messages concerning alcohol-impaired driving. Although sites such as Facebook, Twitter, Instagram, Snapchat, and YouTube can effectively and inexpensively reach large numbers of people, there are no evaluations of alcohol-impaired-driving campaigns that use this approach. Like mass media campaigns and other types of communication described above, social media is unlikely to be effective as a stand-alone strategy; however, it may be a useful approach when combined with other communications to support specific impaired-driving activities. A recent survey of the role and use of social media in traffic safety messaging recommended six practices to

incorporate social media in outreach efforts (Sack et al., 2019). These include reusing the same messages across traditional and social media platforms, using images and videos strategically, timing the messaging and content appropriately, and collaborating with other agencies to maximize visibility.

Court Monitoring

Effectiveness: ★★	**Cost:** $	**Use:** Low	**Time:** Short

In court monitoring programs, people observe, track, and report on DWI court or administrative hearing activities. Court monitoring provides data on how many cases are dismissed or pled down to lesser offenses, how many result in convictions, what sanctions are imposed, and how these results compare across different judges and different courts. Court monitoring programs usually are operated and funded by organizations such as Mothers Against Drunk Driving.

Use:

As of January 2021 court monitoring programs were active in some jurisdictions in 14 States (MADD, 2022). According to MADD, 120 court monitors observed approximately 33,000 impaired-driving cases during 2021. This represents a small fraction of all people arrested for alcohol-impaired driving during any given year.

Effectiveness:

Shinar (1992) found that court-monitored cases in Maine produced higher conviction rates and stiffer sentences than unmonitored cases. Probst et al. (1987) found that judges, prosecutors, and other officials in 51 communities believed that court monitoring programs helped increase DWI arrests, decrease plea agreements, and increase guilty pleas.

Costs:

The main requirement for a court monitoring program is a reliable supply of monitors. Monitors typically are unpaid volunteers from advocacy groups like MADD, or similar organizations. Modest funds are needed to establish and maintain court monitoring records and to publicize the results.

Time to implement:

Court monitoring programs can be implemented very quickly if volunteer monitors are available. A few weeks will be required to set up the program and train monitors.

Approaches That Are Unproven or Need Further Evaluation

Responsible Beverage Service

This countermeasure covers a range of alcohol sales policies and practices that prevent or discourage restaurant and bar patrons from drinking to excess or from driving while impaired by alcohol. Server training programs teach servers how to recognize the signs of intoxication and how to prevent intoxicated patrons from further drinking and from driving. Management policies and programs include limits on cheap drinks and other promotions, support for designated driver programs, commitment to server training, and support for servers who refuse alcohol to intoxicated patrons. Goodwin et al. (2005) provides an overview of responsible beverage service. See also Wagenaar and Tobler (2007) and Voas and Lacey (2011) for reviews and discussion of the research literature on this issue.

Some States have mandatory programs that require at least some alcohol retail employees to attend a server training course. Other States have voluntary programs that provide incentives for retailers to participate (e.g., liability protection or insurance discounts). The quality of server training programs can vary considerably. Wagenaar and Tobler (2007) note that many server training laws "are not optimally designed, do not ensure quality training, and do not ensure all servers are consistently trained, or retrained periodically" (p. 158).

Server training programs are the only segment of responsible beverage service that has been adequately documented and evaluated. Research suggests that server training programs can be effective at reducing excessive drinking if they involve intensive, high-quality, face-to-face server training that is accompanied by strong and active management support (Shults et al. 2001). When server training programs are not intensive and are not supported, they are unlikely to result in greater refusals of service to intoxicated patrons. Despite these positive research findings for well-implemented server training programs, the available evidence does not support the effectiveness of generally used responsible beverage service countermeasures to reduce alcohol-impaired driving crashes.

Other Sanctions

The standard court sanctions for DWI offenses are driver's license suspension or revocation, fines, jail, and community service. All States use some combination of these sanctions. Details of each State's laws may be found in NHTSA's *Digest of Impaired Driving and Selected Beverage Control Laws* (NHTSA, 2017). Some States set mandatory minimum levels for some sanctions, which often increase for second and subsequent offenders. Most of these measures are widely used. The balance of evidence regarding the effectiveness of these countermeasures remains inconclusive.

License suspension or revocation: All States allow post-conviction license actions. This suspension or revocation typically runs concurrently with any administrative license action. Although *administrative* license actions are highly effective in reducing crashes (see the section on Legislation and Licensing above), *court-imposed* license actions appear less effective (Wagenaar & Maldonado-Molina, 2007). Some DWI offenders continue to drive with a suspended or revoked license, and many DWI offenders do not reinstate their license when they are eligible to do so. Consequently, long court-imposed license suspensions may do little to reduce recidivism. Instead, it may be important to encourage DWI offenders to reinstate their licenses, but with appropriate controls such as ignition interlocks and close monitoring.

Fines: Most States impose fines on DWI offenders. Additionally, offenders often face substantial costs for license reinstatement, mandated alcohol education or treatment, insurance rate increases, and legal fees. Available evidence suggests that fines appear to have little effect on reducing alcohol-impaired driving. For example, Wagenaar, Maldonado-Molina, Erickson, et al. (2007) examined alcohol-related fatal crashes across 32 States and concluded that mandatory fines "do not have clearly demonstrable general deterrent or preventive effects" (p. 992). Even though fines may not reduce alcohol-impaired driving, they do help support the system financially.

Jail: All States allow some DWI offenders to be sentenced to jail. The length of sentences varies by State and often depends on the number of prior convictions, the driver's BAC, whether the crash resulted in an injury or fatality, whether a child passenger was present (child endangerment laws), and several other factors. Jail is the most severe and most contentious of the DWI sanctions. Research on the effectiveness of jail is equivocal at best. Very short (48-hour) jail sentences for first offenders may be effective and the threat of jail may be effective as a deterrent (as is done in DWI and drug courts), but other jail policies appear to have little effect (Voas & Lacey, 2011; NTSB, 2000). Wagenaar et al. (2000) reviewed 18 studies and concluded: "The balance of the evidence clearly suggests the ineffectiveness of mandatory jail sentence policies" (p. 12). In fact, they find "numerous studies that indicate that [mandatory jail] might be a counterproductive policy" (p. 12) that increases alcohol-related crashes.

Community service: Many States allow community service as part of a DWI offender's sentence and 9 States allow community service in lieu of mandatory jail for first-time offenders (NHTSA, 2017). Community service can provide benefits to society if offenders perform useful work, but even if appropriate jobs can be found there are costs for program operation, offender supervision, and liability. The effects of community service programs on alcohol-impaired driving have not been evaluated (Century Council and National Association of State Judicial Educators, 2008).

Victim Impact Panels: DWI offenders are often required to attend a victim impact panel, in which offenders hear from people whose lives have been permanently altered by an impaired driver. Each year, an estimated 400,000 offenders attend victim impact panels, conducted by more than 200 MADD chapters across the United States (Voas & Lacey, 2011). Although victim impact panels are intuitively appealing, most studies suggest they do not reduce recidivism (Crew & Johnson, 2011; C'deBaca et al., 2001; Shinar & Compton, 1995; Wheeler et al., 2004).

Designated Driver and Programs

Designated drivers are people who agree not to drink so they can drive their friends who have been drinking. Formal designated driver programs in drinking establishments provide incentives such as free soft drinks for people who agree to be designated drivers. Usually, designated driver arrangements are completely informal. Surveys show that nearly all U.S. drivers agree that having a designated driver is important, and that 72% have served as one themselves (Wicklund et al., 2018).

The designated driver concept has been questioned on two grounds: (1) designated drivers may still drink, though perhaps less than the passengers; and (2) it may encourage passengers to drink to excess. Previous national roadside surveys found self-identified designated drivers were more likely to have a positive BAC in comparison to all drivers on the road (Lacey et al., 2009). A systematic review by CDC found insufficient evidence to determine the effectiveness of designated driver programs (Ditter et al., 2005). A review from Australia concluded that designated driver programs can successfully increase awareness and use of designated drivers, but evidence for changes in alcohol-related crashes is inconclusive (Nielson & Watson, 2009). Generally, the research support is stronger for alternative transportation programs (Fell et al., 2020).

Youth Programs

States, communities, nonprofit organizations, and schools have conducted extensive youth drinking-and-driving-prevention programs over the past 30 years. These programs seek to motivate youth not to drink, not to drink and drive, and not to ride with a driver who has been drinking. Although some programs use scare tactics, many employ positive messages and methods: providing positive role models that discourage alcohol use, promoting positive norms that do not involve alcohol, and encouraging youth activities that do not involve or lead to alcohol use.

A systematic review by CDC found there was insufficient evidence to determine the effectiveness of youth programs (Elder et al., 2005). To increase the perceived risks of drinking and driving, many schools have employed fatal vision goggles, peer-to-peer programs, role plays, or drunk-driving crash reenactments (e.g., "Every 15 Minutes"). Although popular, most of these programs have not been evaluated. The few existing studies suggest these types of programs may produce changes in knowledge or attitudes but have little or no effect on behaviors (Hover et al., 2000; Jewell & Hupp, 2005). Overall, education programs that train young adults on how to resist peer pressure and enhance informed decision-making skills may be the most successful approaches (Botvin & Griffin, 2007; Kelly-Weeder et al., 2011).

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2. Drug-Impaired Driving

Overview

In addition to alcohol, many drugs, both licit and illicit are known or suspected of impairing a driver's ability to operate a motor vehicle safely (National Institute on Drug Abuse, 2019). The impairing effects of alcohol and the dangers of drinking and driving are well-documented. By contrast, there is considerably less research regarding the potentially impairing effects of drugs, other than alcohol, on drivers. Some of the challenges in studying, measuring, and creating countermeasures to address drug-impaired driving include the following (Arnold & Scopatz, 2016; Berning & Smither, 2014; Compton et al., 2009; Compton, 2017; Logan et al., 2016; Smith et al., 2018; Stewart, 2006):

- There is a wide range of drugs, both licit and illicit, that can potentially impair driving. Moreover, the most commonly used drugs constantly change.
- Although the relationship between BAC and driving impairment is clear and well-documented, the relationship between blood levels of drugs and driving impairment has not been established for drugs other than alcohol.
- Alcohol metabolizes in the body in a predictable pattern, whereas other drugs are eliminated at different rates and with variability across people; hence, timing is critical when conducting a drug test. In addition, blood levels of certain drugs can accumulate with repeated administrations and may be detected well after impairment has ceased.
- It is not unusual for drivers to take more than one impairing drug at the same time or to combine other drugs with alcohol. Even individual drugs that are usually non-impairing at therapeutic doses may substantially increase the risk of the crash when combined with alcohol or other drugs due to their synergistic effects. Furthermore, even at therapeutic doses, certain drugs have the potential to impair.
- Alcohol can be measured reliably through breath tests, but other types of drugs can only be measured through more intrusive tests of bodily fluids such as blood, urine, or oral fluid.
- Improvements to the quality and type of data collected during drug-impaired-driving incidents are in initial stages of development and adoption by States and government agencies.
- Evidence-based countermeasures addressing alcohol-impaired driving are likely effective against driving while under the influence of other drugs; however, the challenges associated with understanding the problem of drug-impaired driving and detecting drug-impaired drivers, such as the policy of some agencies to conduct no further drug testing if alcohol is at or above the illegal per se limit, warrant a separate discussion.

Understanding the Problem

Compton et al. (2009) describe four basic issues that must be addressed to better understand the extent of the problem of drug-impaired driving:

- What drugs impair driving ability?
- What drug dose levels are associated with impaired driving?
- How frequently are impairing drugs being used by drivers?
- What drugs are associated with higher crash rates?

There are still sizeable gaps in our understanding of the effects of drugs on driving. In their review of drug-impaired driving, Jones et al. (2003) concluded: "The role of drugs as a causal factor in traffic crashes involving drug-positive drivers is still not understood…. Current research does not enable one to predict with confidence whether a driver testing positive for a drug, even at some measured level of concentration, was actually impaired by that drug at the time of crash." (p. 96).

Despite these challenges, a growing body of research suggests that some over-the-counter prescription medications, and illegal drugs may impair a driver's ability to operate a vehicle (for reviews, see Couper & Logan, 2004; Gjerde et al, 2019; Jones et al., 2003; Kelly et al., 2004; and Strand et al., 2016). Much of this research has involved laboratory or experimental studies using driving simulators. Some epidemiological studies have examined the effect of drugs on crash incidence and crash risk. See Compton et al. (2009) and Compton and Berning (2015) for a discussion of this research.

In most cases, the research investigating the effect of drugs on driving has had variable results, depending on the drug examined and the methodology employed. In addition, for many drugs, there is a lack of high-quality, published research. A summary of suspected crash risks associated with specific classes of drugs are provided below, with research gaps acknowledged.

Cannabis (often referred to as marijuana)

Cannabis is a term for all products derived from the plant *Cannabis sativa* or *Cannabis indica*. While cannabis contains many unique chemical compounds (i.e., cannabinoids), the substance primarily responsible for the psychoactive effects of the drug is tetrahydrocannabinol (THC)[3] (NIDA, 2019). According to the National Institute on Drug Abuse (2019), the acute effects of smoking or consuming THC include: an altered sense of time, distorted perception, impaired coordination, memory loss, and difficulty problem-solving. Regarding the impacts of cannabis on driving, some simulator and on-road, experimental studies have found increased car-following distance, increased lane position variability (i.e., weaving), increased driver reaction time, and decreased performance on divided attention tasks (e.g., performing two or more subtasks simultaneously) (Hartman & Huestis, 2013; Pearlson et al., 2021; Sewell et al., 2009); however, for these and other performance measures, some studies have found an association, while others have found no effects or inconclusive results (Pearlson et al., 2021). Caution should be used when interpreting the findings of simulator and experimental studies, because both types of studies may be susceptible to limitations, including an unrealistic driving environment, tightly

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[3] More specifically, the term THC usually refers to the delta-9-THC isomer (Δ^9-tetrahydrocannabinol) (Felder & Glass, 1998).

controlled conditions, and a low number of study participants, among other factors. In addition, since these studies often examine many performance measures, significant results may be highlighted over nonsignificant results (Smiley, 1999). Also, unlike comparable studies involving alcohol, several studies examining the relationship between cannabis and driver impairment noted that study participants reported being aware of potential driving deficits related to their cannabis consumption, with some participants responding to these real or perceived deficits through compensatory behaviors, such as reducing speed (Pearlson et al., 2021). One finding that has been consistent across most simulator and on-road, experimental studies is that, unlike alcohol, there is little evidence to support a direct dose-response relationship between cannabis consumption, blood THC concentration, and driver impairment (Peterman, 2019).

The epidemiologic research examining the association between cannabis consumption and elevated *real-world* crash risk is also inconclusive. A large-scale study in Virginia Beach, Virginia, found no elevated crash risk for THC-positive drivers after adjusting for demographic variables and alcohol use (Compton & Berning, 2015). In addition, the Virginia Beach case-control study did not find evidence of a synergistic effect on crash risk among drivers testing positive for both alcohol and THC (Lacey et al., 2016). Conversely, a 2021 review of recently published meta-analyses and culpability studies found a slight, but significant, elevated crash risk after recent cannabis usage, especially among drivers with high blood THC concentrations. However, there was considerable heterogeneity across the reviewed studies in terms of rigor, design, and measurement of exposure and outcomes (Pruess et al., 2021). Nevertheless, with more than half of all States permitting medical or recreational cannabis usage, SHSOs are concerned about the potential traffic safety impacts of legalization (NCSL, 2022). While the prevalence of cannabis usage tends to increase in States with legalized cannabis, legalization's impact on traffic safety outcomes is inconclusive (Zvonarev et al., 2019). A study examining the relationship between cannabis legalization and traffic fatalities in Colorado and Washington did not find an association (Hansen et al., 2018). Lane and Hall (2019) observed an increase in traffic fatalities in 2 out of 3 States after cannabis legalization (Colorado and Washington, with Oregon being the exception). However, the effect was modest (one additional fatality per million residents) and was followed by a trend reduction in traffic fatalities. The study of the relationship between cannabis legalization and fatal traffic crash risk is further complicated by challenges related to data quality and completeness at the national level (see Drug-Impaired Driving – Data/Surveillance).

Stimulants

There have been fewer studies examining the risks of stimulants (e.g., amphetamines) on driving. A meta-analysis performed by Elvik (2013) found elevated odds of fatal crash involvement among drivers under the influence of amphetamines as well as cocaine. However, causal relationships could not be established due to the paucity of high-quality studies available, with many of the studies inadequately controlling for potential confounders, among other limitations (Elvik, 2013). Therefore, more research is needed to better characterize the direction and magnitude of relationships between specific categories of stimulants and motor vehicle crash risks.

Antihistamines

The relationship between antihistamines and motor vehicle crashes is ambiguous (Moskowitz & Wilkinson, 2004). A small connection has been found between first-generation antihistamines (e.g., diphenhydramine) and crashes, but second-generation (non-sedating) antihistamines (e.g., cetirizine) do not appear to be associated with an elevated crash risk (Perttula et al., 2014). Extended use of antihistamines may also be associated with crash risk, but this is also an area that needs additional study (Gibson et al., 2009).

Antidepressants

Like many of the other classes of drugs under discussion, results for antidepressants are mixed. The use of second-generation antidepressant medications, such as selective serotonin reuptake inhibitors, appear to have minimal or no relationship with crash risk, especially when a person is acclimated to the drug, but this is not necessarily the case with older types of antidepressants and antidepressants with sedative qualities, such as tricyclic antidepressants and trazodone (Brunnauer & Laux, 2017; Hansen et al., 2015; Myers, 2021). However, it should be noted, that many studies examining the hazard posed by antidepressants are complicated by the fact that depression, along with other mental health conditions, are independent risk factors for traffic crashes (Hill et al., 2017). In these cases, antidepressants may decrease crash risk by treating an underlying potentially impairing medical condition. For example, a New Zealand study found that drivers with a history of suicidal ideation had an elevated risk of crash injury; however, this relationship was not significant among drivers reporting current antidepressant medication (Lam et al., 2005). More research is needed to better understand the relationship between depression (and other medical conditions) and crash risk, as well as the potential mitigating effects of antidepressants and other medications (Hill et al., 2017; Rapoport et al., 2022).

Narcotic Analgesics/Opioids

Opioids are a class of drug that includes both legal and illegal drugs, such as heroin, fentanyl, and prescription medications used for the treatment of pain, such as oxycodone (OxyContin), oxymorphone (Opana), and hydrocodone (Vicodin). Opioids bind to and activate opioid receptors in the human body, blocking pain and releasing dopamine, which can induce feelings of contentedness and relaxation. For this reason, prescription opioid analgesics have been used for decades for the treatment of acute and chronic pain, among other medical reasons. However, both licit and illicit opioids can cause sedation, confusion, slowed breathing, unconsciousness, and death (NIDA, 2021). Due to their sedative and other psychoactive effects, both licit and illicit opioids have been theorized to impair driving ability and result in negative traffic safety outcomes (Beaulieu et al., 2022). However, few experimental or epidemiological studies have adequately characterized the transportation safety risks associated with opioids (Beaulieu et al., 2022; Cameron-Burr et al., 2021; Leung, 2011).

In a recent clinical review, Beaulieu et al. (2022) found that most experimental studies indicated some level of impairment on tests of psychomotor function, including tests assessing driving performance; however, many of these studies suffered from the limitations common to experimental studies, as discussed previously. In addition, most study populations consisted of healthy people with no history of opioid use, a population that may not be representative of people who use opioids on a routine basis, such as people prescribed opioid analgesics for chronic pain management. In addition, a substantial number of studies found no evidence or inconclusive evidence of impairment. A 2011 study (Leung) found even more limited evidence supporting a relationship between opioid analgesics and impairment, especially at therapeutic doses. However, the authors noted that more research is needed, especially regarding the combination of opioid analgesics with other CNS depressants, such as alcohol.

To date, most of the epidemiologic literature is descriptive in nature, documenting the prevalence of opioid positivity in specific populations (e.g., people with serious or fatal motor vehicle crash injuries) (Beaulieu et al., 2022; Cameron-Burr et al., 2021; Leung, 2011; Thomas et al., 2022b).While several studies have noted an increase in the prevalence of drivers testing positive for various opioids, it is unclear how changes in testing procedures may be affecting trends (Cameron-Burr et al., 2021). Among studies examining the association between opioid use and motor vehicle crash risk, the evidence is mixed. While several recent epidemiologic studies have found an association between the use of opioids and motor vehicle crashes, other studies have failed to find an association (Gjerde et al., 2015). NHTSA's Virginia Beach case-control study examined the crash risk of opioid analgesics, along with other prescription and illicit drugs. Narcotic analgesics were not found to be significantly associated with crash risk alone or in combination with alcohol; however, the number of participants testing positive for narcotic analgesics was not sufficient for stratifying analyses by concentration levels (Lacey et al., 2016).

Central Nervous System (CNS) Depressants

CNS depressants are prescription medications that include sedatives, tranquilizers, and hypnotics. These drugs tend to slow brain activity and produce quietening effects and are therefore used for treating sleep and anxiety disorders, among other conditions. CNS depressants include benzodiazepines (e.g., diazepam [Valium], alprazolam [Xanax], clonazepam [Klonopin]; non-benzodiazepine sedative hypnotics (e.g., zolpidem [Ambien], carisoprodol [Soma], eszopiclone [Lunesta]), and barbiturates. CNS depressants produce numerous effects including drowsiness, lack of coordination, difficulty concentrating, and confusion (NIDA, 2018). Barbiturates are now uncommon. However, benzodiazepines and non-benzodiazepine sedatives are a concern for driving because of their potentially impairing effects (Chong et al., 2013; Maust et al., 2019). Two literature reviews found that under experimental conditions, benzodiazepines adversely affect driving ability, particularly maintaining lateral position (Dassanayake et al., 2011; Verster & Roth, 2013). Regarding the epidemiologic evidence regarding CNS depressant use and crash risk, two meta-analyses found an association between benzodiazepine use and increased crash risk; however, neither study formally assessed study quality or publication bias (Dassanayake et al., 2011; Elvik, 2013; Rapoport et al., 2009). A more rigorous meta-analysis performed by Elvik (2013) found an elevated crash risk for benzodiazepines for property damage only, nonfatal injury, and fatal traffic crashes and an elevated property damage only (PDO) crash risk associated with the use of non-benzodiazepine sedative hypnotics. However, Elvik (2013) noted that due to heterogeneity in study design and the failure of many studies to adequately control for confounding factors, a causal relationship could not be established conclusively. Also, NHTSA's Virginia Beach case-control study did not find a relationship between CNS depressants and crash risk with or without combination with alcohol (Lacey et al., 2016). Among studies finding an association between use of CNS depressants and crashes, the risk was modulated by the type of benzodiazepine used, the dose, the time elapsed since use, and whether the drug was combined with alcohol or other drugs, such as opioids (Dassanayake et al., 2011; Leung, 2011; Scherer et al., 2018).

Other licit and illicit drugs

The preceding is not an exhaustive list of substances that may impair driving ability. Law enforcement officers commonly find drug impaired drivers on other substances such as ketamine, MDMA, and inhalants. Studies have suggested that antiemetic agents, antiepileptic agents, antiparkinsonian agents, antipsychotics, hypoglycemic agents, among other medications and drugs may negatively affect driving ability; however, for many of these agents, the evidence is insufficient (U.S. FDA, 2021; Hetland & Carr, 2014; Myers, 2021).

Like alcohol-impaired driving, drug-impaired driving is primarily addressed through a combination of laws, enforcement, and education (AAAFTS, 2018a; AAAFTS, 2018b). Relatively few countermeasures have been developed to specifically address drug-impaired, separate from alcohol-impaired driving, and there has been little evaluation of drug-impaired-driving countermeasures. AAAFTS investigated the potential for alcohol-impaired-driving countermeasures to be applied to drug-impaired driving. The conclusions point to the need for more research to better understand the nature and degree of traffic safety risk posed by drugs, as well as the effectiveness of potential countermeasures to address this issue. See the guide on drug-impaired driving produced by the Center for Problem-Oriented Policing for more information about drug-impaired-driving countermeasures (Kuhns, 2012). Cannabis-specific summaries can be found in NHTSA's Marijuana-Impaired Driving: A Report To Congress (Compton, 2017) and the AAA Foundation for Traffic Safety's report (Logan et al., 2016). Smith et al. (2018) reviewed the state of knowledge on countermeasures against impaired driving due to prescription and over-the-counter drugs.

Data/Surveillance

As mentioned previously, there is a lack of high-quality data for assessing the prevalence of drug-impaired driving, as well as the relationship between drug-impaired driving and motor vehicle crash injury and fatality risk. Such data are necessary for assessing the efficacy of drug-impaired driving countermeasures. In their report, *Advancing Drugged Driving Data at the State Level: Synthesis of Barriers and Expert Panel Recommendations* Arnold & Scopatz (2016) listed 12 recommendations to States to address barriers to collecting and maintaining drug-impaired driving data. These recommendations included training law enforcement officers in performing SFSTs, authorizing officers to collect and test biological samples for drugs and alcohol among all drivers suspected of DWI, developing national model specifications for testing biological specimens, and developing or improving State data collection and reporting systems.

A first step in understanding the scope of the problem of drug-impaired driving is understanding the prevalence of drug use among drivers. One method of obtaining this information is the systematic collection of oral fluid or blood samples through a roadside survey. If performed rigorously with adequate sampling methods, such surveys are representative of the driving population in a given region over a specified time period. However, roadside surveys are not designed to assess drug impairment directly. Impairment is based on a variety of factors including dosage, time since administration, consumption of other psychoactive substances, the person's tolerance of the drug, the person's physiology, etc. Roadside surveys are designed to measure the presence/absence of drugs rather than impairment. In addition, roadside surveys are not designed to measure drug crash involvement or crash risk. Roadside surveys are useful for monitoring the driving public's drug use over time and can be used to evaluate the impacts of implementing countermeasures, under certain conditions (Thomas et al., 2022). In 2007 NHTSA assessed the prevalence of drivers testing positive for alcohol and other drugs with the potential to impair driving-related behaviors (Lacey et al., 2009). The roadside survey was repeated in 2013 and 2014 (Kelley-Baker et al., 2017) and the report documented an increase in the prevalence of drivers testing positive for cannabis from 8.7% to 12.7%. States have also successfully performed high-quality, representative roadside surveys, an example being Washington State (Ramirez et al., 2016). For more information regarding best practices for State roadside surveys for alcohol and drug prevalence, see Thomas et al. (2022).

Another important component of describing the problem of drug-impaired driving is documenting the prevalence of drug use among drivers involved in crashes, including fatal crashes. Until recently, the information captured by FARS regarding the presence of drugs among drivers involved in fatal crashes was extremely limited (Berning & Smither, 2014). In 2018 NHTSA made several changes to FARS to improve the quality of the toxicological data. One change now allows *all positive* drug test results and some ability to record negative results. Previously, FARS allowed entry of only three substances, regardless of the number of drugs present in the biological sample (National Center for Statistics and Analysis, 2019). Other limitations identified by Berning and Smither (2014) remain, including differences in State drug testing and reporting. For a recent, comprehensive overview of current limitations associated with the drug data collected in FARS, see NHTSA's 2022 report, *Drug Testing and Traffic Safety: What You Need to Know* (Berning et al., 2022).

Another approach to improving the quality of drug-impaired driving data is the creation of a State or Federal sentinel surveillance system. According to the Centers for Disease Control and Prevention, public health surveillance is "the systematic, ongoing collection, management, analysis, and interpretation of data followed by the dissemination of these data to public health programs to stimulate public health action" (Thacker et al., 2012, p. 3). In general, sentinel surveillance systems track the frequency of health events in a specified cohort for the purpose of estimating trends in a larger population. While initially intended for tracking infectious disease outbreaks, sentinel surveillance programs have been successfully used for monitoring the incidence of injuries and violence (Chow & Leo, 2017). Due to the effectiveness of sentinel surveillance systems in other fields, experts in transportation have long recommended the creation of a program for establishing the prevalence of drug-impaired driving (or at the least the prevalence of drivers testing positive for drugs), through enhancing existing surveillance systems, and the development of new systems, often involving the linkage of motor vehicle crash and health information, which may contain toxicology results (Kelley-Baker et al., 2019).

At the State level, from 1992 to 2013 NHTSA sponsored 20 States to link crash records to EMS, emergency department, inpatient hospital, death certificate, or medical examiner data as part of the CODES. As many health data systems collect toxicological information, linked crash and health data provides a unique opportunity to better understand the prevalence of drivers testing positive for drugs after a motor vehicle collision, for both fatal and nonfatal events (NHTSA, 2010). One CODES State, Kentucky, was able to supplement the information reported in FARS for their State by linking to death certificate data, increasing the capture of opioid and antidepressant cases (Bunn et al., 2019). The cessation of Federal funding for the CODES program in 2013 resulted in a reduction in State data linkage activities; however, in recent years, other States have initiated linkage programs independent of CODES (National Center for Injury Prevention and Control, 2019). While data linkage holds promise for an enhanced understanding of driving under the influence of drugs, many health data sources have similar limitations to FARS, including missing and incomplete toxicological information.

Although more costly than leveraging existing data systems, creating a new sentinel surveillance system designed specifically for monitoring drug and alcohol impairment may overcome many of the limitations discussed in this chapter. NHTSA began data research on the prevalence of drug and alcohol among serious and fatal road users presenting at selected trauma centers and medical examiners' offices (Thomas et al., 2020; Thomas et al., 2022b). Insights from this study may serve as the basis for a future drug-impaired driving countermeasure for the development of a sentinel surveillance system. Indeed, Kelley-Baker et al. (2019) recommended Level I trauma centers as strong candidates for inclusion in such a sentinel surveillance system.

Emerging Issues

For decades, the public health community has recognized that enforcement and incarceration are not the only solutions to solving the nation's misuse and abuse of licit and illicit drugs (Lancet, 2001). Instead, addiction is best managed as a chronic health condition with evidence-based treatment provided in lieu of, or in combination with, incarceration (Chandler et al., 2009). Many interventions are based on the principle of harm reduction, an approach designed to minimize the negative effects of a health behavior, without necessarily eradicating the behavior (Hawk et al., 2017). Harm reduction interventions have been demonstrated to be effective against drug addiction and overdose (Haegerich et al, 2019; Ritter & Cameron, 2006). An example of this type of approach designed to reduce drug-impaired driving is a program to increase awareness and acceptance of taking alternative forms of transportation while under the influence of drugs (Watson & Mann, 2018). Another strategy would be to enroll convicted drug-impaired drivers into remediation and treatment programs rather than incarceration and other more punitive measures. While there is little evidence rehabilitation programs can reduce drug-impaired driving, these programs have been demonstrated to be effective in reducing alcohol-impaired driving (see Alcohol Problem Assessment and Treatment). One small-scale study of convicted drivers in Ontario, Canada, found that 6 months after completion of a rehabilitative educational and treatment program, participants self-reported a decrease in substance use and misuse, and in negative consequences of misuse (e.g., relationship, legal, financial problems) (Wickens et al., 2018). In addition, it is important to note that many existing countermeasures designed primarily to address alcohol impairment, such as DWI courts, are likely to be effective at reducing drug-impaired driving; however, more research is needed to evaluate their efficacy at preventing drug-impaired driving, specifically. For this current edition of *Countermeasures That Work,* these cross-cutting countermeasures will continue to be described in Alcohol-Impaired-Driving Countermeasures. This placement will be evaluated in future editions.

Another emerging issue with a direct influence on the countermeasures of drug-impaired-driving laws and enforcement of drug-impaired driving is the increasing availability of reputable drug screening tools, for cannabis and other drugs. Blood analysis is considered the "gold standard" of drug screening due to its long history, extensive study and evaluation, and ability to produce quantifiable results. However, it has several constraints including the relative invasiveness of the procedure, the need for a warrant, and often the need to transport the driver to a healthcare facility for the drawing of blood. The latter is especially salient since many drugs are metabolized quickly (Bloch, 2021). One approach to minimizing the burden of performing blood testing for drugs, is training law enforcement officers as phlebotomists. For those States that allow this practice, training officers to draw blood saves money by eliminating hospital and phlebotomist fees, reduces the time required for specimen collection, and simplifies the chain of custody, among other benefits. In 1995 Arizona was the first State to implement a training program for law enforcement officers (NHTSA, 2019). As of 2019 Indiana, Maine, Minnesota, Ohio, Pennsylvania, Rhode Island, Utah, Idaho, Texas, Colorado, and Washington State had implemented law enforcement phlebotomy training programs (Bergal, 2019; NHTSA, 2019). While warrants are generally required for drawing blood from drivers suspected of impairment, many States permit the issuing of electronic warrants ("e-warrants"), also reducing the time required to draw blood after a crash or traffic stop (Bergal, 2019). An alternative to blood analysis is oral fluid testing. Oral fluids can be collected from drivers and sent to a toxicological laboratory for screening and confirmatory testing or collected and tested *on-site*. Note that the latter technique still requires further confirmatory testing in a laboratory. Both forms of oral fluid analysis are less invasive than blood analysis and on-site oral fluid testing can produce results within minutes. In addition, oral fluid requests do not require a warrant (Bloch, 2021). However, a positive test result from an on-site oral fluid test indicates the presence of a drug category,[4] not the quantity of the substance. Also, there are known performance issues with certain devices, including false positive results (i.e., indicating a drug is present when it is not). For example, Buzby et al. (2021) found that three out of five commercially available devices examined (Alere DDS2 Mobile System [DDS2], AquilaScan Oral Fluids Testing Detection System, Securetec DrugWipe S 5-Panel [DrugWipe]), did not meet the recommended levels of performance suggested as part of the Roadside Safety Testing Assessment, in aggregate or for individual drug assays. Two devices, the Dräger DrugTest 5000 (DDT5000) and the Dräger DrugCheck 3000 (DDC3000), had overall performance measures over 97% for sensitivity, specificity, and accuracy (Buzby et al., 2021). While oral fluid roadside testing is not sufficient for ascertaining drug impairment, the results can be used to help law enforcement officers decide to draw blood and perform laboratory testing or to involve a DRE (see Enforcement of Drug-Impaired-Driving Laws). As of 2021 there were 24 States that had statutes allowing the collection of oral fluid samples from drivers suspected of impairment. Alabama, Indiana, and Michigan have had active or pilot oral roadside testing programs (Bloch, 2021). As this is an area of growing research, future editions of *Countermeasures That Work* may include testing programs as a stand-alone countermeasure or as a component of an existing countermeasure.

Key Resources

- For more background on drug-impaired driving, see GHSA (2017) and Thomas et al. (2020).
- For drug-impaired-driving trends, see Kelley-Baker et al. (2017) and Lipari et al. (2016).
- For drug-impaired-driving laws, see NCSL (2020) and GHSA (n.d.).
- For a list of States that have legalized cannabis, see NCSL (2022).

[4] Devices vary on substances they can test for, and detection (threshold) levels of those drugs.

- For a summary of the effects of 16 selected drugs, both licit and illicit, on human performance while driving, see Couper and Logan (2014).
- For a discussion of some of the complexities associated with understanding the problem and countering drug-impaired driving, see Arnold & Scopatz (2016), Compton (2017), Compton et al. (2009), and Gourdet et al. (2020).

Key Terms

- ARIDE: Advanced roadside impaired driving enforcement, a training course designed to educate law enforcement officers about drug-impaired driving and to serve as a bridge between the SFST and DRE trainings
- BAC: blood alcohol concentration in the body, expressed in grams of alcohol per deciliter (g/dL) of blood, usually measured with a breath or blood test
- CODES: Crash Outcome Data Evaluation System
- DUID: driving under the influence of drugs
- DRE: drug recognition expert, a law enforcement officer specifically trained in identifying drivers who are drug-impaired
- DWI: the offense of driving while impaired by alcohol or drugs. In different States the offense may be called driving while intoxicated, driving under the influence (DUI), or other similar terms
- Harm reduction model: a model minimizing the harms of a health behavior, such as drug misuse or abuse, without necessarily extinguishing the behavior
- Illegal per se law: law that makes it an offense to operate a motor vehicle with a threshold of a substance at or above a specified level
- SFST: standardized field sobriety tests, a procedure to assess whether a person is at or above .08 BAC
- Surveillance system: the systematic collection and interpretation of data for the purpose of informing programs, policies, prevention, and the public
- THC: delta-9 tetrahydrocannabinol, the primary psychoactive constituent in cannabis. The THC metabolite, hydroxy-THC, is also psychoactive.
- Zero-tolerance law: in relation to drug-impaired driving, a law that makes it an offense to operate a motor vehicle with any measurable amount of an illicit drug in the body.

Drug-Impaired Driving Countermeasures

Legislation and Licensing

Countermeasure	Effectiveness	Cost	Use	Time
Drug-Impaired-Driving Laws	★	Unknown	Medium†	Short

† Use for drug per se laws

Enforcement

Countermeasure	Effectiveness	Cost	Use	Time
Enforcement of Drug-Impaired Driving	★★★	$$	Unknown	Short

Other Strategies for Behavior Change

Countermeasure	Effectiveness	Cost	Use	Time
Education Regarding Medications	★	Varies	Unknown	Varies

Approaches That Are Unproven or Need Further Evaluation

There are no countermeasures in this category.

Effectiveness:

★★★★★	Demonstrated to be effective by several high-quality evaluations with consistent results.
★★★★	Demonstrated to be effective in certain situations.
★★★	Likely to be effective based on balance of evidence from high-quality evaluations.
★★	Limited evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.
★	No evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.

Cost to implement:

$$$	Requires extensive new facilities, staff, equipment, or publicity, or makes heavy demands on current resources.
$$	Requires some additional staff time, equipment, facilities, and/or publicity.
$	Can be implemented with current staff, perhaps with training; limited costs for equipment or facilities.

These estimates do not include the costs of enacting legislation or establishing policies.

Use:

High	More than two-thirds of the States, or a substantial majority of communities
Medium	One-third to two-thirds of the States or communities
Low	Less than one-third of the States or communities
Unknown	Data not available

Time to implement:

Long	More than 1 year
Medium	More than 3 months but less than 1 year
Short	3 months or less

These estimates do not include the time required to enact legislation or establish policies.

Legislation and Licensing

Drug-Impaired-Driving Laws

Effectiveness: ★	**Cost:** Unknown	**Use:** Medium†	**Time:** Short

† Use for drug per se laws

It is illegal to drive under the influence of drugs in all 50 States, Puerto Rico, and the District of Columbia (Boddie & O'Brien, 2018). However, there is a great deal of variability in how States approach this issue. In some States, impairment-based statutes stipulate that prosecution must prove the driver was impaired (for example, by driving recklessly or erratically). Some States have per se laws in which it is illegal to operate a motor vehicle if there are specific detectable levels of a prohibited drug in a driver's system. Other States have "zero-tolerance" laws, which make it illegal to drive if there is any quantity of illegal substance detected.

Lacey et al. (2010) conducted interviews with law enforcement officers, prosecutors, and other traffic safety professionals in States with per se laws. Most were supportive of such laws. Although they did not believe per se laws made enforcement easier, they reported these laws had a positive effect on the prosecution and conviction of drug-impaired drivers. Moreover, discussions with officers and prosecutors in States *without* per se laws also revealed relatively high conviction rates, with few cases reaching trial.

NHTSA's 2009 *Drug Impaired Driving: Understanding the Problem and Ways to Reduce It: A Report to Congress* included a model drug-impaired-driving law (Compton et al., 2009). Because the relationship between blood levels of drugs and driving impairment has not been established for drugs other than alcohol, the model law does not include a per se provision. NHTSA recommended enhanced penalties for drivers who are under the influence of several drugs (which could include alcohol) above the sanction for only one substance. In addition, NHTSA recommended State statutes provide separate and distinct offenses and sanctions for alcohol- and drug-impaired driving (Compton et al., 2009; Compton, 2017). NHTSA's 2017 *Marijuana-Impaired Driving: A Report To Congress* (Compton, 2017) also recommended measures for improved data and records maintenance at the State level, including the distinction between alcohol-use, drug-use, or both in impaired driving cases, and the distinction between the types of drugs. See Compton (2017) for a detailed list of recommendations.

For a detailed discussion of issues related to drug-impaired-driving laws, see DuPont et al. (2012). The authors make several recommendations including the improvement of drug testing technology, enactment of laws requiring drug testing of all drivers in injury crashes, and the addition of drug use to underage zero-tolerance laws. See also Reisfeld et al. (2012) for arguments in favor of per se laws for drug-impaired driving and a discussion of the challenges of establishing impaired drug thresholds equivalent to a .08 g/dL BAC. Finally, see Robertson et al. (2016) and Gourdet et al. (2020) for recommendations to improve the prosecution of drug-impaired-driving cases.

Use:

The recent trend in legalizing cannabis for medical or recreational use has affected the adoption and enforcement of zero-tolerance and per se laws in the United States, since the metabolites of THC can be detected in the blood and urine for days to weeks after consumption, long after any impairing effects of the drug have concluded (Axel, 2020; Wong et al., 2014). In addition, although there have been recent advances in drug screening tools such as on-site oral fluid testing, this is still an emerging area of study (see Emerging Issues). As of February 3, 2022, there were 37 States, the District of Columbia, and 3 territories that allow for the medical use of cannabis. In addition, 19 States, the District of Columbia, and 2 Territories have enacted legislation permitting adult recreational use of cannabis (NCSL, 2022). Currently, 11 States (Arizona, Delaware, Georgia, Indiana, Iowa, Michigan, Oklahoma, Rhode Island, South Dakota, Utah, Wisconsin) have zero-tolerance laws for one or more drugs, including cannabis. Six States (Illinois, Ohio, Pennsylvania, Montana, Nevada, Washington) have specific per se limits for THC ranging from 1 to 5 ng/mL. One State, Colorado, has a "reasonable inference law" stating that if THC is detected in the blood at levels ≥5 ng/mL, it is reasonable to assume that the driver is impaired. The remaining States have impairment-based laws (NCSL, 2022). More information about the drug-impaired-driving laws in each State can be found in NCSL (2022), GHSA (n.d.), Boddie and O'Brien (2018), Lacey et al. (2010), and Walsh (2009).

Effectiveness:

Lacey et al. (2010) tried to determine whether drug per se laws increased drug-impaired-driving arrests and convictions. However, they were hampered by the fact that many States do not record drug-impaired offenses separately from alcohol-impaired offenses. Similar limitations were found in a study by the AAAFTS (Smith et al., 2019). Watson and Mann (2016) performed a scan of the international literature and found a lack of evidence supporting the effectiveness of zero-tolerance and per se laws in reducing the prevalence of driving under the influence of cannabis. To date, there is insufficient evidence suggesting that State zero-tolerance and per se laws are more effective than impairment-based laws in reducing drug-impaired driving and improving safety outcomes, especially for cannabis.

Costs:

The costs of drug-impaired-driving laws will depend on the number of offenders detected and the penalties applied to them.

Time to implement:

Drug-impaired driving laws can be implemented as soon as appropriate legislation is enacted, although time will be needed to educate law enforcement officers, prosecutors, and judges about the new legislation and to inform the public.

Other considerations:

- *Per se laws and prescription medications:* Some States with per se laws for drug-impaired driving exclude prescription medications from the list of prohibited drugs. Others require the driver to provide a valid prescription to avoid being charged or convicted for drug-impaired driving. Using a medication as prescribed, however, can still lead to impairment in driving ability. See Smith et al. (2018) and Voas et al. (2013) for a discussion of issues related to per se laws and prescription medications.
- *Drug testing of fatally injured drivers:* Drug presence is not reported in many fatal crashes. Moreover, there is inconsistent testing of drugs by laboratories, threshold differences for determining a positive test result, and variation in how results are reported. To better understand and track the drug-impaired driving problem in the United States, improved data and data collection on drug-impaired drivers is needed, see

Berning and Smither (2014) and Berning et al. (2022). D'Orazio et al. (2021) describes minimum recommendations for toxicological investigation of fatal motor vehicle crashes and drug-impaired driving.

- *Equity:* The enactment and enforcement of stricter State drug-impaired-driving laws, such as zero-tolerance laws, has equity implications. As mentioned elsewhere in *Countermeasures That Work*, there are persistent racial and ethnic disparities in the frequency of traffic stops, searches and citations among people of color (Novak & Chamlin, 2012; Epp et al., 2017). For example, in an examination of 20 million traffic stops in North Carolina, Baumgartner et al. (2018) found that Black male drivers were twice as likely to be stopped by law enforcement and, if stopped, twice as likely to be searched, as compared to White male drivers. Although not specific to drug-impaired driving, a San Diego survey of Black men found that their likelihood of receiving DUI arrest citations was 80% higher than among non-Latino/non-Hispanic White men, despite having lower mean BACs at the time of arrest (Alimohammad, 2017). In addition, a second California-based study found that Latino/Hispanic men were 1.66 times as likely to be convicted for driving under the influence of alcohol, as compared to White men (Kagawa et al., 2021). There is little literature focused specifically on racial and ethnic disparities and the enforcement of drug-impaired driving, therefore more studies are needed to examine the extent to which these disparities exist.
- *Public support:* There is strong approval among the general public for laws that prohibit drug-impaired driving. A 2018 survey by the AAAFTS found 81% of drivers support per se laws for cannabis and 77% of drivers support zero-tolerance laws for drugs not legally prescribed (AAAFTS, 2019).

Enforcement

Enforcement of Drug-Impaired Driving

Effectiveness: ★★★	**Cost:** $$	**Use:** Unknown	**Time:** Short

Enforcement of drug-impaired-driving laws can be difficult. Investigations often follow from an officer's suspicion of a driver's impairment, but when their BAC is not consistent with impairment. If drivers have BACs over the legal limit, many agencies do not allow for additional testing. This additional testing can be costly and in many States poly substance use does not carry additional penalties.

Several devices are available that allow officers to screen suspects for the presence of drug categories at point-of-contact, with varying degrees of sensitivity, specificity, and accuracy, although their efficacy is improving (Buzby et al., 2019; Compton et al., 2009; Dobri et al., 2019; Peaire et al., 2018). For a more in-depth discussion of roadside testing, see Drug-Impaired Driving – Emerging Issues.

NHTSA has developed several courses in collaboration with the International Association of Chiefs of Police (IACP) to assist law enforcement officers with the investigation of suspected drug-impaired driving cases. Law enforcement officers who have completed training in DWI detection and SFST can participate in the Advanced Roadside Impaired Driving Enforcement (ARIDE) program. This is a 16-hour course designed to enhance officers' knowledge of the impairing effects of alcohol, other drugs, and polydrug use including alcohol. To achieve this, ARIDE trains officers to properly administer SFSTs, and to "observe, identify, and articulate observable signs of drug impairment" (NHTSA, 2018, p. 9) with the seven drug categories[5] established by the Drug Evaluation and Classification (DEC) program. ARIDE serves as a bridge between the SFST and the more advanced DEC program, also known as the drug recognition program (NHTSA, 2018). The DEC program trains law enforcement officers through a three-phase training process: DRE pre-school (16 hours), DRE school (56 hours), and DRE field certification (~40 to 60 hours). Upon completion DREs are certified to conduct a 12-step protocol to determine three things: (1) whether the person is impaired, (2) whether this impairment is related to drug impairment or a possible medical condition, and (3) if drug impaired, the category or categories of drugs likely causing the impairment. In most instances the evaluation takes approximately 1 hour to complete. If drug intoxication is suspected, a blood, oral fluid, or urine sample is collected and submitted to a forensic laboratory for screening and confirmation testing (DEC Program Technical Advisory Panel, 2020; NHTSA, 2018b; NHTSA, 2018c).

Use:

As of 2022 there were 8,350 active DREs, of whom 1,605 are also instructors, representing all 50 States and the District of Columbia. In addition, from 2009 to 2022 some 155,875 officers and public safety officials received ARIDE training. Also, in 2022 there were 23,278 drug enforcement evaluations conducted by DREs (IACP, 2023). However, it should be noted that the number of drug-impaired driving arrests cannot be known as many States only record "impaired driving" arrests, and do not separate alcohol from drug arrests. It is suspected that many arrests

[5] The seven drug categories established by the DEC are cannabis, CNS depressants, CNS stimulants, dissociative anesthetics, hallucinogens, inhalants, and narcotic analgesics (NHTSA, 2018b).

are a combination of drugs and alcohol. Among the drug recognition evaluation opinions voluntarily reported to the NHTSA DRE Database (ICAP, 2023), CNS stimulants was the most frequently identified drug category, followed by cannabis, narcotic analgesics (opioids), and CNS depressants.

Effectiveness:

Overall, the evidence supporting the ability of DREs to accurately classify the drug responsible is mixed. While several studies have found above 85% agreement between the DRE and the toxicological test results (NHTSA, 1996), other studies have found lower percentage agreement (Shinar et al., 2000). The accuracy of the evaluation is likely highly dependent on the level of experience of the DRE, the category of drug involved, and the numbers of drugs involved (the consumption of several drugs can hide some signs and symptoms and enhance others).

To date, research has not directly identified strategies to reduce drug-impaired driving over and above those used for alcohol use and driving due to the considerable complexities involved with performing such research. However, there has been considerable work done examining the impacts of decriminalization and legalization of cannabis on several aspects of the DWI system, including prevalence and enforcement. See the joint report by NHTSA, GHSA, and the Volpe National Transportation Systems Center (2017) and Otto et al. (2016) for comparative discussions across States.

Costs:

As with other enforcement strategies, the primary costs are for law enforcement time and training. The time to conduct a DRE evaluation is approximately 1 hour. Training includes 72 hours of classroom instruction and approximately 50 hours of field work (NHTSA, 2018c). In addition, DREs must be recertified every 2 years. At a minimum this involves four acceptable evaluations since the date of last certification, 8 hours of recertification training, and submission of an updated Curriculum Vitae and rolling log to the appropriate coordinator for review (ICAP, n.d.). The time required for ARIDE training is considerably less, involving 16 hours of classroom instruction (NHTSA, 2018).

Time to implement:

Drug-impaired driving enforcement can be integrated into other enforcement activities within 3 months; however, time will be needed to train DREs in detecting drug impairment. DRE training consists of 72 hours of classroom instruction, and DRE candidates are also required to perform several supervised field evaluations to become certified (Compton et al., 2009). Providing ARIDE training takes less time to deliver (16 classroom hours), but principal instructors must have suitable qualifications, including current certification as a DRE and completion of the NHTSA/IACP Instructor Development Course (NHTSA, 2018).

Other considerations:

- Drug-impaired driving enforcement shares many of the same issues cited under drug-impaired-driving laws (see Drug-Impaired-Driving Laws – Other Considerations). For example, drug-impaired driving enforcement has equity implications if people of color are disproportionately stopped, evaluated for drug impairment, arrested, convicted, and penalized; therefore, drug-impaired driving enforcement activities should be monitored for potential racial and ethnic bias. If bias is found, prompt action should be taken.

Other Strategies for Behavior Change

Education Regarding Medications

Effectiveness: ★	**Cost:** Varies	**Use:** Unknown	**Time:** Varies

In addition to cannabis and illicit drugs, there are also numerous prescription medications that may have impairing effects (see Drug-Impaired Driving – Understanding the Problem). As part of the 2013-2014 National Roadside Survey of Alcohol and Drug Use, 20% of drivers self-reported use of a potentially impairing prescription medication within the last 2 days, with the most common reported categories of medications being CNS depressants (8%), antidepressants (8%), and narcotic analgesics (8%). Among drivers reporting recent prescription medication use, 78% responded that they had a prescription for the medication. Most drivers reported receiving warning of the potentially impairing effects of their prescribed medication from a health care provider or pharmacist, but there was variability by drug category, with more than 85% of drivers prescribed CNS depressants or narcotic analgesics reporting being warned, as compared to less than 65% of drivers being prescribed antidepressants or stimulants (Pollini et al., 2017). Due to the prevalence of driver use of potentially impairing prescription medications and the lack of reported education given to drivers regarding the medications' potentially impairing effects, there is an opportunity for intervention. Therefore, this countermeasure involves providing education to healthcare providers, pharmacists, and patients about the potential risk of motor vehicle crashes associated with certain prescription medications. For example, healthcare providers and pharmacists can receive instruction relating to potentially driver-impairing prescription drugs, laws relating to medication use and DWI, and how to convey this information to patients to whom they are prescribing medications. Medical providers are also encouraged to select non-impairing alternative medication (if possible) and to consider the patients' medication regime (e.g., other drugs, substances) to avoid drug-additive driving-impairment effects (American Geriatric Society & Pomidor, 2019). More generally, education can also include use of clear warning labels on drug packaging or State PSAs.

Use:

Programs that provide education about the side-effects of medication exist, but there is currently no information about how widespread they are.

Effectiveness:

As an example of an application of this countermeasure, NHTSA worked with Walgreens, the country's largest drugstore chain, to develop a curriculum for pharmacists on medication-impaired driving. The curriculum modules covered potentially driver-impairing prescription drugs, laws relating to medication use and DWI, and the role of pharmacists in counseling patients regarding medications and driving risk. A pilot test with 640 pharmacists showed the curriculum was effective in increasing pharmacists' knowledge of medication-related impaired driving (Lococo & Tyree, 2007). However, this program was not formally evaluated.

A more recent application of the countermeasure was tested in Belgium in 2012. In this example Legrand et al. (2012) tested several methods of training pharmacists about dispensing guidelines for potentially impairing medications, the risks associated with these medications, and methods for communicating these risks to patients. Following training, more pharmacists reported being aware of the effects of medications on driving, and more pharmacists talked with their patients about driving-related risks.

Studies with patients have been less encouraging. Smyth, Sheehan, and Siskind (2013) conducted interviews with patients who were using medications that could influence their driving. Half (49%) did not recall seeing the warning label on the medication. Instead, there was a high level of confidence among patients that they could determine themselves whether it was safe to drive. Monteiro et al. (2013) investigated the effectiveness of pictograms in communicating the degree of driving risk associated with certain medications. Many patients could not understand the pictograms, and often misjudged how risky it would be to drive while taking the medication. Smith et al. (2018) also arrived at similar findings from expert interviews, including the insight that many Americans do not associate the warning to "not operate heavy machinery" to driving their vehicle. The experts in their study suggested adding visual indicators such as changes to the color of the driving-specific warning label, color of the prescription bottle, and increasing the minimum font size to accommodate older drivers. Similarly, a survey a Japanese drivers taking prescription medications found that only 5% of respondents were aware of a pictogram created by the Council of Appropriate Drug Use in Japan to alert drivers of medications with potentially impairing effects. After viewing the pictogram, the results were mixed regarding the efficacy of the pictogram to convey the intended message (Fukuda et al., 2020).

Therefore, there is insufficient evidence to conclude that this countermeasure is currently effective at reducing drug-impaired driving and improving safety.

Costs:

Costs will depend on the program elements and could include printed material, staff time, and administrative costs. Costs will also depend on the target audience: healthcare providers and pharmacists versus drivers, with the former group likely being more costly than the latter (especially if personalized training is involved).

Time to implement:

Educational and communication programs could require a year or more to plan, produce, and implement. Programs that include individualized feedback and training will be more time intensive to implement.

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3. Seat Belts and Child Restraints

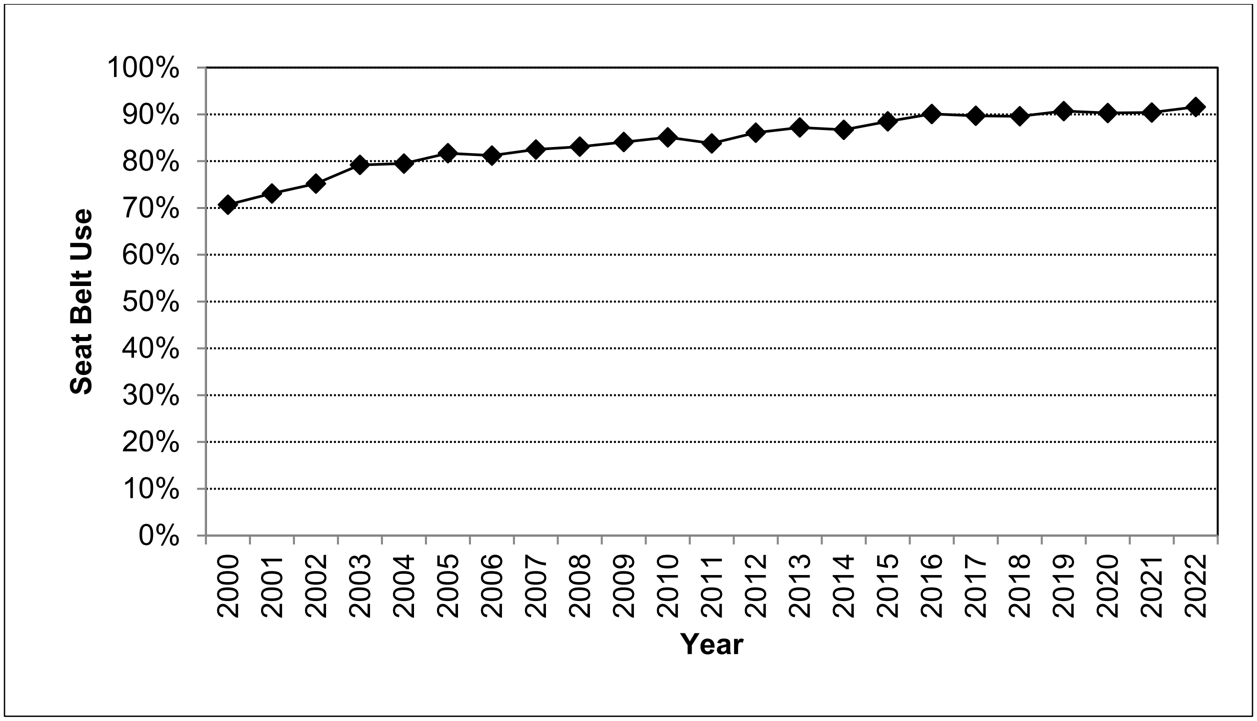
Overview

Abundant research has shown that correctly using an appropriate child restraint or seat belt is the single most effective way to save lives and reduce injuries in crashes. Lap and shoulder combination seat belts, when used, reduce the risk of fatal injury to front-seat passenger car occupants by 45% and the risk of moderate-to-critical injury by 50% (Kahane, 2015). For light-truck occupants, seat belts reduce the risk of fatal injury by 60% and moderate-to-critical injury by 65%.

NHTSA estimates that correctly used child restraints reduce fatalities by 71% for infants younger than 1 year old and by 54% for children 1 to 4 years old in passenger cars. In light trucks the fatality reductions are 58% for infants and 59% for children 1 to 4 years old (Kahane, 2015; National Center for Statistics and Analysis [NCSA], 1996;). In addition, research conducted by the Partners for Child Passenger Safety Program at the Children's Hospital of Philadelphia found that belt-positioning booster seats reduce the risk of injury to children 4 to 8 years in crashes by 45% when compared to the effectiveness of seat belts alone (Arbogast et al., 2009). However, unrestrained children continue to be overrepresented in motor vehicle fatalities, which indicates that additional lives can be saved by increasing restraint use among children (Sauber-Schatz et al., 2014).

All new passenger cars had some form of seat belts beginning with lap belts in 1964, shoulder belts in 1968, and integrated lap and shoulder belts in 1974 (Automobile Coalition for Traffic Safety [ACTS], 2001). New York enacted the first statewide seat belt use law in 1984 with other States soon following. As of August 2020 all States except New Hampshire required adult passenger vehicle drivers and front-seat occupants to wear seat belts and 30 States and the District of Columbia also required seat belts for all rear-seat passengers (GHSA, 2020). From 1978 to 1985 every State and the District of Columbia passed laws requiring child restraints for young child passengers (Kahane, 1986), and most of these laws have since been amended and strengthened to include more children and to close loopholes and exemptions. Still, great variation exists on the requirements and ages covered by State child restraint laws.

Despite the demonstrated effectiveness of seat belts and child restraints and laws requiring their use, challenges remain. Current data show that observed daytime seat belt use nationwide was 91.6% in 2022 for adult drivers and right-front seat passengers combined (NCSA, 2023a). In 2021 seat belt use was over 90% in 23 States, the District of Columbia, and 3 U.S. Territories, with California (97.2%), the District of Columbia (95.9%) and the Northern Mariana Islands (96.4%) achieving belt use rates higher than 95% (NCSA, 2021c). Seat belt use, however, was less than 80% in Massachusetts (77.5%), New Hampshire (75.5%), and the U.S. Virgin Islands, (72.3%) (NCSA, 2022a). Nationally, seat belt use has increased dramatically since seat belt use laws went into effect in the early 1980s (Hedlund et al., 2008; NCSA, 2023a). The national seat belt use rate has been trending upwards over the past 2 decades, rising 21 percentage points since 2000 (NCSA, 2007, 2023a).

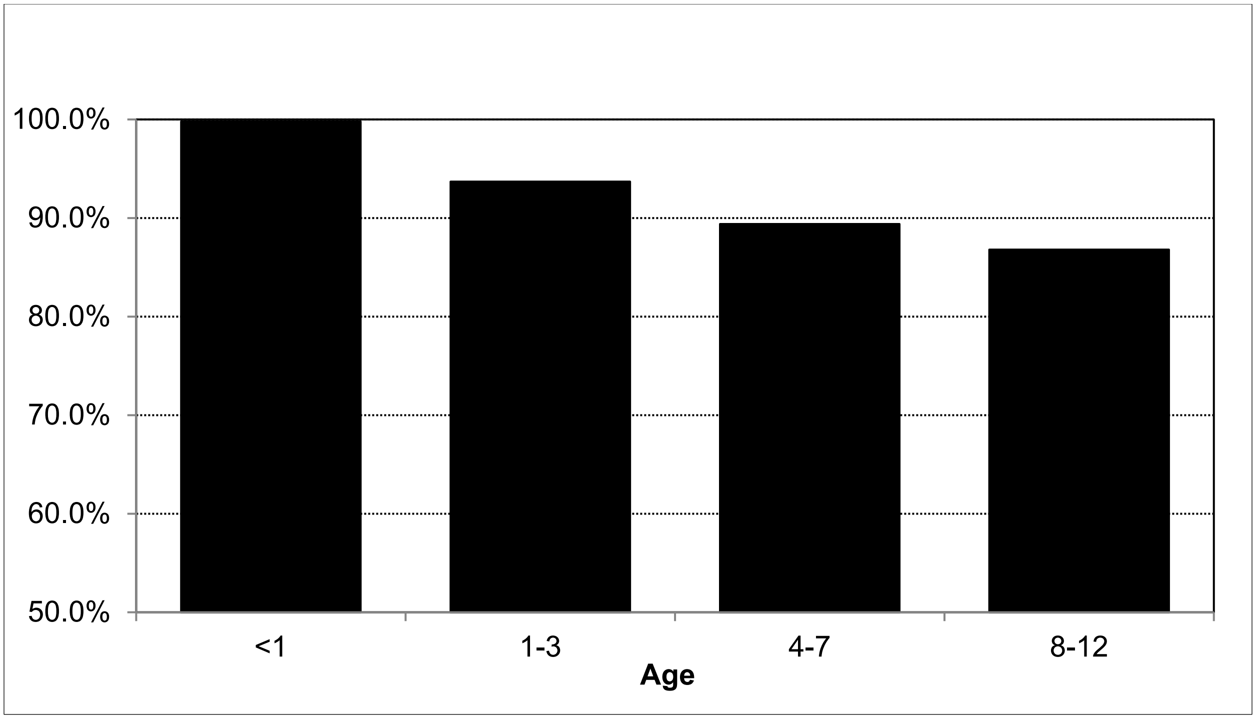


Sources: NCSA, 2007, 2023a

Figure 3-1. U.S. Driver and Front Seat Passenger Seat Belt Use Rates: 2000 to 2022

However, the national seat belt use rate is for daytime seat belt use. Research has found seat belt use to be lower at night. In 2021 some 57% of passenger vehicle occupants killed in crashes at nighttime were unrestrained. In contrast, 43% of fatally injured passenger vehicle occupants in daytime crashes were unrestrained (NCSA, 2023c).

Historically, overall restraint use for children was higher than what was demonstrated in the adult population. More recently, the rates have become similar. In 2021 restraint use for children younger than 13 was 89.8% (Boyle 2023). Restraint use ranged from 99.8% for infants under 1 year old, to 86.8% for children 8 to 12. In general, child restraint usage rates decline as children age.



Source: Boyle, 2023 (*Restraint use rates do not indicate correct use.)

Figure 3-2. Restraint Use Rates for Children by Age, 2021*

However, restraint use for children is more complicated than simply "restrained versus unrestrained." In addition to overall restraint use, it is also important to consider correct restraint use. NHTSA and the American Academy of Pediatrics have recommendations for restraining children based on their age and size (AAP, 2021; Durbin et al., 2018; NHTSA, 2019).

Looking more specifically at appropriate restraint use, the 2021 National Survey of the Use of Booster Seats (NSUBS) shows indications of premature transition to restraint types that are not appropriate for children's ages, heights, and weights (Boyle, 2023). In 2021 some 91.8% of children under age 1 were observed in the appropriate rear-facing seats, essentially unchanged from 91.7% in 2019. Rear-facing and eventually forward-facing car seats are appropriate for children 1 to 3. The 2021 NSUBS found that 86.8% of children 1 to 3 used the appropriate restraint, compared to 83.7% in 2019, and 73.2% of children 4 to 7 were restrained using the appropriate forward-facing car seat or booster seat, which is up slightly from 69.0% in 2019. Of children 8 to 12, 85.8% were appropriately restrained, up slightly from 85.0% in 2019. Children 8 to 12 should use booster seats until the seat belt fits properly.

Despite high observed belt use rates, many unrestrained people die in crashes each year. In 2021 half (50%) of the 26,325 fatally injured passenger vehicle occupants with known restraint use were unrestrained (NCSA, 2023b). Of the 863 children under 15 who died in passenger vehicles in 2021 some 40% were unrestrained (NCSA, 2023b).

Understanding the Problem

Significant effort has resulted in the high observed seat belt use rates seen today. In 1983, before the first seat belt law went into effect, seat belt use was only 14% (IIHS, 2022). Through a combination of seat belt laws, enforcement, and media publicity, the social norms around seat belt use have changed. Today, States commonly record seat belt use rates of 90% or higher. However, many States have not achieved such high belt use rates, and substantial disparities in belt use rates exist even within States with high overall belt use rates.

A recent study examined differences between States with high and low seat belt use on how they approach occupant protection to identify effective strategies employed by high-belt-use States that could be adopted by low-belt-use States (Thomas et al., 2017). There were clear demographic differences between the populations of high- and low-belt-use States (for example, low-belt-use States had higher proportions of drivers residing in rural areas). Political and legislative support for occupant protection and general highway safety were not as strong in low-belt-use States. Further, several of these low-belt-use States lacked sufficient resources for safety, did not have dedicated occupant protection coordinators, spent relatively little on media campaigns, and lacked internal research staff. Examining these differences led researchers to identify four programmatic activities characteristic of high-belt-use States that low-belt-use States could adopt with a reasonable expectation that they would increase seat belt use. These included: (1) build political, law enforcement, and community support to promote seat belt use; (2) increase enforcement of seat belt laws throughout the year; (3) develop in-house research and data analysis capabilities within the SHSO; and (4) determine what motivates a State's population to use seat belts.

Research has shown that caregivers sometimes have difficulty using car seats correctly. Benedick et al. (2020) examined the factors that influence choosing and using a child restraint correctly. They found that while participants were generally able to select an appropriate car seat for a hypothetical child, over two-thirds (68%) of installation attempts and nearly three quarters (71%) of attempts at restraining a doll (either by harness or seat belt) had errors. Interestingly, there was not a significant difference in the percentage of errors among novice and experienced car seat users. Despite the high percentage of actual errors, participants generally expressed confidence in their attempts, indicating an overconfidence in their abilities.

Hall et al. (2018) conducted focus groups with Australian caregivers to better understand barriers and motivators to correct child restraint use. While caregivers were aware that correct use was important, they were not confident in their abilities to correctly use restraints. Commonly cited barriers to correct use included difficulty understanding child restraint use information and a lack of understanding of how to use the restraint correctly.

These findings are not surprising given the high rates of child restraint misuse seen in the United States. The National Child Restraint Use Special Study (NCRUSS), a nationally representative sample from 2011, found 46% of car seats and booster seats each had at least one major error to installation or use that could reduce the effectiveness of the seat in a crash (Greenwell, 2015). A convenience sample of caregivers who brought their car seats to inspection stations in Los Angeles found nearly all seats had some misuse, though the definition of misuse was broader than used in NCRUSS (Bachman et al., 2016). Other studies show caregivers have difficulty with certain aspects of installation. For example, a study testing different labeling instructions to help caregivers correctly use a tether in pickup trucks found that while the tethers were used in 93% of installations, they were only correctly used in 9% (Klinich et al., 2018).

In order to combat this misuse, programs have been implemented to provide parents and other caregivers with “hands-on” assistance with the installation and use of child restraints. The NHTSA Standardized Child Passenger Safety Training Course, complemented by the national certification process (funded by NHTSA and administered by Safe Kids Worldwide) developed and implemented a system to train safety professionals and other interested parties in the fundamentals of correctly choosing and installing the proper car seat for child passengers and correct placement of the child in the car seat. People who successfully completed the course are certified to educate the public in using child restraints properly and provide caregivers with this “hands-on” assistance (Womack et al., 2005). At the end of 2019 there were over 43,000 certified CPS technicians and instructors (Safe Kids Worldwide, 2019).

Additionally, it is important to acknowledge how restraint use of one occupant relates to another. Several studies have identified a link between adult and child occupant restraint status (Benedetti et al., 2017; Lee et al., 2019; Raymond et al., 2018; Starnes, 2003; Vachal, 2019). A study of child passengers in North Dakota found that when drivers were wearing their seat belts, children were 35 times more likely to be restrained than when the driver was not wearing a seat belt (Vachal, 2019). In other words, children are more likely to be restrained when the adults in the vehicle are also restrained. Additionally, a nighttime observational study in Tennessee found a link between front-seat passenger belt use and driver belt use, where 82% of front-seat passengers were restrained when drivers were also restrained, compared to just 42% when drivers were not restrained (Boakye et al., 2019).

Data/Surveillance

While all States conduct annual observational surveys of seat belt use, these surveys generally occur during the day and only include drivers and front-seat passengers, leading to incomplete, and likely overestimates of, overall seat belt use in States (NCSA, 2022).

When police officers respond to crashes, they record seat belt use of the occupants involved in the crashes. In the case of severe or fatal crashes, belt use may be obvious based on the position or injuries of the occupants. However, in less severe crashes, these clues may not be visible, and seat belt use may be reported to the officers from the vehicle occupants themselves. Because failure to wear a seat belt is a violation in most States, unbelted vehicle occupants may report wearing their seat belts to avoid penalty. This could result in an over-reporting of seat belt use in less severe crashes.

An additional complication to complete occupant restraint data is the lack of detailed child restraint information. Many States include “child restraint” as one of the possible occupant restraint options on the crash report form. This ends up grouping all child restraint types into one category and limits the ability to determine if the restraint was appropriate for the child, if the restraint was installed correctly, or if the child was properly restrained.

Emerging Issues

As ride share services become more widely used, additional focus is needed to address the use of seat belts and child restraints in these vehicles. A survey of parents with children under 5 found that nearly 60% reported having transported children differently in ride share vehicles than they would in their personal vehicles, including holding children on laps and allowing children to ride without car seats (Owens et al., 2019). Additionally, many ride-share drivers were unaware of their responsibility when transporting children in their vehicles (Owens et al., 2019). A study of crash-involved children from birth to 19 years old in rear seats of vehicles in New York City found restraint use overall to be much lower in taxis than in other passenger vehicles (51% versus 87%). Children under age 8 were significantly less likely to be in a child restraint (5.9% versus 50%). Children riding in taxis were more likely to have injury and twice as likely to be diagnosed with traumatic brain injury (Prince et al., 2019).

Other studies have found that seat belt use among adults is lower in rear seats (Beck et al., 2019; Taylor & Daily, 2019). To better understand seat belt use behavior in the rear seat, Jermakian and Weast (2018) conducted a survey of adults who did not consistently wear seat belts as rear-seat passengers. They found four general categories to explain not using restraint: ambivalence, misperception of safety benefits, design and usability, and the law. Interestingly, of those who typically rode as rear-seat passengers in vehicles for hire (such as ride share vehicles or taxis) only 57% reported consistently wearing their seat belt compared to 74% among passengers of personal vehicles. This was confirmed by a small observational study conducted by Nemire (2017). Rear seat belt use was lower in taxis compared to personal vehicles. Rideshare vehicles were also observed but the results were inconclusive.

It is not yet clear how seat belt use may be affected by emerging vehicle technologies and the movement towards vehicles with increasing automation. The changing role of the driver to a supervising passenger, driver seats that provide more space during automated trips on the highway, new seat configurations for vehicles that no longer require manual controls, and perceptions of risk could all affect seat belt use. Meanwhile, new driver monitoring systems (DMS) that use in-vehicle cameras provide new methods to measure, evaluate, and enforce driver engagement and compliance. While still early, it is important to consider how technology might change seat belt use in the future so that occupant protection stakeholders can anticipate potential challenges.

Key Resources

- For current information on **U.S. seat belt and child restraint laws:** see IIHS (2023b), *Seat Belt and Child Seat Laws by State*, www.iihs.org/topics/seat-belts/seat-belt-law-table, and GHSA (2021), *Child Passenger Safety,* www.ghsa.org/state-laws.
- Both NHTSA and the American Academy of Pediatrics have best practice recommendations for child passenger safety in vehicles.
    - NHTSA (n.d.), www.nhtsa.gov/equipment/car-seats-and-booster-seats, and NHTSA (2019), *Car seat recommendations for children*, www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/carseat-recommendations-for-children-by-age-size.pdf
    - AAP (2021): Car Seats: Information for Families. www.healthychildren.org/English/safety-prevention/on-the-go/Pages/Car-Safety-Seats-Information-for-Families.aspx

- The National Child Passenger Safety Board (2023) has many **resources for State child passenger safety programs** including resources specifically for CPS State coordinators.
  - Car Seat Safety, web page and portal. www.cpsboard.org/car-seat-safety/
- For **NHTSA's publications** on seat belts and child restraints visit
  - NHTSA's Behavioral Safety Research portal at https://rosap.ntl.bts.gov/cbrowse?pid=dot%3A242&parentId=dot%3A242.
- NHTSA produces **seat belt and child restraint marketing material** for use by States and other organizations.
  - Visit www.trafficsafetymarketing.gov/get-materials/seat-belts/click-it-or-ticket for NHTSA's traffic safety marketing material and resources for *CIOT* and to www.trafficsafetymarketing.gov/get-materials/child-safety/child-passenger-safety-week for Child Passenger Safety Week.

Seat Belt and Child Restraint Countermeasures

Legislation and Licensing

Countermeasure	Effectiveness	Cost	Use	Time
Primary Enforcement Seat Belt Use Laws	★★★★★	$	Medium	Short
Strong Child Passenger Safety Laws	★★★★★	$	High	Short
Increased Fines for Seat Belt Law Violations	★★★★	$	Low	Short

Enforcement

Countermeasure	Effectiveness	Cost	Use	Time
Short-Term, High-Visibility Seat Belt Law Enforcement	★★★★★	$$$	Medium	Medium
Short-Term, High-Visibility Child Passenger Safety Law Enforcement	★★★★★	$$$	Medium	Medium
Nighttime, High-Visibility Seat Belt Law Enforcement	★★★★	$$$	Unknown	Medium
Sustained Seat Belt Enforcement	★★★	Varies	Unknown	Varies

Other Strategies for Behavior Change

Countermeasure	Effectiveness	Cost	Use	Time
Enforcement-based Communication Strategies for Low-Belt-Use Groups	★★★★	Varies	Unknown	Varies
Employer-based Programs	★★★	Varies	Unknown	Varies
Programs for Older Children	★★★	Varies	Unknown	Varies
Programs for Increasing Child Restraint and Booster Seat Use	★★	Varies	Unknown	Varies
Child Restraint Inspection Stations	★★★	$$	High	Short

Approaches That Are Unproven or Need Further Evaluation

There are no countermeasures in this category.

Effectiveness:

★★★★★	Demonstrated to be effective by several high-quality evaluations with consistent results.
★★★★	Demonstrated to be effective in certain situations.
★★★	Likely to be effective based on balance of evidence from high-quality evaluations.
★★	Limited evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.
★	No evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.

Cost to implement:

$$$	Requires extensive new facilities, staff, equipment, or publicity, or makes heavy demands on current resources.
$$	Requires some additional staff time, equipment, facilities, and/or publicity.
$	Can be implemented with current staff, perhaps with training; limited costs for equipment or facilities.

These estimates do not include the costs of enacting legislation or establishing policies.

Use:

High	More than two-thirds of the States, or a substantial majority of communities
Medium	One-third to two-thirds of the States or communities
Low	Less than one-third of the States or communities
Unknown	Data not available

Time to implement:

Long	More than 1 year
Medium	More than 3 months but less than 1 year
Short	3 months or less

These estimates do not include the time required to enact legislation or establish policies.

Legislation and Licensing

Primary Enforcement Seat Belt Use Laws

Effectiveness: ★★★★★	**Cost:** $	**Use:** Medium	**Time:** Short

Primary enforcement seat belt use laws permit law enforcement officers to stop and cite a violator independent of any other traffic violation. Secondary enforcement laws allow law enforcement officers to cite violators only after they first have been stopped for some other traffic violation.

Use:

As of August 2020 there were 34 States and the District of Columbia that had primary belt use laws, 15 States had secondary enforcement laws, and New Hampshire had no belt use law applicable to adults (GHSA, 2020). However, some States only have primary enforcement for certain occupants (for instance drivers or people older than a specified age) and secondary enforcement for other occupants (for example, North Carolina's seat belt law is primary for drivers and front-seat passengers 16 and older, but secondary for rear-seat passengers 16 and older). Twenty States do not have laws requiring the use of seat belts in the rear seat (GHSA, 2020). Most State seat belt use laws cover passengers over a specified age and are designed to work in combination with CPS laws covering younger passengers.

Additionally, in some States with secondary enforcement belt use laws, individual communities have enacted and enforced community-wide primary laws or ordinances. These laws differ from statewide laws only in that they are enacted, publicized, and enforced locally. No comprehensive data are available on how many communities have primary laws, but local implementations have occurred in States such as Missouri (Missouri Department of Transportation, 2017).

Effectiveness:

Early research found that primary enforcement laws were associated with increased seat belt use ranging from 6% to nearly 20% (Hedlund et al., 2008; Nichols, Tippetts, et al., 2010; Nichols et al., 2014; Shults et al., 2004) and a 2% to 10% reduction in occupant fatalities (Farmer & Williams, 2005; Hedlund et al., 2008; Shults et al., 2004). Seat belt increases were found across a diverse range of drivers and passengers (Nichols et al., 2012; Shults et al., 2004), both at night and during the day (Chaudhary et al., 2010; Masten, 2007).

However, more recent studies suggest the safety benefits of upgrading to a primary law from a secondary law may not be as great as when seat belt use was lower overall (Harper & Strumpf, 2017; Harper, 2019). In 2004 seat belt use in primary-law States was over 10 percentage points higher than use in secondary-law States (84% versus 73%) (Glassbrenner, 2004). Today the difference is much less significant. In 2022 seat belt use in primary-law States was nearly 3 percentage points higher than use in secondary-law States (92.2% versus 89.5%) (NCSA, 2023a). High overall seat belt rates and improvements in road and vehicle safety (front and side air bags, electronic stability control, advanced driver assistance systems) have contributed to a decrease in crash fatalities (Farmer & Lund, 2015). While recent studies do still suggest that changing a seat belt law from secondary to primary enforcement has benefits, States may not experience the large impacts seen in earlier studies.

Additionally, research suggests that primary seat belt laws may be less effective in regions with certain economic, societal, and cultural characteristics. Specifically, there is initial evidence that primary seat belt laws were only associated with higher belt use rates in States that had higher levels of academic achievement and higher health rankings (Ash et al., 2014). Moreover, primary-law States that had a high proportion of rural roads relative to urban roads were associated with no significant increase in seat belt usage in comparison to States with secondary seat belt laws.

A further consideration is whether the primary seat belt law covers all seating positions. The NOPUS has typically found higher observed rear-seat belt use in States with belt laws covering all seating positions than in States not requiring rear-seat belt use, though for the first time since 2005 the opposite was true in 2021 (77.7% and 78.8%, respectively) (Boyle, 2022). An analysis of Iowa, which has primary laws for front-seat passengers but no law for rear-seat passengers, found that occupants reported using seat belts 30%-40% less often if they were a passenger in the rear than in the front (McGehee et al., 2014). This is consistent with findings obtained using national household survey data from the ConsumerStyles 2012 database (Bhat et al., 2015).

Specifically looking at the impact of primary enforcement on rear-seat fatalities, Findley et al. (2018) examined rear-seat fatalities to determine the impact of changing from secondary to primary enforcement. From 2011 to 2015 a total of 3,061 unrestrained rear-seat passengers were killed in secondary-law States. Findley et al., determined that between 772 to 1,990 of the fatalities in secondary-law States could have been prevented by the increased restraint use associated with primary-law States.

A good seat belt use law should be comprehensive, covering all seating positions equipped with a seat belt in all passenger vehicles (ACTS, 2001; NCUTLO, 2000; NHTSA, 2003). Such a law sends a clear and consistent message to the public. However, it is also important to consider how the law is enforced once implemented. Primary seat belt use laws have raised equity concerns. See the introduction for more information and discussion related to equity and enforcement practices.

Cost:

Once legislation has been enacted to upgrade a secondary law to primary, the costs are for publicity and enforcement. Publicity costs may be low if the media covers the law change extensively. Law enforcement can adapt its secondary law enforcement strategies for use under the primary law or may be able to use new strategies permitted by the primary law. States wishing to increase enforcement and publicity to magnify the effect of the law change will incur additional costs.

Time to implement:

A primary seat belt use law can be implemented as soon as the law is enacted unless it has a delayed effective date or includes a warning period before enforcement is authorized.

Strong Child Passenger Safety Laws

Effectiveness: ★★★★★	**Cost:** $	**Use:** High	**Time:** Short

From 1978 to 1985 every State and the District of Columbia passed laws requiring child restraints for young child passengers (Kahane, 1986), and most of these laws have since been amended and strengthened to include more children and to close loopholes and exemptions. Still, great variation exists in the requirements and ages covered by State child restraint laws.

There is no consensus on what the ideal CPS law should include. However, research shows the scope and wording of laws can influence restraint use (Benedetti et al., 2017). For example, one study found that children were more likely to ride in the recommended type of restraint if their State's CPS law followed best practices for child occupant protection (i.e., AAP, 2021; Durbin et al., 2018).

In general, strong occupant restraint use laws should be comprehensive and cover all seating positions equipped with a seat belt in all passenger vehicles (ACTS, 2001; NCUTLO, 2000; NHTSA, 2003). NHTSA and other partners have encouraged States to expand their child restraint laws to include "booster" provisions that cover children until they are big enough for the lap and shoulder belts to fit properly.

Use:

As of May 2023 there were 39 States and the District of Columbia that had enacted child restraint laws covering children through at least age 7. One State (South Dakota) only requires a child restraint or booster seat through age 4, and 6 States have laws that go through age 5 (IIHS, 2023a). However, while there are some similarities in terms of who is covered by CPS laws, a wide variation in age, height, and weight requirements exists (GHSA, 2021; IIHS, 2023b). In 3 States, some children under 16 are covered by neither the child restraint nor the seat belt law (IIHS, 2023a).

Effectiveness:

Several research studies (Fell et al., 2005; Margolis et al., 1996) have found restraint use levels among children and teens covered by restraint use laws are higher than those not covered, and that injury levels among children covered by CPS laws are lower than children not covered. Additionally, research in both the United States and Canada has shown that laws requiring child restraints or booster seats for older children are associated with a decrease in fatalities (Brubacher et al., 2016; Mannix et al., 2012).

Several studies have evaluated the effect of extending a State's child restraint law to cover older children (often referred to as a "booster provision") on booster seat use (Gunn et al., 2007). Studies conducted in Washington State (Ebel et al., 2003), Tennessee (Gunn et al., 2007), and Wisconsin (Brixey et al., 2011; Decina, et al., 2008) found increases in booster seat use and child restraint use more generally following expansion of the State's child restraint law. A broader study looking at 35 years of FARS data (1975 to 2011) found that expanding CPS laws to include more children is effective at increasing the age of children in child restraints (Jones & Ziebarth, 2017). Similarly, an observational study of child restraint legislation in Canadian provinces found that provinces with newly passed legislation saw booster/front-facing restraint use increase from 26% to 54% (Simniceanu et al., 2014). During the same period, provinces with existing legislation saw no increase (31% versus 30%). This suggests that legislation on its own may be insufficient, and that the outreach, education, and enforcement activities associated with new legislation play a vital role in increasing restraint use.

Efforts to extend child restraint laws to include older children gained momentum in the 2000s, with South Carolina and Tennessee becoming the first States to explicitly include a booster seat provision in their State laws in 2001 (Bae et al., 2014). The National Survey of the Use of Booster Seats has been conducted by NHTSA since 2006 with biennial updates beginning in 2009. In 2006 some 58% of children 4 to 7 were appropriately restrained in child restraints or booster seats (Glassbrenner & Ye, 2007). In 2021 some 73.2% of children in this age group were appropriately restrained. Interestingly, while appropriate restraint increased during this time period, the percentage of children 4 to 7 in a booster seat decreased (31% in 2019 compared to 41% in 2006), suggesting the majority of the increase in appropriate restraint can be attributed to children 4 to 7 remaining in forward-facing car seats longer (Boyle, 2023). A change in booster seat use is also evident when looking at the restraint use of older children. In 2006 some 8% of children 8 to 12 were using booster seats (Glassbrenner & Ye, 2007). In 2021 some 12.5% of kids in this age group were using a booster seat (Boyle, 2023, 2021).

Most CPS laws are primary; however, most seat belt laws start coverage before a child reaches 18, so older children and teens might be covered by a secondary enforcement seat belt law in some States. Research has found that teens living in secondary enforcement States are less likely to report wearing their seat belt than teens living in primary enforcement States (Garcia-España et al., 2012).

Cost:

The costs of expanding a restraint use law to include all seating positions in all passenger vehicles are minimal. States can expect costs related to enforcement and publicizing any law changes.

Time to implement:

CPS laws can be implemented as soon as the law is enacted and publicized.

Increased Fines for Seat Belt Law Violations

Effectiveness: ★★★★	**Cost:** $	**Use:** Low	**Time:** Short

As of June 2023 a violation of the seat belt law resulted in a fine of $25 to $200 in the majority of States (IIHS, 2023b). Low fines may not convince nonusers to buckle up and may also send a message that seat belt use laws are not taken seriously. Some States use higher fines for first time offenders, the highest being a fine of $200 in Texas (IIHS, 2023b).

Penalties are part of the complete system of well-publicized enforcement of strong seat belt use laws. A nationally representative survey of U.S. adults found that 62.5% of respondents were in favor of raising the fine for not wearing a seat belt to $100. Not surprisingly, among those who reported not regularly wearing a seat belt, support for this and other seat belt policies was lower (Fell, 2019). States should choose penalty levels that strike an appropriate balance; however, without effective enforcement, judicial support, and good publicity, increased penalties may have little effect.

Use:

As of June 2023 there were 17 States and the District of Columbia that had penalties of $30 or more for at least some occupants (IIHS, 2023b).

Effectiveness:

Houston and Richardson (2006) studied the effects of seat belt law type (primary or secondary), fine level, and coverage (front seat only or front and rear seats) using belt use data from 1991 to 2001. They found that primary belt laws and higher fines increase seat belt use.

Nichols, Tippetts, et al. (2010, 2014) examined the relationship between seat belt violation fines and seat belt use and found that increasing fines was associated with increased seat belt use. Increasing a State’s fine from $25 to $60 was associated with increases of 3% to 4% in both observed seat belt use and belt use among front-seat occupants killed in crashes, an effect that was additive with increases attributed to the type of seat belt law. Increasing the fine from $25 to $100 was associated with increases of 6% to 7% for these measures; however, there were diminishing returns for fines above this amount (Nichols, Tippetts, et al., 2014). These studies were conducted when observed seat belt use was lower overall. Increasing fines today may not result in the same gains as seen in these earlier studies. In addition, equity and violators’ financial well-being need to be considered since increasing penalties may be more punitive to some drivers and result in other consequences due to inability to pay.

Cost:

The direct costs associated with increasing fines are minimal.

Time to implement:

Increased fines can be implemented as soon as they are publicized and appropriate changes are made to the motor vehicle records systems.

Enforcement

Short-Term, High-Visibility Seat Belt Law Enforcement

Effectiveness: ★★★★★	**Cost:** $$$	**Use:** Medium	**Time:** Medium

The most common high-visibility seat belt law enforcement method consists of short (typically lasting for 2 weeks), intense, highly publicized periods of increased belt law enforcement, frequently using checkpoints (in States where checkpoints are permitted), saturation patrols, or enforcement zones. This short-duration seat belt enforcement method was developed in Canada in the 1980s (Boase et al., 2004) and demonstrated in several communities in the United States (Williams & Wells, 2004). It was implemented statewide in North Carolina in 1993 using the *CIOT* slogan (Reinfurt, 2004), and subsequently adopted in other States under different names and sponsors (Solomon, Compton, & Preusser, 2004). NHTSA's *CIOT* HVE model is described in NHTSA (2021) and in more detail in Solomon, Compton, and Preusser (2004) and Solomon, Gilbert, et al. (2007).

Effective communications and outreach are an essential part of successful seat belt law HVE programs (Solomon, Compton, & Preusser, 2004). All HVE programs include communications and outreach strategies that use some combination of earned media (e.g., news stories and social media) and paid advertising. Paid advertising can be a critical part of the media strategy and brings with it the ability to control message content, timing, placement, and repetition (Milano et al., 2004).

The May 2002 *CIOT* campaign evaluation demonstrated the effect of different media strategies used in conjunction with enforcement (Solomon et al., 2002). Seat belt use increased by 8.6 percentage points across 10 States that used paid advertising extensively in their campaigns, by 2.7 percentage points across 4 States that used limited paid advertising, and only 0.5 percentage points across 4 States that used no paid advertising. While important for demonstrating effective media strategies at the time, it is important to note this study was done when seat belt use rates were significantly lower. A similar effort today is not likely to result in the same gains. Additionally, the media strategies used in 2002 may not be the same strategies implemented today.

NHTSA and some States now use social networking sites to reach the general public with messages concerning seat belt use. Although sites such as Facebook, Twitter, and YouTube can effectively and affordably reach large numbers of people, there are no evaluations of seat belt use campaigns that use this approach. The CDC offers resources to help with social media, including a toolkit and guide for social media writing (www.cdc.gov/socialmedia/tools/guidelines). In addition, there is information available on NHTSA's traffic safety marketing website (www.trafficsafetymarketing.gov/social-media).

Use:

All States currently conduct short-term, high-visibility belt law enforcement programs in May of each year as part of national seat belt mobilizations (Nichols, Chaffee, Solomon, & Tison, 2016). Some States also conduct seat belt mobilizations in November. NHTSA has supported these campaigns financially with States contributing significant funding as well. See Milano et al. (2004) for a detailed account of the history and evolution of the national campaigns and NHTSA (2016) for a timeline of use over time.

Effectiveness:

It is well established that short-term, HVE programs are effective at increasing seat belt use. CDC's systematic review of 15 high-quality studies (Dinh-Zarr et al., 2001; Shults et al., 2004) found that short-term, HVE programs increased belt use by about 16 percentage points, with greater gains when pre-program belt use was lower. Following the enforcement program, belt use often dropped by about 6 percentage points demonstrating the ratchet effect typical of these programs. (Belt use increases during the program but decreases somewhat afterwards, though belt use remains at a level higher than prior to the program.)

Tison and Williams (2010) summarized the effects of the 2000 to 2006 *CIOT* campaigns and concluded they were an important component of the increase in seat belt use during that period. Nationwide observed seat belt use increased from 79% to 87% over 11 years of CIOT activity from 2003 to 2013, though it is difficult to isolate the effect of CIOT on observed seat belt use from the effect of other interventions done at the same time (Nichols, Chaffe, & Solomon, & Tison, 2016). Research has also found HVE campaigns to be effective in both primary and secondary-law States (Solomon, Chaudhary, & Cosgrove, 2004; Solomon, Gilbert, et al., 2007).

Many of the studies evaluating the effectiveness of *CIOT* were conducted years ago when seat belt use was much lower overall. In recent years seat belt rates have plateaued both nationally and in many States (NCSA, 2022). Because of this, it is unlikely that campaigns conducted today will continue to produce the gains seen in earlier studies. However, continued campaigns are likely important for maintaining high seat belt use rates. Nichols, Chaffe, Solomon, and Tison (2016) found the effect of repeating the CIOT campaign annually acted as a "booster shot" for seat belt use awareness and behavior change. This is demonstrated by several indicators: CIOT tagline recognition increased from 73% to 83%; seat belt citations per 100,000 people dropped from 19 to 12 among reporting jurisdictions; and national observed daytime belt use increased from 83% to 87%. A study of overtime seat belt enforcement in Michigan from 2013 to 2017 found that overtime traffic enforcement was associated with a 6.4% increase in observed driver seat belt use compared to communities who did not participate in overtime traffic enforcement (Acosta-Rodriguez et al., 2020).

Hedlund et al. (2008) compared 16 States with high seat belt rates and 15 States with low seat belt rates. The single most important difference between the two groups was the amount of enforcement rather than demographic characteristics or the amount spent on media. High-belt-use States issued twice as many citations per capita during their *CIOT* campaigns as low-belt-use States. Level of enforcement is also related to type of seat belt law. Nichols, Chaffe, Solomon, and Tison (2016) found that law enforcement in primary belt use law States issued more seat belt citations in the 2013 campaign than did law enforcement in secondary belt use law States. NHTSA examined the effect of enforcement in the 2012 *CIOT* campaign and found that citations per 10,000 residents were twice as high in States with primary laws (16 citations versus 8 citations) as those with secondary laws (Hinch et al., 2014). The authors suggested that increasing citations in secondary-law States (when drivers are stopped for other violations) could be an opportunity to increase belt use.

Smaller-scale campaigns limited to a single travel corridor can yield a short-term improvement in observed seat belt usage along the corridor, but the effects appear to be limited to the enforcement area. Specifically, an HVE campaign conducted along a route frequented by commuters used inexpensive roadway signs and magnetic message strips on enforcement vehicles within the corridor, but only a press release was available to residents in a nearby city, which was typically the destination for commuters (Elliot et al., 2014). Although observed belt use improved significantly within the corridor, observed belt use and overall awareness of the seat belt campaign was unchanged in the nearby city. A likely explanation for this difference is lack of exposure to the location-specific campaign since most respondents from the city reported traveling the route less than once a month.

St. Louis County, Missouri, implemented a primary seat belt use ordinance in March 2007. Following implementation, the St. Louis County Police Department conducted an intense HVE campaign accompanied by publicity in the form of variable message boards and permanent road signs, along an 8-mile corridor on State Highway 21. Observational surveys were conducted along the Highway 21 corridor and a control site prior to the start of the enforcement and immediately after its conclusion. The observational surveys measured increases in belt use from 83% to 88% along the Highway 21 corridor and a small, 59% to 57% decrease in belt use along the control corridor (Nichols, Solomon, et al., 2010).

Cost:

High-visibility enforcement campaigns are expensive. They require extensive time from SHSOs and communications staff and often from consultants to develop, produce, and distribute publicity. Additionally, they require significant time from law enforcement officers to conduct the enforcement. Paid advertising increases a campaign's effectiveness. In the average State, paid advertising costs were nearly $350,000 for the 2007 campaign (Solomon, Preusser, et al., 2009). More recently, the 2013 *CIOT* campaign used extensive paid advertising totaling $8 million nationally and $11 million in individual States (Nichols, Chaffe, & Solomon, & Tison, 2016).

Time to implement:

An HVE program (including media placement) requires 4 to 6 months to plan and implement.

Short-Term, High-Visibility Child Passenger Safety Law Enforcement

Effectiveness: ★★★★★	**Cost:** $$$	**Use:** Medium	**Time:** Medium

As noted in the previous section, high-visibility short-duration seat belt law enforcement programs, such as *CIOT* have proven to be effective at increasing seat belt use. NHTSA typically includes child restraint and booster seat use and enforcement as a part of their *CIOT* campaigns (although adult seat belt use is the focus of *CIOT*). There is concern that law enforcement officers are reluctant to enforce child restraint laws due to competing priorities within their departments and a lack of knowledge on the part of officers on the subject of child restraints (Decina et al., 2008; Decina et al., 1994; NHTSA, 1990). More recent research demonstrates that effective approaches for enforcing child restraint laws – in particular, booster seat laws – are possible, but they depend on top management support and enforcement methods that are dedicated to booster seat and other child restraint laws (Decina et al., 2010).

As with HVE aimed at adult occupants, enforcement of child restraint/booster laws should be coupled with high-visibility communications and outreach (Solomon, Compton, & Preusser, 2004). Paid advertising can be a critical part of the media strategy. Paid advertising brings with it the ability to control message content, timing, placement, and repetition (Milano et al., 2004).

Use:

Many States currently conduct short-term, high-visibility child restraint/booster seat law enforcement programs in May of each year as part of national seat belt mobilizations and in September as part of Child Passenger Safety Week.

Effectiveness:

In their systematic review of evidence of effectiveness for child restraint interventions, Zaza et al. (2001) determined that community-wide information plus enhanced enforcement campaigns were effective in increasing child restraint use. Decina et al. (2010) found that the most effective approaches for enforcing booster seat laws depend on top management support to enforce these laws, having resources to support dedicated booster seat law enforcement programs, and enforcement methods that are dedicated to booster seat and other child restraint laws.

Barriers to enhanced enforcement programs, especially as related to booster seats, include: low awareness of child restraint laws among parents/caregivers; low perception of risk to child passengers; lack of knowledge about the safety benefits of booster seats among the public; lack of knowledge about the safety benefits of booster seats among law enforcement officers and members of the courts; low threat of being ticketed for violations; and lack of commitment to CPS by law enforcement top management (Decina, et al., 2008).

Cost:

High-visibility enforcement campaigns are expensive. They require extensive time from SHSOs, time from law enforcement officers to conduct the enforcement, and time from communications staff and often from consultants to develop, produce, and distribute publicity. Paid advertising increases a campaign's effectiveness but can be expensive.

Time to implement:

An HVE program requires 4 to 6 months to plan and implement.

Nighttime, High-Visibility Seat Belt Law Enforcement

Effectiveness: ★★★★	**Cost:** $$$	**Use:** Unknown	**Time:** Medium

In 2021 some 57% of passenger vehicle occupants killed in crashes at nighttime were unrestrained. In contrast, 43% of fatally injured passenger vehicle occupants in daytime crashes were unrestrained (NCSA, 2023c). Several States have experienced smaller gains in seat belt use associated with enforcement campaigns after conducting them for several years (Nichols & Ledingham, 2008). These programs also have been conducted almost exclusively during the daylight hours, and the available data suggest that belt use is lower at night (Chaudhary et al., 2005; Hedlund et al., 2004; Nichols & Ledingham, 2008).

Resources focused on nighttime seat belt enforcement may provide additional gains in seat belt use and injury reduction. In particular, belt law checkpoints, saturation patrols, or enforcement zone operations could be conducted at night, when belt use is lower, DWI is higher, and crash risk is greater than during the day. Enforcement activities should be conducted in locations with adequate lighting or by using light enhancing technologies. The first demonstration of this strategy took place in 2004 in Reading, Pennsylvania (Chaudhary et al., 2005).

Use:

There is little information available on how frequently nighttime, high-visibility seat belt law enforcement strategies are used. One demonstration of a nighttime program in Pennsylvania was conducted in 2004 (Chaudhary et al., 2005), another demonstration program involving three North Carolina communities was conducted in 2007 (Solomon, Chaffe, & Preusser, 2009), Washington State conducted a 2-year statewide high-visibility nighttime seat belt enforcement program from May 2007 through May 2009 (Thomas et al., 2010), and Oklahoma, Tennessee, and Maryland conducted enforcement waves from 2011 to 2013 (Nichols, Chaffe, & Solomon, 2016; Retting et al., 2018).

Effectiveness:

Research has shown that short-term HVE programs are effective at increasing nighttime seat belt use (Boakye et al., 2018; Chaudhary et al., 2005; Retting et al., 2018; Solomon, Chaffe, & Preusser, 2009; Thomas et al., 2017).

A detailed evaluation of a nighttime seat belt enforcement program in Washington State found that it was effective across outcome measures (Thomas et al., 2017). The program used a combination of HVE and both paid and earned media. Public surveys indicated that 70% of motorists reported hearing or seeing campaign messages and noticed increased enforcement. Over the course of the program, observed daytime and nighttime seat belt use levels trended upwards from initially high levels, with a larger increase occurring for nighttime use (from around 95% to 97% at night). Additional time-series analyses of crash data found that the program was associated with 3.4 fewer nighttime fatalities per month, even after accounting for the effects associated with the State adopting primary seat belt enforcement prior to the program. An evaluation of the first year of this Washington program also looked at the characteristics of observed drivers (through self-report, driving, and criminal records) finding notable differences between unrestrained and restrained drivers by time of day (Thomas et al., 2010). For example, unrestrained nighttime drivers were 2.7 times more likely than restrained daytime drivers to have had a felony arrest and 3.0 times more likely to have had an alcohol citation. As part of the outcome evaluation, debriefings with local law enforcement agencies indicated that enforcement personnel felt that the publicity campaign enhanced their efforts and that they would recommend the program to other agencies.

A 3-year high-visibility nighttime seat belt enforcement program conducted in Maryland successfully raised nighttime seat belt use (Retting et al., 2018). This program included five waves of HVE coupled with extensive paid and earned media. The primary message of the ad campaign was: “Cops are cracking down on seat belt violations, especially at night.” Driver awareness of the seat belt enforcement increased significantly during the HVE period. Furthermore, despite the fact that seat belt use rates were already high in this region (90-95%), there was a small but significant increase in observed nighttime seat belt use in three of the five waves when compared to a pre-HVE period. Control sites showed no changes in nighttime belt use across the same timeframe. A similar pattern was observed with unbelted injury crashes at night. These rates dropped at HVE sites when compared to the pre-HVE period and control sites showed no change in crash rates. Like the Washington State program, nighttime unbelted drivers were more likely to have poorer driving records and more prior citations for speeding, negligent/reckless driving, license-related offences, and crashes.

Cost:

The costs of nighttime high-visibility seat belt law enforcement programs are probably somewhat greater than the costs of programs conducted during daylight hours. In addition to the costs, discussed for Short-Term, High-Visibility Seat Belt Law Enforcement, nighttime programs may entail somewhat higher costs if night-vision technology is used.

Time to implement:

Nighttime high-visibility seat belt law enforcement programs require 4 to 6 months to plan and implement.

Sustained Seat Belt Enforcement

Effectiveness: ★★★	**Cost:** Varies	**Use:** Unknown	**Time:** Varies

Unlike short-term seat belt enforcement that occurs for a limited duration, typically a couple weeks, sustained seat belt enforcement lasts for months or even years. Short-term enforcement is held at points in time (e.g., enforcement as part of the May *CIOT* campaign) while sustained seat belt enforcement is continuous enforcement of seat belt use.

Use:

The extent of vigorous sustained belt law enforcement, with or without extensive publicity, is unknown. Some jurisdictions, including California, Illinois, Kentucky, Oregon, and Washington, enforce their seat belt use laws vigorously as part of customary traffic enforcement activities.

Effectiveness:

There are few studies of the effectiveness of sustained enforcement (Hedlund et al., 2004). California and Oregon, States that are reported to use sustained enforcement, have recorded statewide belt use well above national belt use rates since 2002. Oregon's seat belt use rate has increased from 88% in 2002 to 94.9% in 2021 and California's increased from 91% in 2002 to 97.2% in 2021 compared to 75 to 90.4% nationally (NCSA, 2007: NCSA, 2022).

Nichols and Ledingham (2008) conducted a review of the impact of enforcement, as well as legislation and sanctions, on seat belt use over the past 2 decades. This study concluded that sustained enforcement (implemented as a component of regular patrols or as special patrols) is as effective as "blitz" enforcement (short-term, HVE), but, unlike blitz campaigns, is not usually associated with abrupt drops in belt use after program completion.

While not specifically looking at sustained enforcement, Hezaveh et al. (2019) found a link between the perception of receiving a seat belt ticket and likelihood of reporting seat belt use, indicating the importance of the perception of consistent enforcement.

Cost:

Sustained enforcement may require funds for publicity. As with short-term, HVE programs, publicity costs will depend on the mix of earned and paid media.

Time to implement:

Sustained enforcement by law enforcement officers can be implemented once the law enforcement agency develops and implements a sustained seat belt enforcement plan. If extensive publicity is used, it will take 3 or 4 months to plan and implement initially, but this time will decrease once the program has been implemented for some period of time.

Other Strategies for Behavior Change

Communication Strategies for Low-Belt-Use Groups as Part of HVE

Effectiveness: ★★★★	**Cost:** Varies	**Use:** Unknown	**Time:** Varies

Seat belt use rates have increased substantially over the years. Today, most drivers and passengers wear their seat belts. Nationally, daytime seat belt use was 90.4% in 2021, and 23 States, the District of Columbia, and 3 U.S. Territories reported observed seat belt use rates of 90% or higher (NCSA, 2022a). High seat belt use was achieved through a combination of strong occupant restraint laws, HVE programs (e.g., *CIOT*), and programs targeting those less likely to wear their seat belts.

However, research shows that seat belt use is not universally high. NHTSA's NOPUS provides NHTSA's official measure of nationwide seat belt use overall and reports seat belt use by other factors such as age, race, and gender. The 2021 NOPUS found lower seat belt use rates among males and occupants 16 to 24, groups that have consistently been identified as having lower restraint use (Boyle, 2022).

NHTSA's 2016 National Motor Vehicle Occupant Safety Survey (MVOSS) found similar patterns with young drivers, rural drivers, and pickup truck drivers, all reporting lower seat belt use (Spado et al., 2019).

An in-depth examination conducted in Louisiana of driver factors underlying self-reported seat belt use found that, in addition to demographic factors, driver motivations and habits were strong correlates of belt use (Schneider et al., 2017). Internal (want to) and external (have to) motivations to wear a seat belt along with having a well-formed habit of buckling up early in a trip were associated with 100% belt use. Motivated drivers who were nevertheless inconsistent seat belt users typically lacked well-formed seat belt use habits and routines.

Most non-seat belt users report wearing seat belts at least some of the time. In NHTSA's 2016 national MVOSS, only 0.2% of drivers said they never used their seat belts and another 1% said they rarely used seat belts (Spado et al., 2019). Passenger seat belt use also appears to be strongly associated with driver belt use (Han, 2017). The most frequent reasons given by drivers for not wearing a belt were that they: were only driving a short distance (68%), forgot (36%), found the belt uncomfortable (33%), were driving on low-speed roadways (22%), or were in a rush (21%) (Spado et al., 2019). (Drivers were able to give more than one reason for not wearing a belt so the percentages do not add up to 100%.)

Riding as a backseat passenger is another factor that affects seat belt use. In one survey, 72% said they always use their belt in the back seat, compared to 91% who said they always use their belt when seated in front (Jermakian & Weast, 2018). An analysis of data from the 2016 MVOSS found that 63% of rear-seat passengers reported being full-time users, 26% reported being part-time users, and 11% reported being non-users (Spado et al., 2019). The factors that had the strongest association with rear belt use included support for rear-belt laws, using a belt in the front seat, and belief that their State has a rear-belt law.

Use:

Communications and outreach campaigns directed at low-belt-use groups are common, but no summary is available.

Effectiveness:

Communications and outreach campaigns directed at low-belt-use groups have been demonstrated to be effective for targeted programs that support, and are supported by, enforcement.

Trauma Nurses Talk Tough, originally developed in Oregon in 1988, is a seat belt diversion program implemented by trauma nurses in a hospital setting that targets drivers who have been ticketed for not wearing a seat belt. The program was implemented in Robeson County, North Carolina, a diverse county whose seat belt rates were consistently lower than the rest of the State. Those who went through the program were more likely to have a positive outlook on the use of seat belts. Following the program, observed seat belt use increased significantly in the county at eight survey locations (from 81% to 86%) and two additional sites (from 69% to 78%) (Thomas et al., 2014).

A variety of low-belt-use groups have been targeted by countermeasure efforts. These are discussed in separate sections below.

Young Males

High-visibility enforcement programs generally have been effective in increasing seat belt use. Their publicity messages and placement can be directed at specific lower-belt-use groups. The 2013 *CIOT* campaign targeted 18- to 34-year old males and found they showed greater increases in awareness of seat belt enforcement activity and seat belt checkpoints than the general population (14% versus10% for seat belt enforcement, and 10% versus 7% for seat belt checkpoints, respectively) (Nichols, Chaffe, Solomon, & Tison, 2016).The target group did not show significant increases in awareness of the CIOT slogan (5%), messages to buckle up (6%), or perceived risk of a ticket (6%), while the general population showed significant increases in these indices (6%, 8%, and 5%, respectively). The small sample size for the target group may have contributed to not finding significant increases among this group for some indices.

Pickup Truck Drivers

Between 2004 and 2007 several States conducted *Buckle Up in Your Truck* paid advertising campaigns targeting pickup truck occupants. Messaging focused on the dangers of riding unrestrained in a truck and increased seat belt enforcement efforts. Two programs were conducted immediately preceding a *CIOT* campaign. Increases in observed seat belt use ranging from 2% to 14% were seen following the program (Nichols et al., 2009; Solomon, Chaffe, & Cosgrove, 2007).

Rural Drivers

NHTSA's Region 5 implemented a Rural Demonstration Program (RDP) prior to the May 2005 *CIOT* mobilization. The goal of the RDP was to evaluate strategies for increasing seat belt usage in rural areas. Paid media was used to notify rural residents that seat belt laws were being enforced. Active enforcement was included during the initial phase in three of the six Region 5 States (Illinois, Indiana, Ohio), but only the paid media component was implemented in the remaining 3 States (Minnesota, Michigan, Wisconsin). During the Demonstration Project phase, States that had intensified enforcement had significant increases in usage in their targeted rural areas (Nichols et al., 2007). All six Region 5 States intensified enforcement during the *CIOT* mobilization, but States that had intensified enforcement during the Demonstration Project showed substantially greater overall statewide gains during the *CIOT* phase than did the States that had not intensified enforcement during the RDP.

More recent evaluations of rural programs following the HVE model have yielded mixed results. An evaluation of Rural Initiatives conducted in Missouri and Kansas showed positive outcomes (Thomas & Blomberg, 2016). These States ran multi-wave HVE campaigns focused on rural counties from Spring 2009 to Spring 2010. The evaluations indicated that seat belt use in the rural Missouri counties increased from 66.4% to 69.2%, while seat belt use in the rural Kansas counties increased from 61% to 70%. However, not all counties covered by the program experienced significant increases. Driver awareness of the targeted seat belt safety messages also increased following local media campaigns. A multi-State RDP that covered rural parts of Florida, Georgia, and Tennessee was less successful (Nichols, Chaffe, Solomon, & Tison, 2016). It included an HVE model paired with paid and earned media in four waves from November 2008 to May 2010, and it overlapped with annual CIOT campaigns. The RPD increased driver awareness of rural seat belt messages and the perceived risk of getting a ticket for driving unrestrained. Seat belt use increased in all 3 States but was only significantly greater than at control locations in Georgia. Concurrent, statewide CIOT may have muted the differences relative to control, and the greater effectiveness in Georgia may have been partially attributable to the broader awareness among drivers of seat belt check points (Nichols, Chaffe, Solomon, & Tison, 2016).

Tribal Communities

A multifaceted program was implemented on the Pine Ridge Indian Reservation (PRIR) in South Dakota to address the reservation's high proportion of fatal motor vehicle crashes and chronically low seat belt use rates (Amiotte et al., 2016). Although the PRIR was covered by an existing primary seat belt law adopted by the Oglala Sioux Tribe, the law was rarely enforced by PRIR tribal courts and law enforcement officers stopped issuing seat belts tickets. This contributed to seat belt use rates that were as low as 10% across the PRIR. The program implemented by the PRIR included data collection on belt use, increased policing resources and enforcement, funding for a traffic court to enforce seat belt citations, funding for injury prevention specialists to address child restraint usage, and outreach activities involving local media and school programs. These efforts resulted in a 34% increase in observed seat belt use on the PRIR from 2007 to 2013.

Another study used a similar multifaceted approach for increasing seat belt use in eight tribal communities. Communities combined enforcement, education, awareness raising activities, and media campaigns. Observational data was collected in each community for 4 years and all eight communities saw increases in observed seat belt use. Additionally, motor vehicle crashes decreased for seven of eight communities and injuries decreased for five. The study identified four considerations important for tailoring evidence-based strategies in tribal communities: (1) time enforcement campaigns to the community (not necessarily aligned with national campaigns); (2) use language and imagery that reflect the community; (3) involve local people in media and education events; and (4) use project coordinators who are American Indian/Alaska Natives (Crump et al., 2019).

Many of these programs were conducted a decade or more ago when seat belt use rates were lower overall. Additionally, communication methods have changed dramatically over the past 2 decades. Common advertising or communication strategies today were not common when many of these programs took place. While these programs were important for raising seat belt use rates to the numbers we see today, it is unlikely that they would have a similar effect if done today.

Cost:

Costs vary depending on program quality and delivery. Paid advertising can be expensive.

Time to implement:

A good media campaign will require 4 to 6 months to plan and implement.

Employer-Based Programs

Effectiveness: ★★★	**Cost:** Varies	**Use:** Unknown	**Time:** Varies

In 2020 there were 4,764 work-related fatalities in the United States. Transportation-related incidents were the most frequently reported event and accounted for 37.3% of these work-related fatalities (Bureau of Labor Statistics, 2021). In 2018, over 1,800 people were killed in on-the-job related motor vehicle crashes and an additional 379,000 were injured (Network of Employers for Traffic Safety [NETS], 2021). Employer impacts aren't limited to on-the-job incidents. Crash related injuries and fatalities occurring off-hours can affect employers through insurance costs and lost productivity. In 2018, the total cost of motor vehicle crashes to employers was $72.2 billion (NETS, 2021). In 2018 unrestrained employees and their dependents cost employers approximately $7.4 billion (employees on the job: $1.7 billion; off-work employees and dependents $5.7 billion) (NETS, 2021).

Boal et al. (2016) used data from the 2013 Behavioral Risk Factor Surveillance System (BRFSS) to investigate seat belt use by occupational group. They found that self-reported seat belt behavior was significantly associated with occupation. They found the highest prevalence of inconsistent seat belt use among the following occupational groups: construction and extraction; farming, fishing, and forestry; and installation, maintenance, and repair. A study of oil and gas worker fatalities from 2003 to 2009 found that 28% of work-related fatalities involved motor vehicle crashes. Among those fatalities, 38% were unrestrained (Retzer, 2013).

In their survey of commercial vehicle drivers in Hawaii, Kim and Yamashita (2007) found that while 67% of respondents indicated that they always wear a seat belt, they believed that only 31% of other commercial vehicle drivers always wore a seat belt. When asked why commercial vehicle drivers (as a whole) don't wear seat belts, common responses were inconvenience/frequent stops (29%), not safety conscious (23%), and discomfort (12%).

Use:

No summary of current programs exists.

Effectiveness:

Several workplace seat belt programs were conducted in the 1980s and 1990s. These programs were conducted at hospitals (Nimmer & Geller, 1988; Simons-Morton et al., 1987), universities (Geller et al., 1989; Rudd & Geller, 1985; Geller at al., 1982; Nelson & Bruess, 1986), and other businesses (Cope et al., 1986; Merrill & Sleet, 1984). Programs included varied components such as education, messaging, and incentives. While these early employer-based seat belt programs were largely effective at increasing seat belt use, the program variety and lack of evaluation of some programs makes it is difficult to identify which specific components were most beneficial (Race, 1990). Common elements of effective workplace seat belt use programs involved management's commitment to their employees' safety (including formal policies that require use of a seat belt when in a company-owned vehicle or driving/traveling in a motor vehicle while on the job), education and safety training workshops, and incentives for wearing a seat belt as well as costs for non-compliance (e.g., dismissal after three warnings; Orme et al., 1982; Race, 1990).

A comprehensive review of 48 workplace seat belt interventions from 1980-1997 found that these programs were successful at increasing seat belt use in the target populations (Segui-

Gomez, 2000). It is important to note that these programs were conducted in the 1980s and 1990s when seat belt use rates were significantly lower. With current higher use rates, similar programs today may generate less pronounced but still impactful gains in use as we move toward 100% use.

NETS, in partnership with NHTSA, developed material for a 4-week workplace campaign to improve seat belt use (*2 Seconds 2 Click*). The program includes information and education on the benefits of wearing a seat belt and the costs of not buckling up, weekly activities to keep employees engaged throughout the campaign, as well as material to evaluate the impact on seat belt use. Program material and the implementation plan are available at https://2seconds2click.org/. The Federal Motor Carrier Safety Administration also provides a manual with tools to increase seat belt use for employers (www.fmcsa.dot.gov/safety/safety-belt/increasing-safety-belt-use-your-company-manual).

Cost:

Program costs will vary depending on program components.

Time to implement:

The time needed for implementation will depend on program goals and population. It is important to allow enough time for planning, implementation, and evaluation.

Programs for Older Children

Effectiveness: ★★★	**Cost:** Varies	**Use:** Unknown	**Time:** Varies

The number of older children killed in traffic fatalities has decreased substantially since 2006. For children 8 to 12 years old, there has been a 39% decrease from 527 fatalities in 2006 to 324 fatalities in 2021 (NCSA, 2023b). Similarly, for children 13 to 14 years old there has been a 29% decrease from 368 fatalities in 2006 to 262 fatalities in 2021. While increased seat belt use has undoubtedly contributed to these improvements, there is still room to improve seat belt use within these age groups. The 2021 National Survey of the Use of Booster Seats (NSUBS) found that 13.2% of children 8 to 12 were unrestrained, a slight increase from 2019 (12.8%) (Boyle, 2023). Although restraint use has increased over time the trend is positive, unrestrained children continue to be a concern. In 2021 some 36% of fatally injured children 8 to 12 and 59% of children 13 to 14 were unrestrained (NCSA, 2023b).

As noted by Kuhn and Lam (2008a; 2008b), there is not a great deal of information on the factors influencing restraint use for children 8 to 15 years old. The few available studies have tended to focus on changing nonuse behaviors without investigating attitudinal or motivational factors that might be useful in developing additional strategies.

Use:

Programs and campaigns aimed at increasing restraint use among school-aged children are likely common, but no summary is available. In March 2015 NHTSA announced a campaign focused on older children (ages 8-14), *Don't Give Up until They Buckle Up*. The campaign is targeted to parents and caregivers of "tweens," with material and resources for States and others interested in focusing on this age group. Some pilot programs have been implemented and evaluated that can be used as resources for program development. One extensive resource available is the report titled *Increasing Seat Belt Use Among 8- to 15-Year-Olds: Volumes I and II* (Kuhn & Lam, 2008a, 2008b).

Effectiveness:

The studies that have been conducted have generally produced encouraging results. Effectiveness may vary based on program and population specifics.

Programs Focusing on Tweens

The Avoiding Tween Tragedy Project was a comprehensive program aimed at increasing restraint use among 8- to 15-year-olds in Berks County, Pennsylvania (Alonge et al., 2012). The program included education at elementary, middle, and high schools, law enforcement participation, earned and paid media, and participation in community events. Restraint use increased significantly following the program (13% at elementary schools, 17% at middle schools, and 20% at high schools). Among elementary school students, back seat positioning also increased. The authors recommend that future programs targeting this age group focus on HVE and education using information designed for this age group. Because the behaviors of this age group are strongly influenced by others, a legislative focus on primary enforcement of restraint use for all occupants should be pursued if not already in place.

The Automotive Coalition for Traffic Safety (ACTS) launched two pilot programs in 2005 targeting 8- to 15-year-olds. These short-term school and community-based interventions targeted both children and their parents. Both programs were successful in changing knowledge and attitudes of the parents and children, but limited observations did not show significant changes in belt use among the targeted children (Jennings et al., 2006).

The *Make It Click* Program was developed in Virginia to address low seat belt use among children 8-12 in an economically disadvantaged urban school district (Will & Dunaway, 2017). Children, parents, and teachers were educated about proper seat belt use with activities throughout one school year. Children participated in a creativity contest, a safety-themed play, a buckle-challenge competition, afterschool programs, classroom assignments, and morning announcements. Parents were provided with flyers and presentations, while teachers received regular newsletters to keep them informed about the program. The program resulted in significantly higher observed seat belt use rates at intervention schools (32% before the program versus 68% after). During a follow-up period 4-months after the program, students at the intervention school were 3.3 times more likely to be observed wearing a seat belt than students at the control schools.

Similar improvements were observed in a pilot program to increase restraint use and rear-seating position among elementary schools and day care centers (Williams et al., 1997). The programs, held in conjunction with an ongoing statewide *CIOT* program, included letters and pamphlets sent to parents, proper restraint use demonstrations, assemblies emphasizing proper restraint use (at the schools), and enforcement checkpoints. Proper use increased substantially at elementary schools (36% to 64%; 49% to 71%) with smaller increases at the daycare centers (71% to 76%; 60% to 75%). The researchers concluded also that enforcement is a key ingredient of programs even among school-age children. The smaller increase in use could also be an artifact of the daycare center having younger kids who are traditionally more likely to be restrained than elementary-age kids.

Programs Focusing on Teens

The *Just Get It Across* program developed by the Rainbow Babies and Children's Hospital in Cleveland, Ohio, targeted parents of 13- to 15-year-olds with a message encouraging parents to promote seat belt use among their teens (program description and implementation: University Hospitals Rainbow Babies & Children's Hospital Injury Prevention Center, 2014). The program demonstrated increases in knowledge of seat belt laws and teen-reported reminders to wear seat belts by parents. Observed seat belt use by parents and teens also increased in the target community; however, it is not clear what role the program had in this increase because seat belt use in the control community also increased. Exposure in the control community to *Just Get It Across* messaging along with other seat belt promotions may have interfered with effective evaluation of the program (Zakrajsek et al., 2014).

Colorado and Nevada implemented a Teen Seat Belt Demonstration Project in 2007 to 2008 consisting of publicity and enforcement. Each State held four enforcement waves focused in areas and at times when teenagers were most likely to be driving. In addition to increases in teen awareness of seat belt messages and enforcement, teen belt use increased significantly in both States (5% in Colorado and 8% in Nevada) (Nichols et al., 2011).

A study by Nichols et al. (2018) explored the effectiveness of multi-wave teen seat belt demonstration programs in Louisiana, Mississippi, New Mexico, and Texas. All these programs were established in 2009, with the first wave of focused activities starting just prior to NHTSA's *CIOT* (CIOT) campaign in May 2009. The remaining waves occurred in fall 2009, winter 2010, and in May 2010. Each wave consisted of teen-focused outreach, earned and paid media, and enforcement. Each State also had control areas where the program activity was not promoted. States differed in the type of primary media used for outreach (e.g., Louisiana and Mississippi spent more on television ads while New Mexico and Texas spent more on radio ads). The program in Mississippi appeared to be the most effective with higher awareness of seat belt messages, higher perception of strict enforcement, and statistically significant increases in observed seat belt use among teens in the program areas compared to the control areas. This coincides with the high levels of teen exposure to outreach in Mississippi (i.e., higher gross rating points of media ads) than in other States. Teens in the program areas in Texas had higher levels of awareness compared to the control, but the increases in seat belt use were similar in both areas. Neither Louisiana nor New Mexico showed increases in teen belt use above the control locations.

Kansas has implemented a school-based traffic safety program with some success. *Seat Belts Are for Everyone* (SAFE) aims to increase seat belt use among high school students. Freund et al. (2019) compared 5 schools implementing the SAFE program to 5 similar schools that were not participating in SAFE or any other traffic safety programs. The SAFE program allowed each school to run the program independently that led to different levels of implementation. To evaluate success, seat belt observations were conducted at both program and comparison schools. In aggregate, schools that participated in SAFE had higher seat belt use rates than those that did not participate. However, the inconsistent implementation made it difficult to evaluate.

Cost:

Program costs will depend on the size of the target audience and the components of the program.

Time to implement:

The time needed for implementation will depend on program goals and population. It is important to allow enough time for planning, implementation, and evaluation.

Programs for Increasing Child Restraint and Booster Seat Use

Effectiveness: ★★	**Cost:** Varies	**Use:** Unknown	**Time:** Varies

Abundant research has shown that correctly using an appropriate child restraint or seat belt is the single most effective way to save lives and reduce injuries in crashes. However, unrestrained children continue to be overrepresented in motor vehicle fatalities, which indicates that additional lives can be saved by further increasing restraint use among children (Sauber-Schatz et al., 2014).

According to the 2021 National Survey of the Use of Booster Seats (NSUBS), 0% of children under age 1, 6.3% of children 1 to 3, 10.6% of children 4 to 7, and 13.2% of children 8 to 12 were observed to be unrestrained (Boyle, 2023).

Compared to the 2019 NSUBS, child restraint use in various age groups is either unchanged or slightly higher. In 2021 some 17.7% of children 1 to 3 were rear-facing, essentially unchanged from the 17.4% in 2019. The overall percentage of children 4 to 7 riding in car seats or booster seats increased from 2017 (73.2% versus 69.5% in 2019) with more kids in this age group riding in car seats over booster seats (42.2% in car seats in 2019 versus 32.5% in 2019) (Boyle, 2023).

Use:

Programs and campaigns aimed at increasing child restraint and booster seat use are likely common, but no summary is available.

Effectiveness:

While specific programs are discussed below, overall, the effectiveness of individual programs varies depending on program components, how the program is delivered, and how effectiveness is measured. Several recent systematic reviews summarized the research on interventions aimed at increasing child restraint use and found mixed results (Glerum et al., 2019; O'Toole & Christie, 2019; Sartin et al., 2019).

Programs that aim to increase knowledge or affect self-reported behaviors have shown some success; however, observed child restraint use is not often measured, so it is difficult to determine whether these programs increase child restraint use (Gielen et al., 2018; Glerum et al., 2019; Perez et al., 2020; Sartin et al., 2019). Simply increasing knowledge rarely leads to behavior change (see the Introduction), and research has shown knowledge about car seats to be a poor predictor of installation ability in a study of caregivers of children from birth to 3 who participated in an educational program (Kuroiwa et al., 2018).

Additionally, social desirability bias—that is, the tendency for people to give answers they think will be viewed favorably—makes it difficult to determine if self-reported restraint use behaviors are an accurate reflection of actual restraint use. For example, Perez et al. (2020) found that although 95% of caregivers reported their child was using a child restraint on every trip, 16% of children did not have one in the vehicle when a researcher conducted a check in the parking lot.

Several studies have demonstrated success in increasing observed restraint use. Will et al. (2009) used a message aimed at increasing caregivers' perception of risk and combating barriers to correct restraint use to increase booster seat use among attendees of two large daycare/after-school programs in Eastern Virginia. The intervention included a video made with images to invoke emotions, crash test footage, well-respected experts, and personal stories to convey a message of high-threat consequences without using graphic, "gory" images. The study found significant increases in overall observed restraint use and booster seat use following exposure to the intervention and concluded that applying messages that increase perception of vulnerability using high-threat consequences (without gore) is a promising approach to increase booster seat use. Bryant-Stevens et al. (2013) used a similar approach with a research-based video that shared personal stories of a child's injury and how that injury could have been prevented with a booster seat. Additionally, the program included educational sessions and distribution of booster seats to families in need. A significant increase in observed booster seat use was seen in the intervention community.

One of the issues identified when CPS laws were first being considered was the costs associated with obtaining child restraints. Because of this, many State and local organizations initiated programs to make child restraints available at low or no cost to parents through child restraint loan or rental programs (Zaza et al., 2001). Early research found that distribution programs coupled with educational messaging were effective (Ehiri et al., 2006; Louis & Lewis, 1997; Zaza et al., 2001). However, these studies were conducted when both CPS laws and availability and acceptance of child restraints were different than seen today, and more recent research has shown mixed results (Glerum et al., 2018).

As using child restraints has become the norm and child restraints themselves have become more readily available, use of these programs has decreased significantly. However, distribution programs may still have an impact on child restraint use in populations where child restraint use is low. A study by CDC found that child safety seat distributions—in combination with other evidence-based practices—may have contributed to significant increases in proper child restraint use in five American Indian/Alaskan Native tribal communities (Billie et al., 2016; West & Naumann, 2014). From 2010 to 2014 all five communities conducted distribution of child safety seats along with educational programs and enhanced enforcement practices. All communities reported increases in observed use of child safety seats (ranging from 6% to 40%) with the largest increases in communities with lower restraint use rates.

The "Strike Out Child Passenger Injury" program used community sports programs to promote booster seat use among 4- to 7-year-olds in 20 rural communities across 4 States – Alabama, Arkansas, Illinois, and Indiana (Aitken et al., 2013). In the intervention communities, information about proper restraint use was shared in conjunction with T-ball season. In addition to information, parents were given the opportunity to meet with a CPS technician during a T-ball event to get a personal assessment and recommendation for proper restraint use. Child restraints and booster seats were provided to families in need and baseball-themed prizes were provided to participants. Control communities received only an informational brochure. Following the short program, proper restraint use increased in intervention communities in 3 of 4 States. This study demonstrated that tailoring a program to fit in an established community event can have a short-term impact on restraint use in a rural community where resources are limited.

Cost:

Costs vary depending on program components and delivery.

Time to implement:

A good educational campaign or program will require 4 to 6 months to plan and implement.

Child Restraint Inspection Stations

Effectiveness: ★★★	**Cost:** $$	**Use:** High	**Time:** Short

In addition to using a restraint, it is also important to choose a restraint appropriate for a child's weight, height, age, and developmental stage, and to make sure the restraint is installed correctly. Research has shown high rates of misuse. The National Child Restraint Use Special Study (NCRUSS), a nationally representative survey from 2011, found 46% of car seats and booster seats had at least one major error (an error to installation or use that could reduce the effectiveness of the seat in a crash) (Greenwell, 2015). Similarly, a study of caregivers who brought their car seat to an inspection station in Los Angeles found nearly all seats had some misuse, though the definition of misuse was broader than used in NCRUSS (Bachman et al., 2016).

Both the AAP and NHTSA have recommendations for how to best protect children in vehicles (AAP, 2021; Durbin et al., 2018; NHTSA, 2019). However, research shows that some children are being transitioned to the next restraint type prematurely. For example, all children under age 1 should ride rear-facing. However, observational data from the 2021 National Survey of the Use of Booster Seats show that 7.0% of children under 1 were moved prematurely to forward-facing child restraints. Similarly, 13.2% of children 1 to 3 were not in a rear- or forward-facing child restraints but were instead in booster seats, seat belts alone, or were unrestrained (Boyle, 2023).

Booster seats are recommended until the lap/shoulder combination belt fits properly on its own, typically when a child is 8 to 12 years old or 4 feet, 9 inches or taller. However, 2021 NSUBS data show that many children are moving into the seat belt much earlier than is recommended. In 2021 some 16.1% of children 4 to 7 years old and 73.3% of children 8 to 12 years old were restrained using the seat belt alone (Boyle, 2023). However, due to differences in growth, some children may meet the requirements for seat belts or booster seats earlier than their peers. If a child has grown to meet the requirements of a booster seat or a seat belt before reaching the recommended age group, it is not necessarily misuse.

Several programs have been implemented to provide parents and other caregivers with "hands-on" assistance and education about the proper installation and use of child restraints to combat widespread misuse and prematurely transitioning to the next stage. CPS inspection stations, sometimes called "fitting stations," are places or events where parents and caregivers can receive this assistance from certified CPS technicians. Certification courses for child safety seat checks are available through the National Child Passenger Safety Certification program (http://cert.safekids.org).

Because CPS inspection stations are staffed by certified CPS technicians, the overall availability of CPS technicians throughout a State is an important consideration. A study conducted in Michigan compared where CPS technicians lived/worked to where the greatest needs existed, as defined by at-risk children under age 9 (Macy et al., 2016). In general, there was a reasonable match between where the CPS technicians were located and where the most at-risk children resided. In most counties, the estimated distance that families traveled from home to the nearest seat check location was less than 10 miles. However, there were still many counties that had too few Technicians to adequately meet local needs. Training new CPS technicians at underserved locations may be an important part of maintaining the effectiveness of this countermeasure.

In addition to having CPS technicians and inspection stations available to a community, it is also important that the community is aware of this resource. A study by Levi et al. (2020) examined awareness of CPS resources in a nationally representative sample of caregivers. They found that only two-thirds of respondents had heard of inspection stations and of those who were familiar with the resource, only 44% had received assistance at one. When caregivers who hadn't been to an inspection station were asked why they hadn't used the resource, the most common answer was that they already knew how to install their child restraint. Given that other research has shown caregivers to be overconfident in their abilities to correctly install and use child restraints (Benedick et al., 2020), this suggests a need to conduct better outreach to caregivers who are not actively seeking out assistance from CPS technicians.

Use:

Child restraint inspection stations have become common components of State and local CPS programs. As of 2021 there are about 5,000 inspection stations registered with NHTSA (n.d., see www.nhtsa.gov/equipment/car-seats-and-booster-seats#installation-help-inspection for locations).

Effectiveness:

One study found that Safe Kids Worldwide-sponsored child restraint inspection events held at car dealerships, hospitals, retail outlets and other community locations positively changed parents' behavior and increased their knowledge over a 6-week follow-up period: Children arriving at the second event were restrained more safely and more appropriately than they were at the first (Dukehart et al., 2007). Another small study found that attending inspection stations may be more effective for increasing restraint use in children older than 4 (Kroeker et al., 2015). Specifically, children in this age range were more likely to depart the inspection in a restraint configuration that was appropriate for their size and weight than prior to the inspection. Inspection stations were included in a multifaceted program to increase child restraint use in five tribal communities. At inspection stations, child restraint seats were checked, replaced, and re-installed if needed, and new seats were provided to caregivers that did not have them. Although the specific contribution of the inspection stations was not assessed, the full program resulted in four of the five tribes exceeding their overall restraint-use goals—some by a substantial margin.

Another study evaluated whether a "hands-on" educational intervention makes a difference in whether or not parents correctly use their child restraints. All study participants received a free child restraint and education, but the experimental group also received a hands-on demonstration of correct installation and use of the child restraint in their own vehicles. Parents who received this demonstration were also required to demonstrate in return that they could correctly install the restraint. Follow-up observations found that the intervention group was four times more likely to correctly use their child restraints than was the control group (Tessier, 2010).

An evaluation of the child restraint fitting station network in New South Wales, Australia, found that children whose parents attended fitting stations were significantly more likely to be properly restrained than children whose parents had not visited fitting stations (Brown et al., 2011). While specific to Australia, these results suggest similar benefits are possible in the United States. In fact, a U.S. study found that parents and caregivers who were initially taught how to install a child restraint by a CPS technician were more likely to achieve an accurate installation than those that initially learned from other sources, typically the manufacturer's manual (Mirman et al., 2017).

With an increase in digital technologies and more widespread internet access, program managers are considering different approaches to reach caregivers. A small study in Florida provided parents with a phone app to interact directly with a CPS technician located elsewhere, to receive help installing child seats (Schwebel et al., 2017). The results indicated that the accuracy of installations improved significantly compared to the installation prior to the instruction, and that parents felt more confident about the installation.

Kuroiwa et al. (2018) investigated two educational approaches (traditional lecture/instruction versus brief lesson/video) aimed at increasing caregiver knowledge and car seat installation accuracy. Caregivers of children from birth to 3 were randomized into one of two educational programs, and CPS knowledge and car seat installation accuracy were assessed before and after the class. While the traditional group had a larger increase in knowledge, both groups performed equally when demonstrating car seat installations following the class. In the pre-period only 17% of caregivers in the traditional group and 16% of caregivers in the video group had their car seats installed correctly. Following the educational intervention this increased to 52% and 50%. While a notable improvement, it is important to note that approximately 50% of participants still made at least one error when installing their car seat. The study demonstrated that the video format produced similar installation outcomes as the traditional class. This class format could be both cost- and time-efficient when compared to the traditional class.

Cost:

Program costs will depend on the size of the target audience, the components of the program, and the level of services offered. For example, permanent inspection stations listed on NHTSA's locator must have a currently certified CPS technician on site during the posted hours. Costs for maintaining the service includes personnel costs as well as operational expenses.

Time to implement:

Complete programs typically require several months to plan and implement.

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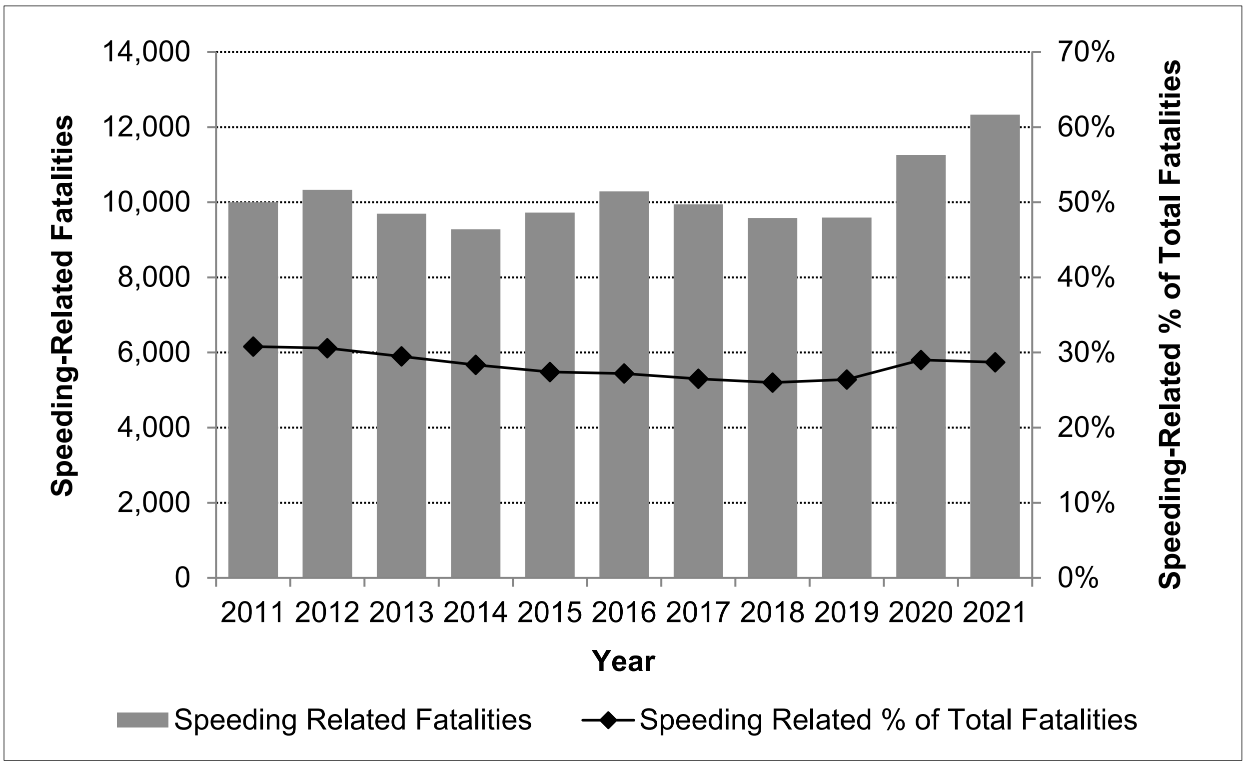
4. Speeding and Speed Management

Overview

NHTSA defines a crash to be speeding-related if any driver involved in the crash is charged with a speeding-related offense or if a police officer indicates that racing, driving too fast for conditions, or exceeding the posted speed limit was a contributing factor in the crash. Speeding-related fatalities have generally decreased over the last decade, as shown in the figure below. However, speeding and racing increased during the early months of the pandemic in 2020. In 2021 there were 12,330 speeding-related fatalities, an increase of 8% from the 11,428 fatalities in 2020 (Stewart, 2023). Speeding was a contributing factor for 29% of fatalities in motor vehicle traffic crashes in the United States in 2021, the highest percentage since 2013 (NCSA, 2022; Stewart, 2023).



Sources: NCSA (2022); Stewart (2023)

Figure 4-1. Speeding-Related Fatalities by Year and as a Proportion of Total Fatalities

Speeding is legally defined by States and municipalities in terms of a "basic speed rule" and statutory maximum speed limits. The basic speed rule generally requires drivers to operate a vehicle at a speed that is reasonable and prudent for roadway conditions. Deciding to take enforcement action is at the law enforcement officer's discretion, which may be affected by weather, surface conditions, traffic volume, and special locations (e.g., work zones, school zones, or other environmental conditions). Statutory speed limits set maximum limits for different types of roads, and generally apply to all roads of that type even when the limits are not posted. Generally applicable limits can be superseded by specific limits posted for roadway segments, usually determined by an engineering study.

Speeding can be dangerous on all types of roads, but particularly on non-interstate rural and urban roadways. In 2020 some 38% of speeding-related fatalities occurred on non-interstate rural roadways, another 49% on non-interstate urban roadways, 8% on interstate urban roadways, and 5% on interstate rural roadways (NCSA, 2022). These percentages do not, however, account for the extent of miles of each road type or VMT on these different road types.

Drivers widely admit to speeding in national surveys. Forty-three percent of drivers in a nationally representative online survey reported driving more than 15 mph over the limit on a freeway in the past month (AAAFTS, 2016). Almost the same percentage admitted to speeding more than 10 mph over the limit on a residential street within the past month.

Speeding becomes an element of aggressive driving when a vehicle's speed substantially exceeds the prevailing travel speeds of other vehicles, and other driving behaviors contribute to unsafe conditions, such as tailgating, weaving, and rapid lane changes. Speeding is a more clearly defined problem than aggressive driving, and strategies to reduce speeding (and other serious traffic law violations) may provide a means to address the problem of aggressive driving. However, speeding is among the most complex traffic safety issues to address and requires a multi-disciplinary approach.

Aggressive and risky driving actions are also perceived to be common, although they are difficult to measure accurately. The 2014 survey by AAAFTS suggests that angry and aggressive driving are increasing, with more than 78% of drivers reporting they engaged in at least one instance of aggressive driving over the previous year including tailgating other drivers to get them to speed up or move over (51%), blocking other vehicles from changing lanes (24%) or cutting off another vehicle on purpose (12%) (AAAFTS, 2016). Nearly 4% of drivers even admitted to engaging in actions that would be considered road rage incidents.

Understanding the Problem

Quite simply, speeding is dangerous, and can increase the risk of crashes and the severity of injury when a crash occurs. Research is clear that higher speed is related to increased crash and injury risk at both the individual driver level, and at a road section level (Aarts & van Schagen, 2006; Elvik et al., 2019). Small changes in average roadway speed can have a large impact on safety (Elvik et al., 2019) for all crash types. The higher the impact speed, the greater the fatality and injury risk to pedestrians and other non-motorists, and this risk starts rising dramatically at speeds above 20 to 25 mph (Tefft, 2013). Speeding contributes to these risks, and to speed variation within a traffic stream, which has also been found to increase crash risk.

Managing speed is therefore an essential aspect of a systems approach that aims to prevent the worst outcomes (death or serious injury) when other parts of the system of users, vehicles, and roadway fail to prevent a crash. Lower speeds can also help to reduce the societal and individual costs of crashes and injury and the burden on post-crash care. Accordingly, speed management is widely considered an essential pillar of a Safe Systems approach to road safety (Dumbaugh et al., 2019; FHWA, 2020).

Despite the evidence that limiting speed reduces the risk of serious and fatal injuries, managing high speeds and speeding behavior remains a consistent challenge for traffic safety professionals. Highway speed limits have been increased in many States in recent years leading to higher speeds and an increased number of crashes. (See the Lower Speed Limits countermeasure section.) Speeding has been increasing since the first observational survey for NHTSA in 2002, especially on major arterials that are not access-limited (NHTSA, 2018). Higher speed means that passenger vehicle compartments have diminishing occupant protection given the forces released in high-speed crashes (IIHS, 2021a). The trend of increasing vehicle size (while providing greater occupant protection) means higher kinetic energies are also absorbed by others involved in crashes with larger vehicles (IIHS, 2021b). In addition, the power to weight ratio of vehicles has been increasing in auto models over time. Other important factors being equal, people driving more powerful vehicles were more likely to exceed the speed limit in an observational study by IIHS (McCartt & Hu, 2017). Drivers of more powerful vehicles also preferred going faster by self-report (Yannis et al., 2013). Furthermore, new driver support features such as adaptive cruise control may not always work as intended, potentially contributing to increases in speeding (Monfort et al., 2022). Socioeconomic and cultural norms also continue to glorify speeding. Motor vehicles are marketed using speed and have capabilities that far exceed any legal limits of even the highest speed highways.

Drivers also report high percentages of speeding (Schroeder et al., 2013). In NHTSA's (2018) survey of driver attitudes and speeding behaviors, 30% were classified as "frequent" speeders, 40% as "sometime" speeders, and 30% as "non-speeders." Driver beliefs sometimes seem at odds with their behavior. For example, two-thirds of drivers strongly agreed that "it is unacceptable to exceed the limits by more than 20 mph," and 91% agreed that "everyone should obey the speed limit because it's the law." Yet 82% agreed that "people should keep up with the flow of traffic," and 51% agreed that speeding tickets have more to do with raising money than they do with reducing speeding. Speeders also tended to be younger compared to non-speeders and sometime speeders, and to view the need to do something about speeding as less important. Across all drivers, however, 87% of surveyed drivers thought it was very important (48%) or somewhat important (39%) that something is done to reduce speeding.

Drivers engage in speeding for many reasons and may value speeding at a personal level, even though they value safety and want government to do something about speeding (Mouter et al., 2018). Most drivers believe speeding is a safety problem and that the government has a duty of care regarding the transportation network, whereas individual drivers are strongly motivated to reduce their personal travel times (Mouter et al., 2018). Drivers also do not individually pay other costs of speeding such as increased external noise or air pollution and so are unlikely to consider these costs in selecting speed, despite the fact that many of these additional costs increase as operating speed increases (Elvik, 2018).

Much of driving takes place at a pre-conscious level. Contrary to widespread belief, drivers often are not consciously trading-off perceived risk with perceived rewards (and continuously) selecting driving speed. Humans tend to learn from experience of road and traffic conditions and develop cognitive "scripts" or routines that simplify the driving task (Dumbaugh et al., 2020; Theeuwes et al., 2012). As a result of this type of pre-conscious response (or due to simply not being aware of the speed limit), many speeding episodes may occur unintentionally or incidentally as found in a naturalistic study of driver speeding behavior (Richard et al., 2012).

Roadways are designed for specific operational purposes, but changes in land development and roadside context can cause discrepancies between the intended purpose of a roadway and its actual function. For example, higher speeds tend to be anticipated in rural contexts, but as land adjacent to rural or suburban roadways are developed to provide more access to residential or commercial facilities (or to accommodate the needs of other kinds of road users), the originally intended operating speed on the roadway may no longer be appropriate (Stamatiadis et al., 2018).

The posted speed limits and the actual operating characteristics of the road—as indicated to drivers by the road profile, the roadside development, and the presence of other road users—both influence perception of appropriate or safe driving speed (when traffic density isn't controlling). These perceptions and preferred speed may differ from actual speed limits (Goldenbeld & van Schagen, 2007; Lee et al., 2017; Mannering, 2009; Yannis et al., 2013). Although speeding-related fatalities are highest on urban, non-interstate roads (NCSA, 2022), drivers also tend to wish for higher speed limits in such areas (Yannis et al., 2013), and frequently do not comply with lower urban speed limits.

Speed is an important element of roadway design because it directly links to other specific geometric features (e.g., curve radii) and because it can be influenced by roadside features (AASHTO, 2018). While roadways are designed and built to nominal standards and to accommodate human factors, in the United States and abroad, these designs historically did not always account for human injury tolerance (Peden et al., 2004) and some speeds that are safe and appropriate in some contexts (like straight segments on freeways) may result in unsafe operating conditions or crash energies that exceed human injury tolerance in other contexts (such as at horizontal curves or where pedestrians and bicyclists are present). The research literature verifies that systemwide crash risk is associated with specific environmental conditions—including the road's cross-section, and roadside elements, like building setbacks—that may contribute to crash-producing mistakes (Dumbaugh & Li, 2011). Performance metrics, however, used to identify problems related to congestion may lead to designs that actually increase the perceived operating speed drivers interpret as safe but actually may not be suitable or appropriate (Lee et al., 2017; Kumfer et al., 2019). Some agencies are now moving away from the kinds of land use analyses (such as assessing vehicular delay) that trades congestion mitigation for safety impacts (Caltrans, 2020). This shift in priority aligns with the U.S. DOT's (2022) goal of prioritizing safety and safe speeds over vehicular throughput.

Some drivers, of course, consciously choose to engage in speeding behaviors because of time pressures, perceived low risk of detection, or perceived high enforcement thresholds (Mannering, 2009; Schechtman et al., 2016; Yannis et al., 2013). Drivers also engage in speeding behavior to conform with the speeds of others (Åberg et al., 1997; Yannis et al., 2013). The amount of annual miles driven has also been correlated with more speeding (Yannis et al., 2013). Some speeding and aggressive driving may also arise among those who enjoy driving fast (Yannis et al., 2013), and from persistent driver attitudes and personality traits (Richard et al., 2016). Drivers who engage in frequent speeding behaviors also tend to take other risks such as driving at higher maximum speeds than other drivers and high-speed variability (compared to other drivers), tailgating, cutting off other drivers, and other risky driving behaviors when in a hurry (Richard et al., 2016).

Aggressive driving may involve driver anger, attempts to gain an advantage over other drivers, and deliberate violations and deviations from normal traffic speeds (Neuman, Pfefer, Slack, Hardy, Raub, et al., 2003). A predisposal to styles or habits of driving that frequently puts others at risk might qualify as aggressive driving and may be the norm for a small proportion of drivers, while others may be provoked to drive aggressively on occasion by exceptional congestion and when time pressures are greatest (such as during rush hours) (Shinar & Compton, 2004). Other drivers' actions are also sources of irritation for "reactive" style drivers who may respond aggressively to being impeded by other drivers or to others' reckless driving or actions perceived as hostile (Björklund, 2008). Other life stressors, such as combat deployments, may also contribute to aggressive driving (Mitra-Sarkar & Andreas, 2009). Others may simply lack impulse control, maturity, or a sense of social responsibility (Fuller et al., 2008). As discussed in the Increasing Penalties countermeasure section, these types of drivers also tend to be most difficult to deter through laws, enforcement, and punishment and may warrant other types of interventions.

Speeding is truly a complex safety problem involving the intersection of socioeconomic norms and trends (including vehicle preferences, consumer trends and others); balancing mobility and safety expectations; design of road networks, land uses, and changes among these; human behavior and fallibility; and legal frameworks, enforcement, and adjudication practices. There are many potentially effective policies, practices and tools that may be restricted, limited, and lacking in political support. For example, the expectation is that drivers should be able to control their own speed, but as research has shown, drivers often lack the ability or the will to always limit speeding on their own. Policies for widespread implementation of technologies such as Intelligent Speed Assistance that could offer the kind of control that drives do not want or are unable to exact for themselves have not garnered the necessary research or political backing in the United States, although they have been widely tested and are being implemented in Europe and other countries that have adopted and implemented the Safe Systems approach. Further, these measures are less likely to be adopted and consistently used on a voluntary basis by those who need them most.

Traffic enforcement in many jurisdictions has proven difficult to sustain (Thomas et al., 2013), and the situation may be getting worse. Surveys suggest that there is decreasing enforcement relative to vehicles miles traveled, and there may be less use of high-visibility traffic enforcement due to manpower issues in some jurisdictions (Byrne et al., 2021). High-visibility enforcement models also may face new challenges from cell phone apps available to alert drivers of radar and speed safety camera (SSC) locations allowing for route changes or speed reductions in the specific areas to avoid citations. In addition, the use of proven technologies such as SSCs that could be used to magnify enforcement and significantly increase general deterrence of speeding have been highly restricted in many States (NTSB, 2017). (See the Speed Safety Camera Enforcement countermeasure.)

Traditional traffic enforcement faces other challenges and feedback loops that limit durability and effectiveness. For example, speed enforcement may be increased due to a speeding and crash problem. When speeding declines, the enforcement may be reduced and the resources directed elsewhere, with the result that speeding soon increases again. Regular traffic enforcement and adjudication also allows significant discretion to law enforcement officers and the courts, which while intended to allow judgement and situational considerations, may lead to different outcomes for different violators. As more citations are issued, a backlog of court cases may result in ineffective and inconsistent prosecution if prosecutors and judges do not believe in the seriousness of speeding cases and sufficient resources are not provided (TRB, 1998; Alexander & Stradling, 2021b). These practices may result in inequitable outcomes and undermine the effectiveness and perceived legitimacy of speed enforcement as a safety issue (Neuman et al., 2009) and may even contribute to less enforcement (Byrne et al., 2021).

These inter-woven conditions explain why it is essential to have a comprehensive and coordinated, system-based approach to managing speed—one that incorporates local and State input from diverse stakeholders. Many engineering countermeasures are available to address speeding, and these measures may be more effective long-term and easier to implement than enforcement. Furthermore, speed lowering designs should be considered alongside changes to speed limits to help achieve speed limit credibility. Many of the countermeasures in this chapter also require involvement of State DOTs because of their role in setting speed limits and evaluating the need for road safety improvements (which should be done before determining need for enforcement strategies). The Key Resources section provides links to guidance for developing such plans and strategies.

Data/Surveillance

The most important data for evaluating speed management programs and countermeasures are crash data and speed data. Roadway inventory data and other data types (land use, census) may also be helpful to better define the context where speeding occurs. States vary how they define speeding in crash data and speeding may be under-reported (NTSB, 2017). Determining speeding during crash investigations can also be difficult and obtaining consistency may be a challenge even within a jurisdiction using the same crash reporting procedures and definitions (Liu & Chen, 2009). Furthermore, crash data do not account for the rates of exposure of speeding among drivers in crashes and drivers who did not crash. Therefore, jurisdictions are encouraged to supplement crash data with measures of traffic speed.

Speed and speeding data, overlaid with crash data, helps provide a more complete picture of where and when speeding is contributing to crashes. Such locations (or locations with similar risks) should be priorities for speeding interventions. Speed data, due to the strong relationship with safety, can also be used in assessing effectiveness of countermeasures that aim to reduce speeding or speed (as in this guide), and provide an earlier measure of effectiveness than crashes. Citation data should be used cautiously since enforcement allocation may potentially be biased toward high crime and previous high citation areas (Braga et al., 2019; Ingram, 2007). Violation data from speed sensors (including at camera sites or speed display devices) may be useful for tracking changes in compliance at these locations.

A representative sample of traffic speed monitoring data could also be used to assess safety performance in a jurisdiction or on particular types of roads. While Federal regulations in the *Manual on Uniform Traffic Control Devices* require collection of operating speed data in relation to speed limit-setting (FHWA, 2016) and although States routinely collect speed and speed limit data as part of the Highway Performance Monitoring System (Office of Highway Policy Information, 2016), speed data collection remains inconsistent across jurisdictions, and more detailed and informative speed distribution data have long been viewed by traffic safety experts as helpful in monitoring safety and establishing speed and safety relationships. More disaggregate measures of speed and speed dispersion by short time intervals could be used to better understand how speed and speeding affect safety and factors that may increase or decrease this relationship (TRB, 1998). In Western Australia, for example, road safety officials established an annual speed survey to measure free-flow travel speeds to establish baseline and assess changes in speeds at locations across the road network (not only at treated locations) as a measure of the safety impacts of speed management programs, including automated speed enforcement (Sultana, 2019). The baseline survey was conducted in 2000; 2018 marked the 18th follow-up survey. In addition, the program aimed to assess performance by different contextual factors, including speed limits, road function, regional differences, and traffic volumes. The results have shown improvement in driver compliance with speed limits as well as reductions in 85th percentile speeds due to the efforts in the State.

Speed data may be collected in different ways, depending on the purpose and need. Speed studies that collect data in the field using standard engineering approaches are deemed most valuable for many safety evaluations or site-specific speeding assessments. However, there are many new types of speed data such as probe (moving speeds) and stationary speed data increasingly available (although they may come with a cost from private vendors) that may be useful in assessing speeding and safety risks at a site or across a network. Some jurisdictions may acquire such data for mobility purposes. Users need to understand the characteristics of data collected using different means, and data collected from probes or stationary sensors should probably be validated against other methods by qualified analysts (Li et al., 2019).

NHTSA has developed the *Model Minimum Uniform Crash Criteria* (currently in the 5th edition; 6th edition expected 2024) to help States improve crash data collection (MMUCC, 2017). Besides collecting elements such as posted speed limit and any driver violations charged, the MMUCC suggests defining "speeding-related" by coding whether each driver involved in the crash was speeding based on verbal or visual evidence.

Emerging Issues

Many drivers frequently use navigation apps on their smartphones. These apps often alert drivers of enforcement efforts that may also offer new levers for increasing deterrence if officers can uncover ways of using these tools to deter speeding more widely. However, the National Sheriffs' Association (NSA) has identified concerns with navigation apps because some drivers may use these apps to avoid enforcement locations (NSA, n.d.). The capabilities of these apps need to be well-understood if they are to be used to support enforcement activities.

As mentioned previously, intelligent speed assistance (ISA) has been found to reduce speeding among drivers who use these systems. Some systems simply provide information to the driver (e.g., speed limit changes). Others provide visual or audible alerts when the speed limit is exceeded. Still others provide accelerator resistance to make speeding more difficult, or automatically prevent driving above the speed limit. Compared to speed governors, which can only limit the maximum speed of vehicles, ISA has the potential to help control speed of all motor vehicle types according to the prevailing limit at a location. ISA systems are currently being tested in Europe. (See the Intelligent Speed Assistance countermeasure for more information.)

Key Resources

For guidance on developing an action plan to manage speed, see the Jurisdiction Speed Management Action Plan Development Package, example plans, and other resources at FHWA's Speed Management Reference Material webpage at https://highways.dot.gov/safety/speed-management/reference-materials

The tools below have been developed to serve as resources for setting safe and credible speed limits. While the first two resources continue to make use of the 85th percentile speed, they incorporate safety information and area context in recommending speed limits:

- *Methods and Practices for Setting Speed Limits* – This report provides a summary of practices available to jurisdictions for setting speed limits (Forbes et al., 2012).

- USLimits2 – This web-based tool provides expert-based assistance in speed limit zoning based on engineering practices. Tool and user guide are available at https://safety.fhwa.dot.gov/uslimits/
    - Note that NCHRP project #03-139 is underway to update this tool.
- *Posted Speed Limit Setting Procedure and Tool*, NCHRP Report 966 – Researchers developed another speed limit setting tool that uses road function and context as a starting baseline for setting limits (Fitzpatrick et al., 2021).
- City Limits – This guide focuses on setting speed limits in urban areas and is available from NACTO (Speed Safety Camera Program Planning and Operations Guide) along with an urban street design guide (*Urban Street Design Guide*, https://nacto.org/publication/urban-street-design-guide/).

Important speeding countermeasure resources include:

- Crash Modification Factors Clearinghouse – This searchable database can be used to obtain estimates of potential crash effects of speeding and speed-related countermeasures in different contexts. (www.cmfclearinghouse.org/).
- Speed Safety Camera Program Planning and Operations Guide – This update of FHWA and NHTSA's 2008 guidelines provides in-depth information on planning and operating an effective and reliable speed safety camera program (NHTSA & FHWA, 2023).

For deeper insight on the complex problem of managing speed see:

- *Safe Systems in the United States: Guiding Principles and Lessons from International Practice* – This document provides a comprehensive review of Safe Systems principles and lessons learned from international Safe Systems practices (Dumbaugh et al., 2019).
- *Reducing Speeding-Related Crashes Involving Passenger Vehicles* – The National Transportation Safety Board (2017) developed a report based on an assessment of evidence, current practices, and recommendations for reducing speeding-related crashes.
- *Pedestrian safety relative to traffic-speed management: A synthesis of highway practice* – This report provides an in-depth look at practices and challenges for managing speed in urban areas where pedestrians are found (Sanders et al., 2019).

Advocacy organizations such as Transportation Alternatives (www.transalt.org) and Families for Safe Streets (www.familiesforsafestreets.org) may be able to help tell the story why speeding is so dangerous and the impacts it has on people, families, and communities. These organizations have helped some communities to achieve political support for managing speed (NHTSA & FHWA, 2023).

Other organizations such as the Vision Zero Network (https://visionzeronetwork.org/) and Toward Zero Deaths (www.towardzerodeaths.org) provide peer networks and resources for jurisdictions that hope to reduce fatalities and serious injuries to near zero. In the United States, Vision Zero is primarily an initiative targeting local jurisdictions to get them to adopt speed-management policies and roadway design practices that encourage driving at speeds that are less likely to result in serious injuries or fatalities. As of November 2022 more than 45 cities had adopted policies from this initiative (Vision Zero Network, 2022).

Speeding and Speed Management Countermeasures

Legislation and Licensing

Countermeasure	Effectiveness	Cost	Use	Time
Lower Speed Limits	★★★★★	$	High	Varies
Variable Speed Limits	★★	$$$	Medium	Varies
Increasing Penalties	★★★★	Varies	High	Varies

Enforcement

Countermeasure	Effectiveness	Cost	Use	Time
Speed Safety Camera Enforcement	★★★★★	Varies	Low	Medium
High-Visibility Enforcement	★★★★	$$$	Medium	Medium

Other Strategies for Behavior Change

Countermeasure	Effectiveness	Cost	Use	Time
Dynamic Speed Display/Feedback Signs	★★★★★	$	High	Short
Intelligent Speed Assistance	★★★	Varies	Unknown	Varies

Approaches That Are Unproven or Need Further Evaluation

Countermeasure
Aggressive Driving and Other Laws
Diversion and Plea Agreements/Traffic Violator School

Effectiveness:

★★★★★	Demonstrated to be effective by several high-quality evaluations with consistent results.
★★★★	Demonstrated to be effective in certain situations.
★★★	Likely to be effective based on balance of evidence from high-quality evaluations.
★★	Limited evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.
★	No evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.

Cost to implement:

$$$	Requires extensive new facilities, staff, equipment, or publicity, or makes heavy demands on current resources.
$$	Requires some additional staff time, equipment, facilities, and/or publicity.
$	Can be implemented with current staff, perhaps with training; limited costs for equipment or facilities.

These estimates do not include the costs of enacting legislation or establishing policies.

Use:

High	More than two-thirds of the States, or a substantial majority of communities
Medium	One-third to two-thirds of the States or communities
Low	Less than one-third of the States or communities
Unknown	Data not available

Time to implement:

Long	More than 1 year
Medium	More than 3 months but less than 1 year
Short	3 months or less

These estimates do not include the time required to enact legislation or establish policies.

Legislation and Licensing

Lower Speed Limits

Effectiveness: ★★★★★	**Cost:** $	**Use:** High	**Time:** Varies

Speed limits can be broadly understood to represent a society's attempt to balance preferences surrounding traffic speed (Howard et al., 2008). Determining the best method, and the balance of priorities for safety, mobility for all types of road users, air quality, noise, and other livability and community values is an inherently complex process that has proven to be challenging (Forbes et al., 2012; Sanders et al., 2019). Public engagement can help determine the community's priorities and well-crafted publicity can help to convey the reasons for lower speed limits (and the other countermeasures in this chapter). An important safety strategy involves setting appropriate speed limits using practices that take into consideration the road segment's design, vulnerable users, traffic operations, land use, and environmental conditions (NHTSA, FHWA, & FMCSA, 2014). While speed limits form the basis for achieving the community's desired balance of safety and other measures relating to mobility, speed limits should be supported by roadway design and operations and a level of enforcement necessary to achieve speed limit credibility and compliance among a vast majority of road users (NHTSA, FHWA, & FMCSA, 2014). (See Understanding the Problem section and Key Resources for more on this topic.)

Speed limits are set both by legislation and by administrative action. Default speed limits apply to all roads in a class such as rural interstates or local streets. Default limits are set by State, municipal, or, at times, Federal law. Speed zones apply to road segments where the default speed limit for that road type is thought to be inconsistent with safe driving. Speed limits in these zones usually are set by administrative action through engineering studies performed by the road managers or DOTs and may require approvals or consensus among partner agencies. Until recently, engineering studies for setting speed limits in speed zones in the United States have been based largely on the road segment's free-flowing travel speeds, with crash experience, road function and land use conditions, presence of non-motorists and other factors often being considered to adjust the posted limit (Fitzpatrick et al., 2021).

Some urban jurisdictions and those with a Vision Zero framework have in recent years set lower speed limits to improve safety, including for people walking and other non-motorized road users (Sanders et al., 2019). Internationally, countries using a Safe Systems approach or having a Vision Zero framework often set limits based on an injury minimization principle to reduce the chances of fatal and injurious crashes. See the Key Resources section for information relating to methods and practices for setting speed limits, and the bullet on Vision Zero below.

Use:

A speed limit is in effect on all road segments in all States. For summaries of each State's maximum speed limits see the GHSA (2018a) and IIHS (2019). NHTSA (2013) provides a publication with each State's complete speed limit laws. The highest speed limits may, however, only be in effect for a portion of rural interstates and other freeway miles.

Examples of cities that have widely lowered speed limits through both statutory actions by classes of road, and by administrative/engineering speed limit reviews include Boston and Cambridge, Massachusetts, Minneapolis, Minnesota, New York City, Portland, Oregon, and Seattle, Washington. Case examples are available at the Vision Zero Network website (https://visionzeronetwork.org/webinar-recap-cities-managing-speed-for-safety-learning-from-seattle-and-minneapolis/) and from NACTO (https://nacto.org/publication/city-limits/the-tools/case-studies-in-lowering-speed-limits/).

Effectiveness:

The effects of maximum (highway) speed limits on speeds, crashes, and casualties have been studied extensively over the past 40+ years. In general, there is significant evidence that when limits are raised, speeds, crashes, and injuries rise, and when they are lowered, speeds, crashes and injuries usually decline (Farmer, 2019).

Effects of changing speed limits on highways

In 1974 the 55 mph National Maximum Speed Limit (NMSL) was enacted to conserve fuel. Travel decreased, speeds decreased on roads where the speed limit was lowered to 55 mph, and total traffic fatalities decreased by 9,100 compared to the previous year. The slower and more uniform speeds due to the 55-mph limit are judged to have saved from 3,000 to 5,000 lives in 1974 (TRB, 1984). In 1995 Congress repealed the NMSL and returned full authority to set speed limits back to the States. Again, increased speed limits produced modest increases in both average and 85th percentile speeds as well as increases in traffic fatalities (TRB, 1998; TRB, 2006). A 2016 study found that each 5 mph increase of State maximum speed limits was associated with an 8% increase in fatality rates on interstates and freeways and a 4% increase on other roads (Farmer, 2017). The study estimated there were 33,000 more traffic fatalities from 1995 to 2013 than would have been expected if State maximum speed limits had not increased since 1993. Another study found that each 1% increase in mileage posted at 70, 75, or 80 mph was, on average, associated with fatality increases of 0.2%, 0.5%, and 0.6%, respectively (Warner et al., 2019). Subsets of fatal crashes involving speeding and driver distraction increased even more.

Two high quality evaluations estimated the crash effects of increased freeway speed limits. A study using 15 years of data estimated the effects of increases in speed limits on sections of Michigan urban freeways from 55 to 70 mph that occurred from 2005 to 2010. Fatal and injury crashes, total crashes, and road departure crashes increased significantly (Kwayu et al., 2020). In a Virginia study, aggregate mean speeds only increased by 1.1 mph in response to the 5 mph increase in freeway speed limits (Himes et al., 2018). At an aggregate level, none of the crash types analyzed, including total, injury, truck, nor run-off-road crashes changed significantly in the analysis of 3 years before and 3 years after the change. However, crashes at interchanges increased significantly (19%).

In Minnesota, raising speed limits from 55 to 60 mph on some two-lane, two-way road sections increased mean speeds by only 1 mph, and 85th percentile speeds remained the same (Saleem et al., 2020). Total crashes still increased significantly by 7%, and injury crashes increased by a not statistically significant 5%.

No U.S. studies were identified where freeway speed limits were decreased, but a study from Korea found that reductions of posted speed limits from 100 to 80 km/h on selected high crash Korean expressways resulted in an estimated 14% reduction in total crashes (Park et al., 2010).

Lower limits in urban areas

Convincing evidence exists that lowering speed limits can reduce average travel speed and crashes in urban areas, even if no or few changes are made to the roadways. However, results achieved may depend on having sufficient enforcement and supporting publicity and communications that reinforce the lower limit and enhance speeding deterrence.

Several North American studies have evaluated the effects of lowering default city-wide speed limits, including from 30 to 25 mph in New York City. A crash evaluation in New York City estimated total crashes were reduced by an average of 39% on streets that fell within the statutory default speed limit change (unposted streets) compared to streets where the speed limit was unchanged (those with posted limits) (Mammen et al., 2020). Vision Zero-related publicity was used to emphasize the speed limit changes in New York City. An evaluation also found that crashes declined in Toronto, Ontario, in response to lowering city-wide speed limits from 40 to 30 km/h (25 to 19 mph) (Fridman et al., 2020).

Several robust evaluations of the effects of reducing posted speed limits in Edmonton, Alberta, found that speeds and crashes on collector and local streets in residential areas decreased significantly when posted limits were lowered by 10 km/h (~6 mph). These changes in posted limits were supported with extensive publicity and enforcement, but no changes were made to the roadway. These reductions in speed limits were associated with a 50% reduction in fatal and injury crashes, a 26% reduction in total crashes, and an 18% reduction in PDO crashes (Islam & El-Basyouny, 2015).

Other international studies provide additional support that lowering urban limits can reduce speeds and road trauma. Crash-based studies (with comparison groups) from Bristol, U.K., estimated that crashes were reduced in response to lowering city-wide speed limits from 30 to 20 mph (Bornioli et al., 2020). More case studies (for Australia, Denmark, Hong Kong, Norway, and others) are presented in the International Transport Forum (2018). Conversely, when urban speed limits were increased from 50 to 70 km/h (from 31 to 43 mph) or from 70 to 80 km/h (from 43 to 50 mph) on urban road segments in Hong Kong, crashes increased by 20 to 30% (Wong et al., 2005).

Lower rural limits

More limited evidence is available on the effects of lowering rural speed limits. The Swedish Transport Administration carried out a system-wide review of speed limits on the national rural road network to assess whether speed limits were properly adapted to the road classifications and designs to align with Sweden's Vision Zero principle (Vadeby & Forsman, 2018). This review resulted in speed limit changes on approximately 20,500 km of rural roads (mostly two-lane), with approximately 17,800 km (about 11,060 miles) receiving lower limits, and about 2,700 km (about 1,680 miles) receiving higher limits. A systematic evaluation of these changes found consistent increases in travel speeds on rural roads where limits were raised and decreases where limits were lowered (Vadeby & Forsman, 2018).

A multi-year crash-based evaluation with comparison group by the same researchers also estimated statistically significant crash reductions for some of the road types with lower speed limits. Fatal and serious injury crashes decreased 38% on grade-separated rural 2+1 roads, and 60% on other rural 2+1 roads where the limits were reduced from 110 to 100 km/hour (~68 to 62 mph). Fatalities were reduced by 41% on the most extensive set of rural two-lane highways where limits were reduced from 90 to 80 km/hr (~56 to 50 mph), although the decreasing trend in fatal and serious injury crashes was not statistically significant.

Victoria, Australia, provides an example of a comprehensive approach to managing speed to lower levels. It implemented a combined review and adjustment of speed limits, enhanced covert and overt forms of enforcement, a media campaign, penalty restructuring, and other efforts. An evaluation found these combined elements reduced injury crashes by 10% and fatal crashes by 27% (D'Elia et al., 2007).

Summary

Lower speed limits can reduce crashes and casualties on highways and in urban areas, and potentially in rural areas, when lower limits result in reduced speeds. In general, speeds tend to decrease, but to a lower degree than the reduction in limits. Similarly, when limits are raised, the reviewed studies show that speeds tend to increase by a smaller amount than the change in limits, and these changes may reflect speeds that existed prior to the change (Vadeby & Forsman, 2018).

If a lower speed limit yields reduced operating speeds, crashes and injuries are expected to decrease (Elvik et al., 2019). Small changes in average speed can, on average, yield significant changes in crash and injury outcomes, but results can vary, in part related to roadway infrastructure, enforcement levels and other factors. See more discussion on achieving compliance with lower limits below.

Cost:

Costs associated with changing speed limits by administrative action/engineering study for a given location or locations include new signs, labor for installation, and for media efforts to publicize the new limit.

Time to implement:

Speed limit changes can be implemented quickly, as soon as signage is in place and the new limits are publicized. For lowering speed limits by statute on a class of roads, more time may be required to garner legislative approval, determine implementation parameters, and develop publicity. Conducting an engineering speed limit review and rezoning a particular corridor to a lower speed can be done more quickly.

Other considerations:

- *Vision Zero Speed Limit Resolutions:* An increasing number of cities are adopting the objectives of Vision Zero to prevent reckless driving, increase safety for all road users, and mitigate injuries and fatalities. A range of measures can be used to achieve objectives through speed limit reductions, automated enforcement of speeding violations using an expansive network of speed cameras, media campaigns, and engineering measures such as speed humps. New York City is one of the early adopters of the program and enacted a law to implement City-wide speed limits of 25 mph in October 2014 (a decrease from the previous 30 mph) (New York City Mayor's Office of Operations, 2015). This speed limit reduction potentially halves the fatality risk for a struck pedestrian. Similarly, Seattle lowered its speed limit to 20 mph on residential streets and to 25 mph on urban arterials in 2016 (Seattle Department of Transportation, 2017) and supports these limits with more signs and other engineering and enforcement strategies (Health Resources in Action, 2013).

- *Safe Systems*: A systems approach to road safety encompasses understanding and recognizing how humans interact with a complex environment such as a road network (and other road users) and how the design of the system may contribute to crashes and injuries (Dumbaugh et al., 2020).
- *Obtaining Speed Compliance:* Lowering speed limits can reduce average driving speeds, but it may be difficult to obtain broad compliance with lower speed limits on roadways designed for much higher speeds (TRB, 1998). As discussed in the Understanding the Problem section, both perceived level of enforcement and perceptions of speed limits can affect speed limit compliance. Gayah et al. (2018) found that the verified presence of heavy police enforcement reduced mean and 85th percentile speeds and helped increase speed limit compliance on rural highways in Montana where limits were set below 85th percentile speeds. However, setting speed limits much higher or much lower than current operating speeds may not achieve desired levels of compliance without other changes to the roadway or to enforcement (Gayah et al., 2018; Lee et al., 2017). Reviews suggest that it can be difficult to implement or sustain enhanced levels of enforcement to keep speeds close to the limit. In general, higher speed limits are very likely to lead to higher average speeds over time *if nothing is done to the roadway* (Hauer, 2009). These and other similar findings mean that the roadway environment should be considered and changed, if needed, along with lowering speed limits when the speed "messaged" by the road is higher than intended for safety. High visibility and speed safety camera enforcement might be used in the short term until such changes can be made.
- *Road designs:* Besides speed limits and enforcement, road design factors such as more traffic lanes, presence of wide shoulders, long sight distance and more "open" land uses may encourage drivers to go faster, whereas on-street parking, sidewalks and pedestrian activity, and downtown land uses encourage drivers to slow down (Gargoum et al., 2016; Ivan et al., 2009; Lee et al., 2017). NCHRP Report 880, *Design Guide for Low-Speed Multimodal Roadways* provides information on road designs that may help DOT partners achieve lower speeds to support lower limits (Elizer et al., 2018; more design resources are mentioned in the Key Resources section). Safety offices and their partners can work with roadway planners, designers, and managers to reduce opportunities for speeding in the longer term.
- *Work Zone speed limits:* If drivers perceive that work zone limits are too low, workers are not present, and other changes to the roadway do not seem to justify the lower limits, they may not comply and extensive enforcement may be needed to enforce the limit (Ullman et al., 2013). Sharma et al. (2017) collected data from nine construction work zones in Iowa during 2014 and 2015. The study found consistent speed reductions associated with work zone speed limits, compared to data collected from the time period when work zones were not in place at the same locations. Indiana DOT funded a project to develop guidance for police enforcement of work zone speed limits. Detailed deployment strategies to obtain the most effective compliance in several types of work zones are described in the report (Chen & Tarko, 2012).

Variable Speed Limits

Effectiveness: ★★	**Cost:** $$$	**Use:** Medium	**Time:** Varies

Variable speed limits (VSLs) have long been used on European freeways to help manage speed and traffic flows in changing conditions (Katz et al., 2012). Variable or dynamic speed limits may be appropriate on roads with significant variations in congestion throughout the day or due to crashes, as well as roads with frequent weather conditions that affect safe travel speed. Sensors in the road detect congestion or weather conditions, then automatically lower the speed limit in stages to manage a more even slowing of traffic, delay of congestion onset, and smooth traffic flows. These changes plus lower speed have potential to reduce crashes, including secondary crashes. Infrastructure is needed to implement VSL active signs over all traffic lanes (generally), and digital communications such as variable message signs and monitoring infrastructure should also be in place (Katz et al., 2012). Use has been recommended for locations that experience variability in traffic volume and flow, weather and surface conditions that affect safe speeds, and other special situations such as work zones (National Center for Rural Road Safety, n.d.).

Lessons from States that have deployed VSL include challenges in traditionally enforcing variable speed limits since officers may not know what limit is in effect (Katz et al., 2012). States should ensure laws and procedures are in place so that charges will stand up in court. Other lessons include ensuring that the systems are only deployed in relation to need. Expert operators will need to periodically review and adjust algorithms that determine when the systems will be activated.

Use:

According to a synthesis report on variable speed limit signs for FHWA, at least 13 U.S. States provided information on VSL systems in use as of 2016. States that have used VSL systems to alter speed limits for weather conditions include Alabama, Delaware, and Washington (Katz et al., 2012). The systems have been used in several urban areas in various U.S. States and European countries to smooth traffic flows and reduce crashes during congested periods (Katz et al., 2012). Oregon has used VSL in both rural and urban areas (FHWA, 2020). More information is available from FHWA's Active Transportation and Demand Management Deployments (Office of Operations, 2016). Variable speed limits or advisory limits have also been used in work zones in some States including Utah, Minnesota, and Texas.

Effectiveness:

VSL systems have been found to reduce crashes (especially rear-end crashes) and speeds in some cases, while improving flow capacity and travel time reliability in others (Katz et al., 2012). They have not worked well in all cases, however, and have been removed in some jurisdictions. A study of safety effects of variable limits deployed on freeways in the St. Louis area for congestion mitigation reported crash reductions of 8%. The congestion relief benefits were not as high as the public and agencies had hoped, however, leading to somewhat equivocal support for the measure (Bham et al., 2010). It appears that the VSL signs were posted only alongside the outer lanes, not over all lanes of the freeway.

An evaluation of a system deployed to address low visibility/heavy fog on I-77 in Virginia found significant reductions in mean speeds and speed variance during activation in the areas where fog was present, although not much change in speeds in transition areas leading to the fog areas (Gonzales & Fontaine, 2018). Preliminary investigation of a Wyoming freeway VSL system showed speed reductions from 0.47 to 0.75 mph for every mph reduction in speed limit (Buddemeyer et al., 2010). An assessment of average speed compliance to VSLs used on another Virginia freeway found that compliance was highest when lower VSLs were posted, but these may have related to higher congestion forcing drivers to slow (Boateng et al., 2019). Hard shoulders also seemed to encourage less compliance. A simulation study determined that implementing VSL upstream of merge areas, rather than downstream, would achieve greater safety benefits (Abdel-Aty & Wang, 2017).

While lower limits may be needed due to work zones, deploying VSL in these areas, in response to weather conditions or congestion, may help to ensure that lower speed limits are more appropriate to the conditions. Outcomes have varied, however, and stakeholders need to consult best practice guides to determine whether and how VSL may help to solve safety problems.

Cost:

The cost will vary according to the type and extent of implementation. Capital costs have ranged from less than $50,000 to more than $5 million. A variable speed limit system covering 40 miles over the Snoqualmie Pass in Washington State was designed and implemented for $5 million in 1997. Operating costs for maintenance, energy, repairs, and potentially clearing the signs of snow/ice in winter should be included in estimates. See the Rural Intelligent Transportation Systems Toolkit (National Center for Rural Road Safety, n.d.), Variable Speed Limit (VSL) at https://ruralsafetycenter.org/wp-content/uploads/2022/08/TM2_Updated2022_508.pdf for more information.

Time to implement:

Determining the need, goals, and expected performance measures of VSL requires a comprehensive engineering and stakeholder review and will likely involve a medium to long time frame. Katz et al. (2012) provide an overview of need assessment, deployment, operations, maintenance, and regulatory and enforcement considerations for the use of VSL.

Increasing Penalties

Effectiveness: ★★★★	**Cost:** Varies	**Use:** High	**Time:** Varies

Varied penalty types and levels for speeding and the various traffic offenses included under speeding and aggressive driving are part of each State's overall driver control system. Penalties typically are low for first offenses that do not produce serious crashes and include small fines and perhaps demerit points assessed against the driver's license. When violations cause a crash producing serious injury or death, the offense may carry criminal charges and sanctions may be more severe.

States use the demerit point system in an attempt to track and deter drivers from committing repeated traffic offenses. As drivers accumulate demerit points, States use various actions and penalties such as warning letters, educational brochures, group counseling meetings, individual counseling, administrative hearings, and driver's license suspension or revocation (Masten & Peck, 2004). The type and level of penalties for speeding and aggressive driving offenses should be considered within the context of a State's overall driver control and problem driver remediation system.

Use:

All States have an existing system of penalties for traffic offenses. These systems include more severe penalties for significant individual offenses, such as those producing serious injury or death, and for repeat offenses. Repeated offenses are often determined through a review of accumulated driver's license demerit points.

Effectiveness:

Internationally, the introduction of penalty point systems, and increases in penalties for speeding, have been associated with safety benefits and general deterrence of speeding. However, there may be limits to the efficacy of increasing punishment for the worst offenders, as the penalty points systems may not completely alter speeding behaviors in those who are the worst offenders.

Population-level deterrence

The greatest effect of increasing fixed penalties seems to apply only to locations with a high level of enforcement (e.g., fixed speed cameras) or the automatic application of penalties.

Evaluations of penalty point systems in European and Middle Eastern countries suggest that the introduction of penalty points, including for speeding, have significantly reduced road traffic injuries (Akhtar & Ziyab, 2013). In Norway, increasing fixed penalties for speeding showed a weak tendency for speeding violations to decrease near camera-enforced sites over time (Elvik & Christensen, 2007) but there was no generalized safety effect of increased penalties over the road system at large. The researchers thought this was likely due to the overall low risk of detection of speeding across the network. Also, European safety researchers suggest that the effect of demerit points and increasing penalties may have decreased over time (Goldenbeld et al., 2013). Maintaining consistent enforcement is part of the challenge. Introduction of a penalty point system in Spain that came into force in 2006, seems to have had an enduring effect on safety, perhaps due to increasing support of traffic enforcement and other safety measures (Izquierdo et al., 2011).

Three Canadian provinces passed legislation from 2007 to 2010 that imposed severe sanctions, including immediate license suspension and vehicle impoundment for speeding by high margins (Gargoum & El-Basyouny, 2018). In British Columbia drivers were subject to mandatory license suspension of 3, 7, or 30 days and vehicle impoundment from 3 to 30 days. In Ontario, drivers were subject to an instant 7-day license suspension and vehicle impoundment, and if convicted large fines, demerit points, and possible imprisonment. In Quebec drivers were subject to a 7-day suspension, double-speed fine, and double demerit points, with repeat offenders being subject to vehicle impoundment for 30-days accompanying a 30-day license suspension. Automatic license suspensions and vehicle impoundments were not part of the penalties before the new legislation. A statistical evaluation estimated the impact on crashes in the provinces associated with the programs, as opposed to specific deterrence effects on drivers penalized under these laws. The programs were associated with statistically significant drops in fatal collisions in Ontario and British Columbia, and in injury crashes in Quebec. Non-statistically significant decreases in injury crashes also occurred in Ontario and Quebec, while British Columbia observed a statistically significant increase in injury crashes. However, the researchers noted that a law affecting impaired driving that had been associated with a drop in injury collisions was repealed during the period after the excessive speeding laws went into effect. Overall, laws increasing the severity of penalties for excessive speeding were associated with reduced fatalities and trauma in these Canadian provinces, suggesting a generalized deterrent effect and safety benefits (Gargoum & El-Basyouny, 2018).

In Victoria, Australia, tightened enforcement tolerances, enhancements to automated and other enforcement, publicity, combined with penalty restructuring (more penalty levels and higher penalties for each) were associated with lower crashes (D'Elia et al., 2007).

Individual-level deterrence

The effects of increasing penalties on violators and subsequent crashes are less clear. Again, the effects may relate to implementation as well as level of enforcement (risk of being caught). Automatic penalties or penalties administered by licensing agencies may be more than those that are processed through the courts (Masten & Peck, 2004).

Masten and Peck (2004) conducted a meta-analysis of prior studies and examined deterrence of future violations and effects on subsequent crashes of different driver improvement and driver control actions for violators. The actions ranged from simple warning letters and brochures to individual meetings, driving courses, group meetings, and license suspensions or revocations. License suspension was the most effective by far, likely due to decreased driving exposure. In addition, court-mandated consequences were not associated with subsequent reductions in crashes by drivers, whereas those administered by licensing agencies were associated with reductions in subsequent violations and crashes. Sanctions such as diverting violators to driving courses or home study programs that included a violation dismissal policy were found to result in a net increase in crashes. Finally, it is uncertain whether the effects from the study are generalizable to all States and to contemporary times, as a large proportion of the included studies were from California (and other western States), and all the studies dated from the 1970s to 1990s (Masten & Peck, 2004). Recent literature searches did not uncover similar studies.

More recently, Australian researchers examined the time to next violation and various other metrics for drivers caught speeding before and after a Queensland law went into effect increasing penalties for speeding (Watson et al., 2015). The penalties included increased monetary fines for all levels and imposed automatic license suspension and eight demerit points for the highest offense category. These offenders were grouped into different categories based on prior offenses (none within the previous 5 years of the "index' offense, prior mid-range offenses, and two or more high prior speeding offenses). There was a significant reduction in the proportion of drivers who re-offended compared to the cohort who offended before the law went into effect. The decreases were significant for the "first" offense group and the mid-range offense group, but not statistically significant for the high-range offenders. Fewer speeding offenses were also committed by the cohort who offended after the law change, and these reductions were significant for all three ranges of offenders (low, medium, and high).

Researchers in Maryland found that various legal consequences for speeding had little impact on future citations for individual drivers (Lawpoolsri et al., 2007). Drivers who received (any) legal consequences had the same likelihood of receiving another speeding citation as drivers who escaped legal consequences. Only fines coupled with probation before judgment (PBJ) was associated with a reduced risk of receiving a subsequent speeding ticket, supporting the idea that the threat of loss of license may have some impact. A follow-on longitudinal study found that drivers who opted for court appearance to contest their speeding citations were more likely to be involved in future crashes and receive future speeding citations than drivers who accepted a guilty verdict and paid fines by mail (Li et al., 2011).

Like the results from Maryland, a U.K. study that examined survey and conviction data found that the immediate threat of being disqualified from driving deterred those with points on their license from further speeding. However, for a subset of drivers, the threat of this sanction did not appear to affect their choice to engage in speeding behavior (Corbett et al., 2008). A study of the effects of Norway's penalty point system found an inverted U-shaped relationship between accumulating points for speeding and other traffic effects and follow-on violations within one year (Sagberg & Ingebrigtsen, 2018). That is, those who had 0 points were least likely to accumulate additional points, but those with prior points were increasingly likely to accumulate more points up to the threat of loss of license for the next infraction. These results suggest that there may be both general and individual deterrent effects of Norway's system, although specific deterrence has limits. Crash effects were not investigated.

Summary

Evidence from the United States and international studies suggest that penalty point systems and increasing consequences for increasing number of degree of violations may improve deterrence among the general population of drivers, *if backed up with sufficient enforcement, and if penalties are automatically applied*. However, increasing punishment and penalties for higher speed and repeat violators may not have the intended deterrent effects on these types of violators and their subsequent crash involvement, unless suspensions are carried out.

Cost:

Costs vary by penalty type and administrator (i.e., the courts versus licensing and vehicle agencies). For example, warning letters are very inexpensive once a record system has been established to identify drivers who should receive letters. Individual counseling and administrative hearings may require substantial staff time. Some costs may be recovered through offender fees.

Other considerations:

- *Effectiveness of penalties is associated with perceived risk of getting caught:* Changes in speeding and aggressive driving sanctions by themselves cannot reduce speeding and aggressive driving. To be effective, sanctions must be well known to violators, and they must perceive a high probability of being caught and having penalties imposed (Preusser et al., 2008; Shinar, 2007). The certainty of punishment may be more important than the level of penalty (Li et al., 2011; Shinar, 2007).
- *Unintended consequences:* The threat of increasing court-administered penalties may overload courts and prosecutors, resulting in delays, plea agreements, and inconsistent outcomes. These situations may in turn affect the perceived legitimacy of speed limit enforcement and the belief that speeding is a safety issue (Neuman et al., 2009). Penalties should also be perceived as fair by those charged with enforcing and upholding sanctions as well as the public. Law enforcement officers in some States expressed reluctance to cite drivers when they themselves perceive increased penalties to be overly punitive or more about raising funds than safety (Byrne et al., 2021). Courts officials may similarly be concerned with these issues and with equity and violators' financial well-being since increasing penalties may be more punitive to some drivers and result in other consequences due to inability to pay.
- *Adjudication may have negative feedback on enforcement:* Some 37% of 568 law enforcement officers surveyed (from municipal, sheriff's and Statewide agencies in 4 States) felt that local prosecutors and judges do not support their traffic safety enforcement efforts, although most thought that traffic enforcement was important to safety (Otto et al., 2019). Thirty-five percent went as far as saying that traffic safety enforcement was a waste of time because prosecutors and judges would not follow through. There is some evidence to support their beliefs. A news investigation in North Carolina found nearly 92% of speeders going 20+ mph over the limit received pleas in the courts that allowed them to escape full penalties (Alexander & Stradling, 2021a). The analysis found that about 16,000 drivers were charged with speeding more than 20 mph over the limit *at least* three times from 2016 to 2020. Over the 5 years, 75 drivers who had charges reduced or dismissed more than once were later involved in fatal crashes (Alexander & Stradling, 2021b). More than 12,000 improper equipment pleas were granted over the 5 years to people who were driving more than 25 mph over the limit, despite earlier legislation that was intended to close such loopholes; some drivers received such deals more than once. Reasons given were that the courts are understaffed, underfunded, and overwhelmed with traffic and other court cases (Alexander & Stradling, 2021b, Alexander, 2021). Attempts to close these loopholes through legislation have also proven insufficient (Alexander & Stradling, 2021b).
- *Expanding use of administrative sanctions:* Given the effectiveness and greater reliability of administrative sanctions, it may be possible to make better use of administrative/civil penalties as used in many speed safety camera programs, to create a system that induces most drivers to willingly comply with speed limits, and reserves the need for more serious driver interventions (that may involve other actions than punishment) for those most unwilling to comply with society's rules and expectations. Furthermore, increasing concerns about court outcomes and equity suggest that while penalties are part of the system of laws intended to deter both the general population of drivers from speeding,

and to reduce repeated violations by specific drivers, States should pay strong attention to the system of enforcement and adjudication and feedback loops over time to understand why these systems may not be working as intended.

- *Repeat and serious offenders:* The threat of punishment is only effective if it deters people from further violations, and as discussed previously, some drivers may not want to change their behavior while others may be unable to control their own behavior. These people may require more in-depth social/behavioral interventions. Recommended methods to reach them include:
    - *Improve traffic record systems* – This strategy is recommended to better identify repeat offenders and to allow patrol officers to immediately access a driver's complete driving record (Neuman, Pfefer, Slack, Hardy, & Waller, 2003). No studies have been identified, as yet, of the effects of improved record systems on repeat offenders. Costs and implementation time will vary.
    - *Provide alternate modes of transportation, electronic monitoring, enforced restrictions or limits on mobility through license plate "striping"* – These recommendations address unlicensed drivers, including those who have already received the maximum penalties but continue to drive (Neuman, Pfefer, Slack, Hardy, & Waller, 2003).
    - *Immediate license suspension or revocation* – One study cited in this section suggests that strong penalties, immediately and automatically applied, can be effective at improving safety in a jurisdiction. Automatic imposition of penalties was a component of the increased penalty systems estimated to reduce fatal and injury crashes in one or more Canadian provinces (Gargoum & El-Basyouny, 2018).
    - *Require mandatory ISA (vehicle-based speed control) systems* – Requiring mandatory systems that enforce the limit, and cannot be turned off by operators, to be installed on violators' vehicles could be an option for repeat and flagrant offenders. Using mandatory ISA for higher risk groups (younger drivers, professional drivers, drivers convicted of serious speeding offenses) was deemed a very cost-effective use of ISA (Vaa et al., 2014), but no evaluations of this measure are known. See the Intelligent Speed Assistance section for more information.
    - *Intense interventions with recidivist, or immature speeders* –As discussed by researchers from the Dutch National Road Safety Institute (SWOV), punishment is a limited means to encourage people to the desired behaviors. For punishment to have an optimal effect, people's motivations and the potential for changing their behavior must be accounted for (Goldenbeld et al., 2013). A few pilot studies have noted some success in helping drivers achieve better control. As examples, a group in Estonia pilot tested an intervention with promising results (Paaver et al., 2013). The intervention was provided by trained psychologists and focused on teaching driving students about impulsive personality and information processing styles, different types of impulsiveness, how to recognize such tendencies in oneself, and potential situational triggers that may induce people to behave impulsively and take risks. The test group had half as many speeding violations over a year following the intervention as a control group of students from the same driving schools. Another effort in the United Kingdom developed and trialed an intensive personal intervention to target

attitudes, skills, and knowledge relating to crash risk among young men with several social and behavioral risk factors and high levels of road traffic collisions (Tapp et al., 2013). The intervention sought to teach “smoothness and control.” The study measured positive and long-lasting impacts among the men who completed the program. One of the challenges, however, was achieving recruitment and completion among this cohort. A small study tested a work-related driver behavior modification program using feedback and goal setting and social-norming branding (Newnam et al., 2014). This trial showed at least short-term improvement in drivers’ compliance with speed limits. These and other research efforts may ultimately lead to changes in education, training, and enforcement interventions that will have more beneficial effects on safety than most driver interventions to date. Finally, an evaluation of a diversionary training course comes from the U.K. The National Speed Awareness Course is an optional short training course provided by police departments (Ipsos MORI et al., 2018). Although speeders can take this course as an alternative to paying penalties for low-level speeding infractions, it is not eligible to those with prior offenses within 3 years, and convictions are not expunged from the driving record. The objective of the course is to convince participants to comply with speed limits by fostering lasting changes in driver attitudes and behaviors towards speeding. The course does this by directly challenging driver existing attitudes, offering insight, awareness and understanding about their speed choices, and importantly, educating them on how they can change their behavior. The effectiveness of the training course was evaluated by comparing crash records for drivers that participated in the course with matched drivers cited for similar levels of speeding, but who did not take the course, or were not offered the course. The evaluation findings indicated that drivers who took the course were significantly less likely to reoffend over the 3-year evaluation period, with the difference diminishing but remaining significant after 6 months.

Enforcement

As mentioned previously, sufficient enforcement is needed across a network to deter drivers from speeding. In addition, enhanced enforcement may be needed to target particularly dangerous areas or corridors where speeding and severe crashes are prevalent. Traffic enforcement, whether by traditional means or through camera and automated technologies can be effective while in place. The safety impact of enforcement can be muted factoring in time and distance from the enforcement location but still can be optimized using various techniques for maximum deterrent effects.

Speed Safety Camera Enforcement

Effectiveness: ★★★★★	**Cost:** Varies	**Use:** Low	**Time:** Medium

SSC enforcement (previously referred to as automated speed enforcement cameras) is a technological system that can be used to enforce speed limits as part of a broader speed enforcement program. SSC enforcement is not intended to replace traditional speed management strategies but can be used as a supplement to other speed management techniques—HVE, traffic calming, and social norming—to alter driver speeding behaviors (NHTSA & FHWA, 2023). SSC systems are an FHWA Proven Safety Countermeasure (Office of Safety, 2021) that can reduce roadway fatalities and injuries by 20% to 37% (Montella et al, 2015; Li et al., 2015).

SSC systems function by capturing violations, recording relevant data about the violations, and recording images of the violator vehicle and license plate (only when triggered by infractions), and when validated, issuing citations to violators. Generally, there are three types of SSC systems used (Office of Safety, 2021):

- Fixed, stationary units that monitor speeds in a single location (e.g., at an intersection);
- Point-to-point (P2P) systems that use cameras to measure the average speed of vehicles (by license plate, typically) over a certain distance between the two cameras to determine if drivers are speeding;
- Mobile units that are typically mounted on a vehicle or trailer and cycled between locations to distribute enforcement efforts.

Some States hold drivers responsible for violations; others hold the vehicle owner accountable for the violation (and sometimes for identifying the driver, if they deny culpability as the driver). A driver-liable approach may require a more involved process and may need to include an image of the driver, which can affect privacy concerns. Review and processing of citations in such States is generally more intensive in nature and places a higher burden on the State to identify the driver for a conviction or finding of responsibility (NHTSA & FHWA, 2023). However, some States that hold the driver liable, tend to assign a range of higher penalties, and may apply penalty points against the license of the driver as with regular traffic enforcement (Miller et al., 2016).

Other jurisdictions use a registered owner liability approach to enforcement. The processes for this approach are generally more limited and are not reliant on charging the actual driver of the vehicle; the owner is assumed to be the driver. This approach places the burden on the registered owner, like a parking ticket (Maisel, 2013). In many cases, the only defenses would be in cases where it can be demonstrated the vehicle had changed ownership, was stolen, or an error occurred in processing the citation. In general, more citations of this type may be processed.

More information can be obtained from national guidance resources. U.S. DOT released automated enforcement program and operational guides with information on identifying problems and setting up and maintaining an effective and transparent, community-supported enforcement program using speed cameras (NHTSA & FHWA, 2008). An update of the Speed Safety Camera Guidelines was released in early 2023 (NHTSA & FHWA, 2023). Eccles et al. (2012) developed a guide for SSC enforcement programs for NCHRP. A program checklist, jointly developed by several safety agencies, is also available to help guide jurisdictions who may want to use these tools (AAA et al., 2021).

In 2011 and 2012 NHTSA surveyed agencies with current or recently discontinued SSC programs (Miller et al., 2016) and found that many agencies seemed unaware of the existence of the national guidelines intended to help jurisdictions develop and operate effective, reliable, and publicly supported safety programs. Another key finding was the frequent lack of strong stakeholder and community engagement in developing programs, a Key Recommendation for effective and reliable programs.

Use:

SSC systems are used extensively in other industrialized countries and were first employed in the United States in 1987 (Miller et al., 2016). As of 2022 speed cameras were being used in approximately 183 jurisdictions in 18 States and the District of Columbia (GHSA, 2023; IIHS, 2023).

The type of SSC system that will be most effective for a particular type of speeding problem depends on a variety of factors. These factors include the duration of speeding problems, whether speeding behavior is localized to a specific site or more widespread, differences in speeding behavior at different locations along a road, legality of different types of SSC, potential sight barriers that may bar cameras from monitoring a sufficient distance within its installation, and the number of lanes that need to be monitored. FHWA Office of Safety (2021) identifies which SSC type may be most useful based on these criteria, reproduced below:

Table 4-1. Use Cases for Different SSC Systems Based on Various Criteria

Selection Criteria	Fixed Units	P2P Systems	Mobile Units
Problems are long-term and site-specific	X	X	-
Problems are network-wide, and shift based on enforcement efforts	-	-	X
Speeds at enforcement site vary largely from downstream sites	-	X	X
Overt enforcement is legally required	X	X	X
Sight distance for the enforcement unit is limited	X	X	-
Enforcement sites are multilane facilities	X	X	-

Source: FHWA Office of Safety, 2021

Effectiveness:

SSC systems have been found to improve safety, but program parameters and site selection factors may affect both safety outcomes and program sustainability.

The use of speed cameras can contribute to reductions in speed and crashes. Decina et al. (2007) reviewed 13 safety impact studies of automated speed enforcement internationally, including one study from a U.S. jurisdiction. The best-controlled studies suggest injury crash reductions relating to the introduction of SSCs are likely to be in the range of 20 to 25% at conspicuous, fixed camera sites. Covert, mobile enforcement programs also result in significant crash reductions area-wide (Thomas, Srinivasan, et al., 2008). Similarly, in South Australia, injury crash data for 35 safety camera intersections for 5 years before and after the speed camera installation showed an estimated reduction of up to 21% (Kloeden et al., 2018). Wilson et al. (2010) reviewed 28 studies of automated enforcement including from U.S. sites and found reductions of 8 to 49% for all crashes and reductions of 11 to 44% for crashes related to serious injuries and fatalities. In Great Britain the effects of fixed speed cameras on crashes were estimated by examining data from before and after camera installations at 2,500 locations. Researchers estimated that installing another 1,000 cameras could prevent approximately 1,130 collisions and approximately 330 serious injuries (Tang, 2017). In France 2,756 speed cameras were installed from 2003 to 2010. A program evaluation estimated that the cameras prevented around 15,000 road traffic deaths during that time (World Health Organization, 2017). Lowering speed enforcement thresholds of automated enforcement also helped reduce mean speeds in Finland (Luoma et al., 2012).

Crash-based evaluations from the United States and Canada have also reported safety benefits from SSC programs in urban areas. Shin et al. (2009) examined effects of a fixed camera enforcement program applied to a 6.5-mile urban freeway section through Scottsdale, Arizona. The speed limit on the enforced freeway was 65 mph; the enforcement trigger was set to 76 mph. Total *target* (off-peak/free-flow) crashes were reduced by an estimated 44 to 54%, injury crashes by 28 to 48%, and property damage only crashes by 46 to 56% during the 9-month program period. In addition to the crash reductions, average speed was decreased by about 9 mph and speed variance also decreased around the enforced zones. Another finding from this study was that all types of crashes appeared to be reduced, except for rear-end crashes, for which effects were non-significant. Thus, there were no obvious trade-offs of decreases in some crash types at the expense of others. The program effects should be considered short-term. There was also very limited examination of spillover effects, including the possibility of traffic or crash diversion to other routes, but given that the corridor was a free-way, diversion to other routes may not have been an issue.

Mobile speed camera operations were also effective on non-freeway streets in North American urban areas including Charlotte, North Carolina; Montgomery County, Maryland; and Edmonton, Alberta, Canada. Crashes and speeds were reduced as a result of a mobile camera enforcement program and publicity on 14 urban arterials in Charlotte (Moon & Hummer, 2010). Publicity alone (before ticketing began) was associated with an 8 to 10% drop in total and fatal crashes. Once enforcement began, the program was associated with reductions of 19% in total and 17% in fatal collisions. These safety effects continued after the program was suspended before gradually returning to pre-intervention levels. A 2016 update of a long-running Montgomery County program found that mean speeds remained lower on treated corridors and lower than comparison sites (Hu & McCartt, 2016). The percentage of vehicles exceeding limits by more than 10 mph decreased an average of 64% at camera sites, 39% at spillover sites, and 43% at comparison sites lacking camera enforcement.

Several studies have been performed on an overt, mobile photo enforcement program in Edmonton. Speed limit violations were reduced both up and downstream of the enforcement locations, which were 7 two-lane urban arterials and 2 collectors with speed limits of 50 km/h (31 mph) (Gouda & El Basyouny, 2017a). Note that some studies have found a tendency for speeds to increase upstream of camera sites and for speeds to change suddenly both upstream and downstream of camera sites (De Pauw et al., 2014). A high-quality, crash-based evaluation estimated that severe crashes (fatal and all injury crashes) were reduced by 20% and speeding-related crashes by 19% (Li et al., 2015). Also, effects were much greater (32% reduction) on segments that were enforced over all the study years (compared to 18% for those that were not enforced in all years) and were also higher on corridors that had at least 3 speeding-related crashes before the enforcement started. A later analysis found a dose-dependent effect on crashes, with safety benefits increasing as the number of enforced sites and issued tickets increased. However, shorter intervals at each site, and greater spatial coverage were also associated with more safety (Li et al., 2017).

In Europe and Australia point-to-point -- also called average speed or speed-over-distance enforcement -- is gaining in popularity to reduce speeding and improve safety in freeway or limited access situations (Soole et al., 2013). Automatic plate recognition and time stamps are used to match vehicles and detect speeding from a first to downstream camera sites. If the average speed for the section is above the enforced speed threshold, a citation may be issued. It is not necessary to monitor vehicles along the entire length of road (NTSB, 2017).

In a review of international evidence this type of SSC system has been found to improve compliance to very high rates (Soole et al., 2013; De Pauw et al., 2014), and reduced speed variation since a majority of motorists travel at speeds closer to the limit (Soole et al., 2013). The technology also has been found to contribute to significant crash reductions (Høye, 2015; La Torre et al., 2019; Montella et al., 2015). Such systems have the potential to smooth traffic flow and may help to avoid negative halo effects such as rapid slowing or speeding up that fixed or overt mobile enforcement sites sometimes experience (Soole et al., 2013). An evaluation of 237 motorway sections in Italy estimated significant reductions for single-vehicle non-injury crashes, multivehicle fatal or injury, and multivehicle non-injury level crashes for motorways with various AADTs. Overall, a 22% reduction in crash frequency was estimated on the Italian motorway network (La Torre et al., 2019). Even greater crash reductions were estimated for a single urban, ring-road motorway (Montella et al., 2015).

In summary, conspicuous speed safety cameras tend to reduce speeds and crashes at treated sites. There is likely a dose-dependent response of amount of enforcement (number of sites, number of issued tickets) and safety effects achieved (Li et al., 2017). Area-wide crash reductions have also been found, but research on area-wide safety effects is more limited (Thomas, Srinivasan, et al., 2008). Specific times may be leveraged to increase program effectiveness through deployment allocation strategies (Kim et al., 2016). It is likely that covert enforcement, also used in Australian programs to increase drivers' perceived risk of being detected, would increase effectiveness over various times and distances. When applied on urban arterials, fixed units may reduce all crashes by 54% and injury crashes by 46% (Shin et al., 2009), P2P units may reduce fatal and injury crashes by 37% (Montella et al., 2015), and mobile units may reduce fatal and injury crashes by 20% (Li et al., 2015).

Cost:

Costs will be based on equipment choices, operational and administrative characteristics of the program, and specific negotiations with vendors. Cameras may be purchased, leased, or installed and maintained by contractors for a negotiated fee (NHTSA & FHWA, 2023). Most jurisdictions contract with private vendors to install and maintain the cameras and, to process images and violations. Operating costs of SSC systems vary based on the nature of the system, administrative costs, and negotiated fees to vendors providing services to a jurisdiction. Many systems are "turnkey" operations, in which a vendor provides all of the equipment, vehicles, and support services necessary to collect violation data and issue a citation. The cost for this service may be based on a fixed monthly fee, or on a negotiated fee for issued or paid citations.

Costs to communities or States for the installation of fixed equipment can vary based on the type of system, the number of devices in use, and the type of sensors being employed to collect violation data. Jurisdictions must make the return-on-investment decisions for accepting these costs based on their determination of need, risk versus mobility assessment, and budgetary projections and constraints.

Fixed camera costs may not be like those for red-light camera programs, based on volume of activity and violations they generate. An economic analysis estimated the total cost savings of the Scottsdale freeway fixed speed enforcement were from $16.5 to $17.1 million per year, considering only camera installation and operational cost estimates and crash cost impacts (other potential economic impacts were not considered) (Shin et al., 2009). Chen (2005) provides an extensive analysis of the costs and benefits of the British Columbia, Canada, mobile speed camera program and estimated a societal savings of C$114 million and a savings of over C$38 million for the Insurance Corporation of British Columbia (ICBC) that funded the program. Gains et al., (2004) reported a 4:1 overall societal cost to benefit ratio of operating the national (fixed) speed camera program in the U.K. based on 33% reductions in personal injury crashes at camera sites and a 40% reduction in the number of people killed and seriously injured. Also, Tang (2017) estimated net benefits of installing 1,000 cameras to be around £21 million in Great Britain based on data from 2,500 fixed cameras crash data.

Time to implement:

Once any necessary legislation is enacted, automated enforcement programs generally require up to 9 months to plan, publicize, and implement.

Other considerations:

- *Recent types of automated enforcement.* Washington, D.C., has implemented camera-supported enforcement to help enforce compliance with stop signs, as well as yielding to pedestrians at crosswalks (District Department of Transportation, 2022) but no evaluations for these uses are available. South Australia uses fixed SSC units, including at midblock locations, as well as combined speed and red-light cameras at intersections, pedestrian, and railway crossings, in addition to P2P systems (average speed over distance) camera enforcement (Kloeden & Hutchinson, 2019). Data show that speeding offense rates decline rapidly in the first 2 to 3 years of speeding enforcement and have continued to decline. Red light running has also declined, but not as consistently (Kloeden & Hutchinson, 2019).

- *Partnerships:* It is widely acknowledged that SSC can be an enforcement multiplier and may be used in locations or at times that are difficult or dangerous to enforce by regular traffic patrol. SSC systems are not intended to replace traditional enforcement but offer an objective method for citing speeders and combined with effective publicity, enhancing widespread, general deterrence. State DOTs are considered good safety partners for identifying locations for deploying SSC based on speeding and crash concerns that cannot be addressed by engineering countermeasures (NHTSA & FHWA, 2023). Washington and Shin (2005) caution that simpler and less expensive engineering solutions (e.g., signal operations modifications, improving motorist information, and physical improvements around intersections) should be sought before implementing camera programs. In addition, a wide variety of other partners including community members should be consulted in developing an effective, community-supported program (NHTSA & FHWA, 2023).
- *Laws:* Many jurisdictions using SSC are in States with laws authorizing its use, and specific legal authorization is strongly recommended to avoid potential court challenges (NHTSA & FHWA, 2023). Some States permit automated enforcement without a specific State law. Others prohibit or restrict some forms of automated enforcement (GHSA, 2018a; IIHS, 2023). In yet others, there is no specific statute, and it cannot be inferred from case law whether the State allows automated enforcement. As of December 2018 nine States permit the use of speed cameras under at least some circumstances, 13 States have laws that prohibit speed cameras, and 28 States have no laws addressing speed camera use (GHSA, 2018a).
- *Publicity:* Publicity is an important component of speed safety camera programs, from the planning stage onward (NHTSA & FHWA, 2023). Reductions in crashes in Victoria, Australia, were attributed to a television advertising campaign that supported, but did not relate directly, to automated speed enforcement initiatives (Bobevski et al., 2007). Publicity can also enhance perceived fairness of the programs. The use of warning signs for drivers to indicate the presence of automated enforcement systems within the community, and in the approaches where the technology is deployed, is highly recommended. These signs enable drivers to come into compliance before a crash or enforcement event occurs and provide fair warning to drivers of potential enforcement action in general.
- *Public acceptance:* A 2011 nationally representative survey of drivers found that 86% thought SSC systems would be acceptable to enforce speed limits in school zones. Significant majorities also thought they would be acceptable at high-crash locations (84%), in construction zones (74%), and in areas that would be hazardous for police officers to stop vehicles (70%) or would cause congestion (63%). Thirty-five percent thought automated camera enforcement of speeds is acceptable on all roads (Schroeder et al., 2013). Support appears highest in jurisdictions that have implemented red-light or speed cameras. A survey of District of Columbia residents found 76% favored speed cameras, with even higher support among non-drivers (Cicchino et al., 2014). Interestingly, support was lower for measures not currently in use, including photo-enforcement of stop signs (50%) and yielding at crosswalks (47%). Again, support was higher among non-drivers for these measures (Cicchino et al., 2014). However, efforts to institute SSC often are opposed by people who believe that speed or red-light cameras

intrude on individual privacy or are an inappropriate extension of law enforcement authority. They also may be opposed if they are viewed as revenue generators rather than methods for improving safety. Drivers responding to the NHTSA survey, although indicating support generally for SSC in certain types of locations or conditions, were also more likely to somewhat agree or strongly agree with the statement that speed cameras are used to generate revenue (70%) than with the statement that speed cameras are used to prevent accidents (55%) (Schroeder et al., 2013). Such concerns should be carefully and openly addressed through program design, vendor selection, payment agreements and more. As mentioned above, program oversight and site selection should be handled by public safety agencies (NHTSA & FHWA, 2023). See more information in the updated Speed Safety Camera Planning and Operations Guide, which includes several case studies on garnering and maintaining public and policy approval.

- *Legality:* State courts have consistently supported the constitutionality of automated enforcement, although programs should have authorizing legislation in place to ensure compliance with State and local ordinances (Poole et al., 2017). Programs operating without explicit statutory authority may be more vulnerable to successful court challenges (Maisel, 2013; Rodier et al., 2007).
- *Covert versus overt enforcement and other program characteristics:* NHTSA and FHWA's operational guidelines document outline other considerations of overt and covert speed enforcement, enforcement threshold, publicity and signing strategies (NHTSA & FHWA, 2023).

High-Visibility Enforcement

Effectiveness: ★★★★	**Cost:** $$$	**Use:** Medium	**Time:** Medium

In the HVE model, law enforcement targets selected high-crash or high-violation locations, corridors, or geographical areas for enhanced enforcement, and publicizes the enforcement widely to maximize general deterrence of speeding beyond those who are stopped. If done well, such a campaign should be perceived as fair, as drivers are being put on notice that the enforcement is occurring, and that it is being done to improve safety. This model is based on the same principles as high-visibility seat belt and alcohol-impaired-driving enforcement. The objective is to convince the driving public that speeding is likely to be detected and therefore not worth the risk of receiving fines, points, or other punishment. (See the chapters on Alcohol-Impaired Driving and Seat Belt Use for more information.)

Enforcement actions for speeding violations should be fair, consistent with local and State statutes, and taken in the interest of preventing traffic crashes. Correspondingly, locations with a demonstrable speeding and heightened crash risk are most recommended for focused enforcement activities.

Effective communications and outreach have long been deemed an essential part of successful speed and aggressive-driving enforcement programs (Neuman, Pfefer, Slack, Hardy, Raub, et al., 2003; Neuman et al., 2009) as well as Speed Safety Camera programs (NHTSA & FHWA, 2023). Key objectives of these communications are to provide information about the program and expected safety benefits, to incorporate public input (which requires two-way communications), and to increase community support.

Beyond these general communications to help create a fair and effective enforcement program, a key objective of publicity is to maximize the general deterrent effects of enforcement by increasing the perception among drivers (not all of whom can be ticketed) that they will be caught speeding. Other State and community partners may help to leverage resources and achieve a wider reach if they have common goals and concerns (GHSA, 2018b).

Use:

Most States provide some funding for speed equipment (47 States and Guam), overtime enforcement (42 States and Guam), or speed public information campaigns (31 States and Guam) (Sprattler, 2012). A 2021 GHSA review of HVE practices and strategies with select State highway safety office officials and law enforcement agencies suggests that HVE is decreasing, along with grant-funded support for such activities (Byrne et al., 2021).

A survey of State practices for GHSA in 2012 found that relatively few States funded aggressive driving enforcement at that time (Sprattler, 2012), and it is likely that high-visibility aggressive driving enforcement campaigns are not common. The 2012 GHSA report (Sprattler, 2012) and a guide from the NCHRP program (Neuman, Pfefer, Slack, Hardy, Raub, et al., 2003) provide a few examples of aggressive driving enforcement programs.

Effectiveness:

Overall, HVE deters speeding where and while being used (if intense enough and implemented well), but some research indicates that effects may disappear within weeks or months once the programs end (Vision Zero SF, 2020). Evaluations of high-visibility speed enforcement programs suggest that intense campaigns with publicity can deter speeding on target urban corridors. San Francisco, California, implemented a year-long HVE program focusing on 11 high injury corridors as a component of Vision Zero efforts during 2016-2017 (Vision Zero SF, 2020). During the most active part of the enforcement campaign, the enforcement was supported with variable message signs deployed on the Sunday evening prior to scheduled enforcement on a given corridor. In addition, varied types of media, online marketing, physical communications (i.e., rear of bus and bus shelter ads), and community-based local activities were performed. More than 1,800 speeding citations were issued to drivers on the target corridors with 1,400 more issued citywide. A controlled evaluation found that 85th percentile and mean speeds were reduced by about 5% during the enforcement actions. The time periods just prior to enforcement periods when the variable message signs were present, but enforcement had not yet begun, also showed a modest reduction in speeds indicating a publicity effect of the signs deployed at the corridor level. However, there was no lasting effect of the enforcement. Speeds started climbing within one week following the last enforcement on a corridor, and by the following month there was no detectable effect on speeding (Vision Zero SF, 2020).

A substantial increase in general traffic enforcement in Fresno, California, that included an increase from 20 to 84 traffic patrol officers, the addition of 20 new police motorcycles and radar guns, and more than three-fold increase in citations in 2 years was associated with decreases in motor vehicle crashes, injury and fatal crashes, and lower rates per population compared to the county where enforcement decreased slightly (Davis et al., 2006). A 2008 test of a 4-week, HVE campaign along a 6-mile corridor with a significant crash history in London, U.K., found significant reductions in driver speeding in the enforced area. There was also a continuing effect up to 2 weeks following the end of the campaign (Walter et al., 2011). A crash-based analysis was not conducted. The campaign was covered by print media as well as by billboards and active messaging along the enforced corridor.

Several earlier NHTSA-supported demonstration programs saw more mixed success. All three demonstrations lasted 6 months and included extensive publicity but differed in other respects. Milwaukee was the most successful. Red light running decreased at targeted intersections. Crashes in the city dropped by 12% in targeted corridors and by 2% in comparison corridors (McCartt et al., 2001). The Indianapolis demonstration was not a success. Average speeds dropped slightly. Total crashes *increased* 32% over the previous year (Stuster, 2004). Crashes increased *more* in the demonstration area than in other areas, and the proportion of crashes involving aggressive driving behaviors also increased in the demonstration areas. Stuster indicated that the most likely explanation for the increases was inaccurate traffic volume data extrapolated from previous years and neighboring areas. Tucson had mixed results. Average speeds dropped moderately (Stuster, 2004). Total crashes *increased* 10% in the demonstration areas and *decreased* in comparison areas. However, the proportion of crashes involving aggressive driving behaviors decreased by 8% in the demonstration areas.

There is less evidence about such campaigns on rural roads, and evidence is mixed from “rational speed limit setting and enforcement’ demonstration programs on rural highways, likely due to difficulty in achieving sustained, higher enforcement levels and other variations in programs and evaluations (e.g., Freedman et al., 2007).

Publicity effects

There is evidence that publicity enhances safety effects of an enforcement campaign, although there has been more success with seat belts and impaired driving campaigns. A meta-analysis of 67 worldwide studies of the effect of road safety campaigns on crashes suggests a general campaign effect of 9% crash reductions; however, anti-drunk-driving campaigns were considerably more effective than anti-speeding campaigns (Phillips et al., 2011). Roadside message delivery, use of enforcement, personal communication or a combination of personal communication with mass media, were other factors associated with greater crash reductions, whereas more recent campaigns (after 2000) tended to be less effective than those before 2000.

Other evidence comes from publicity associated with automated enforcement programs. Reductions in crashes in Victoria, Australia, were attributed to a television advertising campaign that supported, but did not relate directly, to automated speed enforcement initiatives (Bobevski et al., 2007). As mentioned in the SSC Countermeasure section, a study from Charlotte also found that publicity from an aggressive media outreach campaign and on-going publicity related to automated enforcement was responsible for an 8% to 9% reduction in crashes. Effects carried over for several months after the program ended before gradually returning to pre-intervention levels (Moon & Hummer, 2010). Earlier evidence from Australia also suggested that paid media advertising could enhance the effectiveness of automated speed enforcement (Cameron et al., 1992).

As mentioned above, signs rolled out in advance of enforcement actions in San Francisco's high-visibility speed enforcement campaign were associated with a 3% reduction in 85th percentile speeds. This is consistent with the Phillips et al. (2011) finding that direct communications at the roadside are likely more effective than general mass media publicity. As found in Philadelphia's *Heed the Speed* campaign, achieving message penetration through signs, flyers, and other community outreach approaches is a challenge in a large urban setting (Blomberg et al., 2012).

Communications and outreach programs urging drivers to behave courteously or to not speed are unlikely to have any effect unless they are tied to vigorous enforcement (Neuman, Pfefer, Slack, Hardy, Raub, et al., 2003). Campaign messages that are pre-tested to ensure they are relevant to the target audience and that reach the audience with sufficient intensity and duration to be perceived and noticed are most likely to be effective (Preusser et al., 2008).

High-visibility model programs to target specific aggressive driving actions around large trucks have also been undertaken in several States, but there is as yet, no crash-based evidence available. The program, known as TACT (*Ticketing Aggressive Cars and Trucks*) is modeled on the *Click It or Ticket* belt use campaigns. An evaluation found promising results in reducing the number of targeted violations as the program was implemented in Washington State; effects on crashes or injuries were not determined (Nerup et al., 2006; Thomas, Blomberg, et al., 2008). The TACT program was also used in Michigan. The evaluation of this program by Kostyniuk et al. (2014) indicates that TACT messages reminding drivers of the slogan "Leave More Space for Trucks" were successfully received, with 40% of drivers being aware of the slogan. However, given the awareness of this slogan, behaviors of both light vehicle drivers did not change when driving around trucks. A unique part of this implementation of the TACT program was the visibility of two of four police vehicles at one time in a relatively small geographical location. From a deterrence perspective, because drivers generally revert back to the "old behaviors" once a police car passes by, having a second police car available to follow up once drivers think they can revert back to unsafe behavior increases the likelihood that these violators will be apprehended.

In summary, the evaluation evidence suggests that high-visibility, anti-speeding enforcement and publicity campaigns have promise, but safety benefits are far from guaranteed, and are difficult to sustain without continued investment.

Cost:

As with alcohol-impaired driving and seat belt use enforcement campaigns, the main costs are for law enforcement time and for publicity. A Minnesota Speed Management Program cost approximately $3 million, with $2.5 million for increased enforcement, $350 thousand for paid media (primarily radio), and $150 thousand for data collection and evaluation. The Minnesota DOT and State Patrol also made significant in-kind contributions toward project management, sign installation, speed detection equipment, engineering reviews, and fuel and vehicle costs (Harder & Bloomfield, 2007). The three NHTSA-sponsored demonstration projects, *Aggression Suppression* in Milwaukee (McCartt et al., 2001), *Rub Out Aggressive Driving* in Indianapolis (Stuster, 2004), and *We've Got Your Number* in Tuscon (Stuster, 2004), overviewed in the effectiveness section had different funding costs. The Milwaukee demonstration received a $650,000 grant (McCartt et al., 2001) and the other two demonstrations in Indianapolis and Tuscon each received a $200,000 grant (Stuster, 2004). Public-private partners (such as those in interests in injury prevention and public health) may be able to assist with publicity. The cost of the previously mentioned Fresno demonstration included a $70,000 grant from the California State Office of Traffic Safety (Davis et al., 2006). A citation revenue sharing agreement between the city and county was developed in which speeders paid the enforcement costs, rather than taxpayers.

Time to implement:

High-visibility enforcement campaigns may require 4 to 6 months to plan, publicize, and implement.

Other considerations:

- *Work Zone speed enforcement:* Researchers found that stationary police vehicles were effective in Indiana work zones, whereas enforcement patrol was ineffective at lowering speeds in work zones (Chen & Tarko, 2012). In addition, using variable message signs upstream of the stationary vehicle, near the beginning of the work zone was also effective. While effectiveness varied by work zone, the general effective length or distance for a stationary police vehicle was about one mile, suggesting that longer work zones may require several police vehicles deployed at intervals of about one mile.
- *Sustained effort is necessary:* Time (and distance) effectiveness is limited, although program publicity may help to generate somewhat longer-lasting effects. Speed enforcement must be continued at frequent intervals as drivers will quickly revert to speeding. Methods making use of enforcement halos such as enforcing a corridor or other area intensely, and then rotating the enforcement to another zone could also be used to maximize enforcement's deterrent effects. As mentioned in the section on Speed Safety Camera Enforcement, researchers determined that the time halo effects were strongly related to the number of site visits per week and the enforcement hours per week (Gouda

& El-Basyouny, 2017b). They used the analysis to estimate an optimal deployment scenario for the jurisdiction (estimated at eight visits a week for 22 hours, approximately 2.7 hours per visit), which they estimated would result in a 5-day effectiveness halo of reduced speeding. Another approach to generate wider deterrence in Queensland was to randomly target moderate to low levels of conspicuous enforcement on an unpredictable basis to a larger share of network roads that account for a significant majority of injury crashes on the entire network (Newstead et al., 2001). Significant reductions of 12% in all severity crashes and 15% in fatal crashes were estimated. Enhancing such an enforcement strategy with more publicity and signs could potentially increase the safety effects.

Other Strategies for Behavior Change

Dynamic Speed Display/Feedback Signs

Effectiveness: ★★★★★	**Cost:** $	**Use:** High	**Time:** Short

Unstaffed speed display devices, also known as speed feedback signs, which can be portable (on trailers) or permanently installed, can show drivers that they are speeding and may encourage some drivers to slow down. These feedback signs (with radar to detect speeds) may also suggest to drivers that speeds are being monitored or enforcement is nearby. Portable changeable message signs (PCMS) are a similar device that can be triggered by speeding but display a message such as "Slow Down Now."

Automated speed display monitors also provide a method to collect location-specific travel speed data. A meta-analysis of dynamic speed feedback devices found that these devices are effective at reducing speed at installation locations for different vehicle types across a variety of roadway contexts (Fisher et al., 2021).

Use:

Use of permanent installations seems to be growing but the actual number of displays and signs in use is unknown. Use of the displays tend to occur in work zones, school zone, transitional zones, and curves.

Effectiveness:

Several studies have shown these signs can slow speeds while in use. A high-quality multi-site study for FHWA has also documented crash reductions. However, speeds seem to rebound quickly downstream and as soon as the devices are removed (Donnell & Cruzado, 2008; Hajbabaie et al., 2011; Walter & Broughton, 2011), prompting recent efforts to evaluate permanent installations. Most studies have evaluated use of these devices in school zones, work zones, and other risky locations such as at curves.

Signs that provided either an implication that speeds were being monitored or a social norms message ("Average Speed" at the site; "Your Speed") were effective at reducing speeds in a 50 km/h (31 mph) zone (Wrapson et al., 2006). Several U.S. studies have found promising reductions of speeds in school zones in response to permanent installations of speed display or changeable message signs (Lee et al., 2006; O'Brien & Simpson, 2012; Rose & Ullman, 2003), and little sign of driver "habituation" to the signs during school hours (O'Brien & Simpson, 2012).

Other studies have shown that speed trailers or portable changeable message signs, which may include speed feedback plus other messages such as "Slow Down Now" when triggered by a threshold speed, can also be effective in reducing speeds in work zones (Brewer et al., 2006; Mattox et al., 2007). In work zones, a combination of a parked police vehicle and speed feedback trailer reduced average and 85th percentile traffic stream speeds and free flow speeds to a similar degree as automated camera enforcement, whereas the effect of speed trailers alone was the same as no treatment. The presence of parked police alone was also effective, but to a lesser extent than the combination of police + trailer or the camera system. The number of speeders above 10 mph over the limit was essentially reduced to zero by both the automated enforcement and police

+ trailer combination. However, the treatment effects on speeds in work zones disappeared within 40 – 50 minutes of removal (Hajbabaie et al., 2011).

Permanently installed dynamic speed display signs also decreased speeds and crashes at rural, two-lane curves (speed limits 50 to 60 mph). A high-quality evaluation of dynamic speed display or curve warning signs installed at 22 rural, two-lane sites in 7 States estimated that crashes were decreased by 5 to 7% (Hallmark et al., 2015). The evaluators tested speed feedback signs and dynamically activated curve warning signs with the message "Slow Down" when motorists exceeded the 50th percentile speed on sites selected for speeding and crash problems. The speed sign displayed the vehicle's actual speed, up to a certain threshold, which was selected to avoid the possibility that displaying actual speeds would encourage some motorists to test their speeds above this level. Once this maximum speed was displayed, the signs replaced the number or message with the actual speed limit or advisory limit. The evaluation found both sign types reduced the average mean speed and proportions of vehicles exceeding by 5, 10, 15, and 20 mph at 1 month, 12 months, and 24 months after installation at most locations. Although trends suggested the speed feedback signs were slightly more effective at reducing speeds at more sites compared to the "slow down" signs, statistical tests could not confirm this trend.

In summary, use of travel speed or other speed feedback messages displayed only when the motorist is exceeding a threshold speed can be effective at slowing speeds when used at locations where drivers can perceive the need to slow (school zones, curves, work zones). Use of visible law enforcement presence may enhance effectiveness. Some drivers may not reduce speed in response to these devices unless they perceive that law enforcement is nearby.

Cost:

Hallmark et al. (2015), identified reliable, durable (would last at least 2 years) systems that cost less than $10,000 per sign for installation, support, and maintenance for a curve-based permanent speed feedback sign evaluation, but some types of signs did experience technical issues. (Signs may be powered with solar panels.)

Time to Implement:

Once law enforcement agencies and engineering safety partners have determined locations where dynamic speed display may help to control speeds, implementation time should be fairly short.

Other considerations:

- *Work zones:* See NCHRP Report 746 (Ullman et al., 2013) for in-depth discussion of advantages, disadvantages, and deployment considerations for various methods of traffic enforcement in work zones. According to this report, there have been insufficient controlled trials to identify the optimal mix of enforcement types and other treatments for different highway types, geometries, and work zone situations. The report reiterates the importance of work zone speed limits that reflect the situation, including the presence of workers or alignment changes. A study of speed controlling strategies before freeway (repaving) work zones in Oregon recommended using a combination of reduced speed limit signs, portable changeable message signs, and speed feedback signs based on reductions in speed achieved with different combinations of these treatments (Gambatese & Zhang, 2014). There is more information about deployment in the report.

Intelligent Speed Assistance

Effectiveness: ★★★	**Cost:** Varies	**Use:** Unknown	**Time:** Varies

A key premise of speed management is that drivers must at all times and locations know what the speed limit is in order to be able to obey that limit. With the complex task of driving and navigating in traffic as well as policies that may encourage minimal posting of speed limit signs (or no posting in areas under default, statutory limits), drivers may need more help knowing the speed limit.

Intelligent speed assistance or intelligent speed adaptation (ISA) involves in-vehicle technologies that use GPS data interacting with accurate, digitally mapped speed limit data for the entire network or vehicle-based speed limit sign recognition. ISA systems can vary from minimal systems that provide information to active speed limit control that could be mandatory or voluntary (i.e., with on/off activation switches). Systems may:

- Provide information only (display the speed limit and changes);
- Provide visual or audible alerts when the speed limit is exceeded, but the driver can decide how to react (termed open system);
- Provide accelerator resistance to make speeding more difficult, but still possible (termed half-open). This system is like cruise control, except the speed limit (not the driver) determines when to engage speed resistance. Drivers may be able to turn off the system with a switch; and
- Automatically prevent speeding above the speed limit (mandatory speed compliance).

Compared to speed governors, which can only limit the maximum speed of vehicles, ISA has the potential to help control speed of all motor vehicle types according to the prevailing limit at a location.

Use:

While ISA has received limited trials in the United States, several vehicles with optional ISA advisory capabilities (open ISA level) are currently available (NTSB, 2017), and ISA systems that limit gas flow to engines are also available on a limited number of newer models (IIHS, 2021a). Internationally, the European Union is further along, having passed legislation in 2019 that will require all new vehicles sold starting 2024 to be fitted with ISA (European Commission, 2021). According to a summary on the SAE International (Visnic, 2019) website, European ISA will work much like cruise control to prevent the vehicle from traveling in excess of the posted speed limit by limiting engine power (and not through automatic braking). The systems will, however, be equipped with on/off switches to encourage public acceptance, but the default status will be “on” each time the vehicle is started. The systems can also be overridden by the driver, who remains in control of the vehicle speed. The EU also updated other vehicle safety measures, including a requirement for event data recorders to show whether the system was being over-ridden at the time of the crash.

Effectiveness:

ISA has been found to lower speeding among drivers using the systems. Varied types of systems have been widely studied in European countries for acceptability and effects on driver behavior.

In Europe, the effects on speeding have been dramatic for both warning and control type ISA systems, decreasing the amount of speeding and narrowing the speed distributions *while the systems are being used* (Biding & Lind, 2002; Carsten, 2012; Lai & Carsten, 2012; van der Pas et al., 2014; Várhelyi et al., 2004). Like other speed control measures, there seems to be little potential for a lasting educational benefit or "training" of drivers to control their speed once the systems are deactivated (Chorton & Conner, 2012; van der Pas et al., 2014; Várhelyi et al., 2004). In a long-term study of 284 drivers using an active accelerator pedal, Várhelyi et al. (2004) found that while driver speeds increased somewhat from initial drops, speeds remained lower over the long-term (5 to 11 months), remained lower when the systems were active, and were significantly lower than that of other drivers. Furthermore, emissions were reduced, and travel times were not significantly increased.

Based on relationships between speed and safety, substantial crash savings are expected (van der Pas et al., 2014). Assuming that the risk of speeding, and speeding-related fatalities and injuries could be virtually eliminated among those using the systems, Vaa et al. (2014) estimated that ISA was the most effective driver support system for saving lives and reducing injuries compared to speed governors, adaptive cruise control, electronic stability control, and other non-speed-related driver systems such as alcohol interlock technologies. The European Transport Safety Council estimated that the upcoming fitting of ISA on all cars, vans, buses, and heavy goods vehicles will eventually cut road deaths by 20% across the European Union countries.

In U.S. trials involving young drivers and repeat speeding violators, results have also found reductions in speeding and compliance with speed limits. Researchers developed and pilot-tested a half-open system (increased accelerator counter pressure) when the limit was exceeded by young drivers 18 to 24 years old—22 in the experimental group (with system on for half the drives) and 22 in the control group with no ISA (Blomberg et al., 2015). The experimental group showed less speeding on drives when the ISA was activated compared to not activated and compared to the control group. The researchers also assessed user perceptions of the performance and "likability" of the system. In general, performance was rated more highly than likeability-related factors. De Leonardis et al. (2014) also found significant reductions (22%) in the average amount of trip distance that 78 Maryland drivers with prior speeding citations sped during a 4-week treatment period compared to baseline driving. Only alerts were given in this system. However, as in other trials, speeding began rebounding within 2 weeks of alerts being discontinued. In another U.S. study of 85 teen drivers randomly assigned to different groups, the only condition that achieved reduced speeding behavior was when an in-vehicle system alerted the teens to the speeding, parents received reports on the unsafe behaviors, and teens believed the parents would *not* be notified if they corrected the speeding (Farmer et al., 2010). Again, there were no lasting effects on speeding behavior once the systems were inactivated.

There is a need to provide current and accurate maps of speed limits (Carsten, 2012), and to have reliable speed limit sign-reading camera and related technologies (NTSB, 2017), as well as to have the technologies installed in new vehicles or retrofitted to older vehicles. Speed limit maps currently must be purchased by vehicle owners in the United States. According to information provided to the NTSB by vehicle manufacturers providing ISA systems, updated maps may not be regularly purchased by U.S. owners (and maps may also be updated only once per year) (NTSB, 2017). Newer technologies could also make use of speed limit sign-reading technologies.

Other uncertainties still exist about the rate of driver adoption of the technologies, driver behaviors or potential adaptations over time, and even external forces that may potentially affect the costs and benefits of ISA (van der Pas et al., 2012). For example, only about half of Swedish drivers in one study indicated they would accept a non-driver controlled ISA system in their cars, whereas a majority would accept it as a driver-controlled system (Várhelyi & Mäkinen, 2001). Other evidence suggests that prospects for wide-spread voluntary adoption of ISA, even with financial incentives such as reduced insurance premiums or vehicle price discounts, may be limited (Vaa et al., 2014).

Estimates of speed and safety relationships suggest widespread or universal deployment of ISA could lead to significant crash, fatality, and injury reductions. The largest safety benefits for various types of potential ISA roll-outs, would likely be for systems requiring mandatory speed limit compliance that cannot be over-ridden by the driver or turned off (Carsten & Tate, 2001). In addition, dynamic systems that could react to variable conditions such as surface friction and traffic, as well as fixed and variable speed limits, could yield maximum crash savings – up to 15 times the cost to implement and run the system per some estimates (Carsten & Tate, 2001). Requiring ISA for higher risk groups (younger drivers, professional drivers, drivers convicted of serious speeding offenses) was deemed most cost-effective among partial ISA roll-outs (Vaa et al., 2014).

Other considerations:

- *Voluntary (driver-controlled) systems:* Relying on voluntary adoption may not be sufficient to achieve consistent use by serious offenders or younger driver groups who may benefit most from ISA. Serious offenders were more likely to disable or over-ride ISA than other drivers (van der Pas et al., 2014). Younger drivers may also be less likely to adopt ISA, even with incentives (Chorlton et al., 2012; Lahrmann et al., 2012), although it is possible that the right level or type of incentives have not been identified. Once the systems are in use, feedback on rewards/incentives should be in real time. Also, while most previous violator participants in the Maryland study seemed to accept the ISA systems, they also expressed concerns about providing driving speed data to insurance or licensing agencies. They anticipated negative consequences, including the potential for revocation of their driver licenses and increased insurance premiums. Such concerns would need to be addressed to encourage drivers to voluntarily use such a system to help control their speed (De Leonardis et al., 2014).
- *Rewards:* Although several field tests from Europe found that drivers exceeded limits less when offered economic incentives such as reduced insurance premiums or discounts (for lease vehicles), the interaction of incentives with ISA or use of incentives alone to encourage safer drivers has met with mixed results. Incentives combined with ISA or ISA alone contributed to less speeding among a group of Danish volunteers, but incentives alone had a small effect (Lahrmann et al., 2012). Furthermore, the researchers were unable to recruit sufficient volunteers based on the promise of these incentives. Conversely, Reagan et al. (2013) found that a modest monetary incentive alone, when displayed in real time in the vehicle to an already recruited sample of younger U.S. drivers, achieved significantly more compliance with speed limits. A system of increasing intensity of alerts alone also decreased speeding. The study excluded drivers

with less than 5 years driving experience or with prior convictions or suspensions for impaired or reckless driving (arguably the groups most in need of the intervention).

- In other studies of incentives, lease cars in the Netherlands were equipped with technology that continuously monitored and displayed whether drivers were allowing a safe following distance and complying with the speed limit but did not otherwise intervene. Rewards were given by the lease company for good driving behavior over a 16-week period. Drivers were about 20% more likely to drive within posted speed limits and 25% more likely to maintain adequate following distances when receiving feedback and rewards (Mazureck & van Hattem, 2006). A pay-as-you drive plan to save young drivers' insurance costs also reduced the percentage of miles that young drivers exceeded the limit by 14% (Bolderdijk et al., 2011).
- *Related technologies:* Adaptive cruise control (ACC) works similarly to standard cruise control, except that, in addition to maintaining a speed set by the driver, a radar system in the front of the vehicle detects and responds to other vehicles in the lane ahead to maintain a safe following distance. A study involving 40 Boston area drivers found that drivers using ACC were *more* likely to speed on interstates and freeways, and by a higher degree than when manually controlling the vehicle's speed (Monfort et al., 2022). The vehicles in the study allowed the drivers to easily modify their speed up or down by 5 mph using a toggle control, which may have contributed to the results observed. These findings highlight the importance of details, and human adaptation to the way systems are designed as well as voluntary efforts to control speeding behavior. ITS may not suffer from these effects since the vehicle detects the speed limit from signs or from speed limit geo-databases. However, designers, evaluators, and policymakers should be attuned to the potential for other unintended adaptations or effects.
- *Need for political action:* The main roadblock to implementation may be political, rather than safety or technological reasons (Carsten, 2012). Policymakers are ever attuned to public perception and pushback. More State and national-level discussion and communication about the dangers of speed, and the most effective strategies for controlling speeding may be needed.

Approaches That Are Unproven or Need Further Evaluation

Aggressive Driving and Other Laws

Aggressive driving actions are covered by specific traffic laws, such as the laws regarding speeding, improper lane changes, and following too closely, or by general laws, such as those that target reckless driving, or specific aggressive driving statutes. It has proven challenging to arrive at a consensus for a definition of aggressive driving, and hence to come up with enforceable laws. Not every moving violation is aggressive driving. However, violations that encroach on others' safe space, such as driving much faster than prevailing speeds, following too closely, making unsafe lane changes, and running red lights, either on one occasion or over a period of time, may indicate a pattern of aggressive driving. Although some States have passed laws criminalizing aggressive driving, it should not be confused with road rage, which is an intentional assault by a driver or passenger with a motor vehicle or a weapon that occurs on the roadway or is precipitated by an incident on the roadway.

Most existing reckless driving statutes carry relatively minor penalties and aggressive driving laws may be difficult to prosecute (Flango & Keith, 2004). Aggressive drivers, as distinct from aggressive driving, often can be identified as those who violate traffic laws repeatedly or whose violations lead to crashes producing serious injury or death. Existing statutes, including reckless driving laws, may be strengthened or aggressive driving laws may be enacted (Newman, Pfefer, Slack, Hardy, Raub, et al., 2003). Currently, there is no evidence that aggressive driving laws affect aggressive driving and related crashes.

Diversion and Plea Agreements /Traffic Violator School

In many jurisdictions, drivers who have accumulated a specific number of demerit points on their driver's licenses are given the option of attending Traffic Violator School to reduce their punishment. In most instances, if they complete Traffic Violator School, their traffic offenses are dismissed or removed from their driving record (Masten & Peck, 2004).

Negotiated plea agreements are a necessary part of an effective and efficient court system. However, plea agreements may allow offenders to have their penalties reduced or eliminated (Masten & Peck, 2004), and may introduce unequal treatment of offenders into the system. Evidence suggests that programs that allow reductions in charges or diverting problem drivers to Traffic Violator Schools in exchange for reduced sanctions (points or license suspension/ revocation) are unlikely to be effective for improving safety and may have counteractive effects (Gerbers, 2010; Masten & Peck, 2004).

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5. Distracted Driving

Overview

Distracted driving has received a great deal of attention over the last decade. Although much of the attention and research has concentrated on cell phones and texting, that is just one of many potential distractions behind the wheel. NHTSA defines distracted driving as "any activity that diverts attention from driving, including talking or texting on your phone, eating and drinking, talking to people in your vehicle, fiddling with the stereo, entertainment or navigation system—anything that takes your attention away from the task of safe driving" (NHTSA, n.d.-a). Distractions can take many forms. Some activities may take a driver's eyes off the road (visual distraction), the driver's mind off the task of driving (cognitive distraction), or the driver's hands off the wheel (manual distraction) with some behaviors, including texting, combine all three categories of distraction. NHTSA estimates that distracted driving contributed to 3,522 fatalities during 2021, or 8% of all traffic fatalities (NCSA, 2023).

Understanding the Problem

The public perceives driver distraction to be a serious traffic safety issue. In 2020 the AAAFTS (2021) surveyed more than 2,800 U.S. motorists and found that 96% of respondents said using a cell phone to text or email while driving was extremely or very dangerous. Similarly, in 2015 NHTSA conducted 6,001 telephone interviews and asked respondents how safe they would feel in a variety of situations in which they are passengers in vehicles operated by drivers who are engaged in other activities. Almost two-thirds (65%) said they would feel "somewhat" or "very" unsafe if the driver talked on a handheld cell phone, and almost all (95%) would feel unsafe if the driver sent text messages or emails (Schroeder et al., 2018).

Although people are concerned about distracted driving, they frequently admit to engaging in such behaviors behind the wheel. In the AAAFTS (2021) survey, 37% of respondents admitted to talking on the phone while driving during the past 30 days. Thirty-four percent admitted to reading a text or email while driving, while 23% had manually typed or sent an email or text message. The NHTSA survey also asked about a variety of behaviors related to distracted driving (Schroeder et al., 2018). Among the behaviors that drivers reported doing at least sometimes:

- 82% talked to other passengers;
- 68% adjusted the car radio;
- 48% ate or drank;
- 42% interacted with children in the back seat;
- 38% made or accepted phone calls;
- 36% used a navigational system;
- 12% read email or text messages;
- 9% sent text messages or email;
- 5% took pictures with phones.

People perceive the use of hands-free devices as less risky than handheld devices. Nearly half (47%) of the respondents in the NHTSA survey reported feeling safe if the driver was using a hands-free cell phone to make or answer calls, compared to just 35% for handheld phones (Schroeder et al., 2018).

Each year, NHTSA conducts a nationwide observational survey of driver electronic device use—the NOPUS. Observations are conducted by trained data collectors from 7 a.m. to 6 p.m. During 2021 an estimated 7.6% of drivers were using some type of phone (handheld or hands-free) at any given moment during the daytime (NCSA, 2022). Among different subgroups, observed cell phone use while driving was higher among females, younger drivers, drivers in urban areas, and drivers who were not carrying passengers.

More than one factor can affect drivers' decisions to engage in distracted driving. Most often, the perceived benefits outweigh the perceived risks (Lissy et al., 2000). A study of 249 university undergraduate students reported that the perceived benefits of cell phone conversations while driving include less boredom and the feeling of "getting more done" (Sanbonmatsu et al., 2016). Students who reported using their cell phones while driving were also more likely to perceive higher ability to drive when distracted for themselves and others. Unsurprisingly, these students were also less likely to support legislation to restrict cell phone use while driving. The presence of legislation regulating cell phone use does not necessarily prevent drivers from engaging in such behaviors. An analysis of reported cell phone use among U.S. adolescent drivers (16-18 years) was conducted using the 2011 to 2014 Traffic Safety Culture surveys. The study found that legislation banning handheld phone use may lower the incidence of reported phone conversations in this population; however, texting bans were not associated with similar decreases in reported texting behaviors while driving (Rudisill et al., 2018).

The role of distraction in crashes is difficult to ascertain. Pre-crash distractions often leave no evidence for law enforcement officers or crash investigators to observe, and drivers are often reluctant to admit to having been distracted prior to a crash. Distraction-affected crashes is a measure that focuses on distractions that are most likely to influence crash involvement, such as dialing a cell phone or texting, and distraction by an outside person/event (NHTSA, 2012). According to NHTSA's National Center for Statistics and Analysis, there were 3,522 fatalities in distraction-affected crashes in 2021, an increase of 368 fatalities in comparison to 2020 (NCSA, 2023). Eight percent of all fatal crashes in 2021 were distraction-affected crashes.

Additionally, police crash reports vary across jurisdictions in reporting distracted driving. Some jurisdictions identify distraction as a distinct field in the reports, whereas others identify distraction in the crash narrative. This inconsistency in reporting leads to wide variation in the number of distracted driving crashes between States.

The risks posed by specific distracted driving behaviors are beginning to be understood thanks to naturalistic driving studies that use onboard sensors and cameras to capture data right before crashes as well as during normal driving situations. The Second Strategic Highway Research Program Naturalistic Driving Study (SHRP2 NDS) included 3,500 participants, 35 million miles of continuous driving data, and 905 injury and PDO crashes. Researchers have used SHRP2 data to examine the crash risk associated with various observable distractions compared to regular driving (Dingus et al., 2016). The table below shows the change in crash risk when drivers are engaged in potentially distracting behaviors. For example, using a handheld cell phone increases the risk of a crash 3.6 times compared to not using a phone. The table also shows baseline percentage of time drivers engaged in a distracting task while driving. The distractions that increased risk the most were dialing a handheld phone, texting, reading/writing, reaching for an object, and looking at an object outside the vehicle. Each of these involves several sources of distraction. For example, dialing or texting on a handheld cell phone takes a driver's hands, eyes, and attention away from the task of driving. Talking on a handheld phone did not increase crash risk to the same extent, but drivers engaged in this behavior more often than other types of distractions.

Table 5-1. Estimated Change in Crash Risk When Engaging in Potentially Distracting Behaviors, SHRP2 Study of U.S. Drivers

Type of Distraction	**Change in Risk (Odds Ratio, 95% CI)**	**Baseline Prevalence**
Total handheld cell phone use	*3.6 (2.9 – 4.5)*	*6.4%*
Dialing	12.2 (5.6 – 26.4)	0.1%
Texting	6.1 (4.5 – 8.2)	1.9%
Reaching	4.8 (2.7 – 8.4)	0.6%
Browsing	2.7 (1.5 – 5.1)	0.7%
Talking	2.2 (1.6 – 3.1)	3.2%
Total in-vehicle device use	*2.5 (1.8 - 3.4)*	*3.5%*
Adjusting the climate controls	2.3 (1.1 – 5.0)	0.6%
Adjusting the radio	1.9 (1.2 – 3.0)	2.2%
Adjusting other device (e.g., touchscreen)	4.6 (2.9 – 7.4)	0.8%
Reading/writing (including tablet)	9.9 (3.6 – 26.9)	0.1%
Reaching for object (other than cell phone)	9.1 (6.5 – 12.6)	1.1%
Looking at outside object	7.1 (4.8 – 10.4)	0.9%
Eating	1.8 (1.1 – 2.9)	1.9%

Source: Dingus et al. (2016).

A recent study focused on the relationship between drivers' handheld cell phone use and subsequent crash involvement. Owens et al. (2018) performed a case-crossover analysis using the SHRP2 NDS data. A total of 566 crashes of varying severity were matched to 1,749 instances of normal driving on variables including the subject driver, weather, time of day, and speed. The use of handheld cell phones in general, and specifically performing tasks with visual and manual elements (such as texting) were significantly associated with increased crash involvement (excluding crashes where the driver was struck from behind). Of the visual-manual tasks, texting was significantly associated with increased crash involvement. The table below presents these changes in crash involvement when using a handheld cell phone relative to driving without performing secondary tasks.

Table 5-2. Estimated Change in Crash Risk When Using a Handheld Cell Phone Relative to Driving Without Performing Secondary Tasks

Type of Distraction	**Change in Risk (Odds Ratio, 95% CI)**
Any cell phone use	*1.80 (1.06 - 3.07)*
Overall visual-manual tasks	2.19 (1.19 – 4.02)
Texting	2.54 (1.18 – 5.50)

Source: Owens et al. (2018).

The study also found that increases in crash involvement associated with visual-manual tasks were greater for crashes in free-flow traffic. Rear-end crashes and run-off road crashes were more prevalent in the crash data than other types of crashes; drivers' visual-manual cell phone interactions were associated with increased instances of both these crash types. Run-off road crashes were also significantly associated with any cell phone use (Owens et al., 2018). There are differences between the Owens et al. study and the Dingus et al. study as to what was controlled for, but the differences in odds ratios indicate that more research is needed.

Another naturalistic study was conducted from 2007 to 2015 with approximately 15,000 teen drivers (16 to 19 years old). Videos of a total of 2,229 moderate to severe crashes were analyzed (Carney et al., 2018). About 59% of these crashes involved teen drivers who were distracted in the 6 seconds prior to a crash. The most common distractions included attending to passengers (15%), using a cell phone for any purpose (12%), or attending/reaching inside the vehicle (11%). Similarly, Klauer et al. (2014) used a naturalistic study to examine distracted behaviors and their effects on the risk of being involved in a crash or near crash among 42 newly licensed (novice) drivers. Some of the findings are shown in the table below. Novices were eight times more likely to be involved in a crash or near crash when dialing a cell phone and seven times more likely to be involved in a crash or near crash when reaching for a cell phone. These findings are consistent with the SHRP2 NDS study described above and demonstrate that the risks posed by various types of distraction are problematic for young drivers just as they are for the general driving population.

Table 5-3. Estimated Change in Crash Risk When Engaging in Potentially Distracting Behaviors, Newly Licensed (Novice) Drivers

Type of Distraction	**Change in Risk (Odds Ratio, 95% CI)**
Using a cell phone	
Dialing	8.3 (2.8 – 24.4)
Reaching for phone	7.1 (2.6 – 18.9)

Type of Distraction	Change in Risk (Odds Ratio, 95% CI)
Texting	3.9 (1.6 – 9.3)
Reaching for object (other than cell phone)	8.0 (3.7 – 17.5)
Looking at outside object	3.9 (1.7 – 8.8)
Eating	3.0 (1.3 – 6.9)

Source: Klauer et al. (2014).

None of the distractions listed in the tables above are easily addressed by current behavioral countermeasures, to limit distracted driving. One reason is it is difficult to convince or require drivers to avoid distractions while driving. Many drivers consider some distractions, such as eating or drinking, listening to the radio, or talking on a cell phone, to be important activities and they are unlikely to give them up. Moreover, studies indicate that drivers themselves are poor judges of the performance decrements that result from distracting activities (Horrey et al., 2008). The 2015 NHTSA survey found that a large portion of drivers do not believe that their driving performance is affected by cell phone use, and that over half of drivers who talk on the phone while driving believe that their driving is the same while using a cell phone (Schroeder et al., 2018).

Few studies have examined if the standard behavioral countermeasures of laws, enforcement, and sanctions (which are used successfully for impaired driving, seat belt use, and speeding) are effective for distracted drivers. The results of three NHTSA demonstration projects, focused on HVE that includes paid and earned media, suggest that these elements show promise in reducing the use of handheld phones and texting (Cosgrove et al., 2011). With respect to young drivers, some States address distracted driving through graduated driver licensing provisions such as limiting teenage passengers, or by restricting cell phone use.

Job-related distracted driving may be addressed through employer policies and programs. Employer-based resources are available from the Network of Employers for Traffic Safety through trafficsafety.org. The National Safety Council (NSC) provides resources to employers, including an online distracted driving course at www.nsc.org/safety-training/defensive-driving/courses/online/distracted and the National Distracted Driving Committee has sample employer policies at https://usnddc.org/downloads/.

Although behavioral countermeasures are limited, several engineering strategies have the potential to address distracted driving. Rumble strips, both on the shoulder and the centerline, have demonstrated their effectiveness in preventing crashes associated with inattention (Persaud et al., 2016). Engineering countermeasures are not discussed in this guide because they generally do not fall under the jurisdiction of SHSOs.

Data/Surveillance

Practitioners and researchers need high-quality data both to identify problems and to evaluate how well countermeasures are working. Unfortunately, it is challenging to collect accurate data about the role of distracted driving in crashes. NHTSA estimates that distracted driving contributed to 3,522 fatalities during 2021, or 8% of all traffic fatalities (NCSA, 2023). However, in-depth investigations of fatal crashes in Norway from 2011 to 2015 found that inattention among at-fault drivers contributed to almost one-third of these crashes (Sundfør et al., 2019). Similarly, naturalistic driving studies suggest distraction may be much more common than what is typically found in crash data. For example, researchers at the University of Iowa examined 1,691 crashes involving drivers 16 to 19 who were participating in a study using in-vehicle recording devices. The devices captured forward view and in-cab video during the 6 seconds preceding each crash. The researchers selected crashes where the teen struck another vehicle or object. (Crashes in which the teen's vehicle was struck from behind were excluded.) Overall, drivers were engaged in some type of potentially distracting behavior prior to 58% of these crashes. The most common distractions were attending to passengers and cell phones (Carney et al., 2015). In another study using instrumented vehicles, drivers in 40% of truck crashes and 56% of motorcoach crashes were involved in some type of potentially distracting behavior prior to the crash (Hammond, Soccolich, & Hanowski, 2019). Taken together, these studies suggest that potentially distracting behaviors are more common than what appears in official statistics based on police reports.

To the extent possible, States should strive to improve crash data collection related to distraction. The fifth edition of Model Minimum Uniform Crash Criteria (2017) recommends that crash reports include the following driver behaviors: not distracted; talking/listening; manually operating (texting, dialing, playing game, etc.); other action; unknown. Additionally, the criteria recommend that crash reports include the following sources of distraction: hands-free mobile phone; hand-held mobile phone; other electronic device; vehicle-integrated device; passenger/other non-motorist; external (to vehicle/nonmotorist area); other distraction (animal, food, grooming); not applicable (not distracted); unknown. Training for law enforcement officers is also critical to ensure they understand distracted driving laws and accurately record distracted driving when conducting crash investigations (National Traffic Law Center, 2017).

Emerging Issues

New technologies such as lane departure warning, forward collision warning, and autonomous braking hold promise for reducing crashes among drivers who are inattentive (IIHS, 2012, 2014). Such technologies, once available only in luxury brands, are now offered in many new vehicles. Additionally, in-vehicle technology in the future may be able to detect driver distraction by monitoring driver performance and then alerting drivers (Aghaei et al., 2016; Donmez et al., 2007; Koesdwiady et al., 2016; Kuo et al., 2019). On the other hand, built-in technologies such as navigation and entertainment systems in vehicles may create more potential distractions (Strayer et al., 2017). NHTSA developed Visual-Manual Driver Distraction Guidelines for In-Vehicle Electronic Devices pertaining to original equipment in-vehicle electronic devices (Visual-manual NHTSA driver distraction guidelines for in-vehicle electronic devices, 2013). Although voluntary, the Guidelines encourage automobile manufacturers to design in-vehicle devices so that potentially distracting tasks are limited while driving.

Many smartphone applications are able to restrict or limit access to electronic devices while driving, such as the "Do Not Disturb While Driving" or "Driving Focus" feature for iPhone. Incoming calls, texts, and notifications are silenced when the vehicle is in motion. Research shows this type of "blocking" technology reduces the number of interactions drivers have with their phones (Albert & Lotan, 2019). However, these apps are voluntary and must be activated by users. A nationally representative survey of 800 iPhone owners conducted by the IIHS found that only 1 in 5 had the feature set to activate automatically when they drive (Reagan & Cicchino, 2020). Surveys suggest that while some drivers may be willing to block visual/manual interactions with a phone while driving (e.g., texting and browsing), they want to retain the ability to use navigation, listen to music, and use Bluetooth (Oviedo-Trespalacios et al., 2019).

Another growing safety concern is distraction among pedestrians who are using electronic devices in the roadway environment. A literature review from NHTSA found that, based on the limited available research, distraction is associated with a small, but statistically significant decrease in pedestrian safety (Scopatz & Zhou, 2016). This issue is discussed in more detail in the chapter on Pedestrian Safety.

Key Resources

- The AAAFTS has prepared a brief summary describing the effectiveness of educational/behavioral, legislative, and technology countermeasures aimed at distracted driving (Arnold et al., 2019): https://aaafoundation.org/wp-content/uploads/2019/11/19-0553_AAAFTS-DD-Countermeasures-Brief_r3.pdf
- NHTSA (n.d.-a) programs, statistics, and other resources about distracted driving are available at its web page and portal at www.nhtsa.gov/risky-driving/distracted-driving
- NHTSA's Driver Distraction: A Review of the Current State-of-Knowledge (Ranney, 2008): www.nhtsa.gov/sites/nhtsa.dot.gov/files/810787_0.pdf
- NHTSA's *Understanding the Effects of Distracted Driving and Developing Strategies to Reduce Resulting Deaths and Injuries: A Report to Congress* (Vegega et al., 2013) that describes NHTSA-funded studies to address the problem of distracted driving: https://rosap.ntl.bts.gov/view/dot/1999
- NCHRP has a guide for addressing collisions involving distracted or fatigued drivers in support of the AASHTO Strategic Highway Safety Plan, *A Guide for Reducing Crashes Involving Drowsy and Distracted Drivers*: Volume 14: Guidance for Implementation of the AASHTO Strategic Highway Safety Plan (Stutts et al., 2005): https://download.nap.edu/cart/download.cgi?record_id=23420
- GHSA's survey (2006) of all 50 States to determine what efforts States are pursuing to address distracted driving: www.ghsa.org/sites/default/files/2016-12/2013_distraction.pdf

Distracted Driving Countermeasures

Legislation and Licensing

Countermeasure	Effectiveness	Cost	Use	Time
GDL Passenger Limits for Young Drivers	★★★★★	$	High	Medium
Cell Phone Laws	★★	$	Medium	Short

Enforcement

Countermeasure	Effectiveness	Cost	Use	Time
High-Visibility Cell Phone Enforcement	★★★★	$$$	Low	Medium

Other Strategies for Behavior Change

Countermeasure	Effectiveness	Cost	Use	Time
Employer Programs	★★	$	Unknown	Short

Approaches That Are Unproven or Need Further Evaluation

Countermeasure
Communications on Outreach and Distracted Driving

Effectiveness:

★★★★★	Demonstrated to be effective by several high-quality evaluations with consistent results.
★★★★	Demonstrated to be effective in certain situations.
★★★	Likely to be effective based on balance of evidence from high-quality evaluations.
★★	Limited evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.
★	No evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.

Cost to implement:

$$$	Requires extensive new facilities, staff, equipment, or publicity, or makes heavy demands on current resources.
$$	Requires some additional staff time, equipment, facilities, and/or publicity.
$	Can be implemented with current staff, perhaps with training; limited costs for equipment or facilities.

These estimates do not include the costs of enacting legislation or establishing policies.

Use:

High	More than two-thirds of the States, or a substantial majority of communities
Medium	One-third to two-thirds of the States or communities
Low	Less than one-third of the States or communities
Unknown	Data not available

Time to implement:

Long	More than 1 year
Medium	More than 3 months but less than 1 year
Short	3 months or less

These estimates do not include the time required to enact legislation or establish policies.

Legislation and Licensing

GDL Passenger Limits for Young Drivers

Effectiveness: ★★★★★	**Cost:** $	**Use:** High	**Time:** Medium

Studies suggest teenagers and adults are similar in terms of how often they engage in potentially distracting activities while driving (Foss & Goodwin, 2014; Klauer et al., 2014). However, teenagers are at higher risk for a crash when engaged in distracting activities compared to adults (Klauer et al., 2014). Driving requires more of their deliberate attention compared to experienced drivers (Lansdown, 2002). Moreover, key areas of the brain are still developing during adolescence, making it difficult for teenagers to manage potential distractions (Keating, 2007).

Passenger restrictions are a key element of graduated driver licensing (GDL) that reduce the likelihood of distractions for newly licensed drivers. Passengers, especially teenage passengers, are a major source of distraction for young, beginning drivers (Foss & Goodwin, 2014). The NCHRP guide for reducing crashes involving young drivers describes key provisions of GDL laws (Goodwin et al., 2007). The Insurance Institute for Highway Safety (2021a) and the Governors Highway Safety Association (2021) summarize State GDL laws. These summaries are updated monthly. See the chapter on Young Drivers for a complete discussion of GDL.

Use:

As of June 2021 all 50 States and the District of Columbia had some GDL components in place. Laws in 46 States and the District of Columbia limit the number of passengers allowed with a driver with a provisional license (IIHS, 2021a).

Effectiveness:

Many studies have documented that GDL in general, and passenger restrictions in particular, reduce teenage driver crashes and injuries (Chaudhary et al., 2018; Goodwin et al., 2007; Hedlund & Compton, 2005; Williams, 2007a). In an analysis of naturalistic driving data, the most frequently seen driving behavior leading up to a teen crash was attending to passengers (Carney et al., 2015). Limiting the number of young passengers to none or one significantly decreases crash risk and injuries (Masten et al., 2013; McCartt et al., 2010; McCartt & Teoh, 2015; Zhu et al., 2016). See the chapter on Young Drivers for more information.

Cost:

Costs are minimal. Information about GDL restrictions can be provided through driver education courses, licensing offices, schools, and other settings.

Time to implement:

GDL passenger restriction changes require several months to implement for drivers receiving a provisional license. They then will take 1 or 2 years before all provisionally licensed drivers are subject to the new restrictions.

Cell Phone Laws

Effectiveness: ★★	**Cost:** $	**Use:** Medium	**Time:** Short

Cell phones have become an essential feature of modern life. In a 2015 NHTSA survey of more than 6,000 U.S. residents, 42% admitted to answering phone calls while driving and 56% of these drivers continued driving while talking on the phone (Schroeder et al., 2018). NHTSA's 2021 national observation survey found 2.5% of drivers on the road at any given moment were talking on a handheld cell phone (NCSA, 2022). NHTSA currently estimates that 7.6% of drivers are using some type of phone (handheld or hands-free) in a typical daylight moment. These estimates may underrepresent cell phone use given the inherent difficulty in accurately observing these behaviors.

Many studies have investigated the effects of cell phone use on driving (See Caird et al., 2018, and McCartt et al., 2006, for reviews). Experiments on simulators or test tracks indicate that talking on a cell phone has some effect on driving performance, most commonly slowed reaction times, but these experiments cannot measure the impact on crash risk. Analyses of crash events using SHRP2 NDS data found that talking on a cell phone doubled the odds of the driver being involved in a crash (Dingus et al., 2016). Reaching for a phone, texting, and dialing a phone increased crash risk even more—by 5 times, 6 times, and 12 times, respectively. The elevated risk of a crash was much higher when operating a phone in comparison to more traditional sources of distraction such as tuning a radio or talking to a passenger. Dialing and texting are particularly dangerous behaviors because they take a driver's eyes, hands, and attention away from the task of driving. Experimental studies using driving simulators suggest that texting drivers spend up to 400% more time looking away from the road and are more likely to leave their lane than when not text messaging (Drews et al., 2009; Hosking et al., 2009). Finally, studies have found that hands-free phones offer little or no safety advantage over handheld phones (Caird et al., 2018; Ishigami & Klein, 2009; McEvoy et al., 2005; Redelmeier & Tibshirani, 1997). However, comparing the results of several studies, the risks associated with talking on a cell phone has conflicting results in the literature.

States have been very active in using legislation to address this issue. Since 2000 every State has considered legislation to curtail distracted driving or driver cell phone use. In 2020 legislators in 41 States considered more than 115 bills related to distracted driving (Bloch et al., 2021). As of November 2021 talking on a handheld cell phone was prohibited in 24 States (IIHS, 2021b). No State completely bans all types of cell phone use for all drivers. Bans on texting are more common than bans on handheld cell phone use. Overall, public support is high for this legislation. In surveys of the general public from 70% to 80% favor bans on handheld cell phone use, and 88% to 97% support bans on texting while driving (AAAFTS, 2018; Guarino, 2013; Schroeder et al., 2018).

Drivers' attitudes and beliefs about the safety of using a cell phone while driving are incongruous with their actions. Maher & Ott (2013) found that drivers in New Jersey are knowledgeable about the law and assert that the law is necessary; however, a significant portion of these drivers also admitted to having violated the law. A more recent national survey indicates that communication of the existence of State laws has generally been effective (Schroeder et al., 2018). Just over 90% of drivers in States that have laws banning cell phones know that these laws are in place. However, driver perceptions are less accurate in States without these laws, where just over half of drivers incorrectly believe that their State has such a law. Driver responses also suggest that communication efforts have fostered the perception that drivers are at risk of getting stopped for cell phone use. Specifically, over half of drivers think they are very or somewhat likely to get a ticket for talking on a cell phone while driving, while only 3.6% of drivers report ever having been stopped for engaging in this behavior (Schroeder et al., 2018).

Use:

As of November 2021 talking on a handheld cell phone was prohibited in 24 States (IIHS, 2021b). The cell phone bans in each of these States are primary laws. In addition, several local jurisdictions such as Hampton, Virginia, and Cheyenne, Wyoming, have enacted their own restrictions on cell phones. Most States prohibit text messaging while driving. As of November 2021 there were 48 States and the District of Columbia that prohibit text messaging for all drivers (IIHS, 2021b).

Effectiveness:

Evaluations in New York, Connecticut, the District of Columbia, and in other countries consistently show that cell phone laws reduce handheld phone use by about 50% shortly after the laws take effect (McCartt et al., 2006). However, a review and synthesis of 11 peer-reviewed articles found that, while bans are highly effective at reducing cell phone use while driving, the effect on crash outcomes is mixed (McCartt et al., 2014). Some studies showed no change in crash rates for both handheld cell phone use and texting, while others showed increases in crashes after the ban (although most of the studies reviewed had limitations that diminish the strength of their conclusions). These findings suggest that the impact on crash rates from cell phone bans is not clear, even though such bans are effective at reducing handheld cell phone use. Additionally, in a review of 11 articles Ehsani et al. (2016) found that cell phone restrictions do not appear to result in a long-term deterrence of cell phone use among young drivers.

For example, with respect to laws banning handheld cell phone use, a study by the Highway Loss Data Institute (HLDI) investigated State-level automobile insurance collision claims in California, Connecticut, New York, and the District of Columbia. When compared to neighboring States, there was no change in collision claim frequency after these jurisdictions implemented handheld cell phone bans. The data from HLDI is proprietary, and not all crashes result in a collision claim, so collision claim rates may differ from crash rates (HLDI, 2009). Liu et al. (2019) looked specifically at crashes caused by cell phone use before and after a handheld ban was enacted in California in 2008. They found a 66% reduction in crashes caused by handheld phone use after the ban took effect, but a slight increase in crashes involving hands-free phones. This suggests some drivers may have switched from handheld to hands-free phones after the ban. However, cell phones caused only a tiny fraction of all crashes (less than 1%), suggesting these crashes were severely underreported in the data.

Several studies have examined the effectiveness of laws prohibiting texting while driving. One study evaluated the effect of a texting ban in Michigan (Ehsani et al., 2014); another examined insurance collision claims in States with texting bans compared to neighboring States without such bans (HLDI, 2011). Both studies found small *increases* in various types of crashes and collision claims following enactment of texting bans. One possible explanation is that texting drivers attempt to avoid detection by hiding their phones from view, which may result in more time with drivers' eyes off the roadway. Crash increases were also found in a study of crash data in New Jersey (Maher & Ott, 2013). While crashes declined statewide, cell phone-related crashes increased after a cell phone and texting law was enacted. In contrast to these studies, another study of 16 States found a 4% reduction in motor vehicle-related emergency department visits in States that had texting bans (Ferdinand et al., 2019).

Cost:

As with any law, costs are required to publicize and enforce it. A handheld cell phone law can be enforced during regular traffic patrol because drivers who are using a handheld phone can be observed relatively easily. However, some States with cell phone bans allow drivers to use a phone for specific purposes while driving (e.g., navigation), which can make enforcement more challenging. As with other traffic safety laws, paid and earned advertising supporting highly visible law enforcement may be necessary to achieve substantial effects.

Time to implement:

A cell phone law can be implemented quickly. Publicizing the law is important and will take longer.

Other considerations:

- *Cell phone bans for young drivers:* Thirty-six States and the District of Columbia have phone use bans specifically targeting young drivers. Sometimes these restrictions are included in a State's GDL system. However, evaluations of cell phone restrictions specific to teenage drivers suggest these restrictions have little effect on cell phone use (Ehsani et al., 2016; Foss et al., 2009; Goodwin et al., 2012).

Enforcement

High-Visibility Cell Phone Enforcement

Effectiveness: ★★★★	**Cost:** $$$	**Use:** Low	**Time:** Medium

Numerous studies demonstrate that HVE can be effective in curbing alcohol-impaired driving and increasing seat belt use among drivers (see the chapters on Alcohol-Impaired Driving and Seat Belts and Child Restraints). NHTSA has examined whether the HVE model could be effective in reducing handheld cell phone use and texting among drivers.

The objective is to deter cell phone use by increasing the perceived risk of getting caught. The HVE model combines dedicated law enforcement with paid and earned media supporting the enforcement activity. Law enforcement officers actively seek out cell phone users through special roving patrols or through a variety of enforcement techniques such as the spotter technique where a stationary officer will radio ahead to another officer when a driver using a cell phone is detected. Officers report that higher vantage points, SUVs, and unmarked vehicles are strategies useful in identifying violators (Chaudhary et al., 2014). Both earned and paid media are critical to ensure the general public is aware of the enforcement activity and to increase the perception that being caught is likely.

NHTSA conducted an HVE demonstration project aimed at reducing cell phone use among drivers. The program tagline was *Phone in one hand. Ticket in the other*. Pilot programs were tested in Hartford, Connecticut, and Syracuse, New York, from April 2010 to April 2011. Law enforcement officers conducted four waves of enforcement during the year. Approximately 100 to 200 citations were issued per 10,000 population during each enforcement wave. Paid media (TV, radio, online advertisements, and billboards) and earned media (e.g., press events and news releases) supported the enforcement activity. For more details about the program, see Chaudhary et al. (2014).

To examine the effectiveness of HVE in larger jurisdictions, NHTSA implemented an HVE campaign in Delaware and in nine California counties in the Sacramento area. Three waves of enforcement were conducted from November 2012 to June 2013. Paid and earned media were like that in Hartford and Syracuse. See Schick et al., (2014) and Chaudhary et al. (2015) for more information. Finally, NHTSA undertook a third demonstration program to determine the enforceability of texting laws and to test methods for enforcing these laws. Law enforcement agencies in Connecticut and Massachusetts participated in the program. Four waves of enforcement were conducted in each State in 2013 and 2014 (Retting et al., 2017).

Evaluations have revealed several insights and "lessons learned" for conducting successful enforcement campaigns. Important practices include officer training to ensure officers understand distracted driving laws and recognize the signs of a distracted driver (e.g., lane departure, traveling too slowly); pre-planning of enforcement operations; maximizing resources through local and State agency coordination; and the need for strong distracted driving laws. See Lemaster-Sandbank et al., (2020) and Retting et al. (2017) for more information.

Additionally, NHTSA and the National Traffic Law Center (2017) have developed guidance for successful enforcement and prosecution of distracted driving cases, available at: www.nhtsa.gov/sites/nhtsa.gov/files/documents/812407-distracteddrivingreport.pdf.

Finally, NHTSA has developed a free "virtual live" curriculum on distracted driving program management (U.S. DOT, n.d.) that covers public safety and distracted driving laws. For more details, visit https://tsi-dot.csod.com/LMS/catalog/Welcome.aspx?tab_page_id=-67&tab_id=20000326.

Use:

To date, many States have implemented HVE programs to address talking on a cell phone and texting while driving. Perhaps the largest effort is *Connect to Disconnect,* a.k.a. C2D, a distracted driving enforcement and awareness initiative to reduce cell phone use among drivers. The initiative takes place in April each year, and more than 40 States have participated. See for example NHTSA's Traffic Safety Marketing's Event Planning Guide at www.trafficsafetymarketing.gov/sites/tsm.gov/files/2022-03/15508m-2022_c2d_planningguide-033022-v5a-tag_0.pdf (NHTSA, n.d.-b).

Effectiveness:

Results from the NHTSA HVE program suggest handheld cell phone use among drivers dropped 57% in Hartford and 32% in Syracuse (Chaudhary et al., 2014). The percentage of drivers observed manipulating a phone (e.g., texting or dialing) also declined. Public awareness of distracted driving was already high before the program, but surveys suggest awareness of the program and enforcement activity increased in both Hartford and Syracuse. Surveys also showed most motorists supported the enforcement activity. Similar reductions in cell phone use were observed following the campaign in California (34% reduction) and Delaware (33% reduction), although decreases were also noted in comparison communities (Chaudhary et al., 2015; Schick et al., 2014). Although these results are encouraging, the effect of HVE campaigns on crashes is not certain. An analysis of crash data from before and after the enforcement period found no effects of HVE on the incidence of distraction-related crashes (Chaudhary et al., 2015).

Cost:

HVE campaigns are expensive. They require time from law enforcement officers to conduct the enforcement. In addition, time is needed from State highway safety office and media staff and often from consultants to develop, produce, and distribute advertising, educational material, and other communications tools. In the NHTSA demonstration program (Chaudhary et al., 2014), both Connecticut and New York received $200,000 to implement and evaluate the program, and each State contributed an additional $100,000 to the Federal funds. Paid media costs for the program in the 2 States were over $500,000.

Time to implement:

An HVE program requires 4 to 6 months to plan and implement.

Other considerations:

- *Challenges enforcing cell phone laws:* Enforcement of cell phone use and text messaging laws is challenging. Twenty-six police officers from three Washington State counties participated in focus groups to determine factors that influence consistent enforcement of distracted driving legislation (Nevin et al., 2017). The factors that challenged effective enforcement included inconsistency in what corresponds to legal use of handheld devices, policies that do not extend to all drivers under all situations, and lack of clarity in what constitutes a reportable driving violation. Other factors, including officers' own beliefs and attitudes towards distractions in their own driving, drivers' reactions when pulled over, departmental priorities related to distracted driving enforcement, and prevalent local sociocultural norms also affected the success of enforcement practices. Establishment of dedicated traffic patrol units, changes in local public perception through campaigns, and clear delineation between prohibited activities and other electronic device use in the law were identified by focus group participants as important for improving the effectiveness of enforcement. In addition, some focus group participants noted that officer education on distracted driving can bring about a cultural change. The authors developed an educational roll-call video for daily officer briefings that can help curb their own distractions while driving and motivate them to enforce distracted driving (Nevin et al., 2017; see this mp4 video file attached as Appendix B at www.ncbi.nlm.nih.gov/pmc/articles/PMC5927816/bin/NIHMS942376-supplement-Online_Appendix_B.mp4).

Other Strategies for Behavior Change

Employer Programs

Effectiveness: ★★	**Cost:** $	**Use:** Unknown	**Time:** Short

This countermeasure involves State-based programs that address job-related distracted driving, which may pose a liability risk to employers. Employers can protect themselves by implementing policies that prohibit distracted driving and by monitoring compliance. There are many ways States can work with employers to address distracted driving. Some States such as Delaware and Kentucky have corporate outreach program staff devoted to distracted driving (GHSA, 2013). The programs usually involve dissemination of traffic safety material to employers, or sometimes directly to the employees themselves. States can also assist employers in promoting and enforcing policies to reduce distracted driving. Legally, employers can be held accountable for employees who are using a cell phone (or otherwise distracted) and who are involved in a crash as part of their work (NSC, 2015).

Various resources are available to employers to develop and maintain programs to prevent distracted driving. The NSC (2023) has created a free Safe Driving Kit that includes resources for building leadership support for a cell phone policy and tools to communicate to employees, available at www.nsc.org/road/safety-topics/distracted-driving/distracted-driving-for-employers. The NETS program founded by NHTSA and led by private employers provides various training and outreach material for member organizations, including a distracted driving module (NETS, 2017) found at https://trafficsafety.org/dsww-site/safe-driving-is-serious-business/. The National Distracted Driving Coalition (Robertson et al., 2022) has sample workplace policies for distracted driving available at https://usnddc.org/downloads/. New Jersey has developed a sample cell phone use policy for businesses (New Jersey Department of Law and Public Safety & Division of Highway Traffic Safety, n.d.), available at www.nj.gov/lps/hts/downloads/Sample_Cell_Phone_Policy.pdf. The Texas Department of Insurance (n.d.) presents guidelines that employers may consider when incorporating measures to curb distracted driving by employees, including a sample agreement policy on on-the-job device use that should be signed by both employer and employee: www.tdi.texas.gov/pubs/videoresource/stpcellphone.pdf.

Use:

At least 17 States and the District of Columbia have worked with employers in their States to develop distracted driving policies (GHSA, 2013). At the Federal level, agencies including the Federal Railroad Administration and Federal Motor Carrier Safety Administration have passed rules that prohibit texting or using handheld cell phones while driving (Restrictions on Railroad Operating Employees, 2011).

Effectiveness:

Few employer distracted driving programs have been systematically evaluated. Owens Corning used the NSC Safe Driving Kit to develop a cell phone policy for their drivers. The company reported a 95% reduction in reportable injuries (NSC, 2014a, 2014b), although it is not clear how much of this reduction could be attributed to the cell phone policy. Cummins, Inc., also used the NSC Safe Driving Kit with its 48,000 employees. It reported a decline in crash rates following the new cell phone policy, but specific numbers were not provided (NSC, 2015).

Cost:

In comprehensive programs that are available at no cost, expenses will consist only of material production and employer time for training.

Time to implement:

An employer program can be implemented within 3 months.

Approaches That Are Unproven or Need Further Evaluation

Communications on Outreach and Distracted Driving

This countermeasure involves distracted driving communications and outreach campaigns directed to the general public. Since distracted driving is a particular concern among teenage drivers (Foss & Goodwin, 2014; NHTSA, 2012), distracted driving campaigns may specifically target teen drivers. Some campaigns carry a general "pay attention" message, while others are directed at specific behaviors such as cell phone use.

Distracted driving communications and outreach campaigns face challenges in how the issue of distraction is characterized and understood by drivers. Drivers "know" at some level that they should be alert. However, as discussed in the Overview, distractions come in many forms. Distractions outside the car are not under the driver's control. Many distractions inside the car also cannot be controlled easily (conversations, children), or are intentional (listening to music, eating). They may in fact be useful to keep drivers alert on a long trip.

Many organizations have developed or conducted distracted driving communications and outreach campaigns directed to the general public. Examples include *U Drive. U Text. U Pay* (NHTSA), *Put It Down* (U.S. DOT), *No Phone Zone* (Oprah Winfrey), *Texting While Driving: It Can Wait* (AT&T), and *Stop Texts, Stop Wrecks* (NHTSA and the Ad Council).

The ultimate goal of these campaigns is to reduce distracted driving, but their effectiveness for reducing distraction and ensuing crashes have not been evaluated well and they face substantial obstacles. As discussed in the Introduction, communications and outreach by themselves rarely change driving behavior. To have any chance, stand-alone campaigns must be carefully pre-tested, communicate health information not previously known, be long-term, and have substantial funding (Williams, 2007b). A broad "stay alert" message may be too general to have any impact. Furthermore, commonly used fear appeals are generally ineffective and, in some cases, may actually encourage *greater* distracted driving, especially among young adults (Bummara & Choi, 2015; Lennon et al., 2010). This "boomerang effect" of fear appeals is thought to occur because people deny the threat or feel their personal freedom is threatened, making the undesirable behavior even more attractive (Lennon et al., 2010). Finally, high-quality communications campaigns are expensive to develop, test, and implement. For all these reasons, communications and outreach alone are not a recommended approach to address distracted driving.

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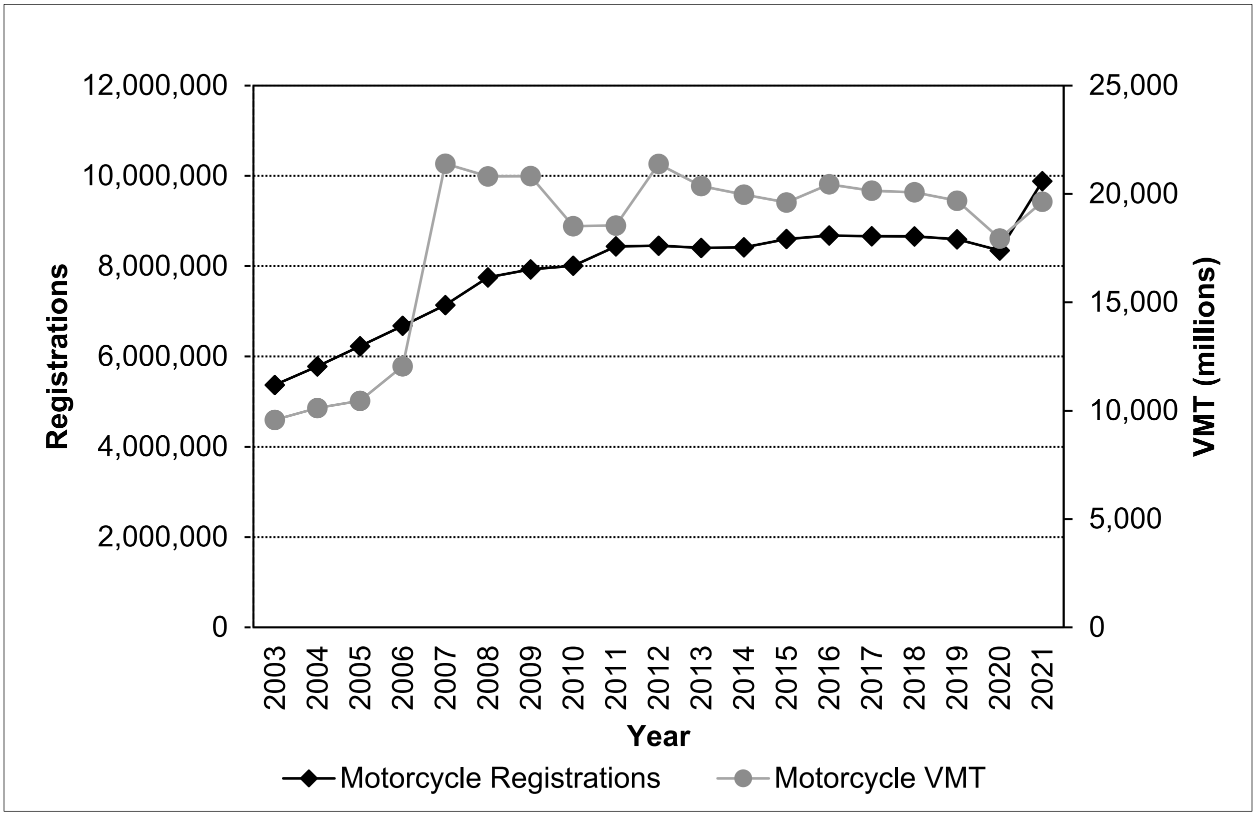
6. Motorcycle Safety

Overview

Riding a motorcycle is among the riskier modes of transportation. Not only does operating a motorcycle require more physical skill and strength than driving a passenger vehicle, but motorcycles lack a protective structure, offering the rider virtually no protection in a crash. Furthermore, the motorcycle's smaller size relative to most motor vehicles may make it less visible to drivers and will also make it more vulnerable in a collision with larger, heavier passenger vehicles and trucks.

Motorcycling increased in popularity in the early 2000s with increases in both motorcycle registrations and VMT during that time. Since 2011, both registrations and VMT have remained relatively consistent (NCSA, 2000; NCSA, 2023).

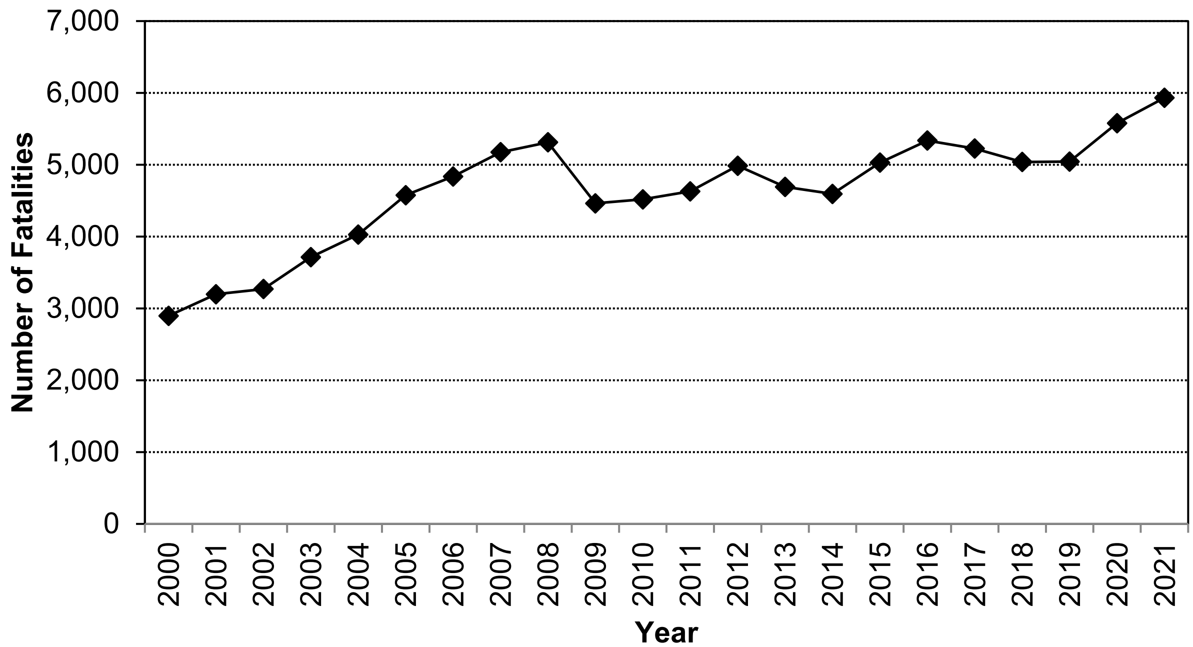


Source: FHWA (2003 to 2023), Table VM-1

Figure 6-1. Annual Motorcycle Registrations and Vehicle Miles Traveled (VMT)

Along with this growth in popularity and riding exposure was a rise in the number of crashes and fatalities involving motorcyclists. From 2000 to 2008 the number of motorcyclists killed in crashes increased by 83% and the number injured increased by 66% (NHTSA, 2011). Since 2015 more than 5,000 motorcyclists have been killed in traffic crashes annually (NCSA, 2023). Of increasing concern is the rise in fatal crashes since the COVID-19 pandemic for all road users, including motorcyclists (Office of Behavioral Safety Research, 2021).

Despite accounting for only 3.5% of registered vehicles, motorcyclists comprised 14% of all motor vehicle traffic fatalities in 2021. Additionally, motorcyclists were nearly 24 times more likely to die in traffic crashes per VMT than passenger car occupants (NCSA, 2023). Moreover, in 2021, per 100 million VMT, there were 30.68 motorcyclist fatalities compared to 1.22 passenger car occupant fatalities per 100 million VMT (NCSA, 2023).



Source data: NHTSA (2011), NCSA (2023)

Figure 6-2. Motorcyclist Fatalities in Crashes

Although motorcycles lack the protective vehicle structure of passenger vehicles, there are actions motorcyclists can take to protect themselves in a crash. Wearing a motorcycle helmet that meets the performance standards of Federal Motor Vehicle Safety Standard 218 (Motorcycle Helmets, 49 CFR Part 571, 2011; "compliant helmet") is one of the most effective ways to reduce the chance of serious injury or death in a crash. In 2021 some 39% of fatally injured motorcyclists were not wearing a helmet (NCSA, 2023). Research indicates that helmets reduce motorcycle rider fatalities by 22% to 42% and brain injuries by 41% to 69% (Coben et al., 2007; Cummings et al., 2006; Deuterman, 2004; NHTSA, 2003; NHTSA, 2006; NHTSA, 2019). A Cochrane Collaboration review of 61 studies concluded that risk reductions were on the high end of these ranges (Liu et al., 2008).

A study of hospital data in the 2013 National Trauma Data Bank compared medical outcomes of helmeted versus unhelmeted motorcyclists involved in a crash. Compared to helmeted motorcyclists, unhelmeted motorcyclists were more likely to be admitted to the Intensive Care Unit (ICU), more likely to need ventilation, and more likely to have clinical indicators of significant/severe injury (Patel et al., 2019). Another study found that riders who were wearing a helmet were less likely to have a cervical spine injury (Page et al., 2018). Notably, other studies have found no evidence that helmets increase the risk of neck injuries (Brewer et al., 2013; Potts et al., 2008, Strategy E1; NHTSA, 2000; Philip et al., 2013; Ulmer & Preusser, 2003).

Understanding the Problem

While motorcycles are often grouped into one vehicle type, there is significant diversity in the type of motorcycles being purchased and ridden. Overall, registrations have steadily increased and doubled from 2002 (4.2 million) to 2017 (8.4 million) (Teoh, 2019). Most registrations in 2018 were cruiser (3.5 million) and touring bikes (1.8 million). Registrations for supersport motorcycles peaked from 2008 to 2010, and then declined to about 602,000 in 2018; however, supersport registrations were still 66% higher in 2018 than in 2002.

Along with the growth of motorcycle ownership and miles traveled since about 1998, there has been a shift in the age of motorcyclists fatally injured. Motorcyclists under age 30 accounted for 80% of motorcyclist fatalities in 1975 and 28% in 2019. On the other hand, the proportions of fatalities among older age groups have increased with the primary driver of this increase being motorcyclists 50 and older who went from 3% of motorcyclist fatalities in 1975 to 37% in 2019 (IIHS, 2021a).

Different motorcycle types tend to attract different rider groups. Fifty-two percent of supersport operator fatalities in 2019 were 30 years old or younger. In contrast, most of the fatally injured cruiser (64%) and touring bike operators (81%) were 40 or older (IIHS, 2023a). Helmet use varied among operators of different motorcycle types in 2021; 81% of fatally injured supersport operators and 51% of cruiser and touring bike operators were helmeted (IIHS, 2023a). These results suggest that the types of risks taken may vary in association with the style of bike chosen (Teoh & Campbell, 2010).

In 2021 some 38% of motorcyclist fatalities (IIHS, 2023a) occurred in single-vehicle crashes. Ninety-two percent of motorcyclists killed were males (IIHS, 2023a), and passengers comprised 5% of motorcycle fatalities (NCSA, 2023).

Speeding is more prevalent in fatal crashes involving motorcycle operators than among other types of motor vehicle operators. For example, in 2021 some 33% of all motorcycle operators involved in fatal crashes were speeding, compared to 22% of passenger car drivers, with riders 21-to-24 years having had the highest speeding involvement in fatal crashes at 49% among all rider age groups (NCSA, 2023).

Alcohol-impaired riding is a factor in fatal motorcycle crashes. In 2021 some 28% of the motorcycle operators involved (killed or survived) in fatal crashes had BACs of .08 g/dL or higher, which is a higher percentage of alcohol impairment than for drivers of passenger cars (24%), light trucks (20%) and large trucks (3%); riders killed at night were three times more frequently alcohol-impaired than those during the day, and 43% of riders killed in single-vehicle crashes were alcohol-impaired (NCSA, 2023). Of concern is the 4.4% increase in the number of alcohol-impaired riders in fatal crashes from 2019 to 2020, from 1,462 to 1,526 (Steward, 2022). A NHTSA study on the prevalence of drugs and alcohol in seriously or fatally injured road users from 2019 and 2020 indicated an increase in substance use during the COVID-19 public health emergency (Thomas et al., 2020). The study had a relatively small sample of motorcyclists that affected the statistical power of the analyses; nonetheless, there was a statistically significant increase in the percentage of motorcyclists (63.4%) having at least one category of drugs in their systems in the 3rd quarter of 2020 compared to the 1st quarter of 2020 (45.9%), and increases in the prevalence of several categories of drugs in the 2nd quarter and 3rd quarter of 2020.

Motorcycle operators involved in fatal crashes had worse prior driving records than other passenger vehicle drivers, including more DWI convictions, speeding convictions, and suspensions or revocations. Additionally, 36% of the motorcycle operators involved in fatal crashes in 2021 did not have valid motorcycle operator licenses, compared to 17% of passenger vehicle drivers in fatal crashes did not have valid licenses (NCSA, 2023).

Large-scale riding events are a phenomenon somewhat unique to the motorcycling population. At these events, many riders (hundreds of thousands at some events) converge in one location for a period of time. It is possible during these large events to have a "mass casualty" situation where there is a sudden influx of patients requiring medical assistance. EMS response time can impact outcomes for motorcyclists involved in crashes, especially in areas where response time is limited due to road congestion or rurality. There has been limited research to evaluate an intervention to improve EMS response time during a large-scale motorcycle event (DuPree et al., 2019).

Many environmental factors can also affect motorcycle safety. Slippery roadway surfaces and markings, surface irregularities and debris, unpaved shoulders, and unforgiving roadway barriers all can be dangerous. These issues are not discussed at length in this guide because SHSOs have little or no authority or responsibility for them. However, FHWA recently completed and published several studies committed to identifying effective motorcycle safety countermeasures, promoting roadway maintenance and design practices that account for motorcycle-specific safety concerns, and maintaining a research program that supports an improved motorcycle riding environment on American highways.

Data/Surveillance

Motorcycle crashes in State crash data. Many motorcycle crashes are single-vehicle crashes. These crashes may go unreported unless the rider is seriously injured. Another data issue is what constitutes a "motorcycle." Many new types of powered 2-wheeled vehicles have grown in popularity in recent years, discussed in "Emerging Issues" below.

Emerging Issues

There is an increasing diversity in the types of powered 2-wheel vehicles that are available and being used across the Nation. Larger and more powerful motorcycles continue to enter the market but at the same time, increasingly popular are smaller, low-powered 2-wheelers such as mopeds and seated scooters. These trends will likely have safety consequences. For example, the variations in rider position, power, and the operating space of mopeds and seated scooters result in different riding exposure. Crash data on these emerging vehicle types are not readily available, and variations in State laws defining and regulating these vehicle types vary, resulting in different crash reporting procedures and making it difficult to track crash data trends. Although these vehicles have lower speed and power capabilities (most States classify these vehicles based on their maximum speed, generally 20 to 30 mph), research has shown similar injury patterns among riders of low-speed vehicles and larger motorcycles, specifically as it relates to head injuries (Wentzel et al., 2020). The similar pattern of head injuries may reflect helmet noncompliance. Thus, while riders of low-powered cycles may face different safety problems than motorcycle riders, some countermeasures aimed at motorcycles (such as helmet use laws) also apply to low-powered cycles.

There are technological solutions on the market or in development that have the potential to reduce motorcycle crashes. Motorcycle antilock braking systems have been demonstrated to be effective (Teoh, 2013) and are widely available. Autonomous emergency braking and collision avoidance systems are at various stages of development and implementation (Savino et al., 2020). Additionally, the presence of similar systems on passenger vehicles has the potential to reduce certain types of passenger vehicle/motorcycle crashes, though these types of crashes represent a relatively small proportion of total motorcycle crashes (Teoh, 2018).

Key Resources

- The NHTSA Motorcycle Safety 5-Year Plan (NHTSA, 2019a) is a comprehensive plan for NHTSA activities to address the safety of motorcyclist over the coming years. The Motorcycle Safety 5-Year Plan is available here: www.nhtsa.gov/sites/nhtsa.gov/files/documents/13507-motorcycle_safety_plan_050919_v8-tag.pdf
- Reviews about the effectiveness of motorcycle helmets in preventing injury and death can be found from the Community Guide at www.thecommunityguide.org/findings/motor-vehicle-injury-motorcycle-helmets-universal-helmet-laws.
- Baer, Cook, and Baldi (2005) reviewed and summarized each State's motorcycle education and licensing programs and practices. A companion report (Baer, Baldi, & Cook, 2005) describes training and licensing programs and actions to promote training and licensing.
- Under a cooperative agreement with NHTSA, AAMVA updated its *Motorcycle Operator Licensing System* and *Integrating Motorcycle Rider Education and Licensing* manuals, by publishing the *Guidelines for Motorcycle Operator Licensing*. The GMOL provides guidelines for State motorcycle licensing programs (Hanchulak & Robinson, 2009).
- NHTSA published a brochure on how to identify noncompliant helmets (NHTSA, 2019b) and provides further information to choose the right fit at www.nhtsa.gov/motorcycle-safety/choose-right-motorcycle-helmet.
- NHTSA has Ride Sober or Get Pulled Over campaign material available at www.nhtsa.gov/campaign/ride-sober
- See NCHRP Report 500, Volume 22, Guide for Addressing Collisions Involving Motorcycles (Potts et al., 2008), for a thorough discussion of environmental and other strategies: https://doi.org/10.17226/14204
- See FHWA (2023) for more information on infrastructure and design changes that could improve motorcycle safety. https://highways.dot.gov/safety/other/motorcyclist/motorcycle-safety
- NHTSA (n.d.-a) has an online interactive dashboard for producing visualizations of data from fatal crash records, available here: https://cdan.dot.gov/DataVisualization/DataVisualization.htm

Motorcycle Safety Countermeasures

Legislation and Licensing

Countermeasure	Effectiveness	Cost	Use	Time
Universal Motorcycle Helmet Use Laws	★★★★★	$	Medium	Short
GDL for Motorcyclists	★★	$	Medium	Short

Enforcement

Countermeasure	Effectiveness	Cost	Use	Time
Alcohol-Impaired Motorcyclists: Detection, Enforcement, and Sanctions	★★★	Varies	Unknown	Varies

Other Strategies for Behavior Change

Countermeasure	Effectiveness	Cost	Use	Time
Motorcycle Rider Training	★★	$$	High	Varies
Strategies to Increase Rider Conspicuity and Use of Protective Clothing	★	Varies	High	Medium

Approaches That Are Unproven or Need Further Evaluation

Countermeasure
Motorcycle Helmet Use Promotion Programs
Communication Campaigns Aimed at Alcohol-Impaired Motorcyclists
Communication Campaigns to Increase Motorist Awareness of Motorcyclists

Effectiveness:

★★★★★	Demonstrated to be effective by several high-quality evaluations with consistent results.
★★★★	Demonstrated to be effective in certain situations.
★★★	Likely to be effective based on balance of evidence from high-quality evaluations.
★★	Limited evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.
★	No evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.

Cost to implement:

$$$	Requires extensive new facilities, staff, equipment, or publicity, or makes heavy demands on current resources.
$$	Requires some additional staff time, equipment, facilities, and/or publicity.
$	Can be implemented with current staff, perhaps with training; limited costs for equipment or facilities.

These estimates do not include the costs of enacting legislation or establishing policies.

Use:

High	More than two-thirds of the States, or a substantial majority of communities
Medium	One-third to two-thirds of the States or communities
Low	Less than one-third of the States or communities
Unknown	Data not available

Time to implement:

Long	More than 1 year
Medium	More than 3 months but less than 1 year
Short	3 months or less

These estimates do not include the time required to enact legislation or establish policies.

Legislation and Licensing

Universal Motorcycle Helmet Use Laws

Effectiveness: ★★★★★	**Cost:** $	**Use:** Medium	**Time:** Short

Universal coverage motorcycle helmet use laws require all motorcycle riders and passengers to wear a helmet. Motorcycle helmets are highly effective in protecting motorcycle riders' heads in crashes. Research indicates that helmets reduce motorcycle rider fatalities by 22 to 42% and brain injuries by 41 to 69% (Coben et al., 2007; Cummings et al., 2006; Deuterman, 2004; Liu et al., 2008; NHTSA, 2003; NHTSA, 2006; NHTSA, 2019). The first universal helmet law was enacted in 1966 and universal laws were in effect in 47 States and the District of Columbia by 1975. After Federal penalties were eliminated in 1975 for States failing to have a universal law, about half the States repealed their laws. Several States have since reenacted universal helmet laws or enacted partial coverage laws; that is, helmet laws that cover only certain riders.

In addition to the requirement to wear a helmet, many States require motorcyclists to wear helmets that comply with FMVSS 218. Federal regulations require all motorcycle helmets sold in the United States to meet or exceed the FMVSS 218 standards. Helmets that do not meet the FMVSS 218 performance requirements are considered noncompliant.

Use:

As of October 2021 there were 18 States and the District of Columbia that have helmet laws that require all motorcycle riders to wear a helmet while riding (IIHS, 2021b). Illinois, Iowa, and New Hampshire do not have motorcycle helmet laws. The remaining States have laws covering only riders under a specified age, typically 18 or 21. Additionally, 17 States have motorcycle helmet laws that do not cover certain vehicle types, typically lower-powered vehicles like mopeds or scooters.

Effectiveness:

A systematic review of U.S. motorcycle helmet laws found that States with universal coverage laws: (1) had motorcycle helmet use rates 53 percentage points higher than States with partial coverage or no law; (2) had 29% fewer motorcycle fatalities; and (3) had lower fatality rates per registered motorcycle and per vehicle mile traveled (Guide to Community Preventive Services, 2013). Universal helmet laws are also associated with economic benefits at the societal level due to avoided productivity loss and healthcare costs (Peng et al., 2017). In 2021 observed compliant helmet use was 86.1% across States with universal helmet laws, compared to 53.4% across States with no law or partial coverage laws (NCSA, 2022).

Partial Coverage Helmet Laws

Some States have helmet laws that mandate use only for young riders or riders with inadequate insurance. Helmet use is generally low in these States (GAO, 1991; Olsen et al., 2016; NCSA, 2022). Compared to States with no motorcycle helmet law, States with partial coverage helmet laws have motorcyclist fatality rates that are 7% to 10% lower, however, this is significantly smaller than the 22% to 33% reduction in States with universal helmet laws (Houston & Richardson, 2008). Additionally, while partial coverage helmet laws typically require helmets for young riders, this does not appear to translate into meaningful reductions in young rider fatality rates because it is easy to evade these laws (Brooks et al., 2010; Houston, 2007). For example, when Florida eliminated the requirement that all motorcycle riders 21 and older wear helmets, there was an 81% increase in motorcyclist fatalities (Ulmer & Northrup, 2005). Fatalities even increased among riders under 21 who were still covered by the helmet law.

Uncertified Helmets

Some motorcyclists choose to wear, or unknowingly wear, helmets that are not marketed or sold as FMVSS 218-compliant motorcycle helmets. These "novelty" helmets do not have the certification label affixed to them as required by FMVSS 218 and would unlikely comply with the performance requirements of FMVSS 218. Nationally, in 2019 FMVSS 218-compliant helmet use was 70.8%, but the use of uncertified novelty helmets increased from 9.0% in 2018 to 12.6% in 2019 (NCSA, 2020). Use of helmets that meet FMVSS 218 is higher in States that require all motorcyclists to wear helmets (86.1%) compared to States with no, or partial coverage, helmet laws (53.4%) (NCSA, 2022).

Motorcycle riders wearing novelty helmets are essentially no safer than if they wore no helmets at all. Rice et al. (2017) found that riders wearing novelty helmets had 2.26 times the risk of fatal injury compared to wearing FMVSS 218-compliant helmets. Novelty helmets do not meet the performance requirements of FMVSS 218 and lack the ability of a helmet to protect the rider in the event of a crash. The availability of novelty helmets and noncompliant helmets on the internet is extensive and is likely to continue to grow. There are many companies importing helmets that do not meet the minimum safety standards of FMVSS 218 that is expected to exacerbate this issue.

According to the National Agenda for Motorcycle Safety, effective strategies to increase the use of FMVSS 218-compliant helmets are a high priority (NHTSA, 2013a). A challenge in States requiring FMVSS 218-compliant helmets is to educate motorcycle riders on how to identify a compliant helmet. Some noncompliant helmets are easily identified. Some examples include helmets that have spikes or other projections, making them easy to identify as noncompliant; labels indicating the helmet is a novelty helmet and not a NMVSS 218 compliant motorcycle helmet; or lack of an impact-attenuating liner is also a visual indication that a helmet would not be able to protect a user in the event of a crash. Compliant helmets are formally identified by a certification label on the back of the helmet that includes the symbol DOT as well as the manufacturer's name or brand as well as the precise model designation. However, counterfeit DOT stickers are readily available and easy to place on uncertified helmets. In May 2013 NHTSA published an amendment to FMVSS 218 to strengthen helmet labeling requirements, making it easier to identify that a helmet is noncompliant, and improving the ability to enforce helmet laws.

Costs resulting from crashes. Hospital admissions and treatment costs have also increased following repeal of universal helmet laws (Derrick & Faucher, 2009; GAO, 1991; Peng et al., 2017). Almost half of all motorcyclists admitted to hospitals lacked sufficient health care insurance or were covered by government services, so the public ultimately shares many of these costs, as well as a greater long-term burden of care (Derrick & Faucher, 2009; GAO, 1991; NHTSA, 2019; Patel, 2019). In addition, an analysis of insurance claims data found that when Michigan's helmet law was amended from a universal coverage law to a partial coverage law (effective since April 2012), claims increased by more than 22% compared with control States (HLDI, 2013). Medical costs related to motorcycle crashes are typically higher in States with partial helmet laws. Olsen et al. (2016) reported that median medical costs were 37% lower for emergency department visits and 21% lower for in-patient hospital charges in States with universal helmet laws. The Community Preventive Services Task Force found in their systematic review of 22 studies that universal coverage motorcycle helmet laws resulted in significant economic benefits (Guide to Community Preventive Services, 2013; Peng & Community Preventive Services Task Force, 2017; Peng et al., 2017). These studies show that universal coverage laws provide greater safety and cost benefits than laws that cover only a specific age group or riders having a certain amount of insurance.

Cost:

Once legislation requiring universal helmet use has been enacted, implementation costs are minimal. Universal helmet use has vocal proponents and detractors that will help to publicize the new law extensively. Motorcycle helmet laws can be enforced during regular traffic patrol operations because helmet use is easily observed.

Time to implement:

A universal helmet use law can be implemented as soon as the law is enacted; however, enacting such a law is complex and time-consuming, and may require people to galvanize support within a State to pass legislation.

Other considerations:

- *Opposition to motorcycle helmet laws:* Any effort to enact a universal helmet law can expect immediate, well-coordinated, and highly political opposition (NHTSA, 2003). Helmet law opponents claim that helmet laws impinge on individual rights. They also claim that helmets interfere with motorcycle riders' vision or hearing, though research shows that these effects are minimal (NHTSA, 1996). See Jones and Bayer (2007) for a history of opposition to helmet laws in the United States. Derrick and Faucher (2009) also discuss national policy, organized opposition, and helmet law changes over 4 decades.
- *Compliance benefits from enacting other safety laws:* Helmet law compliance has been shown to benefit from the enactment and enforcement of other motorcycle safety laws. In 2007 existing motorcycle safety laws in Puerto Rico were augmented to reduce the legal BAC limit to .02 g/dL, and require motorcycle riders to wear protective safety apparel, along with other requirements. One benefit of the amended law was that the use of DOT-compliant motorcycle helmets increased, even though helmet laws already existed (Fell et al., 2017). From 2006 to 2007 Puerto Rico riders' use of DOT-compliant motorcycle helmets rose from 39.4% to 56.4% and continued to increase to greater than 70% three years later. Observed DOT-compliant helmet use reached 86%, 4 years after the 2007 Puerto Rico law change.

Graduated Driver Licensing for Motorcyclists

Effectiveness: ★★	**Cost:** $	**Use:** Medium	**Time** Short

Graduated driver licensing (GDL) is a multi-phase system designed to gradually expose new drivers to increasingly complex driving situations. Nearly all States have graduated driver licensing systems in place for beginning automobile drivers. Under GDL, new drivers must pass through learner permit and provisional license stages before becoming fully licensed. A learner's permit allows driving only while supervised by a fully licensed driver and a provisional license prohibits unsupervised driving under certain conditions, such as at night or with passengers. GDL programs for automobile drivers are proven to be effective in reducing crashes (Hedlund et al., 2003, 2006; Williams et al., 2012). See the chapter on Young Drivers for a full discussion on the effectiveness of GDL for automobile drivers.

In general, the concept of GDL for new motorcyclists is similar. Under such a system, new motorcycle operators are subject to specific restrictions limiting their exposure to higher-risk situations. This could include limiting riders to smaller, less powerful motorcycles and to certain times of day, with additional restrictions on maximum speed and carrying passengers. As the rider gains experience, riskier riding situations are permitted.

While all 50 States, the District of Columbia, and Puerto Rico require motorcycle riders to obtain motorcycle operator licenses or endorsements before they ride on public highways (MSF, 2018), licensing requirements vary substantially. A full GDL system for motorcyclists has not been implemented in the United States. However, many States have components of GDL. For example, most States have motorcycle learner permit phases where riding is restricted to certain circumstances, typically prohibiting passengers, riding during certain times of day, riding on certain types of roads, and often requiring supervision by fully licensed motorcyclists. However, for many States this permit phase is only required for certain beginning riders, typically those under 18 or 21 (MSF, 2018).

Use:

All States require motorcycle riders to obtain motorcycle licenses or endorsements to ride on public highways. As of 2022 only 15 U.S. States had some form of GDL for motorcyclists, though these requirements apply only for new riders under a certain age, typically 18 or 21 (MSF, 2022).

Effectiveness:

Much of the research on GDL for motorcyclists has been done in Australia and New Zealand. In New Zealand a single graduated licensing system exists for the entire country. In Australia, like the United States, the provisions vary among its six states and two territories. Nonetheless, the general GDL principles are consistent throughout.

An investigation of the effects of the original New Zealand GDL system on motorcyclist hospitalizations from 1978 to 1994 found a 22% reduction in hospitalizations among riders 15 to 19 following implementation of GDL. Concurrently there was a decrease in the number of license holders in this age range, as well as an overall decrease in the number of new motorcycle registrations, suggesting that the benefit of GDL largely resulted from reduced exposure (Reeder et al., 1999).

In Queensland, Australia, a study examined the effect of a series of changes to the GDL system on the required duration of the learner license (Haworth et al., 2010). Beginning in 2007 people who applied for learner motorcycle licenses were required to have been licensed to drive passenger vehicles for at least 12 months. This change effectively increased the minimum age at which riders were eligible for motorcycle learner licenses. In 2008 an additional requirement limited new riders to motorcycles with engine capacity ≤ 250 cc for their first year. There was a dramatic shift in the type of licenses issued following this change, from full unrestricted licenses to provisional licenses. This study did not look at the effect of this change on crash rates.

Cost:

GDL's primary costs result from the intermediate license, which adds to licensing agency workload by requiring each beginning driver to receive three licenses in succession rather than two. These costs are typically covered by small fees charged by the licensing agency.

Time to implement:

Licensing changes typically require up to a year to plan, publicize, and implement.

Other considerations:

- *Unlicensed riders:* Despite State requirements, some motorcycle riders are not properly licensed. In 2021 some 36% of motorcycle riders involved in fatal crashes did not have valid motorcycle licenses, compared to only 17% of passenger vehicle drivers (NCSA, 2023). Licensing systems in some States provide no incentive to become fully licensed because learner's permits may be renewed indefinitely (Potts et al., 2008, Strategy C3; MSF, 2022). The prioritized recommendations of the NAMS (NHTSA, 2013) recommends several approaches to encourage full licensure. For example, Maryland compared its vehicle registration and driver licensing files and sent a letter to each owner of a registered motorcycle who did not have a motorcycle operator's license. The letter reminded each registered owner that a motorcycle endorsement was required of anyone operating the registered motorcycle. This quick and inexpensive strategy prompted 1,700 owners to become licensed within 4 months. A randomized controlled experiment of this intervention suggested that while the method did increase licensure, a large percentage remained unlicensed (Braver et al., 2007). California also tried this approach with similar licensure results (Limrick & Masten, 2013). In 2007 Washington State added an authorization to impound vehicles operated by drivers without proper endorsement (including motorcycles). However, an evaluation of the effects of this law did not find significant impact on new or total motorcycle endorsements following implementation of the law (McKnight et al., 2013).

Enforcement

Alcohol-Impaired Motorcyclists: Detection, Enforcement, and Sanctions

Effectiveness: ★★★	**Cost:** Varies	**Use:** Unknown	**Time:** Varies

Alcohol impairment is a substantial problem for motorcyclist operators, even more than for drivers of other motor vehicles. In 2021 some 28% of motorcycle operators involved in fatal crashes had BACs of .08 g/dL or higher, which is higher than the rate for passenger car drivers (24%) and light-truck drivers (20%) (NCSA, 2023). Fatally injured motorcycle operators 35 to 39 years old and 40 to 44 had the highest percentages of alcohol impairment (35% each), followed by motorcyclists 30 to 34 and 50 to 54 (33% each) and 50 to 54 (32%) (NCSA, 2023). An additional 7% of fatally injured motorcycle operators had at least some measurable level of alcohol in their blood (BAC .01 to .07 g/dL). Fatally injured motorcycle operators with BACs .08 g/dL or higher were less likely to wear helmets than were sober operators–52% versus 66%. In 2021 some 39% of operators killed in single-vehicle crashes on weekdays had BACs of .08 g/dL or above, and on weekends, this figure climbed to 46%. The 2013 and 2014 National Roadside Survey found that 5.0% of motorcycle operators on weekend nights had BACs of .08 g/dL or above, as compared to 1.4% of passenger vehicle drivers (Ramirez et al., 2016).

Motorcyclists are included in, and affected by, the comprehensive strategies to reduce alcohol-impaired driving discussed in detail in the chapter on Alcohol-Impaired Driving. However, some law enforcement and sanction strategies may be especially useful for motorcyclists, while others may be less effective.

Law enforcement officers on traffic patrol use characteristic driving behaviors, or cues, to identify drivers who may be impaired by alcohol. Some of the cues for motorcycle operators, such as trouble maintaining balance at a stop, are different from those for cars and trucks. Stuster (1993) identified and validated 14 cues useful for identifying alcohol-impaired motorcycle operators. NHTSA published a brochure and a law enforcement training video discussing the cues (NHTSA, 2013b). The cues for motorcycle operators are part of the SFST training given to all law enforcement officers.

Vehicle impoundment or forfeiture can be an effective deterrent to drinking and driving for all drivers (see the chapter on Alcohol-Impaired Driving). It may be even more effective for motorcyclists. Research by Becker et al. (2003) confirmed earlier findings that many motorcyclists do not find traditional impaired-driving sanctions such as fines and license suspension to be effective deterrents (although self-reported beliefs may not reflect actual effectiveness of sanctions). However, motorcyclists tended to be highly concerned for the safety and security of their motorcycles.

These findings suggest a potentially effective strategy to reduce alcohol-impaired motorcycling: HVE using officers trained in identifying impaired motorcycle riders, with offender sanctions including vehicle impoundment or forfeiture. This strategy would treat motorcyclist operators on an equal footing with other vehicle drivers in impaired-driving enforcement and publicity, but it may be controversial and therefore difficult to enact or enforce. However, a Washington State law that allows officers to impound motorcycles for impaired riding was not found to cause unforeseen problems with law enforcement officers or with towing companies (McKnight et al., 2013).

Use:

As of 2008 there were 32 of 43 responding States that reported that they have programs for law enforcement on how to detect impaired motorcyclists or enforce laws related to operating motorcycles while impaired (Baer et al., 2010). NHTSA (2006) provides resources for law enforcement and State programs on the detection of impaired riding, including examples of State programs that distribute the NHTSA cue cards and brochures to law enforcement (Illinois), provide a web-based seminar for officers (Minnesota), and regularly establish high-visibility law enforcement presence at major rider events (Ohio, Wisconsin).

Effectiveness:

Some agencies have reported success in using the cues for identifying alcohol-impaired motorcycle riders (Potts et al., 2008, Strategy B3). Although there is limited evidence of the effects of enforcement and sanctions on impaired motorcycle riding, sobriety checkpoints and saturation patrols have demonstrated effectiveness in reducing impaired driving and crashes generally. See the chapter on Alcohol-Impaired Driving for more information on enforcement strategies and other tools.

Cost:

Law enforcement training costs are low and training material is available. Enforcement itself can be carried out during regular traffic patrols and as part of all impaired driving enforcement programs. A major campaign including alcohol-impaired motorcycle operators may require additional costs for publicity.

Time to implement:

Law enforcement training can be conducted quickly. Saturation patrols can be implemented within 3 months if officers are trained in detecting impaired drivers and in SFST. A major campaign will require 4 to 6 months to plan and implement. See the NHTSA HVE toolkit for implementation information (NHTSA, n.d.-b, at www.nhtsa.gov/enforcement-justice-services/high-visibility-enforcement-hve-toolkit).

Other considerations:

- *BAC limits:* BACs as low as .05 g/dL caused some detectable levels of impairment, primarily in reaction time, among experienced riders in tests on controlled courses (Creaser et al., 2007). Puerto Rico passed a law in 2007 lowering the BAC limit for motorcyclists to .02 g/dL. In Fell et al. (2017) law enforcement officers said it was difficult to detect operator impairment with BACs of just over the .02 g/dL limit. Nevertheless, more than half of citations at checkpoints for riding impaired were for BACs from .01 to .07 g/dL, suggesting that checkpoints are a successful method of enforcing the .02 g/dL limit.
- *Drugs other than alcohol:* Drugs other than alcohol can impair motorcycle riders. These include over-the-counter and prescription medications as well as illegal drugs. The 2013-2014 National Roadside Survey reported that 22.3% of nighttime weekend motorcycle operators who provided oral fluid or blood samples tested positive for drugs (illegal drugs or medications), compared to similar numbers of passenger car drivers, 24.3% (Kelley-Baker et al., 2017). The extent to which various drugs impair driving performance or contribute to crashes is not well understood, however, for either 4-wheeled vehicles or for

motorcycles. Furthermore, individual differences in metabolism of drugs and level of impairment, as well as polydrug use complicate the understanding of drug impairment on motor vehicle drivers (Compton et al., 2009). (See Compton et al.'s 2009 Report to Congress on drug-impaired driving for a discussion of current knowledge and recommendations for improving States data and records systems and statutes). Law enforcement should consider drugs as potential impairing agents for motorcycle riders just as for other vehicle operators. See the chapter on Drug-Impaired Driving for more information.

- *Targeted enforcement:* As with other crash problems, better identification of problem areas (either impaired riding or impaired riding crashes) and targeting enforcement to such locations, events, or times could improve enforcement effectiveness.
- *Alcohol Ignition Interlocks:* One strategy to reduce alcohol-impaired motorcycling is to use ignition interlocks to prevent impaired motorcyclists from being able to operate their motorcycles. Although it is feasible to implement interlocks on motorcycles, there are liability and safety concerns primarily associated with retests that must be considered. In a study of motorcycle interlocks, most study participants considered retesting while riding to be unsafe (Marques & McKnight, 2017). It can sometimes be difficult to find a safe place to stop and perform the retest. The requirements and option to implement motorcycle interlocks depends on State regulations. Some States require interlocks on all vehicles driven by offenders, while other States expressly forbid them on motorcycles, and the level of enforcement varies greatly between jurisdictions.

Other Strategies for Behavior Change

Motorcycle Rider Training

Effectiveness: ★★	**Cost:** $$	**Use:** High	**Time:** Varies

As of 2019 all 50 States offered some form of rider education (MSF, 2019). Training also is provided by some rider organizations, manufacturers, the U.S. Military, and others. Many States encourage training either by requiring it for all motorcycle operators or those under a specified age, or by waiving some testing requirements for motorcycle riders who complete and pass an approved training course (MSF, 2018).

Although training is available, it is not at all clear what constitutes appropriate rider education and training, or whether current training reduces crashes. Evidence suggests that in addition to teaching motorcycle control skills, programs would better prepare riders if they trained riders to recognize potentially hazardous riding situations and encourage riders to assess their own abilities and limitations, and to ride within those constraints (e.g., Clarke et al., 2007; Elliott et al., 2007). Crash analyses have been used to identify crash factors leading to the greatest injury severity (Pour-Rouholamin & Jalayer, 2016); results from such analyses can be used to prioritize critical issues to emphasize in a training program. NHTSA supported the development of Model National Standards for Entry Level Rider Training, released in August 2011. These Model Standards recommend content for motorcycle rider training courses. States are encouraged to go beyond the standards to address State-specific crash needs (Windwalker Corporation & Highway Safety Services, LLC., 2011).

Victoria, Australia, recently undertook a comprehensive approach to develop a motorcycle graduated licensing system (M-GLS) education and assessment curriculum. The process included identifying the target population for the curriculum, describing the tasks graduates of the course should be able to complete, specifying the knowledge, skills, and attitudes necessary to complete the task, and how to convey that information through the curriculum. The result was a 3-stage curriculum guided by best practice and research on adult learners with a focus on the skills identified as particularly important for beginning riders (Senserrick et al., 2017).

The NAMS encourages training (NHTSA, 2000). NHTSA's Motorcycle Safety 5-Year Plan recommends that States conduct frequent and timely education and rider training at sites that are accessible throughout each State (NHTSA, 2019). Potts et al. (2008, Strategy C2) further recommends that States evaluate crash experience, compare data and crash scenarios with training and licensing practices, and adjust as needed to ensure practices are effectively targeting crash problems. This effort requires cooperation on the part of agencies, including those responsible for collecting and analyzing crash data and those responsible for training and licensing.

States should provide motorcycle training on a timely basis to those who wish to take it. See Baer, Baldi, and Cook (2005) and NHTSA (2006) for examples of successful methods to use training capacity more effectively, including creative scheduling, centralized online registration systems, and use of private providers.

Use:

Most States offer training to both experienced and beginning motorcycle riders. For more information about the features of training and education programs offered by the States, see Baer et al. (2010) and MSF (2019).

Effectiveness:

Kardamanidis et al. (2010) evaluated the results of 23 studies for a Cochrane Review and found conflicting evidence regarding the effectiveness of motorcycle rider training in reducing crashes or offenses. Due to the poor quality of available studies (most of the studies had selection and detection bias) the authors were unable to draw any conclusions about its effectiveness. However, data suggests that having mandatory pre-license training for motorcyclists may reduce crashes and offenses by discouraging motorcycle riding, thus limiting exposure.

While studies regarding motorcycle rider training up to this point are inconclusive, a study conducted by Boele and de Craen (2014) investigated the possibility of training higher order motorcycle skills with “risk’ training. Specifically, their study investigated if the training influenced motorcyclists’ safe riding behavior and their hazard perception in the short term (a few months after training) and long term (12 to 18 months after training). Training participants were divided into experimental and control groups. Riders in both groups participated in a pre-test, which included a questionnaire and on-road ride. They also completed a short-term post-test, which included the same pre-test questionnaire and on-road ride as well as a hazard perception test. Finally, this was followed by a long-term post-test, which included the same pre-test questionnaire and on-road ride, and a hazard perception test. Participants in the experimental group received the “risk” training between the pre-test and the short-term post-test activities. In terms of observed riding behavior, results indicated that participants in the experimental (risk training) group demonstrated more safe riding behaviors compared to those in the control group. In terms of hazard perception during the short term, post-test results indicated that participants in the experimental (risk training) group identified more hazards than participants in the control group. This same result was found for the long-term post-test; however, it was not statistically significant indicating that the impact on hazard perception was not sustained in the long term.

Although the results of the Boele and de Craen (2014) study are positive, the authors are quick to caution the idea of implementing this training on a large scale. Specifically, they attribute retention of the training’s effect to following the design and curriculum closely as well as the didactic and substantive quality of trainers, which need to be considered with any implementation of this training.

Cost:

Rider training programs are funded in part by the States and in part by fees paid by the students who take them. Many States offset some or all their costs through motorcycle license or student registration fees.

Time to implement:

Rider training currently is conducted in all States. Training capacity is limited by the number of available training sites, qualified instructors, and motorcycles and helmets for students to use during training. Some measures to increase capacity can be implemented quickly while others may take 6 to 12 months.

Strategies to Increase Rider Conspicuity and Use of Protective Clothing

Effectiveness: ★	**Cost:** Varies	**Use:** High	**Time:** Medium

Motorcycle riders should wear clothing that provides both protection and visibility. FMVSS 218 helmets (See Countermeasure "Universal Motorcycle Helmet Use Laws") with face shields protect the eyes from wind and foreign objects in addition to protecting heads in crashes (Brewer et al., 2013). Well-constructed jackets, pants, boots, and gloves can prevent abrasions and bruises. If made of impact-resistant materials, they even may prevent arm and leg fractures or serious torso and spinal cord injuries (NHTSA, 2000). The benefits of protective clothing, in particular protective clothing equipped with body armor, was further confirmed by a series of studies of Australian motorcyclists involved in crashes (de Rome et al., 2011; de Rome et al., 2012).

A common perception among riders is that a frequent cause of motorcycle crashes involving other vehicles is that other vehicle drivers do not see the motorcycles. The 1981 Hurt et al. (1981) study from the United States and a 2007 study from the United Kingdom (Clarke et al., 2007) report that right-of-way collisions involving other motorists are more frequently the fault of the other motorists. Failure of the other motor vehicle driver to perceive the motorcyclist seems to occur in a significant portion of these types of crashes. One easy way to increase motorcycle conspicuity is through continuous headlight use. Most motorcycles manufactured since 1979 have headlights that turn on automatically when the vehicle is started (Potts et al., 2008, Strategy D2). Additionally, 24 States require daytime headlight use for all motorcycles manufactured after a certain date (all at least 20 years ago) (MSF, 2020). However, the increasing prevalence of passenger vehicles using continuous headlights may reduce the visibility and effectiveness of motorcycle headlights (Cavallo & Pinto, 2012).

A second way to increase conspicuity is to wear brightly colored clothing, use white or bright-colored helmets (for increased visibility during daylight), and incorporate retroreflective materials or devices (for increased visibility at night). Research studies confirm that motorcyclists wearing conspicuous clothing or helmets are less likely to be involved in crashes (Wells et al., 2004; Potts et al., 2008, Strategy D1). However, many riders choose not to wear brightly colored clothing or riding gear.

Additional technology such as auxiliary head and brake lights, flashing headlights, and other vehicle technologies enhance conspicuity, but the effects on crashes have not been studied. Adoption of these technologies may be useful to promote among the motorcycling community, may require changes in laws if visibility enhancing technologies are restricted by States, and may also involve working with manufacturers and producers of motorcycles and auxiliary devices (Potts et al., 2008).

Communications and outreach campaigns promoting protective and conspicuous clothing have been conducted by States and by motorcyclist organizations. Some States also teach the benefits of using high-visibility clothing in their training programs. Potts et al. (2008, Strategy D1) provide examples of material from Oregon and the MSF and references to additional material from the SMSA, and the Gold Wing Road Riders Association.

Use:

As of 2008 of the 44 States responding to a survey question, 33 reported encouraging conspicuity-enhancing clothing and helmets to enhance motorcyclists' visibility (Baer et al., 2010). The extent or nature of these efforts is unknown. There are no data on how many motorcycle riders wear various types of protective clothing (other than helmets) or use auxiliary devices. Helmet manufacturers and distributors report that more than half the helmets sold for street use are black and the predominant color of motorcycle clothing is black (Potts et al., 2008, Strategy D1).

Effectiveness:

The use of high-visibility clothing and protective gear enhances safety. There is some limited evidence to suggest that a program aimed at increasing conspicuous and protective clothing would be successful. An Australian study found that the observed proportion of riders wearing full body protection increased in the month following an enforcement/educational campaign with an emphasis on conspicuous and protective clothing (among other safety issues). However, it is unclear whether any real safety benefits were sustained (Baldock et al., 2012).

In Puerto Rico, changes to motorcycle safety laws were accompanied by an outreach effort to inform motorcyclists about the changes and to encourage compliance. In response, motorcyclists adopted the practice of wearing protective clothing, and law enforcement officers expressed that riders appeared to be aware of the law and expected to be stopped and cited for infractions (Fell et al., 2017). Four years after enactment of the law, observations of motorcyclists found that more than 80% of motorcyclists wore protective apparel, and 68% of riders wore reflective vests after 6 pm in compliance with the law.

Cost:

Good communications and outreach campaigns can be expensive to develop and implement. Information promoting protective and conspicuous clothing is available from various sources including MSF, other motorcyclist organizations, and States that have conducted these campaigns (Potts et al., 2008, Strategy D1).

Time to implement:

A proper campaign, including market research, message development and testing, and implementation, will require at least 6 months to plan and implement.

Other considerations:

- *Thermal discomfort:* While some protective gear is vented and designed to mitigate overheating, some motorcyclists may avoid wearing protective clothing in hot weather. Riding in hot weather while wearing protective clothing has been shown to elevate body core and skin temperature and cardiovascular stress, leading to increased reaction time, errors, perceived workload, and mood disturbances (de Rome et al., 2016; de Rome & Brown, 2016; de Rome, 2019).

Approaches That Are Unproven or Need Further Evaluation

Motorcycle Helmet Use Promotion Programs

Several States without universal motorcycle helmet use laws promote helmet use through communications and outreach campaigns and helmet use in general is encouraged by agencies such as the MSF, GHSA, NHTSA, and the World Health Organization (WHO). However, there is little evidence that these efforts to educate and promote helmet use among motorcyclists in the absence of universal helmet laws are effective, unless the publicity helps to gain enactment of such laws (Potts et al., 2008).

In general, initiatives such as this fail because they do not follow the principles of human behavior discussed in the Introduction. In the case of motorcycle helmet use, this strategy assumes that people in States without universal helmet laws are not wearing helmets because they lack information or understanding about the availability or benefits of motorcycle helmets and presumes that by telling people helmets are beneficial, they will change their behavior.

A parallel experience is evident in the efforts to increase seat belt use through educational and promotional efforts prior to the enactment of laws requiring seat belt use. Years of educational and promotional campaigns did little to increase seat belt use. It was only after laws requiring use were enacted that seat belt use began to rise substantially. NHTSA, MSF, GHSA, WHO, and other groups encourage helmet use. NHTSA has developed helmet use promotion brochures, flyers, and public service announcements suitable for television and radio that are available online (www.trafficsafetymarketing.gov/get-materials/motorcycle-safety for material). Potts et al. (2008) describe elements that should be included in a campaign should one be undertaken. The WHO has published a manual for policy makers and road safety practitioners to use when developing programs improving motorcycle helmet use (WHO, 2006).

Baer et al. (2010) distributed self-report surveys to States on their motorcycle safety programs and received responses from 45 States. Thirty-three of the 43 States that responded to a question on helmet use promotion, both with and without helmet laws, indicated they actively promote helmet use, but the nature and extent of these promotions is unknown. Only one State reported using paid broadcast media spots.

There appear to be no formal evaluations of the effect of helmet use promotion programs in States without universal helmet laws. However, helmet use remains substantially lower in States without universal helmet laws than in States with such laws (NCSA, 2019).

Communication Campaigns Aimed at Alcohol-Impaired Motorcyclists

Many States have conducted communications and outreach campaigns directed at drinking and riding, and organizations including AMA and MSF have produced campaigns and material on drinking and riding. There are few evaluations of the effectiveness of any of these campaigns at any level, from awareness to knowledge and attitude change to any effect on motorcyclists' drinking and riding behavior. Additionally, research on drinking and driving campaigns directed at all drivers suggests that these communication campaigns are unlikely to have a positive effect unless they are carefully researched and planned, well-funded, well executed, achieve high levels of target audience exposure (perhaps using paid advertising), use high-quality messages that are pre-tested for effectiveness, and are conducted in conjunction with enforcement activities directed at impaired motorcyclists.

This type of communication campaign assumes that motorcyclists who ride after drinking are not aware of the potential dangers or consequences of this behavior. While we often assume we understand why people behave a certain way, in reality human behavior is usually much more complicated. A focus group study (Becker et al., 2003) examined motorcyclists' attitudes, beliefs, and behaviors regarding drinking and riding. It concluded that many motorcyclists have strong feelings of freedom, independence, and individual responsibility and believe that drinking motorcyclists endanger only themselves. Consequently, they believe that government efforts to discourage drinking and riding are inappropriate. These beliefs also limit some motorcyclists' willingness to take actions to prevent others from riding while impaired. See the Introduction for more information about principles of human behavior. See the Alcohol-Impaired Driving chapter for more information on countermeasures that work to address impaired driving.

Communication Campaigns to Increase Motorist Awareness of Motorcyclists

Several States have conducted communications and outreach campaigns to increase motorists' awareness of motorcyclists. Typical themes are *Share the Road* or *Watch for Motorcyclists*. Some States build campaigns around *Motorcycle Awareness Month*, often in May, early in the summer riding season. (See NHTSA's Traffic Safety Marketing website for "Motorist Awareness of Motorcycles" material www.trafficsafetymarketing.gov/get-materials/motorcycle-safety).

Thirty-six of 44 States that responded to a survey question reported that they communicate about ways for drivers to increase their awareness of motorcycles and motorcyclists (Baer et al., 2010). NHTSA (2006, Section 5) and Potts et al. (2008) provide examples or links to campaigns from a dozen States. A review of literature uncovered no evaluations of the effectiveness of campaigns to increase driver awareness of motorcyclists.

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7. Young Drivers

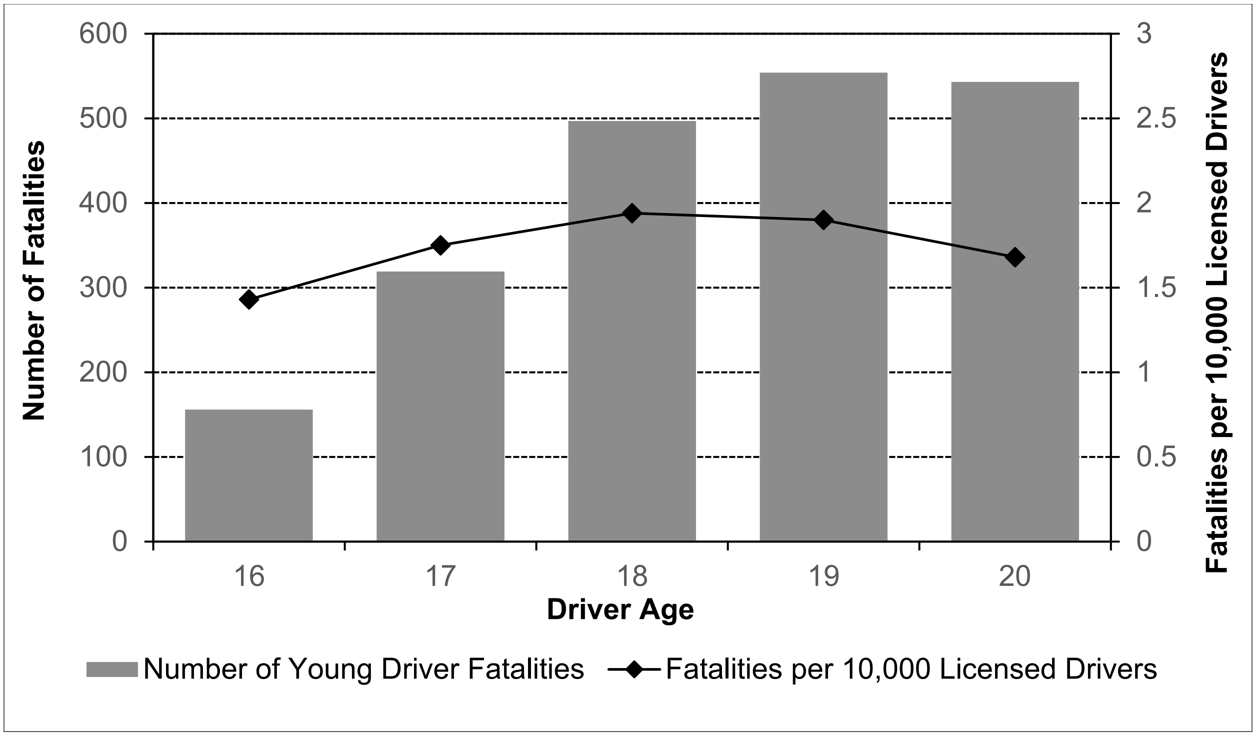
Overview

Motor vehicle crashes were the leading cause of unintentional death in 2020 for the 15- to 24-year-old age group in the United States (CDC, n.d.). In 2021 some 2,116 drivers 15 to 20 years old were killed, and an estimated 203,256 were injured in motor vehicle crashes (NHTSA, 2023). In comparison with adult drivers, young drivers are substantially over-involved in crashes. In 2021 drivers 20 and under made up 5.1% of licensed drivers in the United States, yet they made up 8.5% of total drivers in all fatal crashes and 12.6% of drivers in all crashes. As shown in the figure below, drivers 15 to 20 years old have the highest involvement in fatal crashes of any age group.

Source: NHTSA (2023)

Figure 7-1. Driver Involvement in Fatal Crashes per 100,000 Licensed Drivers, 2021

As shown in the figure below, the number of young driver fatalities increases with age and then begins to decline. The rate of young driver fatalities per 10,000 licensed drivers is relatively stable among drivers 16 to 20 (from 1.4 at 16 to 1.9 at 18 and 19 then declining to 1.7 at 20).



Sources: NCSA (2023); FHWA (2022), Table DL-20

Figure 7-2. Young Driver Fatalities, 2021

Except for drivers 80 years and older, per mile driven, young drivers are more involved in fatal crashes than older drivers. The trend has largely remained the same over the years (McCartt & Teoh, 2015). From April 2016 to March 2017 drivers 16 to 19 years old had the highest crash rate per 100 million travel miles as compared to all other age groups, except 80 years and older (Insurance Institute for Highway Safety [IIHS], 2021b). Drivers 16 to 19 years old were involved in 4.8 fatal crashes per 100 million travel miles, compared to 3.3 for drivers 20 to 24, 2.3 for drivers 25 to 29, 1.4 for drivers 30 to 59, 1.3 for drivers 60 to 69, 1.8 for drivers 70 to 79, and 5.4 for drivers 80+. Of the passenger vehicle occupants 16 to 19 killed in 2021 some 62% were drivers (IIHS, 2023). Thirteen percent of all passenger vehicle fatalities were passengers of teen drivers 13 to 19. In addition, 57% of teen passenger fatalities 13 to 19 were passengers of teen drivers 13 to 19.

From 2012 to 2021, there was a 18% increase in the number of young drivers (15 to 20) involved in fatal crashes, compared to a 33% increase in all drivers involved in fatal crashes during the same period (NHTSA, 2023). The number of young drivers involved in police reported crashes decreased 2% from 2018 to 2019. Many factors likely contributed to this long-term decline in fatal crashes including teen drivers waiting longer to get licensed, the advancement in vehicle safety technology, establishment of multi-stage licensing systems, and education and enforcement of traffic laws (Alderman & Johnston, 2018; Shults, Banerjee et al., 2016).

Understanding the Problem

Young drivers have high crash risks for two main reasons, as documented by extensive research summarized in Hedlund et al. (2003). First, they are inexperienced and just learning to drive. The mechanics of driving require much of their attention, so safety considerations frequently are secondary. They do not have experience in recognizing potentially risky situations or in reacting appropriately and controlling their vehicles in these situations. Second, normal adolescent development involves increases in novelty seeking and risk-taking behaviors (Kelley et al., 2004). In fact, research on adolescent development suggests that key areas of the brain involved in judgments and decision making continue to develop beyond adolescence (Dahl, 2008; Keating, 2007; Somerville, 2016; Steinberg, 2007). In addition, adolescents are more prone to seek rewards and overlook risks, especially in the presence of peers (Chein et al., 2011; Spear, 2011).

Inexperience makes certain circumstances more dangerous for younger drivers. In addition, due to typical adolescent brain development, young drivers are more likely to put themselves in risky circumstances (Alderman & Johnston, 2018; Ferguson, 2003; Williams, 2003). Young drivers are especially at-risk in the following five circumstances.

- *Nighttime Driving:* Driving is more difficult and dangerous at night for everyone, but particularly for teenagers (Lin & Fearn, 2003; Paterson & Dawson, 2016). Young drivers have less experience driving at night than during the day, and drowsiness and alcohol may be more of a factor at night.
- *Driving under the Influence of Substances:* Young drivers' inexperience with both driving and drinking means that they have a higher crash risk at all BACs than older drivers (Voas et al., 2012). Self-reported incidence of alcohol-impaired driving by high school seniors has steadily decreased from 9.1% in 2015 to 8.1% in 2017 and to 7.8% in the most recent survey in 2019 (CDC, 2020). The percentage of high school seniors reporting that they rode with an impaired teen driver has steadily decreased from 28.2% in 2009 to 17% in 2019. In contrast, the percentage of high school seniors who self-reported driving after the use of drugs (including marijuana and combinations of drugs and alcohol) in 2017 was 13%. Historical data on young drivers' driving under the influence of drugs other than alcohol is sparse; however, some surveys show that the use of marijuana and other illicit drugs may be more prevalent than alcohol in young drivers (Li et al., 2016; O'Malley & Johnston, 2013).
- *Passenger Interactions:* Teenage passengers can distract young drivers and encourage them to take risks (Foss & Goodwin, 2014; Lin & Fearn, 2003).
- *Seat Belt Use:* Seat belts reduce the risk of injury or fatality in a crash (see Seat Belts and Child Restraints), but teenage drivers and passengers have lower reported belt use rates than adult drivers and passengers (Ferguson, 2003; Shults, Haegerich et al., 2016).
- *Cell Phone Use:* All drivers are at higher risk when talking or texting; however, young drivers have more difficulty handling distractions (Lee, 2007). Teenage and young drivers have repeatedly been found to have increased levels of crash risk due to distractions involving cell phone use (Carney et al., 2016; Delgado et al., 2016; Guo et al., 2017; Klauer et al., 2014).

Data/Surveillance

Young driver safety cannot be adequately measured by involvement in crashes alone (Williams, 2003). Young drivers often drive less than adults, so to account for differences in exposure the most precise measure of young driver crash risk is based on crash rates per VMT. Naturalistic driving studies have shown that crashes and near crashes per mile driven are higher among young drivers compared to older experienced drivers (Gershon et. al., 2018; Seacrist et al., 2018; Simons-Morton et al., 2011). It may be beneficial for SHSOs to collect teen driver exposure data; however, it is very costly and time intensive to do. As an alternative, SHSOs can examine crash rates per population or by licensed drivers, by single year of age, to better target countermeasures.

Emerging Issues

The emergence of advanced driver assistance systems (ADAS) has important implications for young driver safety. ADAS are systems that use a variety of sensors, software technology and safety features working together to assist drivers with certain driving tasks (e.g., staying in the lane, parking, avoiding crashes, reducing blind spots). They have become standard on new vehicles and are intended to increase driver safety but do not perform the driving function. The driver must remain fully engaged in the driving task at all times. A driver should drive as if they do not have the technology and allow these safety features to back them up when needed.

ADAS features have the potential to reduce young driver crashes. However, to date, very little research has been conducted with this population. One small scale naturalistic study found teens with ADAS warning systems had fewer lane departures and more turn signal use, but they were more likely to leave less following distance between vehicles (Jermakian et al., 2017). Another study found forward collision warning systems had the biggest benefit to drivers under 25 years old measured by the frequency in property damage liability and bodily injury liability claims (HLDI, 2015).

ADAS also has implications for driver training and testing. As the role of the driver changes from manual control of the vehicle to more supervisory control, driver education programs will need to be updated to teach drivers to safely operate vehicles with ADAS (Manser et al., 2019). In addition, it will be necessary to update driver testing to make sure young drivers both understand the functions and limitations of ADAS and are prepared to intervene when ADAS fails or the vehicle is asked to perform outside its operational design domain (AAMVA, 2019).

Key Resources

The agencies and organizations listed below can provide more information on young drivers and links to other resources.

- NHTSA (n.d.), *Teen Driving*, web page: www.nhtsa.gov/road-safety/teen-driving
- Association of National Stakeholders in Traffic Safety Education general website and home page: http://anstse.info/
- For NHTSA's publications on young drivers visit
    - NHTSA's Behavioral Safety Research portal at https://rosap.ntl.bts.gov/cbrowse?pid=dot%3A242&parentId=dot%3A242
- CDC (2022), *Teen Driver and Passenger Safety*, [Web page and portal]. www.cdc.gov/transportationsafety/teen_drivers/index.html

- Children's Hospital of Philadelphia (2020) Center for Injury Research and Prevention, *Teen Driving Safety Research,* [Web page and portal]. https://injury.research.chop.edu/teen-driving-safety-research
- GHSA (2023), *Teen Driver safety*, web page: www.ghsa.org/html/issues/teens/index.html
- IIHS (2023), *Teenagers*, web page: www.iihs.org/iihs/topics/t/teenagers/topicoverview
- NSC (2023), *Car crashes are the #1 cause of preventable death for teens*, web page: www.nsc.org/driveithome
- AAA (2022), Teen Driver Safety, web page: https://exchange.aaa.com/safety/teen-driver-safety/
- Injury Prevention. (2006). *The science of safe driving among adolescents.* [Table of contents page of the journal's June 2006, Volume 12, suppl 1, listing 11 articles in that issue]. https://injuryprevention.bmj.com/content/12/suppl_1#-Thescienceofsafedrivingamongadolescents
- The special issue of the 2007 *Journal of Safety Research* containing 17 articles presented at the Novice Teen Driving: GDL and Beyond – Research Foundations for Policy and Practice Symposium (2007, February 5-7), Tucson, AZ. Journal of Safety Research, 38/2. www.sciencedirect.com/science/journal/00224375/38/2
- The special issue of the 2008 *American Journal of Preventive Medicine* (Williams et al., 2008). www.ajpmonline.org/issue/S0749-3797%2808%29X0014-5
- See also Simons-Morton (2019), Alderman & Johnston (2018) and Williams et al. (2012) for summaries of much of the research on young driver issues.

For a detailed discussion of strategies for reducing crashes involving young drivers, see:

- NCHRP Report 500 guide for the AASHTO Strategic Highway Safety Plan: *A Guide for Reducing Collisions Involving Young Drivers* (Goodwin et al., 2007)
- Governors Highway Safety Association: Curbing Teen Driver Crashes: An In-Depth Look at State Initiatives (GHSA, 2012).

Young Driver Countermeasures

Legislation and Licensing

Countermeasure	Effectiveness	Cost	Use	Time
Graduated Driver Licensing (GDL)	★★★★★	$	High	Medium
GDL Learner's Permit	★★★★★	$	High	Medium
GDL Intermediate License Nighttime Restrictions	★★★★★	$	High	Medium
GDL Intermediate License Passenger Restrictions	★★★★★	$	High	Medium

Enforcement

Countermeasure	Effectiveness	Cost	Use	Time
Enforcement of GDL	★★	$	Unknown	Short

Other Strategies for Behavior Change

Countermeasure	Effectiveness	Cost	Use	Time
Programs to Assist Parents/Guardians of Young Drivers	★★	$$	Medium	Short
Electronic Technology for Parental/Guardian Monitoring	★★★	$	Low	Short
Hazard Perception Training	★★	Varies	Low	Varies

Approaches That Are Unproven or Need Further Evaluation

Countermeasure
GDL Supervised Hours
GDL Cell Phone Restriction
Intermediate – Violation Penalties
Pre-Licensure Driver Education
Post-Licensure Driver Education
Advanced Driver Training Course

Effectiveness:

★★★★★	Demonstrated to be effective by several high-quality evaluations with consistent results.
★★★★	Demonstrated to be effective in certain situations.
★★★	Likely to be effective based on balance of evidence from high-quality evaluations.
★★	Limited evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.
★	No evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.

Cost to implement:

$$$	Requires extensive new facilities, staff, equipment, or publicity, or makes heavy demands on current resources.
$$	Requires some additional staff time, equipment, facilities, and/or publicity.
$	Can be implemented with current staff, perhaps with training; limited costs for equipment or facilities.

These estimates do not include the costs of enacting legislation or establishing policies.

Use:

High	More than two-thirds of the States, or a substantial majority of communities
Medium	One-third to two-thirds of the States or communities
Low	Less than one-third of the States or communities
Unknown	Data not available

Time to implement:

Long	More than 1 year
Medium	More than 3 months but less than 1 year
Short	3 months or less

These estimates do not include the time required to enact legislation or establish policies.

Legislation and Licensing

Graduated Driver Licensing

Effectiveness: ★★★★★	**Cost:** $	**Use:** High	**Time:** Medium

GDL is a three-phase system for beginning drivers, consisting of a learner's permit, an intermediate license, and a full license. A learner's permit allows driving only while supervised by a fully licensed driver. An intermediate license allows unsupervised driving under certain restrictions. These usually include limits on driving at night or with teenage passengers. The learner's permit and the intermediate license each must be held for a specified minimum period of time.

GDL serves two functions: reducing risk and reducing exposure. GDL allows beginning drivers to acquire driving experience in less-risky situations and under direct supervision during the learner's permit phase. It helps young drivers avoid dangerous conditions such as late-night driving or driving with teenage passengers in the vehicle during the intermediate phase. GDL delays full licensure by requiring a minimum time in both the learner's permit and intermediate phases. Compared to earlier requirements in many jurisdictions, where beginning drivers could receive a full license at age 16 (and sometimes earlier) by passing a minimal driving test, GDL reduces the amount of unsupervised driving by 16-year-olds. GDL also ensures that young drivers are more mature when they receive their first unrestricted license. Based on a national survey, most parents (61 to 98% depending on the policy) support GDL policies that are as strong as, or even stronger, than policies currently in place in the United States (Williams et al., 2011).

All States now have some form of GDL in place. IIHS (2021c) documents GDL laws in each State and the website is updated monthly. The papers in the special issue of the 2007 *Journal of Safety Research* (Editorial Board, 2007) describe GDL's history, components, effectiveness, parental roles, potential enhancements, and research needs. Strategies for implementing or improving GDL systems are described in NCHRP's *Guide for Reducing Collisions Involving Young Drivers* (Goodwin et al., 2007, strategies A1 through A5). See also NHTSA's *Traffic Safety Facts* on GDL (NHTSA, 2008) and *Teen Driver Crashes: A Report to Congress* (Compton & Ellison-Potter, 2008), and the Traffic Injury Research Foundation's *New GDL Framework: Evidence Base to Integrate Novice Driver Strategies* (Mayhew et al., 2014).

Use:

All States and the District of Columbia had some GDL components in place as of November 2021. In addition, all States and the District of Columbia had a three-phase GDL system in place (IIHS, 2021b).

Effectiveness:

GDL's effectiveness in reducing young driver crashes and fatalities has been well-documented (Baker et al., 2007; Chapman et al., 2014; Chaudhary et al., 2018; Fell et al., 2011; Lyon et al., 2012; Masten et al., 2011; Masten et al., 2013; Masten et al., 2015; McCartt et al., 2010; Russell et al., 2011; Shope, 2007; Simpson, 2003; Williams, 2017). The most restrictive GDL programs—those with at least a 6-month holding period during the learner stage, a night restriction beginning no later than 10 p.m., and restrictions allowing no more than one teen passenger—are associated with a 38% reduction in fatal crashes and a 40% reduction in injury crashes among 16-year-old drivers (Baker et al., 2007). In addition to reducing crashes, GDL is associated with declines in hospitalization rates and charges for 16-year-old drivers (Margolis et al., 2007; Pressley et al., 2009) and healthcare resource utilization for drivers 16 to 20 years old and their occupants (Conner & Smith, 2017).

Costs:
GDL's primary costs result from the intermediate license, which adds to licensing agency workload by requiring each beginning young driver to receive three licenses in succession rather than two. These costs are typically covered by small fees charged by the licensing agency.

Time to implement:
Licensing changes typically require up to a year to plan, publicize, and implement.

Other issues:

- *Age of licensure:* Over the years, there has been discussion about the most appropriate age for allowing teenagers to drive independently (Foss et al., 2014; Williams, 2009; Williams et al., 2013). Licensing ages vary from State to State, from a low of 14½ in South Dakota to a high of 17 in New Jersey. Delaying licensure, either through higher entry ages or GDL requirements such as extended learner stages, can reduce young driver crashes (Foss et al., 2014). For example, New Jersey's GDL system has eliminated most crashes among 16-year-old drivers and has reduced crashes among 17-year-olds by 16% (Williams et al., 2010).
- *Applying GDL to older novices:* In most States, GDL only applies to drivers under the age of 18. If teens delay licensure until age 18 or older, they miss the safety benefits of GDL. Tefft and Foss (2019) report approximately one-third of first-time license holders in the United States are 18 or older. In addition, older novice drivers, 18 to 20 years old, have increased crash rates immediately after licensure like that of 17-year-old novice drivers (Curry, Metzger, et al., 2017). This indicates there might be value in extending GDL provisions to older novice drivers 20 years old and younger. A recent study examined Indiana's GDL that extended its nighttime driving restriction and passenger restriction to include all newly licensed drivers under 21 years old and found crashes were actually higher among drivers licensed under the new system (Wang, Foss, Goodwin, et al., 2020) However, the nighttime and passenger restrictions were in addition to an already implemented 6-month learner permit for all drivers under 21 so it was not possible to determine the independent effect of the 6 month learner period for older novices. More research is needed to determine whether GDL—which was designed for teenagers—can benefit older novices who may have different life circumstances (e.g., living away from home) and different driving needs (e.g., full-time jobs).

GDL Learner's Permit

Effectiveness: ★★★★★	**Cost:** $	**Use:** High	**Time:** Medium

With a learner's permit, novices can drive when accompanied by an adult supervisor. The learner's permit allows and encourages beginning drivers to acquire substantial supervised driving experience. To aid this, most States require the learner's permit to be held for a minimum period of time, and most require a minimum number of supervised driving hours. Surveys show that parents/guardians and teenagers strongly support the learner's permit holding period and supervised driving requirements (Block & Walker, 2008; Mayhew, 2003; McKay et al., 2008; Williams, 2011; Williams et al., 2011).

Use:

As of November 2021, 48 States and the District of Columbia required learner's permits to be held for at least 6 months, with 7 of these States requiring a minimum holding period of a full year. However, 2 States (Connecticut and South Dakota) reduce the required length of time for a permit to be held if the young driver completes driver's education (IIHS, 2021b).

Effectiveness:

Since learner's permit drivers are being supervised, it is not surprising that crash rates during the learner's permit period are very low (Mayhew et al., 2003), with learner drivers having rates of crashes/near-crashes and risky driving like adults (Gershon et al., 2018). For young drivers holding their first unsupervised license, the available evidence suggests that crash rates decreased after jurisdictions with no learner's permit holding requirement implemented a 6-month requirement (Ehsani et al., 2013; Mayhew, 2003). Moreover, longer permit holding periods appear to result in even larger crash reductions. Masten et al. (2013) found that a 9- to 12-month leaner's permit holding period resulted in 26% lower fatal crash incidence among 16-year-old drivers and 17% lower incidence among 17-year-olds compared to requiring learner permits for up to 4 months.

Costs:

Once GDL is in place, requirements for the learner's permit can be implemented at very little cost.

Time to implement:

GDL requirement changes typically require about 6 months to notify the public and implement the changes.

GDL Intermediate License Nighttime Restrictions

Effectiveness: ★★★★★	**Cost:** $	**Use:** High	**Time:** Medium

Driving at night increases the fatal crash risk per mile of travel for all drivers, and especially for teenage drivers (Hedlund et al., 2003; Tefft et al., 2013; Williams, 2003). A study found that the rate of driver fatalities was 5 times higher among 16- and 17-year-olds from 10 p.m. to 5:59 a.m. compared to driving during the day (Tefft et al., 2013). At night, driving is more difficult, driver drowsiness is more common, and alcohol is more likely to be used. Many intermediate license drivers have limited experience driving at night. For these reasons, a nighttime driving restriction can help reduce risk for intermediate level drivers.

The restricted hours vary widely, from 6 p.m. to 6 a.m. in the most restrictive State, to 1 a.m. to 5 a.m. in the least restrictive (IIHS, 2021b). The most common hours are 11 p.m. or midnight to 5 or 6 a.m. However, a starting time earlier than midnight will prevent more crashes, especially since teenage driver crashes occur more frequently before midnight than after (Foss & Goodwin, 2003; Shults & Williams, 2016; Williams, 2003). An analysis of fatal crash data for drivers 16 and 17 estimated that while these drivers only take about 11% of their trips from 9 p.m. to 5:59 a.m., these trips account for almost one-third (31%) of fatal crash involvement in this age-group (Shults & Williams, 2016).

NHTSA's 2007 Motor Vehicle Occupant Safety Survey found that 73% of the general public believe teenagers should not be allowed to drive unsupervised after 9 p.m. (Block & Walker, 2008). Another national survey of parents found 90% support a nighttime driving restriction, with 77% saying it should be 10 p.m. or earlier (Williams et al., 2011). These perceptions match observed driving trends, which show that greater reductions in crash rates are associated with nighttime restrictions starting at or before 10 p.m. (Shults & Williams, 2016). There is an almost two-fold increase in the proportion of young driver (16 and 17) involvement in fatal crashes before midnight compared to after midnight. Twenty-three States and the District of Columbia had nighttime restrictions starting at 12 a.m. or later, with almost 93% of nighttime travel by drivers 16 and 17 ending before midnight.

Use:

As of November 2021 there were 49 States and the District of Columbia that restricted intermediate license drivers from driving during specified nighttime hours (the exception is Vermont). Many States allowed driving during the restricted hours for work or school-related activities (IIHS, 2021b).

Effectiveness:

The effectiveness of nighttime driving restrictions in reducing both nighttime driving and nighttime crashes has been demonstrated conclusively (Fell et al., 2011; Hedlund et al., 2003; Hedlund & Compton, 2005; Lin & Fearn, 2003; Lyon et al., 2012; Masten et al., 2013; McCartt et al., 2010). The earlier a nighttime restriction begins, the greater the reduction in crashes. For example, night restrictions that begin at 9 p.m. are associated with an 18% reduction in fatal crashes compared to no restriction. The reduction is only 9% when the night restriction begins at 1 a.m. (McCartt et al., 2010).

Costs:

Once GDL is in place, a nighttime driving restriction can be implemented or modified at very little cost.

Time to implement:

GDL requirement changes typically require about 6 months to notify the public and implement the changes.

GDL Intermediate License Passenger Restrictions

Effectiveness: ★★★★★	**Cost:** $	**Use:** High	**Time:** Medium

Young passengers are associated with a substantial increase in the risk of a fatal crash for teenage drivers (Chen et al., 2000; Ouimet et al., 2010; Ouimet et al., 2015; Preusser et al., 1998; Tefft et al., 2013). Each additional passenger is associated with an additional increase in fatal crash risk (Chen et al., 2000; Ouimet et al., 2015; Preusser et al., 1998; Tefft et al., 2013). Fatal crash risks are highest when young male drivers carry same age passengers, especially if those passengers are also male (Chen et al., 2000; Ouimet et al., 2010; Ouimet et al., 2015; Tefft et al., 2013).

To reduce this risk, most States include a passenger restriction in their GDL requirements for intermediate licensees. According to NHTSA's 2007 Motor Vehicle Occupant Safety Survey, 86% of the general public believe that teenagers should have a restriction on the number of teenage passengers they can carry (Block & Walker, 2008). In a national survey, 89% of parents say they support passenger restrictions; 82% think the passenger limit should be one or zero (Williams et al., 2011).

Use:

As of November 2021, 46 States and the District of Columbia restricted in some way the number of passengers who can be carried by an intermediate license driver (IIHS, 2021b). The most common passenger restrictions limit teenage drivers to zero or just one passenger. Some restrictions apply to all passengers and some only to passengers younger than a specified age. A few States allow exceptions for transporting family or household members.

Effectiveness:

There is growing evidence that passenger restrictions are effective in reducing young driver crashes, though the restrictions sometimes are violated (Carpenter & Pressley, 2013; Fell et al., 2011; Goodwin & Foss, 2004; Lyon et al., 2012; Masten et al., 2013; McCartt et al., 2010; Williams, 2007). California allows no passengers younger than 20 for teenagers who hold intermediate licenses. Four studies demonstrate the positive effects of this restriction. For example, one study showed a 38% decrease in 16-year-old-driver crashes in California in which a teen passenger was killed or injured (Williams, 2007). A NHTSA study evaluated passenger restrictions in California, Massachusetts, and Virginia. Results showed 16-year-old driver crashes were reduced in all 3 States, as were motor-vehicle-related injuries among 15- to 17-year-olds (Chaudhary et al., 2007). In North Carolina a teen passenger restriction was enacted independent of any other changes to the State's GDL system. After this restriction 16-year-old-driver crashes involving passengers decreased by 32% (Foss, 2009). National studies have also found large crash rate reductions for passenger restrictions. For example, McCartt et al. (2010) found a 21% reduction in fatal crashes among 15- to 17-year-olds when no passengers were permitted and a 7% reduction when one passenger was allowed. Similarly, Masten et al. (2013) found a 20% lower fatal crash rate among 16-year-old drivers and a 12% lower fatal crash rate among 17-year-old drivers when no more than one young passenger was allowed for at least the first 6 months of independent driving.

Costs:

Once GDL is in place, a passenger restriction can be implemented at very little cost.

Time to implement:

GDL requirement changes typically require about 6 months to notify the public and implement the changes.

Enforcement

Enforcement of GDL

Effectiveness: ★★	**Cost:** $	**Use:** Unknown	**Time:** Short

Parents/guardians are often in the best position to enforce GDL requirements. However, law enforcement support for GDL nighttime driving and teenage passenger restrictions may be useful to emphasize that the requirements are important. GDL violations are penalized by driver license actions, such as suspension or revocation of the learner's permit or intermediate license or an extension of the time before full licensure. This means they can be applied administratively and do not involve criminal court proceedings.

Presently, GDL requirements do not appear to be enforced vigorously. Although surveys of law enforcement officers found that most were supportive of GDL, officers were not familiar with GDL details and considered GDL enforcement a low priority (Goodwin & Foss, 2004). A study in 2 States identified modest numbers of citations for some offenses, noting that other GDL restrictions were rarely enforced (AAAFTS, 2014). Some GDL provisions such as nighttime driving restrictions are inherently difficult to enforce because violations are difficult to detect (Hedlund et al., 2003). A study in one State found that intermediate license drivers and their parents/guardians were quite aware of their GDL law's nighttime and passenger restrictions (Goodwin & Foss, 2004). Both restrictions were violated, though not frequently. Similarly, Curry, Pfeiffer, and Elliott (2017) found that teen non-compliance with passenger and nighttime restrictions was low, 8.3% and 3.1%, respectively. Another study using focus groups found that nearly all teen drivers admitted to having violated passenger restrictions, at least occasionally, but teens were mixed in their beliefs about whether police routinely enforce GDL restrictions (Chaudhary et al., 2007).

Another issue with enforcement concerns the difficulties in identifying drivers that qualify as falling under the GDL system in each State. It has been suggested that young drivers should be required to affix a vehicle decal identifying them as qualifying for the GDL program to make them more readily identifiable (Curry, Elliott, et al., 2015). New Jersey was the first State to implement this potential countermeasure.

Use:
The amount of enforcement of GDL laws is unknown.

Effectiveness:
One study investigated whether well-publicized enforcement, including checkpoints near high schools, could increase compliance with seat belt laws and GDL provisions. The study found only modest increases in seat belt use and compliance with the GDL passenger restriction, although levels of compliance prior to the enforcement efforts were already high (Goodwin et al., 2006).

A study of fatal teen driver crashes from 1998 to 2016 in New Jersey reported both extensive public health campaigns and targeted enforcement of GDL laws are necessary for the prevention of such crashes (Bonne et al., 2018). GDL was implemented in New Jersey in 2002. However, significant reductions in teen fatal crashes and the number of fatally injured teenagers were seen only after a comprehensive campaign of public awareness, education, and enforcement began in

2010. School outreach, classroom discussions, parent/teen orientations, and public service announcements on GDL were distributed as part of the awareness campaign. Enforcement practices consisted of checkpoints near high schools and targeted enforcement of GDL provisions based on decals. Teen driver crashes in the 4-year pre-campaign period (2006 to 2010) were compared with a 6-year post-campaign period (2010 to 2016). Teen-involved crashes decreased 31%, teen driver fatalities decreased 47%, and teen-involved fatal crashes decreased by 43% after the campaign.

Studies evaluating the effectiveness of vehicle decals in New Jersey have found increases in citations for violations of licensing restrictions and decreases in crash rates among intermediate license holders in the year after the requirement went into effect (Curry et al., 2013; McCartt et al., 2012). A longer term (2-year) evaluation of the effect of the decal provision on police-reported crash rates and citations was conducted and baseline comparisons using data from a 4-year pre-decal period were performed (Curry, Elliott, et al., 2015). The study showed that the adjusted crash rates for intermediate license holders were 9.5% lower after the decal provision. There were no changes in crash rates or citations for holders of learner's permit (Curry, Pfeiffer, et al., 2015). A follow-up study found that the decline in crash rates could not be attributed to increases in young drivers' compliance with passenger or nighttime restrictions but may have been the result of a general increase in safer behaviors when displaying decals (Palumbo et al., 2018).

Costs:

GDL law enforcement costs will depend on how the enforcement is conducted. Enforcement through regular patrols will require moderate costs for training. Special patrols or checkpoints will require additional staff time. To be most effective, all enforcement efforts will require good publicity to both teens and parents/guardians. Publicity to teens can be delivered through high schools, colleges, recreational venues attended by youth, and media directed to youth. The cost of vehicle decals can be paid for by the licensee when they receive a learner's permit or intermediate license. In New Jersey, vehicle decals cost $4 for a pair.

Time to implement:

Enforcement programs can be implemented within 3 or 4 months, as soon as appropriate training, publicity, and equipment are in place.

Other considerations:

- *Compliance with restrictions:* Several studies have shown that teenagers do not always comply with GDL restrictions (Goodwin & Foss, 2004; Williams et al., 2002). To the extent that teens do not adhere to restrictions, the effectiveness of GDL may be reduced. It should be noted, however, that GDL has been shown to be effective even in the absence of police enforcement. In general, compliance with restrictions will be higher in States that have well-designed GDL systems with restrictions that are considered reasonable by parents/guardians and teens (Foss & Goodwin, 2003). Curry, Pfeiffer, and Elliott (2017) used the quasi-induced exposure (QIE) method to estimate young, intermediate drivers' compliance with passenger and nighttime restrictions in New Jersey. The QIE method assumed that young intermediate drivers in multi-vehicle crashes—where the teen driver was *not* at fault—were reasonably representative of the population of young intermediate drivers. Data from a total of 9,250 teenage drivers who were involved in multi-vehicle crashes from July 2010 to June 2012 were examined. Noncompliance with the passenger restriction was, on average, 8.3%, and noncompliance with the nighttime restriction was 3.1%. Certain groups and situations were associated with higher rates of noncompliance—male drivers, those residing in low-income and urban areas, weekend trips, and trips in the summer months. The authors concluded that outreach activities should be focused, where possible, on higher-risk situations and groups with higher noncompliance.

- *Citation dismissal in the courts:* One study in 2 States noted relatively high rates of GDL-related citations being dismissed by the courts, which could have a negative impact on the effectiveness of those programs (AAAFTS, 2014).

Other Strategies for Behavior Change

Programs to Assist Parents/Guardians of Young Drivers

Effectiveness: ★★	**Cost:** $$	**Use:** Medium	**Time:** Short

Most parents/guardians are heavily involved in teaching driving skills to their beginning teenage drivers and supervising their driving while they have a learner's permit. Parents/guardians are often in the best position to enforce GDL restrictions for intermediate drivers and to impose additional driving restrictions on their teenagers. Parents/guardians strongly support GDL; however, many parents/guardians do not understand the dangers of high-risk situations for teen drivers, such as driving with teenage passengers. A review of naturalistic driving data collected from young drivers indicated that most parental/guardian guidance is reactive and may not allow for the teens to practice driving in complex situations (Simons-Morton et al., 2017). Parents/guardians could use systematic guidance and assistance in supervising and training teens (Hedlund et al., 2003; Goodwin et al., 2007, Strategies C1-C3; Simons-Morton et al., 2017). For summaries of the research on parent/guardian involvement in teen driving, see Simons-Morton and Ouimet (2006) or Simons-Morton et al. (2008). For a review of promising parent programs, see GHSA (2013).

In hopes of better equipping parents/guardians to supervise and manage their teens' driving, there has been a growing interest in programs that involve direct interaction and engagement with parents and guardians. Although many such programs have been developed, the following programs are highlighted because they have been evaluated and shown promising results: Checkpoints, Steering Teens Safe, TeenDrivingPlan, and the Share the Keys Program. See Curry, Peek-Asa, et al. (2015) for a review of similar programs.

Checkpoints: The original Checkpoints program, developed by Simons-Morton and colleagues at the National Institute of Child Health and Human Development, is a program that uses videos and periodic newsletters to reinforce the need for parents/guardians to limit their newly licensed teens' driving under risky conditions. A central feature of the program is a written agreement that parents/guardians and teens review and sign. The agreement limits teens' driving under various high-risk situations, such as driving at night, with other teens in the car, or in bad weather (Simons-Morton & Hartos, 2003). The facilitated Checkpoints program has been adapted from the original version to include a 30-minute in-person session to introduce teens and parents/guardians to the Checkpoints program, and to have them work in pairs to begin developing a parent/guardian-teen driving agreement (Zakrajsek et al., 2009).

Steering Teens Safe: This is a 45-minute in-person program that focuses on improving parents'/guardians' communication skills by teaching them to use motivational interviewing techniques to talk to their teens about safe driving. Parents/guardians receive a DVD and a workbook with 19 safe driving lessons to help parents/guardians to discuss, demonstrate, and practice safe driving behaviors and skills with their teens. Steering Teens Safe is intended for parents/guardians of teens who are in the learner permit phase (Peek-Asa et al., 2014; Ramirez et al., 2013).

TeenDrivingPlan: This is a web-based program for parents/guardians to use during the learner permit phase to increase the quantity and quality of their supervised driving practice. The TeenDrivingPlan includes 53 web-based videos, a web-based planner to help teens and parents/guardians structure their practice sessions, and a web-based log to record and rate driving practice sessions (Mirman et al., 2014).

Share the Keys (STK) program: Previously known as the New Jersey Parent/Teen Driver Orientation Program, the Share the Keys program was developed to provide parents/guardians with education on New Jersey's GDL program, laws, and the importance of parental/guardian involvement in teen driver safety (Knezek et al., 2018). The program lasts for 60 to 90 minutes and is delivered as a 26-slide deck with 10 videos focused on parental/guardian involvement and their role in preventing risky teen driver behaviors. Parenting styles (e.g., Authoritarian) and opportunities for parents/guardians to serve as role models of ideal behavior (e.g., not texting while driving) are covered in the content. Parents/guardians and teens are asked to collaboratively develop contracts and pledges related to GDL restrictions. Companion guides and online resources are provided to the parents/guardians and teens for information during the supervised training period.

Use:

Checkpoints and TeenDrivingPlan are available on the web. Steering Teens Safe is not yet available for the public. Share the Keys presentations can be scheduled by schools and communities free of charge, with online resources available for the public at any time.

Effectiveness:

Checkpoints: Results from testing in several States show the original Checkpoints program produces modest increases in parents'/guardians' restrictions on teen driving (Simons-Morton & Hartos, 2003; Simons-Morton et al., 2005). However, a study in Connecticut found no differences in violations or crashes for families who participated in the Checkpoints program when compared with families who did not participate in the program (Simons-Morton et al., 2006).

The facilitated Checkpoints program has been evaluated and has had promising results. Zakrajsek et al. (2009) evaluated the program delivered by trained health educators in driver education classes and found that, relative to a comparison group, parents/guardians who participated in the facilitated Checkpoints program showed greater awareness of teen driving risks, were more likely to complete a parent/guardian-teen driving agreement and reported setting stricter limits on their teens' driving during the intermediate license phase. Zakrajsek et al. (2013) conducted an evaluation of the facilitated Checkpoints program delivered by driver education instructors and found that parents/guardians who participated in the program were more likely to report that they used a parent/guardian-teen driving agreement and had stricter limits on their teens' driving. Teens also self-reported less risky driving. However, they found no differences in crashes for teens who participated in the program compared to teens who did not participate.

Steering Teens Safe: The Steering Teens Safe program has been evaluated via randomized controlled trials (Peek-Asa et al., 2014; Peek-Asa et al., 2019). One study examined the effectiveness of parent/guardian communication about driving safety as perceived by the teen driver, and the teens' self-reported risky driving (Peek-Asa et al., 2014). Teens in the Steering Teens Safe program reported a higher quality of parent/guardian communication than control teens, and the teens in the program reported a 21% reduction in self-reported risky driving compared with control teens. Peek-Asa et al. (2019) report that, compared to teen drivers who received no feedback on their driving, drivers with electronic feedback and drivers with combined electronic and parental/guardian feedback based on event monitoring had 65% and 85% fewer unsafe driving events (such as distracted driving, speeding, or driver and passenger seat belt use) respectively. Hamann et al. (2019) examined how family communication patterns influenced the effectiveness of the Steering Teens Safe program. They found the program had the most impact on families with a laissez-faire communication style. Families with a laissez-faire communication style in the combined electronic and parental feedback intervention group had an average of a 29% reduction in the teen's unsafe driving event rate compared with teens in the group who just received electronic feedback.

TeenDrivingPlan: To date, one randomized controlled trial has been conducted to measure the effects of the TeenDrivingPlan. Mirman et al. (2014) found that families who used the plan reported more driving practice in various environments and situations (i.e., night and bad weather) compared to teens not in the program. In addition, teens that were in the TeenDrivingPlan group were less likely to be terminated during an on-road driving test compared to teens not in the program (6% and 15%, respectively).

Share the Keys (STK) program: A longitudinal survey-based evaluation was performed on the initial STK program implementation in New Jersey. Overall, parents/guardians reported high levels of engagement with their teens in the GDL process. In general, parents/guardians were more reluctant to take on authoritative/authoritarian roles in their teens' GDL process, which was associated with a lack of teen driver compliance with nighttime curfews and passenger restrictions. Some positive changes were observed, such as the increase in passenger limit compliance over time. Parents/guardians also appreciated the ability to engage with other parents/guardians and teen drivers in the program to allow for clarification of their own roles as monitors and enforcers. STK can be combined with other programs such as Checkpoints to provide consistent benefits in the short term (Knezek et al., 2017).

Although evaluations of programs to assist parents/guardians have not yet shown reductions in young driver crashes, there is still reason to be optimistic. Programs such as Checkpoints have increased parent/guardian limit setting, and several studies show that teenagers whose parents/guardians impose more strict driving limits report fewer risky driving behaviors, traffic violations and crashes (see Simons-Morton, 2007, for a review). Educational programs alone are unlikely to produce changes in behavior. However, education in combination with other strategies may deliver stronger results.

Costs:

Checkpoints and the TeenDrivingPlan are available on the web for free. However, to use the facilitated version of Checkpoints, staff time would be needed to implement in the in-person session. Share the Keys presentations are provided free of charge to schools and communities. The cost of Steering Kids Safe is unknown.

Time to implement:

The original Checkpoints program and the facilitated program are available immediately. However, to implement the facilitated Checkpoints program on a large scale, it would likely take a year for planning, staff training, and dissemination. The TeenDrivingPlan is available immediately online. Share the Keys resource guides are available online. Interactive 60–90-minute presentations must be scheduled. Steering Teens Safe program implementation details are not available, but a website is planned - https://iprc.public-health.uiowa.edu/resources/interventions/.

Electronic Technology for Parental/Guardian Monitoring

Effectiveness: ★★★	**Cost:** $	**Use:** Low	**Time:** Short

Various technologies have been developed to aid parents/guardians in monitoring their teenage drivers. Monitoring can include driving behaviors and performance (e.g., aggressive driving, drowsiness, and distraction), as well as situational aspects of trips (geographic extent, passengers, road, and trip characteristics; Lerner et al., 2010). For example, many GPS companies offer "teen tracking" services that will notify parents/guardians if their teens go beyond geographical boundaries or if they are speeding at any given time.

The smartphone-based Teen Driver Support System (TDSS) has been used to provide real-time feedback to teen drivers about unsafe driving behaviors. If a monitored driver does not cease the unsafe behavior (e.g., texting or aggressive driving), text notifications are used to report the behavior to parents/guardians (Creaser et al., 2015). In addition to aftermarket in-vehicle systems, vehicle-embedded systems that enable parental/guardian monitoring and setting limits on speed and infotainment use are becoming available.

Use:

The extent of the use of electronic monitoring and feedback systems is currently unknown; however, the advent of smartphone-based systems and applications may provide low-cost alternatives to more expensive aftermarket devices.

Trust in teenagers, costs, or concerns about privacy may dissuade parents from using electronic monitoring systems (McCartt et al., 2007; Curry, Peek-Asa, et al., 2015). One survey in Ireland of teen drivers' willingness to use a smartphone-based monitoring system indicated that the risk of increased insurance premiums and the potential for device-based distraction deterred willingness to use the technology (Kervick et al., 2015). However, peer approval and adoption of the technology was associated with positive willingness.

Effectiveness:

While more research is needed to determine the impact of electronic monitoring on crashes and fatalities among young drivers (Reyes et al., 2016), many studies have reported positive benefits due to electronic monitoring of teen drivers in both learner and early post-licensure periods. In addition, electronic monitoring technologies help reduce the incidence of risky driving behaviors among teens by encouraging parental/guardian feedback. (Carney et al., 2010; Farah et al., 2014; Farmer et al., 2010; McGehee et al., 2007; Musicant & Lampel, 2010; Peek-Asa et al., 2019; Simons-Morton et al., 2013).

Reyes et al. (2016) conducted two studies to evaluate if post-drive electronic device feedback provided to newly licensed teen drivers and their parents/guardians could reduce risky behaviors, and if video feedback enhanced benefits of the intervention. In the first study, the rate of unsafe driving events (such as abrupt acceleration, deceleration, or steering maneuvers; traffic violations; or improper seat belt use) for teens who received feedback from an electronic monitoring device (video-based or non-video based) were significantly lower than the control group. Mean unsafe event rates were 6.1 per 1,000 miles for teens with either form of feedback in comparison with 35.3 per 1,000 miles among teens with no feedback. There were no significant differences between the video and non-video intervention groups, suggesting that the provision of any feedback to teens and their parents/guardians is likely to deter unsafe driving behaviors among teens. A second study was conducted with teen drivers of varying ages during unsupervised driving experiences (Reyes et al., 2018). Irrespective of age or experience, teens in the intervention group who received video feedback along with their parents/guardians, had lower rates of unsafe driving events than teen drivers who received no feedback.

Creaser et al. (2015) evaluated the effectiveness of the TDSS program. Participants were placed in one of three groups: (1) in the TDSS group teens who received real-time in-vehicle coaching (2) the TDSS+ group teens received in-vehicle coaching and parents/guardians received notifications when risky driving was detected and (3) the control group that received no interventions. Teens in TDSS or TDSS+ had reduced instances of speeding compared to teens in the control group and teens in the TDSS+ group had reductions in kinematic driving events (i.e., braking, turning, and accelerating). One evaluation of the Steering Teens Safe program points to the importance of electronic monitoring systems in enabling event-focused feedback and communication between parents/guardians and teen drivers (Peek-Asa, et al. 2019). Peek-Asa et al. (2019) found that teen drivers who received parental/guardian feedback based on electronic monitoring had 85% fewer unsafe events than those that received no feedback at all, whereas those that received only electronic feedback had 65% fewer events than the control group.

Currently, there are no evaluations of vehicle-embedded electronic monitoring systems for parental/guardian monitoring.

Costs:

The costs of electronic monitoring devices are usually paid for by the teen drivers and their families. Costs to the State or agency are low, but the device purchase and maintenance costs to parents/guardians can be substantial. Smartphone-based systems can offer low-cost alternatives to vehicle-based devices.

Time to Implement:

Use of monitoring devices can start immediately upon installation.

Hazard Perception Training

Effectiveness: ★★	**Cost:** Varies	**Use:** Low	**Time:** Varies

Horswill et al. (2021) stated, “Hazard perception is typically defined as a driver’s ability to anticipate situations that may lead to a collision and has been conceptualized as a driver’s situation awareness of crash-relevant aspects of the traffic environment” (p. 2). Research shows hazard perception errors are common in the crashes of young drivers (Curry et al., 2011; McKnight & McKnight, 2003). Novice drivers also perform worse on hazard perception tests than experienced drivers (Borowsky et al., 2010; Wetton et al, 2011). Furthermore, performance on hazard perception tests is associated with crash involvement. Horswill et al. (2015) found that novice drivers who failed a hazard perception test at licensure were more likely to be involved in crashes the year after taking the test and Horswill et al. (2020) found that scores on a hazard prediction test correlated with self-reported crash involvement. Consequently, several programs have been developed that focus on teaching hazard perception skills generally using computer simulation (summarized in McDonald et al., 2015, and Thomas, Blomberg, & Fisher, 2012). The Risk Awareness and Perception Training (RAPT) program is a computer-based training module designed to improve visual scanning, hazard anticipation, and hazard avoidance skills in novice drivers (Pollatsek et al., 2006; Pradhan et al., 2009). Other computer-based training programs have been developed, including SAFE-T, which addresses similar skills as RAPT—hazard anticipation, hazard avoidance, and attention maintenance to the forward roadway (Yamani et al., 2016). Similarly, the Accelerated Curriculum to Create Effective Learning (ACCEL) is an omnibus PC-based training program targeted at building six skills in novice drivers—strategic hazard anticipation, tactical hazard anticipation, strategic attention mitigation, tactical attention mitigation, strategic attention maintenance, and tactical attention maintenance (Fisher et al., 2017).

Use:

RAPT is available on the web. SAFE-T and ACCEL are not currently available to the public. It is not known how many young drivers complete some type of hazard perception training, but it is likely very low.

Effectiveness:

McDonald et al. (2015) reviewed 19 studies of hazard perception training programs for drivers under 21. Most studies used computer-based training or driving simulation. In all studies, young drivers demonstrated improvements in hazard perception skills after training. However, none of the studies looked at crash outcomes for participants, so it is unknown whether skills learned during hazard perception training transferred to “real world” situations. The authors conclude that more research is needed to determine how well hazard anticipation skills are retained over time and whether this training decreases subsequent crashes.

NHTSA funded a set of studies to further enhance RAPT and evaluate its effectiveness (Thomas et al., 2016). The evaluation was conducted in California in collaboration with the California DMV. A total of 5,251 drivers 16 to 18 were recruited and assigned to either RAPT or a control group. Outcomes showed a 23.7% lower crash risk for male drivers who received the RAPT training relative to the male drivers in the control group. The results for female drivers did not show an effect of training on crash risk. The authors propose that further research with larger and more diverse samples might help identify reasons for potential gender differences in crash risk. In a further enhancement of RAPT, Thomas et al. (2017) updated the graphics from the first study to high-definition videos and animations. An evaluation of this version with 205 trainees indicated that the revisions were a significant improvement over previous implementation and both novice and experienced drivers increased their pre-post scores measured by a computer assessment and using eye-tracking in a live traffic environment.

In limited, small-scale evaluations, SAFE-T and ACCEL training programs have shown positive training effects. Specifically, drivers who completed the SAFE-T training were more likely to anticipate hazards, were quicker and more effective at responding to hazards, and more likely to keep their glance durations under the 2-second threshold compared to drivers in the placebo group (Yamani et al., 2016). Compared to placebo-trained teens, novice drivers who completed the ACCEL training showed significant improvement in performance in five of the six trained skills: tactical and strategic hazard anticipation, strategic hazard mitigation, and tactical and strategic attention maintenance (Fisher et al., 2017). While they appear promising, these programs have not yet been evaluated as an integrated part of a driver education program. See also Unverricht et al. (2018) for a review and meta-analysis of novice driver training programs.

Cost:

The cost for training varies. RAPT is provided online free of charge. Other training programs using driving simulation can be very expensive. The cost to scale hazard perception training to the full population of novice drivers—through driver education or some other means—will depend greatly on the type of training chosen.

Time to implement:

For a family that is interested in hazard perception training, the RAPT program is available immediately to implement and takes 30-45 minutes to complete. However, it may take a year or more to establish hazard perception training for an entire population of young drivers.

Approaches That Are Unproven or Need Further Evaluation

GDL Supervised Hours

As of November 2021 there were 47 States and the District of Columbia that required some minimum number of supervised driving hours during the time a young driver has a learner's permit, with about half of them requiring 50 hours (IIHS, 2021b). However, evaluations have found no relationship between the number of required supervised driving hours and fatal crash involvement among young drivers (Ehsani et al., 2013; Foss et al., 2012; Masten et al., 2013; McCartt et al., 2010). Based on telephone interviews with parents/guardians in 5 States, only 32% knew the correct number of supervised driving hours their teen was required to complete (Foss et al., 2012; O'Brien et al., 2013). Therefore, the lack of effect of supervised hours on fatal crash outcomes may be explained, in part, by a lack of parental/guardian knowledge of the supervised driving requirements.

GDL Cell Phone Restrictions

Research shows young drivers are at higher risk of crashing when they reach for a cell phone, dial a cell phone, or text while driving compared to when they do not engage in these behaviors (Klauer et al., 2014). As of November 2021 there were 36 States and the District of Columbia that had cell phone bans specifically targeting young drivers (IIHS, 2021a). Cell phone restrictions do not seem to reduce young drivers' phone use. For example, an observational study of young drivers in North Carolina found no change in cell phone use after the State's cell phone ban took effect despite widespread awareness of the restriction among licensed teens (Foss et al., 2009; Goodwin et al., 2012). Studies that have examined the effects of cell phone bans on young driver crashes have not been conclusive. Some studies suggest that texting bans for young drivers may *increase* crashes, perhaps as the result of concealing phones from view to avoid fines (Ehsani et al., 2014; HLDI, 2010). In a review of the research Ehsani et al. (2016) conclude that cell phone restrictions do not appear to result in a long-term deterrence of cell phone use by young drivers.

GDL Intermediate License Violation Penalties

A probationary feature is included in the intermediate phase of many graduated licensing systems, which is commonly referred to as contingent advancement. Typically, contingent advancement means that an intermediate license holder must maintain a violation free driving record for a specified amount of time before they can obtain a full license. Almost all States penalize some GDL or traffic law violations by delaying full licensure. The few evaluations of early stand-alone probationary license systems generally found no substantial benefits (McKnight & Peck, 2003; Simpson, 2003). In general, it appears that awareness of penalties for license violations among parents and teens is relatively low, enforcement is rare, and licensing delays are not always applied even when violations are enforced (Goodwin & Foss, 2004; Steenbergen et al., 2001; Williams, 2007).

Pre-Licensure Driver Education

Driver education has long been advocated and used to teach both driving skills and safe driving practices. Most commonly, this includes 30 hours of classroom instruction and 6 hours of behind-the-wheel practice, although requirements vary considerably across States (Thomas, Blomberg, Korbelak, et al., 2012). This training can include either commercial or high school driver education programs. See Smith (1994), Mayhew (2007), or Williams et al. (2009) for concise reviews of the history of driver education in the United States

The effectiveness of driver education has been examined in several research studies (Mayhew, 2007; Roberts & Kwan, 2001; Thomas, Blomberg, & Fisher, 2012; Vernick et al., 1999; Williams et al., 2009). See Beanland et al. (2013) for a review of the effectiveness of driver training programs.

Some of the evidence suggests that it is ineffective in the long term at reducing the risk of citations, crashes, injuries, or death. Many States offer incentives for taking driver education, such as reducing the required number of supervised driving hours, waiving portions of licensing tests, or lowering the minimum permit or unrestricted license age (Thomas, Blomberg & Fisher, 2012). However, research shows that driver education incentives that allow teens to accelerate the GDL process may actually increase crashes (Mayhew, 2007).

In contrast, some studies have found a decrease in crash risk associated with driver education. A recent evaluation of Oregon's driver education program showed a small decrease in the risk of collisions and convictions for teens who had participated in the driver education program (Mayhew et al., 2017). Similarly, Shell et al. (2015) compared teens who completed driver education with those who completed a supervised driving log and found the driver education group had significantly fewer crashes, injury or fatal crashes, violations, and alcohol-related violation. In both studies, selection bias is a concern because the teens who took driver education self-selected taking the course, and thus may be different in some personality traits, compared to teens who chose not to take driver education.

Overall, it may be unreasonable to expect pre-licensure driver education to produce sizable reductions in crashes, given the content and focus. According to Compton and Ellison-Potter (2008, p. 6), knowing the "rules of the road" and safe driving practices are only one part of driving safely; teens also crash due to risk-taking and inexperience. Therefore, it is "…unlikely that an educational program alone, no matter how well designed and implemented, would result in dramatic reductions in teen crash rates." Also, given the effects of driver education on crashes is likely to be small it is not surprising that most previous evaluations have failed to detect any effect. For example, Peck (2011) estimated that a study would need 35,000 participants to reliably detect a 10% reduction in crashes. It is also difficult to design a rigorous evaluation of driver education. In a State that requires driver education, random assignment of teens to a driver education program is not possible, as all students would take the same course. If a State does not require driver education, selection bias is an issue.

While some of the research shows that under some conditions the benefits of pre-licensure driver education might be inconclusive, NHTSA has identified potential safety benefits and, through support from the driver education community and the Association of National Stakeholders in Traffic Safety Education (ANSTSE), developed the Novice Teen Driver Education and Training Administrative Standards (NTDETAS) to enhance driver education delivery in the States. In addition to an overall revision of the 2009 NTDETAS, the new version includes updates to the instructor training and instruction delivery standards (NHTSA, 2017). NHTSA offers a State Assessment Program to assist States in meeting the standards. At the request of a State, NHTSA will send a team of peers with expertise in different areas of the NTDETAS to review current State practices and make recommendations for improving the program.

Post-Licensure or Second-Tier Driver Education

This countermeasure involves post-licensure driver education curricula that are integrated with driver education included in GDL (Smith, 1994). These “second-tier” post-licensure courses teach safety-related information, building on the on-road experience that the students have acquired in their initial months of driving. They should not be confused with “advanced driving training” courses that teach driving skills such as panic braking, skid control, and evasive lane-changing maneuvers.

Michigan is the only State that has adopted a two-stage system of driver education (Mayhew, 2007). This countermeasure has not been systematically examined. There is insufficient evaluation data available to determine the effectiveness of the countermeasure.

Advanced Driver Training Courses

Advanced driver training courses have been growing rapidly in the United States. These courses combine classroom instruction with behind-the-wheel practice in a parking lot or driving range. The objective is to teach young drivers skid control and other maneuvers that are believed to be important in handling emergency situations. Few of these courses have been evaluated, but the available research suggests they are not beneficial. In fact, some studies show that participants may be more likely to crash—or crash sooner—than teens who do not participate in such programs (Wang, Foss, O’Brien, et al., 2020). Although more research is needed, it appears that advanced driver training programs may increase teens’ confidence more than it increases their driving abilities (Gregersen, 1996; Katila et al., 1996).

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8. Older Drivers

Overview

In 2021 more than 20% of licensed drivers in the United States were 65 or older (FHWA, 2022). As drivers age, their physical and mental abilities, driving behaviors, and crash risks all change, though age alone does not determine driving performance. Many features of the current system of roads, traffic signals and controls, laws, licensing practices, and vehicles were not designed to accommodate older drivers. Older Americans are increasingly dependent on driving to maintain their mobility, independence, and health. The challenge is to balance mobility for older drivers with safety for all road users.

The U.S. population 65 and older increased at a much faster rate (35.1%) than the total population (7.4%) from the years 2010 to 2020 (U.S. Census Bureau, 2010, 2020). The U.S. Census Bureau estimates that by 2030 the resident population over 65 will be 73 million and will comprise 21% of the total U.S. population (Vespa et al., 2020).

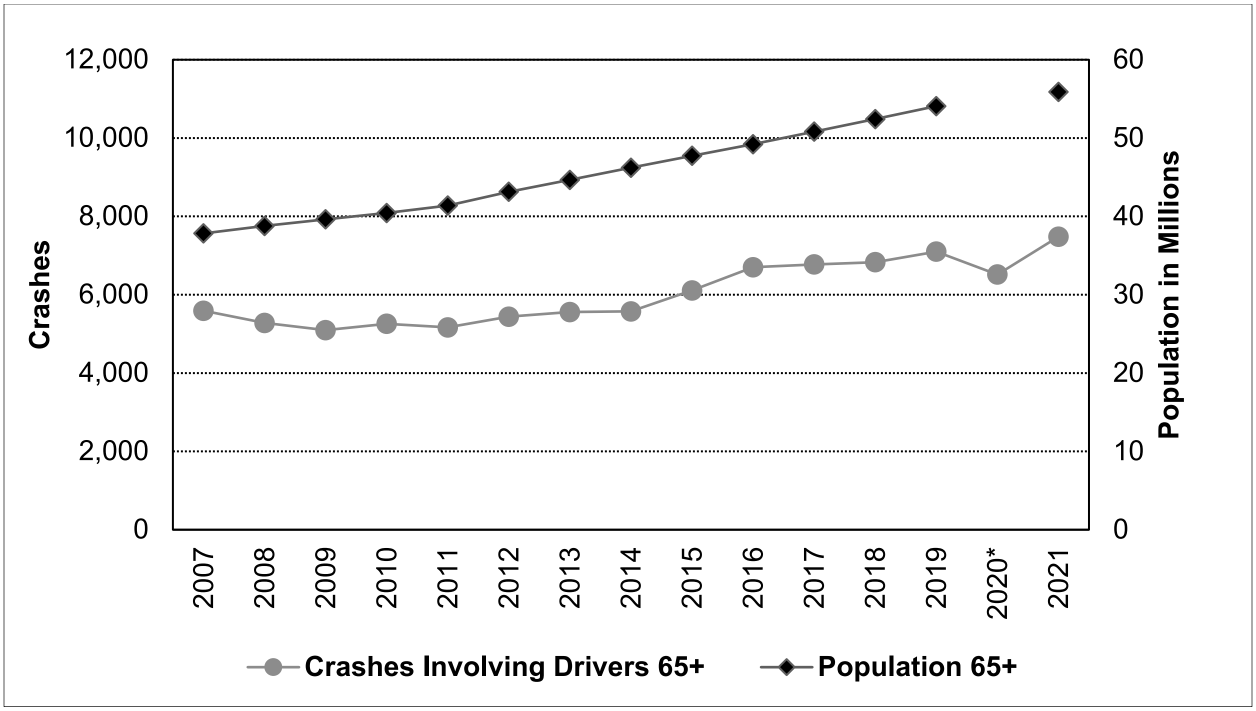
As the U.S. population 65 and older has grown, the proportion of licensed drivers 65+ has also risen, from 14% in 2001 to 21% in 2021 (FHWA, 2002, 2022). The proportion of fatal crashes involving older drivers follows a similar trend, rising from 11% in 2001 to 19% in 2021.

Table 8-1. People 65 and Older: Number and Proportion of Total Population

Year	Population 65+ (in millions)	% of Total Population	Licensed Drivers 65+ (in millions)	% of All Licensed Drivers	Drivers 65+ in Fatal Crashes	% of All Fatal Crashes
2001	35.3	12.4%	27.6	14.4%	6,446	11%
2021	55.8	17.1%	49.6	21.3%	7,481	19%
2030	73.1*	21%*	?	?	?	?

*Projected numbers based on 2017 population estimates
Sources: FHWA (2002, 2022); NCSA (2012); Stewart (2023); U. S. Census Bureau (2011, 2021); Vespa et al. (2020)

The number of fatalities involving older drivers has been increasing in recent years, after experiencing a period of decline from 2000 to 2009. In 2021 there were 8,209 fatalities involving older drivers compared to the 29-year low of 5,613 in 2009 (NCSA, 2012; NHTSA, 2023). However, the older population has grown at a rate faster than the increase in fatalities involving older drivers.



Source: NCSA (2012); NHTSA (2023); U.S. Census Bureau (2011, 2010 to 2021).
*2020 U.S. Census American Community Survey 1-Year Estimate not available due to data quality concerns.

Figure 8-1. Fatal Crashes Involving Drivers 65+ and Population Estimates

Not only is the U.S. population aging, with older people making up a larger proportion of the total population, but drivers are maintaining their licenses for longer as well. The proportion of people 65 or older who held driver licenses rose from 78% in 2001 to 89% in 2021 (FHWA, 2002, 2022b; U.S. Census Bureau 2011, 2022). Notably, 59% of people 85 years and older maintained their licenses in 2020, compared to approximately half (50%) who maintained licenses in 2000 (FHWA, 2002, 2022b).

With current life expectancy in this country at 78.8 years on average (Kochaneck et al., 2020), and with advances in medical science, older Americans are staying mobile and active longer. Those who will reach 65 in the coming decade have been projected to drive more miles and are expected to continue driving later in life than previous generations. This increasingly active and mobile older population gives rise to the need to enhance their safety, and the safety of all road users, while addressing their mobility needs and quality of life.

Understanding the Problem

As people age, physical and cognitive changes that are part of the normal aging process can affect their ability to drive safely. These changes include:

- *Declines in Functional Ability.* Drivers' overall functional abilities decline as their physical, visual, and cognitive capabilities diminish with age. Physical capabilities including hearing, muscle tone, reaction time, and visual capabilities (especially vision at night) all decline, albeit at very different rates on the individual level. The state of current research on visual scanning ability and availability of training programs for visual scanning skills has been summarized in a 2018 NHTSA report (Lococo & Staplin).

Cognitive capabilities can also diminish. Driving is a complex activity that requires a variety of high-level cognitive skills that can diminish through changes that occur with normal aging or because of dementia. Merickel et al. (2019) found that drivers with greater cognitive dysfunction displayed more erratic braking and accelerating behaviors in certain conditions such as daytime and on interstates. As drivers get older, they tend to be overrepresented in crashes requiring navigation of more complex situations such as intersections, left turns, and reacting to an impending crash (Stutts et al., 2009). That said, mild cognitive decline can still allow for safe driving (Staplin et al., 2019). Overall, tests of functional ability to drive may provide better indicators of crash risk.

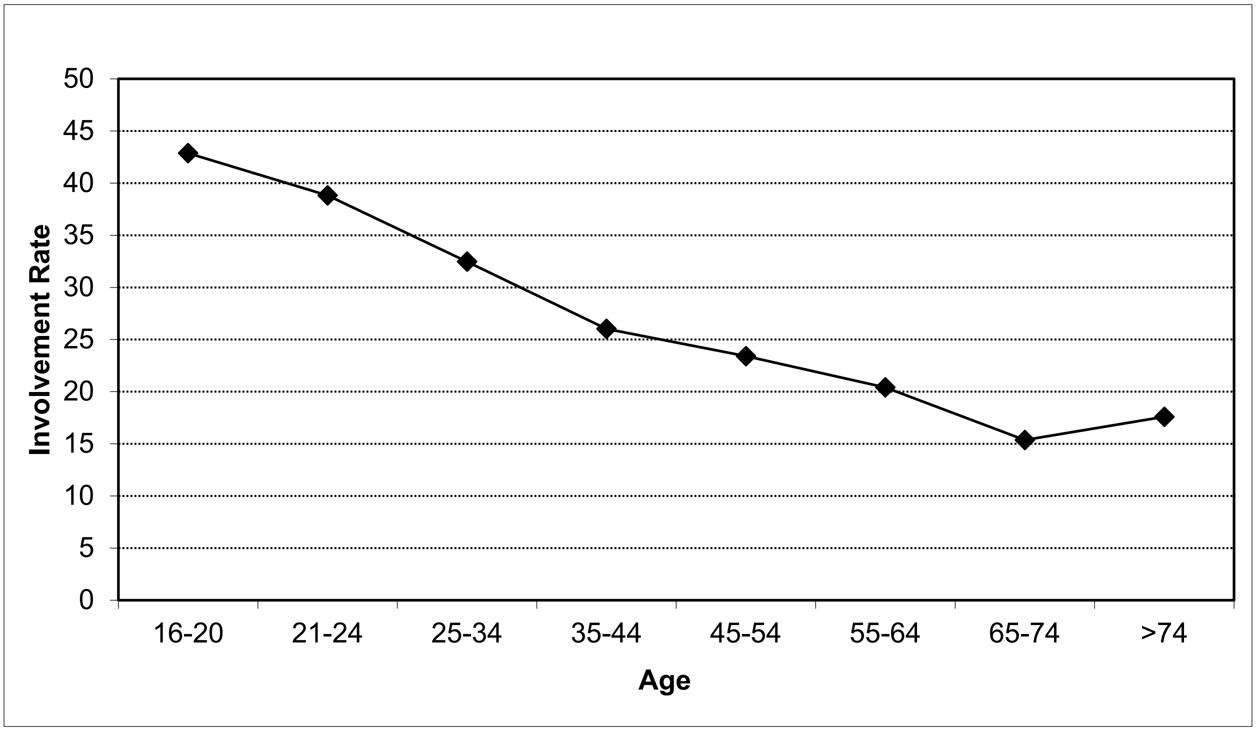
- *Increased Medication Use.* Over 90% of older drivers take prescription medications (Rosenbloom & Santos, 2014). These medications alone or in combination with other medications may be necessary to control disease or health conditions, but also may cause drowsiness or otherwise affect driving.
- *Driving Errors.* Older drivers are less likely to drive aggressively or speed. However, they may exhibit other risky behaviors, such as driving more slowly than prevailing traffic or failing to detect or accurately judge the speed of an oncoming vehicle while making an unprotected left turn. The most frequent driving errors made by older adults include the failure to yield right-of-way (Mayhew et al., 2006), inadequate surveillance, and misjudgment of gaps (Cicchino & McCartt, 2015). Older adults are more likely to be involved in angle collisions, overtaking- and merging-related collisions, and crashes in intersections (Lombardi et al., 2017).

Driver behaviors also change with age. Some of these changes may help protect the driver from serious injury and crashes. These behaviors include:

- *Decreased Impaired Driving.* Older drivers are less likely than younger drivers to be involved in alcohol-related crashes (Stutts et al., 2009).
- *Limit Setting.* Many older drivers recognize and avoid driving at times and in places they feel uncomfortable, such as at night, on high-speed roads, or in unfamiliar situations (Staplin & Lococo, 2003). Older drivers are underrepresented in nighttime crashes, probably due in part to their limited nighttime driving (Stutts et al., 2009). Evidence suggests that drivers who avoid situations such as bad weather, poor visibility, and complex parking procedures may be experiencing declines in their driving skills (Schulz, 2019). However, the synthesis of self-regulation literature conducted by Molnar et al. (2015) indicates that factors aside from awareness of changes in functional ability (such as reduced need to travel, increased schedule flexibility, and general feelings of discomfort) also contribute to limit setting. While older adults drive fewer miles annually than younger drivers, the 2017 National Household Travel Survey indicates that older drivers spend more time driving and take more trips than previous cohorts of older drivers (Pomidor, 2019).
- *Seat Belt Use***.** Seat belts are even more effective in preventing injuries and fatalities to older than to younger occupants (Potts et al., 2004). While belt use among older occupants is slightly higher than the national average—91.7% for occupants 70 and older compared to the overall national estimate of 90.7% in 2019 (Enriquez, 2020)—the fact remains that about 8% of older occupants are unbelted. Communications and outreach on the benefits of seat belt use may be more effective with older occupants because they

may be more attentive to health and safety issues. In one study, for example, signs urging seat belt use resulted in a substantial increase in belt use in six senior communities compared to controls, and use remained higher after 4 years (Cox et al., 2005). For more information on countermeasures to increase seat belt use, see Chapter Seat Belts and Child Restraints.

As a result of many of the changes and differences referenced above, the fatal crash involvement rate for drivers 65 and older is *lower* than for drivers younger than 65.



Source: NHTSA (2023)

Figure 8-2. Driver Involvement in Fatal Crashes per 100,000 Licensed Drivers - 2021

However, since older drivers drive fewer miles annually compared to younger drivers, the fatal crash rate alone does not accurately describe the risk. The average fatal crash rate *per mile traveled* is higher for drivers 70 and older than for all age groups except drivers 16 to 19 (IIHS, 2023). Unfortunately, the fatal crash rate per mile traveled is also imperfect as older drivers tend to favor local roads that, while are typically lower speed, include more points of potential hazards. Additionally, older adults experience increased fragility and frailty. Fragility, as measured by deaths per drivers involved in crashes, begins to increase at age 60 and rises steadily with advancing age. Older occupants, including drivers, are more likely to sustain a serious injury or fatality than younger occupants. Frailty can also cause long-term health issues that make it difficult for older driver and occupants to recover from injury. Fragility, rather than an increased tendency to get into crashes, accounts for about 60% to 95% (depending on age group and sex) of the increased fatality rates per miles traveled in older drivers (Li et al., 2003).

Of all the subject areas in this countermeasure guide, those related to older drivers are perhaps the most complex because they involve so many issues beyond traffic safety. Driving cessation can have a substantial effect on an older adult's mobility and on physical and mental health.

Sooner or later, in the interest of safety, most older people must restrict or cease driving, either by choice or as the result of the State licensing authority restricting or revoking their license. SHSOs and licensing agencies are encouraged to plan and implement their older driver policies and programs as part of integrated community activities to improve older people's safety, mobility, and health.

Data/Surveillance

Older driver safety is a complex topic that cannot be adequately measured by fatal crash rates alone. Because older drivers reduce or stop driving as they age, even while continuing to hold onto their licenses, crash rates per licensed driver do not tell the complete story. Crash rates per vehicle mile traveled better account for drivers who are no longer driving or limiting driving, but it can overstate the risk as older drivers tend to stick to more local roads, which have higher crash rates overall compared to limited access highways and freeways. Using crash rates per vehicle mile traveled in conjunction with crash rates per licensed driver allows SHSOs to better target countermeasures appropriately. Given that older adults are more likely to be fatally injured in crashes as a result of increased fragility and that the proportion of the U.S. population over 65 will continue to grow in the coming years, it is important to consider both older passengers and older pedestrians in addition to older drivers when designing safety programs. Focusing too heavily on older drivers alone fails to account for the inherent safety risks that older Americans face as they shift from the role of drivers to that of passengers and pedestrians. For more information on pedestrian countermeasures, see the Chapter on Pedestrian Safety.

Emerging Issues

The emergence of driver assistance and autonomous vehicle technologies have been proposed as potential solutions to mitigate older driver crash risk and to address mobility limitations. However, the needs of older adults present challenges to the design, implementation, and use of these technologies. The full impact of these technologies will not be known until they become more readily available.

Research on the impacts of driver assistance technology on older drivers is limited. Eby et al. (2018) found that 70% of participants in the LongROAD project felt that the use of in-vehicle technology made them safer drivers. A scoping review conducted by Classen et al. (2019) found that research supports some demonstrated safety benefits of intuitive in-vehicle information systems (IVIS) and ADAS for older drivers. However, research also found that IVIS systems can negatively affect driving safety, particularly when the number of systems in use increases (Classen et al., 2019).

Research on self-driving technology is largely theoretical, as these vehicles are not yet available to the general public. Robertson et al. (2019) found that perceived safety benefits were associated with perceived ease of use for limited self-driving vehicles, underscoring the importance of intuitive and easy to use vehicle technologies. While increased mobility is often theorized as a benefit of autonomous vehicles for older adults, questions remain about the ability of older drivers to take over driving when needed (Knoefel et al., 2019). Even for drivers who are capable of retaking control, older drivers may require more advanced warning or a higher intensity of warning than younger drivers (Sall et at., 2018). Finally, autonomous vehicles may prove to be too expensive for many older adults. Rahman et al. (2020) found that most of their survey respondents reported that the potential additional cost of purchasing a self-driving vehicle would not be affordable.

Key Resources

General information on older drivers:

- Traffic Safety for Older People – 5-Year Plan (NHTSA, 2013)
- Highway Safety Program Guideline No. 13: Older Driver Safety (NHTSA, 2014)
- Improving the Safety of Older Road Users (TRB, 2005)
- NHTSA (n.d.): Older Drivers webpage: www.nhtsa.gov/road-safety/older-drivers
- Traffic Safety Marketing: Older Drivers Page (Toolkit portal page): www.trafficsafetymarketing.gov/get-materials/older-drivers/older-driver-safety
- Clearinghouse for Older Road User Safety (2023) untitled web home page and search page: www.roadsafeseniors.org
- Transportation Safety Institute (n.d.) - Older Road User Program Management Course. https://tsi-dot.csod.com/LMS/LoDetails/DetailsLo.aspx?loid=e8bbd245-6dba-4fae-85e8-0757f0451c43&query=%3Fs%3D1%26q%3D&back_key=1#t=3

Roadway design recommendations and engineering training:

- FHWA (2022a): Web page and portal dedicated to older drivers. *Engineering Guidance and Training*. https://highways.dot.gov/safety/other/older-road-user/engineering-guidance-and-training

Law enforcement tools and training information:

- Transportation Safety Institute (n.d.). Educating Law Enforcement Officers on Older Driver Issues. [Online web course]. https://tsi-dot.csod.com
- The International Association of Directors of Law Enforcement Standards and Training (n.d.). Older Driver Law Enforcement Training. [Web page and portal]. www.iadlest.org/training/older-driver-law-enforcement-training
- Training, Research and Education for Driving Safety [TREDS] (2023). TREDS Law Enforcement Programs. [Web page and portal]. University of California San Diego. https://treds.ucsd.edu/law-enforcement

Clinician/physician tools and training information:

- Medscape, an online web page and portal belonging to WebMD LLC, has content related to continuing medical education (CME) or continuing education (CE) on the subject of driving fitness at www.medscape.org/viewcollection/33270 [Restricted site with free account registration].

Older Drivers Countermeasures

Legislation and Licensing

Countermeasure	Effectiveness	Cost	Use	Time
License Screening and Testing†	★★★★	$$	High	Medium
Licensing Agency Referrals††	★★★★	$$	Low	Medium
License Restrictions	★★★★	$	Low	Short
Medical Review Protocols†††	★★	Varies	High	Medium
In-Person Renewal and Vision Test	★★	$$$	Medium	Medium

†Proven for identifying drivers whose driving should be limited.
††Proven for identifying at-risk drivers.
†††Part of a comprehensive system for identifying and restricting at-risk drivers. Quality varies considerably.

Enforcement

There are no countermeasures in this category.

Other Strategies for Behavior Change

Countermeasure	Effectiveness	Cost	Use	Time
Formal Courses for Older Drivers (classroom + on-road feedback)†	★★★★	$$	Low	Medium

†Proven for improving on-road driving when classroom-based training is paired with individualized feedback.

Approaches That Are Unproven or Need Further Evaluation

Countermeasure
General Communications and Education
Formal Courses for Older Drivers (classroom only)

Effectiveness:

★★★★★	Demonstrated to be effective by several high-quality evaluations with consistent results.
★★★★	Demonstrated to be effective in certain situations.
★★★	Likely to be effective based on balance of evidence from high-quality evaluations.
★★	Limited evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.
★	No evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.

Cost to implement:

$$$	Requires extensive new facilities, staff, equipment, or publicity, or makes heavy demands on current resources.
$$	Requires some additional staff time, equipment, facilities, and/or publicity.
$	Can be implemented with current staff, perhaps with training; limited costs for equipment or facilities.

These estimates do not include the costs of enacting legislation or establishing policies.

Use:

High	More than two-thirds of the States, or a substantial majority of communities
Medium	One-third to two-thirds of the States or communities
Low	Less than one-third of the States or communities
Unknown	Data not available

Time to implement:

Long	More than 1 year
Medium	More than 3 months but less than 1 year
Short	3 months or less

These estimates do not include the time required to enact legislation or establish policies.

Legislation and Licensing

License Screening and Testing

Effectiveness†: ★★★★	**Cost:** $$	**Use:** High	**Time:** Medium

†Proven for identifying drivers whose driving should be limited.

State licensing agencies vary considerably in their procedures for screening and evaluating a driver's abilities and skills (Potts et al., 2004; Pomidor, 2019; Lococo, Stutts, et al., 2017; NHTSA, 2017).

The *Model Driver Screening and Evaluation Program Guidelines for Motor Vehicle Administrators* (Staplin & Lococo, 2003) was developed as part of the final stage in a research program that investigated the relationships between functional impairment and driving skills, methods to screen for functional impairment, and the cost, time, legal, ethical, and policy implications of the guidelines (Staplin et al., 2003a).The goal of these guidelines is to keep drivers on the road as long as they can drive safely through early identification and assessment together with counseling, remediation, and license restriction when needed (Staplin & Lococo, 2003). The guidelines, tested in Maryland, outline a complete process of driver referral, screening, assessment, counseling, and licensing action (Staplin & Lococo, 2003; Staplin et al., 2003b). They include nine visual inspection tests licensing agency personnel can administer to screen for functional ability (Staplin & Lococo, 2003). The results of a survey of State motor vehicle departments outline some of the legal, policy, cost, and other criteria required before the implementation of guidelines in some States.

In 2008 the screening and testing of older drivers was a major discussion at the North American License Policies Workshop sponsored by AAAFTS. One of the general themes of this workshop was "while certain declines are generally associated with aging, consensus is lacking on whether or at what age people should be required to be screened or tested. Regardless, it is generally accepted that final licensing decisions should be based on functional performance, not age, as there is wide variation in how people age" (Molnar & Eby, 2008, p.3). In 2009 NHTSA and AAMVA developed the *Driver Fitness Medical Guidelines,* which provides guidance for driver licensing authorities by medical condition based on available evidence.

Use:

The AAAFTS publishes the database, *Driver Licensing Policies and Practices,* showing each State's driver licensing policies and practices regarding older and medically at-risk drivers. This database was updated in 2019 (Graham et al., 2020). Additionally, the IIHS (2021a) maintains a list of license renewal procedures by State that compares older driver requirements to the general population. See Countermeasure "License Restrictions" for more information.

Effectiveness:

There is strong evidence that State screening and assessment programs identify some drivers who should not be driving at all or whose driving should be limited. The Maryland pilot test of the model guidelines concluded, "the analysis results ... have provided perhaps the best evidence to date that functional capacity screening, conducted quickly and efficiently, in diverse settings, can yield scientifically valid predictions about the risk of driving impairment experienced by older individuals" (Staplin et al., 2003b). In a study evaluating the use of a screening tool on

Alabama drivers 18 to 87, older drivers (65 and older) performed significantly worse than drivers younger than 65 years old, and older drivers with a crash history performed worse than older drivers without crashes (Edwards et al., 2008).

Cost:

Costs associated with the model guideline functional screening include both administrative and support service expenses (Staplin et al., 2003a).

Time to implement:

States should be able to modify their driver license screening and assessment procedures in 4 to 6 months.

Licensing Agency Referrals

Effectiveness†: ★★★★	**Cost:** $$	**Use:** Low	**Time:** Medium

† Proven for identifying at-risk drivers

Older drivers come to the attention of licensing agencies at regular license renewals, as discussed in Countermeasure "License Screening and Testing," or when they are referred to the licensing agency for reevaluation of their driving skills.

Licensing agencies in all States accept reevaluation referrals for drivers of any age. A survey of all State licensing agencies found three sources accounted for 85% of referrals: law enforcement (37%), physicians and other medical professionals (35%), and family and friends (13%) (TRB, 2005). The remaining 15% came from crash and violation record checks, courts, self-reports, and other sources. Furthermore, case studies of driver referrals from 6 States (Maine, Texas, Wisconsin, Ohio, Washington, and Oregon) were performed in 2012 (Lococo, Sifrit, et al., 2017). A random sample of 500 drivers referred for initial medical review were selected from each State. Many of these were referrals by the driver (self-referral), physicians, licensing agency staff, or law enforcement officers. The States varied in terms of the licensing outcomes. Overall, 99% of cases in Oregon and Texas resulted in changes in licensing status. While overall changes in licensing status were lower in the 4 remaining States (ranging from 76 to 88%), most physician referrals (ranging from 90 to 97%) resulted in licensing status changes. The authors concluded that the identification of the source of referrals has implications for educational countermeasures to increase the number and quality of referrals.

States can increase driver referrals by establishing and publicizing procedures for referring drivers, establishing referral policies and providing appropriate training and information to law enforcement officers, and informing physicians and health professionals of their reporting responsibilities. The presence of medical advisory boards (MABs) or medical professionals providing case review of medically at-risk driver referrals may help improve licensing decisions at little extra cost to the program (Lococo et al., 2016; Lococo, Sifrit, et al., 2017; NHTSA, 2017). In 2009 NHTSA, in collaboration with the American Association of Motor Vehicle Administrators, produced *Driver Fitness Medical Guidelines* to provide guidance to licensing agencies for use in making decisions about an individual's fitness for driving (NHTSA, 2009). Guidelines are provided for a variety of physical limitations and impairments as well as medical conditions. In addition, this guide provides information that State licensing agencies can use to educate medical professionals about the effects of functional impairments and medical conditions on safe driving in order to encourage them to refer drivers for additional evaluations related to driving. Many of the components of this guide have been incorporated into the *Clinician's Guide to Counseling Older Drivers* (Pomidor, 2019).

NHTSA published a literature review on the effects of medication use and medical conditions on older drivers' functional driving performance and safety (Lococo et al., 2018). A range of medical conditions were reviewed considering their potential effects on crash risk, and the researchers prioritized eight conditions as particularly concerning for older driver safety: diabetes, dementia, obstructive sleep apnea, glaucoma, hepatic encephalopathy, macular degeneration, stroke, and Parkinson's disease.

Referrals by Law Enforcement

Law enforcement officers can observe drivers directly at traffic stops or crashes. With appropriate training, they can identify many drivers who should be referred to the licensing agency for assessment. The International Association of Directors of Law Enforcement Standards and Training (IADLEST) has developed a training course for law enforcement instructors covering a range of topics related to older people and driving. This course aims to train instructors on how to provide law enforcement officers with the information they need to effectively interact with and evaluate older drivers. Additionally, the University of California at San Diego's Training, Research and Education for Driving Safety (TREDS) has created law enforcement training and tools aimed at helping law enforcement officers identify and refer medically impaired drivers. NHTSA also provides a series of video and web-based resources to help law enforcement officers determine signs of older driver driving impairments. See Key Resources for more information.

Referrals by Health Care Providers

Health care providers (HCPs), including physicians, nurse practitioners, and physician assistants, are in an excellent position to assess if changes in their patients' physical or cognitive abilities may increase their crash risk. In addition, various clinicians, such as pharmacists, nurses, occupational or physical therapists, social workers, or case managers, can, in the course of their work, assess for physical, cognitive, or functional limitations warranting further evaluation, counseling, or referral to the licensing agency. As of 2019 six States require physicians to report patients who have specific medical conditions, such as epilepsy or dementia (Graham et al., 2020). Other States require physicians to report "unsafe" drivers, although States vary in their definitions of "unsafe." In all 50 States and the District of Columbia physicians are permitted to report medically at-risk drivers (Dunlap and Associates, Inc., 2019). Physicians should balance their legal and ethical responsibilities to protect their patient's health and confidentiality with their duty to protect the public from unsafe drivers. Physicians have been held liable for damages from crashes involving patients because they failed to report the patient to the licensing agency (Pomidor, 2019).

Licensing decisions based on drivers' medical fitness to drive can be established through review by an MAB or with one or more medical professionals performing reviews of the referrals (NHTSA, 2017). Having medical professionals or an MAB perform case reviews provides certain advantages, including legal immunity to physicians voluntarily referring at-risk drivers (Lococo et al., 2016; NHTSA, 2017). NHTSA conducted a study of MAB structures, referrals, and outcomes in 6 States, and found that physician referrals resulted in changes in license status in 90% of cases studied (Lococo, Sifrit, et al., 2017). In fact, physician referrals were most likely type of medical referral to result in changes to driver license statuses, and the presence of an MAB may serve to promote physician referrals (NHTSA, 2017). See Countermeasure "Medical Review Protocols" for more information.

The *Clinician's Guide to Assessing and Counseling Older Drivers* (Pomidor, 2019) provides detailed information for physicians and medical professionals. The guide was prepared by the American Geriatrics Society and includes information on performing a brief in-office Clinical Assessment of Driving Related Skills (CADReS). The CADReS screening tool assesses some aspects of the key functional areas of vision, cognition, and motor/sensory functions to help physicians identify specific areas of concern as they relate to driving. An evaluation of an earlier version of CADReS (McCarthy et al., 2009) suggests that while this tool was able to identify all the study participants who failed the behind-the-wheel test included as a part of the study, the tool may need to be revised to give physicians a more effective and efficient tool for in-office assessments.

To encourage use of the *Clinician's Guide to Assessing and Counseling Older Drivers*, a multi-media curriculum was developed by the AMA with the goal of heightening knowledge and skills necessary for a clinician to evaluate driver fitness in a typical care encounter. The guide also provides information on developing a plan for further evaluation by other specialists or licensing authorities, if needed. An evaluation of this curriculum found continuing education training can enhance health professionals' confidence and clinical practices related to driver fitness evaluations and mobility planning (Meuser et al., 2010). To further facilitate clinicians' ability to assess driving fitness and challenges, Medscape creates and hosts CME/CE content for medical professionals in collaboration with NHTSA. See Key Resources for more information.

Referrals by Families and Friends

Many States have established procedures for family members and friends to report drivers of any age whose abilities may be impaired (Lococo, Stutts, et al., 2017). Some States only accept referrals submitted on specific forms while others accept referrals in the form of a letter. Many States offer online guidance for families and friends to determine how and when to report safety concerns. The AAAFTS publishes a database of licensing practices and policies for medically at-risk drivers that summarizes State-level policies (Dunlap and Associates, Inc., 2019). Tools exist to help family members identify at-risk drivers. The Fitness-to-Drive Screening Measure (FTDS) is a free online 54-item tool, taking approximately 20 minutes to complete, that was previously created to be completed by a driver or proxy (someone who has been a passenger with the driver). A review of use data indicated that the length of the FTDS may inhibit completion and ultimately the utility of the screening tool (Classen et al., 2018). Therefore, Classen et al. created and validated a short form version (FTDS-SF) that includes 21 items and requires less time to complete. The FTDS-SF successfully predicted on-road outcomes with acceptable accuracy. The authors note that the FTDS-SF misclassified 59 (out of 200) participants as at risk and therefore recommend use of the tool to initiate conversations with potentially at-risk drivers.

Use:

A survey of all State licensing agencies found fewer than 100,000 drivers 65 and older are referred each year from all sources, or less than 0.4% of the 28.6 million older licensed drivers (TRB, 2005). The number of referrals varies substantially across the States, from a few hundred to 50,000. Law enforcement officers provide more than one-third of all referrals to licensing agencies for driver screening and assessment (TRB, 2005).

Effectiveness:

Establishing and publicizing effective referral procedures will increase referrals. Potts et al. (2004) provide examples and web links. As one example, Pennsylvania increased physician referrals substantially by sending letters to all physicians (Potts et al., 2004).

A recent analysis of older driver hospitalizations in 37 States from 2004 to 2009 showed no significant association between mandatory physician reporting laws and older drivers' crash-related in-patient stays. This was true even among the 27 States that provide legal immunity to referring physicians (Agimi et al., 2018). The authors note that a lack of association between mandatory reporting laws and crash-related hospitalizations may be a result of insufficient awareness of the law and requirements, attempts to avoid damaging rapport, and insufficient training to identify at-risk drivers.

Licensing referrals may improve other measures of older driver safety. A study of Missouri's voluntary reporting law (enacted January 1, 1999) and the resulting licensing outcomes found crash involvement of reported drivers decreased after implementation of the law and, to a lesser degree, mortality declined as well. The sharp decline in crashes among reported drivers was presumably a result of driving reduction or cessation following the reporting or licensing review process. Though the Missouri law is not specific as to age, the mean age of reported drivers was 80 and only 3.5% of the 4,100 people (reported by a combination of law enforcement officers, driver license office staff, physicians, family members, and others) retained their drivers' licenses after the process. This low percentage may be, in part, a result of drivers prematurely giving up their license due to an intimidating or onerous process. Half of reported drivers failed to complete the first step of the process (physician review within 30 days of notification), which resulted in license revocation (Meuser et al., 2009).

A mandatory reporting law in Oregon was enacted in 2002 and requires primary care physicians and other health care providers functioning as a primary provider, to report drivers with cognitive impairments to the Department of Motor Vehicles. Reports by primary care providers result in automatic license suspensions, but the suspended driver can request retesting or a hearing to appeal the suspension. A study of this Oregon law found over 1,600 drivers reported as being cognitively impaired from 2003 to 2006; most of the reported drivers were older than 80. The most common cognitive impairments were in judgment and problem solving, but impairments in memory and reaction time were also reported about half the time. Of the 1,664 people reported who lost their licenses less than 20% requested retesting or a hearing to contest their license suspensions, and only about 10% of the total number reported and suspended (173) regained their licenses (Snyder & Ganzini, 2009).

To better understand the observations and concerns of family members and to investigate why older drivers were referred to the licensing agency, Meuser et al. (2015) reviewed Missouri reporting forms submitted by family members indicating an older person was potentially unfit to drive. Of the 689 older adults, 448 were reported for cognitive issues (e.g., confusion, memory loss, or becoming lost while driving) and 365 included a diagnostic label such as Alzheimer's disease, cognitive impairment/dementia, or brain injury. When the observations of family members and physicians were compared, agreement was high for Alzheimer's disease (100%) and for acute brain injury (97%). However, agreement was lower for cognitive impairment/dementia (75%). This discrepancy suggests that family members and physicians may understand cognitive impairment differently. Overall, the researchers concluded that physicians and driver licensing authorities would do well to consider family member observations when assessing fitness-to-drive in older people.

Cost:

Costs for establishing and publicizing effective referral procedures vary depending on the procedures adopted but should not be expensive. Educational and training publications are available for use with law enforcement and medical professionals. Funds will be required to distribute this material and for general communications and outreach. If referrals increase substantially, then licensing agency administrative costs will increase.

Time to implement:

States seeking to improve referrals will require at least 6 months to develop, implement, and publicize new policies and procedures.

License Restrictions

Effectiveness: ★★★★	**Cost:** $	**Use:** Low	**Time:** Short

Medically at-risk drivers who are referred to State licensing agencies are screened for fitness to drive by a variety of mechanisms (see Countermeasure “License Screening and Testing” for more information). If a State licensing agency determines that a driver poses excessive risks only in certain situations, the driver can be issued a restricted license. License restrictions preserve the driver’s mobility while protecting the driver, passengers, and others on the road.

Most States offer licensing restrictions for medically at-risk drivers who are deemed to be safe under certain circumstances. Restrictions include daytime driving, road types and speed, trip purpose, specific geographical area, and more. The AAAFTS publishes the *Driver Licensing and Policies* database, which includes a section on the types of restrictions each State may impose (Dunlap and Associates, Inc., 2019). One of the more common restrictions is daytime driving only.

Use:

The number of States currently issuing restricted licenses specifically for older drivers is not known, but the AAAFTS *Driver Licensing Policies and Practices* database shows 49 States and the District of Columbia can place at least some types of conditions or restrictions on the licenses of older or medically at-risk drivers (Dunlap and Associates, Inc., 2019). Restrictions are generally determined using medical records or in consultation with physicians.

Effectiveness:

Several studies show driver license restrictions lower the crash risk for older drivers, though their crash risk is still higher than similar-aged drivers with unrestricted licenses (Potts et al., 2004; Vernon et al., 2001). Research conducted by Braitman et al. (2010) found license restrictions may be an effective alternative to complete driving cessation, providing drivers with some degree of continued mobility and independence. However, they also concluded that while the overall safety benefits of license restrictions may be unknown, license restrictions tend to reduce driving exposure, especially in higher risk situations.

Langford and Koppel (2011) found imposing a license restriction was usually associated with a reduction in absolute crash rates and identified three restrictions producing lower crash rates for consideration. The three restrictions (driving within a specified distance of home, not driving at night, and driving only in specified areas) can be thought of as major components of a graduated driving reduction program.

Iowa offers tailored drive tests that allow drivers to be tested in their own community on roads they would typically drive and, if successful, these drivers are allowed to drive where they have demonstrated proficiency. An evaluation of the “local drive test” (LDT) option, offered to older Iowa drivers who might not otherwise be able to renew their licenses, found the overall crash rate of LDT drivers was higher than the general population of licensed drivers 65 and older, but was lower than the overall driver crash rate for Iowa drivers (Stutts & Wilkins, 2012).

NHTSA published a report on older drivers’ compliance with license restrictions (Joyce et al., 2018). The study used a combination of approaches, including a literature review, a driving evaluator panel consisting of license administrators and law enforcement officers from Florida, Iowa, and Virginia, an analysis of driver license and crash data from the 3 States and Maryland, and a field study of driving exposure of adults 70 and older. Restrictions included daytime driving only, maximum limit on travel speeds, and limits on geographic locations or distances traveled from home. In Maryland, the restrictions on locations and distances traveled included limits on trip purpose. Results demonstrated that drivers generally complied with restrictions imposed by licensing agencies. Crash rate analysis from the 4 States showed mixed outcomes. Drivers with restrictions had lower crash rates than when they drove without restrictions in Iowa and Maryland. In Virginia, the crash rates slightly increased post-restriction. Restrictions for speed and location (geographic limits) were associated with about 25% reduction in crash rates in Iowa. Conversely, the daytime-driving-only restriction was not associated with a crash rate reduction. This result is not unexpected given that self-restriction of nighttime driving is common among older drivers and therefore licensing restrictions of this nature are unlikely to result in observable change.

Cost:

Once drivers have been screened and assessed, the costs of issuing a restricted license are minimal.

Time to implement:

Restricted licenses can be implemented as soon as any needed policy or legislation changes are enacted.

Medical Review Protocols

Effectiveness[†]: ★★	**Cost:** Varies	**Use:** High	**Time:** Medium

[†]Part of a comprehensive system for identifying and restricting at-risk drivers. Quality varies considerably.

This countermeasure involves the use of medical review protocols by licensing agencies to evaluate people with medical conditions or functional limitations that could affect their ability to drive safely. The medical review may be performed by an MAB or by in-house medical professionals. Medical review protocols are designed to inform what licensing actions are appropriate for people with specific medical conditions or functional impairments. In 2017 NHTSA published a series of reports on studies outlining the operational benefits of medical review practices. A summary of the studies is available as a Traffic Tech report (NHTSA, 2017).

More than half of the States have MABs or in-house medical professionals that assist licensing agencies in evaluating people with medical conditions or functional limitations that may affect their ability to drive (Lococo, Stutts, et al., 2017). MABs generally make policy recommendations on what licensing actions are appropriate for people with specific medical conditions or functional limitations. In 2016 and 2017 NHTSA published a series of reports on the analysis of the implementation of driver medical review protocols. These reports document the medical review structures and processes of all States and include case studies for several States. Most State MABs review individual cases, though this activity varies widely: 5 States reported that their MABs reviewed 1,000 cases or more in 2012 while another seven reviewed 10 or fewer cases (Lococo, Stutts, et al., 2017).

In 2005 NHTSA released a summary of recommended strategies for MABs and national medical guidelines for driving, prepared in collaboration with AAMVA (Lococo & Staplin, 2005). MABs should play a Key Role in each State as the link between health care professionals, licensing agencies, law enforcement, and the public. They should take the lead in defining how various medical conditions and functional impairments affect driving by defining medical assessment and oversight standards, improving awareness and training for healthcare providers, law enforcement, and the public, advising health care professionals on how drivers can compensate for certain medical conditions or functional impairments, and reviewing individual cases.

NHTSA and AAMVA produced a guide in September 2009, *Driver Fitness Medical Guidelines,* designed to provide guidance to licensing agencies in making decisions about an individual's fitness for driving (NHTSA, 2009). These guidelines, as well as the American Geriatrics Society *Clinician's Guide to Assessing and Counseling Older Drivers* (Pomidor, 2019), can provide guidance to MABs as they define how various medical conditions and functional impairments affect driving and what steps can be taken to compensate for any limitations noted due to relevant conditions and limitations.

Use:

More than half of the States report currently having an MAB or a formal liaison with another office that functions as an MAB (Lococo, Stutts, et al., 2017).

Effectiveness:

NHTSA performed a detailed examination of driver review practices across the country to identify the strengths and weaknesses of the different implementations. The 51 agencies were grouped into four categories based on two criteria:

- Presence of a State MAB or similar liaison with a State Health Department, and
- Availability of in-house medical professionals to review license referral cases (Lococo et al., 2016).

Lococo, Stutts, et al. (2017) presented the descriptions of driver review practices among the 51 driver licensing agencies.

Seven States were selected for detailed analysis of their medical review practice—Maine, North Carolina, Texas, Wisconsin, Ohio, Washington, and Oregon. These States were surveyed on the structure and operation of their driver review programs, which included information on sources for medical referrals, activities of the MAB, and the type of medical information collected from the drivers. States with MABs relied on the medical standards that were in place; these generally also granted legal immunity to physicians, which resulted in high physician referrals. States without an MAB or in-house physician were found to rely on the assessments of the driver's physician and licensing tests. Driver appeals of licensing decisions in these States were found to be the lowest.

Lococo et al. (2016) reviewed the licensing outcomes of 4 of these States that had data readily available. They found that greater than 90% of referrals in the 3 States with an MAB or medical professional on staff resulted in a licensing action compared to less than half of the referrals in States without an MAB. This indicates that the MAB/medical professional model may help identify at-risk drivers. The authors concluded that having an MAB or medical professional on the case review staff offered some benefits to the medical review process, most notably providing access to medical expertise when needed.

Cost:

MABs are comprised of physicians and other health care professionals together with appropriate administrative staff. Costs will be minimal for an MAB whose activities are limited to policy recommendations. Costs for an MAB that evaluates individual cases will depend on the caseload. The presence of an MAB or in-house medical staff may not always result in higher overall costs (Lococo et al., 2016).

Time to implement:

States probably will need at least a year to establish and staff an MAB, depending on what duties the MAB undertakes. States likely can expand the functions of an existing MAB in 6 months.

In-Person Renewal and Vision Test

Effectiveness: ★★	**Cost:** $$$	**Use:** Medium	**Time:** Medium

Driver's licenses in most States are valid for 4 to 8 years, with a few States having as long as a 12-year renewal cycle (IIHS, 2021a). To renew an expiring license, drivers in many States must appear in person, pay the license fee, and have new pictures taken for their licenses. Many States require a vision test for license renewal. Some States allow all drivers to renew by mail or electronically.

More than half the States change license renewal requirements for drivers older than a specified age, typically 65 or 70. These changes may include a shorter interval between renewals, in-person renewal (no renewal by mail or electronically), or a vision test at every renewal. A few States require written or road tests for some older renewal applicants. IIHS (2021a) summarizes these requirements.

AAMVA recommends that all drivers renew licenses in-person and pass a vision test at least every 4 years (Staplin & Lococo, 2003; TRB, 2005). Very few States meet these recommendations for all drivers. In-person renewals could be even more useful, for drivers of all ages, if they included functional ability tests as recommended in the NHTSA-AAMVA *Model Driver Screening and Evaluation Program: Volume 3: Guidelines for Motor Vehicle Administrators* (Staplin & Lococo, 2003) (see Countermeasure "License Screening and Testing").

Use:

Many States have different license renewal requirements for older drivers. These include 20 States with a shorter interval between renewals, 19 States that require more frequent vision tests or screenings at renewal, and 1 State (Illinois) that requires road tests for applicants 75 and older. Seventeen States and the District of Columbia prohibit online or renewals by mail (IIHS, 2021a).

Effectiveness:

License examiners report that in-person renewals and vision tests are effective at identifying people whose driving skills may be impaired (Potts et al., 2004). However, no known data are available on the number of potentially impaired drivers identified through these practices, and the effectiveness of more frequent renewals and vision tests on crashes is inconclusive (Koppel et al., 2020). Furthermore, studies regarding the effectiveness of vision screening for license renewal indicate that the value of the vision tests commonly used for licensing decisions as predictors of increased crash risk is inconclusive and that the aspects of vision currently assessed for licensing do not adequately explain unsafe driving (Bohensky et al., 2008).

Nonetheless, several studies have found that in-person renewals reduce fatal crashes, particularly for drivers 85 and older. Morrisey and Grabowski (2005) found that in-person license renewal was associated with reduced statewide traffic fatalities among the oldest drivers (85+). Similarly, in a study that analyzed the effects of laws and licensing policies in 46 U.S. States on the fatal crash involvement rates of older drivers from 1985 to 2011, Tefft (2014) found that requiring an in-person renewal was associated with a 25% reduction in fatal crash involvement for those 85 and older. There is a question, however, as to whether the large effects of in-person renewal requirements were due to the examiners being able to remove unsafe older drivers from the driving population or to older drivers possibly ceasing to drive prematurely. Other driver license renewal policies investigated (vision test, knowledge test, on-road driving test, and mandatory reporting laws for physicians) were not found to reduce fatal crash involvement rates of older drivers. Conversely, an earlier study found that fatalities among drivers 80 and older in Florida decreased by 17% after the State passed a law requiring these drivers to pass vision tests before renewing their driver licenses (McGwin et al., 2008). Agimi et al. (2018) similarly found that vision tests during in-person renewals were associated with significantly lower crash hospitalization rates among drivers 60 to 74. A systematic review of literature on in-person license renewal, which included several of the aforementioned studies, found inconclusive evidence on the safety benefits of these policies (Koppel et al., 2020).

Cost:

More-frequent license renewals or additional testing at renewal impose direct costs on driver licensing agencies. For example, a State that reduces the renewal time from 6 years to 3 years for drivers 65 and older would approximately double the licensing agency workload associated with these drivers. If 15% of licensed drivers in the State are 65 or older, then the agency's overall workload would increase by about 15% to process the renewals. If more frequent renewals and vision tests identify more drivers who require additional screening and assessment, then additional costs are imposed. See Countermeasure "License Screening and Testing" for additional discussion.

Time to implement:

A vision test requirement for renewal or a change in the renewal interval can be implemented within months. The new requirements will not apply to all drivers for several years until all currently valid licenses have expired, and drivers appear at the driver licensing agency for licensing renewal.

Other considerations:

- *Road tests and medical reports:* Several Australian States require a medical report, a road test, or both for drivers over a specified age to renew their licenses. Langford et al. (2004) compared Australian States with and without these requirements. They found that Australian States with these requirements had higher older-driver crash rates than States without them. They conclude that there are "no demonstrable road safety benefits" to requiring medical reports or road tests for older drivers.

Other Strategies for Behavior Change

Formal Courses for Older Drivers (Classroom + On-Road Feedback)

Effectiveness†: ★★★★	Cost: $$	Use: Low	Time: Medium

†Proven for improving on-road driving when classroom-based training is paired with individualized feedback.

Formal courses specifically for older drivers have historically been offered by organizations including AAA, AARP, and the National Safety Council, either independently or under accreditation by States (Potts et al., 2004; TRB, 2005). The courses typically involve 6 to 10 hours of classroom-based training in basic safe driving practices and in how to adjust driving to accommodate age-related cognitive and physical changes. A relatively new course, the Smart DriverTEK course, offered by AARP, educates drivers on the safety features and technologies in their vehicles (Donahue, 2018). The course is delivered as short-duration workshops, either in-person or online, and includes material on technologies such as smart headlights, reverse camera systems, collision and proximity warning (e.g., blind spot, lane departure, and forward collision), and post-crash emergency (also known as automatic crash or advanced automatic crash) notification systems.

Courses combining classroom and on-the-road instruction have been offered in a few locations (Potts et al., 2004) but are not available on a wide scale. Sangrar et al. (2019) completed a systematic review of older driver training programs and concluded that interventions including a tailored or individualized approach to providing feedback and training can improve both self-perceptions of driving and on-road performance. While there is a growing body of evidence that classroom-based trainings paired with individualized on-road training can improve driving performance, there are few programs within the United States that offer courses of this nature.

Use:

Courses are taught in all States, but most do not include an individualized feedback component that has been demonstrated as effective at improving driving performance.

Effectiveness:

Courses that combine classroom-based education with individualized on-road training show promising outcomes. Marottoli (2007) concluded that a training program combining classroom education with on-road training improved the performance of older drivers on written and on-road tests and may allow these drivers to retain their licenses longer, but Marottoli did not attempt to assess the program's impact on subsequent crash rates. Bedard et al. (2008) concluded that an in-class education program coupled with on-road education led to improvements in the participants' knowledge of safe driving practices and improvements on some aspects of safe driving performance, but further research is required to determine if these changes will affect crash rates. The value of physical training in addition to education is reinforced by research results by Romoser and Fisher (2009). They found that active training, such as practice with feedback, is a more effective strategy for increasing older drivers' likelihood of side-to-side scanning for threats than is passive training (classroom lecture or video only) or no training. Similarly, several international studies have found that individualized feedback results in a decrease in critical errors and unsafe driving actions (Anstey et al., 2018; Gagnon et al., 2019; Sawula et al., 2018; Shimada et al., 2018). While these studies do not assess crash rates or follow participants long term, the results support the conclusion that classroom-based interventions can improve driver safety when paired with tailored feedback.

Korner-Bitensky et al. (2009) conducted a review of articles published from 2004 to 2008 on the effectiveness of older driver retraining programs for improving driving skills and reducing crash rates. Four studies met the inclusion criteria for the review and provided strong evidence that education combined with on-road training improves driving performance. They also found moderate evidence that education alone is not effective in reducing crashes but when combined with physical retraining, does improve driving performance. Sangrar et al. (2019) conducted a comprehensive literature review to determine if older driver training programs affect road safety knowledge, self-perception of skills, and objective measures of driving performance. They found that approaches that included tailored feedback can change self-perception of driving and improve on-road performance. They conclude that future research should investigate the long-term effects of these programs. Simulators provide an alternative method of individualized training that has been explored in recent years. Research has found that simulator-based training has positive effects on subsequent simulator drives, with drivers improving on specific measures of driving behavior (Cuenen et al., 2019; Urlings et al., 2019). However, these studies did not measure whether the changes were demonstrated in the real driving environment. Additionally, simulator-based training poses a particular challenge with older drivers as simulator sickness is more prevalent in older adults (Keshavarz et al., 2018).

Cost:

Courses that include an on-road component in addition to a classroom component would incur considerable costs, as the very mechanism that is most likely to improve outcomes (individualized feedback) is time and labor intensive.

Time to implement:

The individualized feedback component of these courses is time intensive to implement. The closest, large-scale model of individualized on-road feedback is the driver's education system. While this model can provide some insights into implementation of classroom and on-road feedback, the driver's education model likely involves more hours in both a classroom setting and behind the wheel than what would be required for an older driver program of this nature.

Approaches That Are Unproven or Need Further Evaluation

General Communications and Education

Many organizations offer educational material for older drivers to inform them of driving risks, help them assess their driving knowledge and capabilities, suggest methods to adapt to and compensate for changing capabilities, and guide them in restricting their driving in more risky situations (Potts et al., 2004).

Other material is available to assist drivers and family members in understanding how aging affects driving, the effects of medications and health conditions, how to assess an older driver's skills, how to use specialized vehicle equipment to adapt to certain physical limitations, how to guide older drivers into voluntarily restricting their driving, and how to report older drivers to the department of motor vehicles if necessary (TRB, 2005).

A NHTSA-sponsored project conducted by Eby et al. (2008) sought to improve existing self-screening tools for older drivers by focusing on symptoms associated with medical conditions. The researchers created a self-screening survey to provide feedback to older drivers to increase general awareness of issues associated with driving and the aging process, and to provide recommendations for behavioral changes and vehicle modifications drivers could make to maintain safe driving. Evaluation results found the self-screening instrument had a positive value, but primarily as a "screening tool to determine gross impairment rather than fitness to drive" (Eby et al., 2008, p. 19).

Law enforcement officers have formed many partnerships with public and private organizations to give talks, teach safe driving courses, work with media on news stories and public service announcements, and other communications and outreach initiatives. TRB (2005) summarizes several examples.

A review of the literature yielded no evaluations of the effects of general communications and education on driving or on crashes.

Formal Courses for Older Drivers (Classroom Only)

Formal courses specifically for older drivers have historically been offered by organizations including AAA, AARP, and the National Safety Council, either independently or under accreditation by States (Potts et al., 2004; TRB, 2005). The courses typically involve 6 to 10 hours of classroom-based training in basic safe driving practices and in how to adjust driving to accommodate age-related cognitive and physical changes. A relatively new course, the Smart DriverTEK course, offered by AARP, educates drivers on the safety features and technologies in their vehicles (Donahue, 2018). The course is delivered as short-duration workshops, either in-person or online, and includes material on technologies such as smart headlights, reverse camera systems, collision and proximity warning (e.g., blind spot, lane departure, and forward collision), and post-crash emergency (also known as automatic crash or advanced automatic crash) notification systems.

Participants of these courses often report an increase in knowledge or awareness and self-report changes to driving behavior. However, none of the courses have been shown to reduce crashes (Potts et al., 2004). Graduates of both the AARP classroom and online courses report that they changed some driving behaviors because of the course (Skufca, 2011). The most thorough evaluation studied approximately 200,000 course graduates and a 360,000-driver comparison group in California from 1988 to 1992. It found that course graduates had fewer citations but no fewer crashes than non-graduates (Janke, 1994). Similarly, Owsley et al. (2004) evaluated the effects of a well-designed 3-hour educational course promoting safe driving strategies for older drivers with some visual defects. Course graduates reported that they regulated their driving more following the course than a control group that did not attend the course. However, there was no significant difference in crash rates between course graduates and the control group, an outcome that has been reinforced by subsequent research (Kua et al., 2007; Nasvadi & Vavrik, 2007; Owsley et al., 2004).

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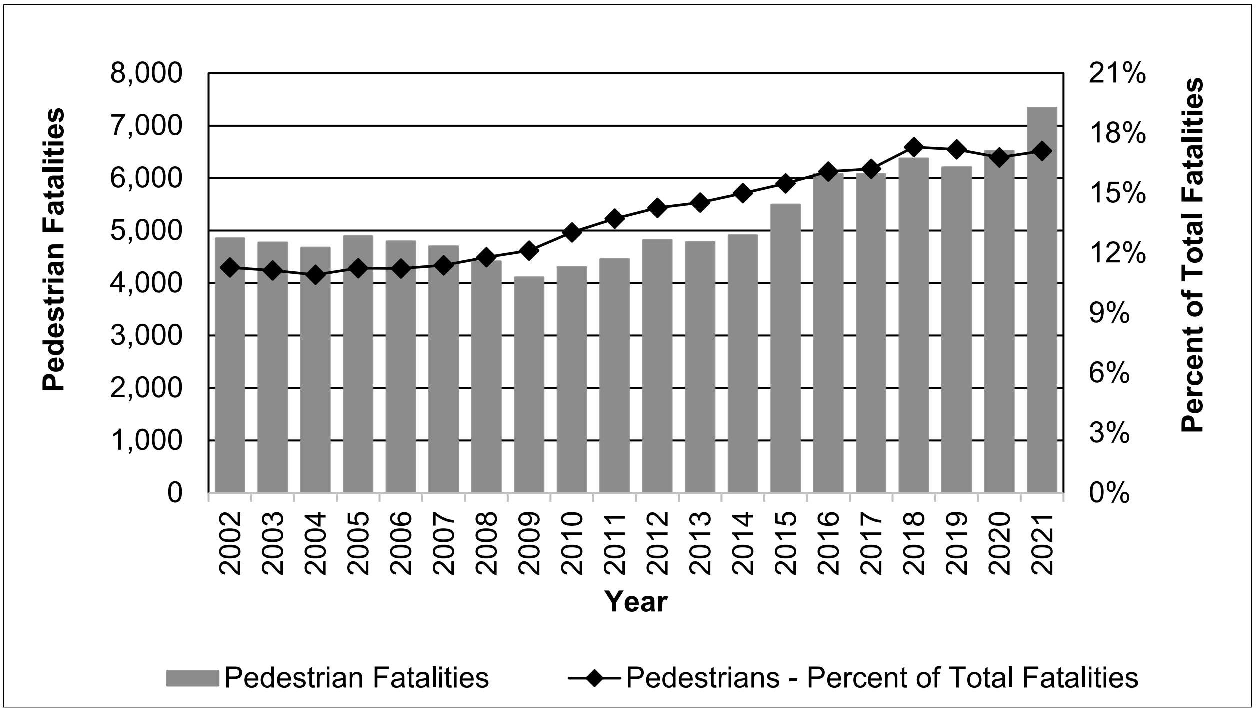
9. Pedestrian Safety

Overview

Pedestrian fatalities per year steadily decreased from the late 1970s to 2009 when the United States reached a low of 4,109 deaths (Reish, 2021; Schneider, 2020). However, the number of pedestrian fatalities has increased since 2009, leading to a 5-year average of 6,502 pedestrian deaths during the 5 most recent years (2017 to 2021). During this period, pedestrians accounted for 16 or 17% of total traffic fatalities (NCSA, 2023c).



Sources: NCSA (2022, 2023c)

Figure 9-1. Pedestrian Fatalities in Motor Vehicle Crashes, 2002 to 2021

Fatality rate trends—or fatalities adjusted per number of walking trips or miles traveled by walking—are unavailable because there is no systematically collected and consistent measure of walking (exposure) to estimate and compare fatality rates each year. In the United States, the National Household Travel Survey is the most comprehensive snapshot of travel trends, including walking. The 2017 NHTS estimates that walking trips represent approximately 10.5% of all transportation mode trips reported (McGuckin & Fucci, 2018), which means that pedestrian fatalities make up a disproportionate share of all traffic fatalities.

In 2021 some 7,388 pedestrians died and approximately 60,577 were injured in traffic crashes in the United States (NCSA, 2023c).

Characteristics of fatal crashes involving pedestrians include:

- *Light conditions:* 76% of pedestrians were killed in collisions that occurred when it was dark, with another 4% occurring during dusk or dawn (Schneider, 2020). Retting (2021) notes that during the years 2010-2019 —a time when pedestrian fatalities have been increasing—the number of pedestrian fatalities that occurred in the dark increased by 58%, while daylight fatalities increased by 16%.

- *Roadway location:* 73% of pedestrian fatalities occurred at non-intersection locations (Schneider, 2020). A study linking FARS data with roadway data and aerial imagery to identify pedestrian fatality "hot spots" found that common characteristics of these locations included five or more lanes to cross (70%), speed limits of 30 mph or higher (75%), and traffic volumes exceeding 25,000 vehicles per day (62%) (Schneider et al., 2021).
- *Time:* 25% of all pedestrian fatalities occurred from 6 p.m. to 8:59 p.m. and 26% from 9 p.m. to 11:59 p.m. (NCSA, 2023c)
- *Hit-and-run:* 23% of pedestrian fatalities in 2021 involved hit-and-run drivers (NCSA, 2023c), a proportion that has remained consistent for decades (Schneider, 2020). Investigators and researchers may never know about the characteristics of the driver, or the vehicle involved. As with other crash problems, there can be significant regional variation; an analysis of FARS data from 1998 to 2007 found that hit-and-run crashes accounted for 6.6.% of pedestrian fatalities in Mississippi and 29.8% in the District of Columbia (MacLeod et al., 2012). Common environmental and temporal factors surrounding hit-and-run crashes include poor lighting conditions, early morning time frame, and occurrence on the weekend.

Characteristics of pedestrians fatally injured in crashes include:

- *Sex:* 70% of pedestrians killed were males. Walking rates are similar for men and women (Buehler et al., 2020), but men are more than twice as likely to be killed in a traffic crash as a pedestrian (NCSA, 2023c).
- *Age:* The age groups 60 to 64 and 65to 70 had the largest percentage of pedestrian fatalities (23%) with age group 60 to 64 having the highest fatality rate (3.18 per 100,000 population). The average age of pedestrians killed has remained similar over the past 10 years (ranging from 45 to 48). Adults over 65 walk less than other age groups (Buehler et al., 2020), yet in 2021 some 18% of all pedestrian fatalities with known age were 65 and older. Adults 65 and older make up 15% of the population (NCSA, 2023c). Older pedestrians are more likely to die from their injuries when struck due to the inherent fragility associated with the aging process. Factors that may increase vulnerability to being struck for some older pedestrians include age-related physical changes that lead to walking more slowly; difficulty crossing the curb; difficulty judging walking speeds and oncoming vehicle speeds; difficulty in interactions with turning vehicles at intersections; and possible confusion about pedestrian signal phases (Dommes et al., 2012; Holland & Hill, 2010; Coffin & Morrall, 1995). Over the past 4 decades, there has been a steady decline in the proportion of pedestrian fatalities among children 14 and younger (Schneider, 2020). In the late 1970s children younger than 15 represented 18% of all pedestrian fatality victims. By 20211 they represented just 2.4% of all pedestrian fatalities (NCSA, 2023c; Schneider, 2020). These decreases correspond with declining rates of walking by children as measured by national surveys of household travel (Buehler et al., 2020; Kontou et al., 2020).

- *Race/ethnicity/national origin:* Several studies have documented the overrepresentation of Black and American Indian or Alaska Natives in pedestrian-motorist crashes as well as immigrants and areas with low-incomes (Anderson et al., 2010; CDC, 2013; Chakravarthy et al., 2012; Chen et al., 2012; Schneider, 2020; Zaccaro, 2019). These disparities by race, aggregated at the national level, remain when controlling for population as measured by the Census and for pedestrian activity as measured by walking trips or distances by the NHTS (Schneider, 2020; Zaccaro, 2019). Some studies attribute the inequities to how pedestrian facilities are distributed within communities (Kravetz & Noland, 2012). Other studies have found that areas with lower income and minority populations have higher transit use and walking rates (or exposure) that may partially explain elevated crash figures (Cottrill & Thakuriah, 2010). In trying to understand higher pedestrian crash rates for recent immigrants in New York City, researchers postulated that social-behavioral mechanisms and differing "safety cultures" play a role in pedestrian crashes. These characteristics, depending on from where someone has emigrated, may result in more acceptance for jaywalking or lower likelihood of yielding to pedestrians (Chen et al., 2012).

At the national level, walking trends and other travel trends are most commonly estimated using the NHTS, conducted by the FHWA. During the 2016-2017 survey period, an estimated 39 billion walking trips were made for all purposes (work or work-related commute, shopping and errands, school and church, social and recreational, and other trips), representing approximately 10.5% of trips by all transportation modes reported. When looking at all modes of transportation, walking accounted for about 4% of all trips to work. Of all walking trips, commuting to work makes up only a small percentage (6.5%) of walking trips (McGuckin & Fucci, 2018). The largest proportion of walking trips were made for recreational and social reasons (47.5%) followed by shopping and personal errands (29.5%). Buehler et al. (2020) provides a more thorough discussion of walking (and bicycling) trends observed during the most recent survey (2017) and in comparison, to the 2001 survey period.

Walking volume (sometimes generally referred to as mode share or exposure) has a complex and non-linear relationship with crashes. Because of this relationship, relying on the absolute number of crashes does not necessarily indicate danger for pedestrians. Strategies focused on increasing mode share and improving safety are then often considered in tandem (e.g., Safe Routes to School programs). The idea behind increasing mode share comes out of the concept of "safety in numbers," the decrease in risk of serious injury related to an increase in walking volume. A non-linear relationship between traffic volumes (motorist, pedestrian, or bicyclist) and crashes has been well-documented in a body of evidence that spans geographic levels (i.e., intersection, area, municipality, county) (AASHTO, 2010; Bhatia & Wier, 2011; Elvik & Bjørnskau, 2017; Elvik & Goel, 2019; Jacobsen et al., 2015). However, these findings are difficult to interpret because they do not show increased volumes as a clear cause of reduced risk (Bhatia & Wier, 2011; Schneider et al., 2017). Many studies also have not measured or accounted for other potential safety factors such as motorist speed, congestion, or law enforcement activity.

A recent meta-analysis of motorist-pedestrian or motorist-bicyclist injury crashes estimated that there is safety in numbers for both pedestrians and bicyclists (Elvik & Bjørnskau, 2017). By their estimate, if the number of pedestrians or bicyclists doubles (100% increase), the increase in crashes is expected to be 41%. These estimates indicate that while an increase in volume of pedestrians and bicycles leads to increases in crashes, crashes do not increase as much as volume increases. A subsequent expanded meta-analysis determined that the safety in numbers effect may be stronger for pedestrians than bicyclists, and at the macro level (cities) than the micro-level, such as an individual junction (Elvik & Goel, 2019). A literature review on safety in numbers found agreement throughout the research on the existence of a safety in numbers effect. However, the underlying causes of the effect were still not fully understood (Kehoe et al., 2022).

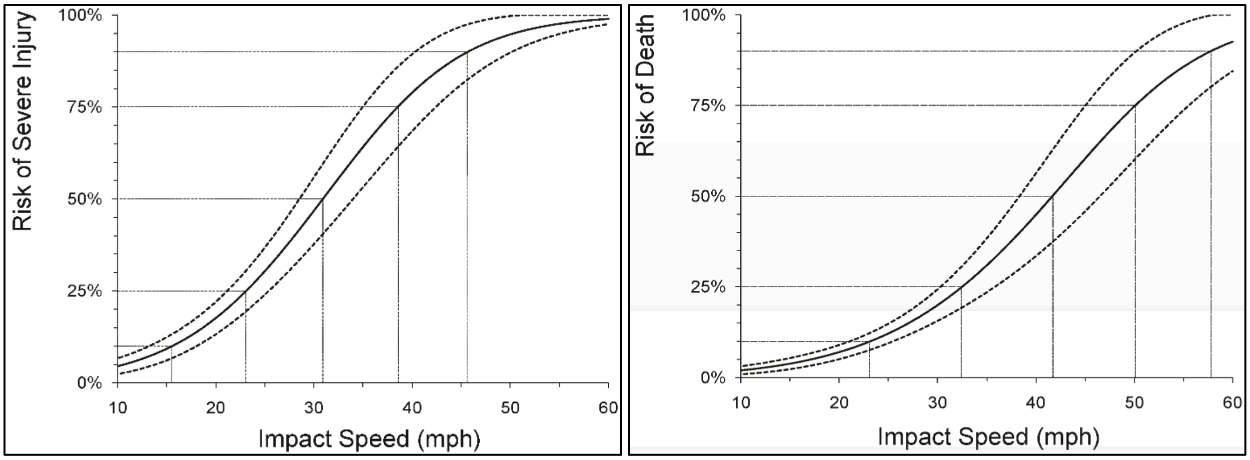
Understanding the Problem

Roadway environment, vehicle type and design, weather, and road user behaviors contribute to pedestrian crashes. These factors are not mutually exclusive, and risky behaviors such as speeding, impairment, and distraction introduce a compounding effect. Reducing risky driver behaviors improves safety for people walking. While reductions in crashes and injuries are the gold-standard for evaluating countermeasure effectiveness, it is important to note that the absence of crashes does not necessarily indicate the presence of safety. People may be dissuaded from walking along certain routes because of perceived threats to safety even in areas without high crash numbers.

Traditional safety management methods attempt to address safety through infrastructure improvements at high-crash locations, but they may be unable to reduce the network-wide risks. The Safe System approach has been adopted by cities, States, and the U.S. DOT to eliminate fatalities on the roadway (U.S. DOT, 2022). The *National Roadway Safety Strategy* recognizes that no mistake made by a road user should lead to death and seeks to build a transportation system that prevents serious and fatal crashes for all road users. The Safe System approach is a way to look beyond reducing raw crash numbers toward reducing (and eventually eliminating) the forces and risks in our transportation system that create death and serious injury. This concept is especially important for pedestrian safety because modern vehicle technology protects occupants from much of this energy impact, but people outside the vehicle remain particularly susceptible (Kumfer et al., 2019).

Driver speed

Pedestrians are particularly vulnerable to severe injury and fatality in crashes; countermeasures aimed at reducing speeds have the potential to save lives for both pedestrians and drivers. The risk of death or serious injury increases along an S-shaped curve as the impact speed—which is a product of speed limits, the built environment's cues to drivers, and driver behavior—increases. The study by Rosen and Sander (2009) estimated the risk of pedestrian fatality based on driver impact speeds using data from a sample of more than 2,000 pedestrian fatalities. The study estimated fatality risk curves based on driver impact speeds, ranging from 8% at 31 mph and reaching 50% at 47 mph. Other studies have estimated similar relationships, although the magnitude varies (Leaf & Preusser, 1999; Tefft, 2011). The figure below shows the adjusted, standardized risk of severe injury and the risk of death for pedestrians by impact speed from a sample of 422 pedestrians 15+ years struck by a single forward-moving car or light truck model year 1989–1999, United States, 1994–1998. Risks are adjusted for pedestrian age, height, weight, body mass index, and type of striking vehicle, and standardized to the distribution of pedestrian age and type of striking vehicle for pedestrians struck in the United States in years 2007–2009. Dotted lines represent pointwise 95% confidence intervals. Serious injury is defined as AIS score of 4 or greater and includes death irrespective of AIS score (Tefft, 2011).



Source: Tefft (2011)

Figure 9-2. Risk of Severe Injury (Left) and Death (Right) in Relation to Impact Speed

Tefft (2011) also includes graphics showing risk in relation to speed for older adults and by type of striking vehicle. Since travel speed data are challenging to obtain, researchers often use speed limit data as an imperfect surrogate. In their guide on systemic pedestrian safety analysis, Thomas et al. (2018) consider speeds greater than 25 mph as risk factors in areas of pedestrian activity. Driving speed also appears to affect the tendency for drivers to yield to pedestrians at crosswalks, with fewer drivers yielding as speeds increase (Bertulis & Dulaski, 2014; Gårder, 2004; Sandt, Gallagher & Gelinne, 2016). See Speeding and Speed Management for speed-related countermeasures. For a comprehensive synthesis on speed management and countermeasures that may reduce speed, see *NCHRP Synthesis: Pedestrian Safety Relative to Traffic-Speed Management* (Sanders et al., 2019).

Alcohol

The role of alcohol in pedestrian crashes has not been well defined, based on the lack of complete and high-quality data on alcohol use or BACs of drivers and pedestrians involved in crashes. A BAC of .08 g/dL is commonly used to indicate impairment in a road user regardless of mode. While this measure relates to the ability to operate a vehicle, research has not established whether this is a meaningful threshold for walking. In 2021 some 43% of all crashes resulting in pedestrian fatalities involved either a driver or pedestrian with a BAC of .08 or higher (NCSA, 2023c). Thirty-one percent of pedestrians killed in crashes had BACs of .08 or higher, while 19% of fatal pedestrian crashes involved drivers with BACs of .08 or higher. From 1982 to 2014 the proportion of fatally injured pedestrians with BACs of .08 or higher decreased at a lesser rate than fatally injured passenger drivers with BACs of .08 or higher (Eichelberger et al., 2018). While crash statistics measure the BACs of road users, other studies attempt to link alcohol use with pedestrian safety in particular. A study that combined crash data and driving record data from 5 States found that people with prior alcohol-related driving offenses may be at greater risk for being killed as a pedestrian with a BAC over .08 compared to those without prior driving offenses (Blomberg et al., 2019). While studies involving roadside data collection have assessed the prevalence of drinking and drugged driving, less in known about the prevalence among people walking or bicycling. A convenience sample of seriously and fatally injured road users suggests drug and alcohol prevalence is similarly high regardless of mode (Thomas et al., 2020). Alcohol use is also related to the land uses that permit alcohol sales surrounding a road. A study of alcohol outlet density and pedestrian safety in Baltimore City found that each additional off-premises alcohol outlet was associated with a 12.3% increase in the risk of pedestrian injuries in the neighborhood, and an attributable risk of 4.9% (Nesoff et al., 2018). Alcohol-related countermeasures that may also help address certain pedestrian crashes are presented in the Chapter on Alcohol-Impaired Driving.

Vehicle Type

Alongside factors such as speed and pedestrian age, the design of the vehicle contributes to the injury severity for the person outside the vehicle as well as the occupants. Eighty-five percent of all pedestrian injuries are caused by impact with the vehicle, even if the pedestrian strikes the pavement (Hu & Klinich, 2012). Vehicle weight, size, and power have been found in several studies to increase the risk of fatality and injury when a pedestrian is struck (Thomas et al., 2018). Although involvement of all types of passenger vehicles and medium or heavy trucks in pedestrian fatalities increased from 2009 to 2016, the rate of increase was highest among SUV-class vehicles (81%) compared to minivans and large vans (15%), and passenger cars (41%) (Hu & Cicchino, 2018). During this time, the number of registered SUVs increased 37%. In addition, the power-to-weight ratio increased significantly among all weight classes of passenger vehicles, and pedestrian fatality involvement of pickups, and medium or heavy trucks, each increased by 32%. Anywhere from double to triple the risk of fatality for the pedestrian has been correlated to crashes with light trucks when compared to crashes with passenger vehicles (Hu & Klinich, 2012). From 2016 to 2018 about 6.6% of all pedestrian fatalities involved a large truck (defined in FARS as a truck with a gross vehicle weight rating greater than 10,000 pounds) (FMCSA, 2020). While most people walking or bicycling who are fatally struck by a motorist are initially struck by the front of the vehicle, large trucks make up the highest percentage of right-side impact and rear impacts in pedestrian fatalities (NCSA, 2023c).

Distraction

Distraction is considered anything that diverts a traveler's attention from the primary task of navigating the roadway environment and responding to critical events. In the case of pedestrian distraction, the conversation has focused on distraction via smartphones. A literature review from NHTSA found that, based on the limited amount of research done on pedestrian distraction, distraction is associated with a small but statistically significant decrease in pedestrian safety (Scopatz & Zhou, 2016). Talking on cell phones is associated with cognitive distraction that may reduce the frequency of prudent pedestrian behaviors (Hatfield & Murphy, 2007; Nasar et al., 2008; Ortiz et al., 2017; Stavrinos et al., 2009, 2011); however, the results from real-world observational studies are mixed (Walker et al., 2012; Thompson et al., 2013). A study of road user distraction at four intersections in Washington, DC, found that of the 4,871 people observed, the primary form of distraction was engaging with other people for both pedestrians (44%) and drivers (49%) (Ortiz et al., 2017). More than a quarter (27%) of all people observed were distracted by cell phone use. The prevalence of distraction among pedestrians was higher than for drivers: pedestrians had 1.5 increased odds of being distracted. Thompson et al. (2013) sampled pedestrian behaviors at 20 high risk intersections and reported that only pedestrians who were texting were associated with suboptimal crossing behaviors. Most interactions (20 of 21) between distracted pedestrians *and* distracted drivers resulted in some form of evasive maneuver by either (Ortiz et al., 2017).

The studies described above report 7% to 30% of pedestrians using varying types of portable electronic devices and confirm that device use effects pedestrian crossing behavior, but they do not establish direct links between pedestrian distraction and pedestrian-involved crashes. Looking specifically at smartphone use, a review of observational studies of distracted walking found rates ranging from 1.1% to 8.4% of observed pedestrians (Gary et al., 2018). The review also separately considered survey-based studies, which tended to find higher rates of smartphone distraction. Nationally representative estimates on use of portable electronic devices are not available since distraction is not a universal variable on police crash reports, but would likely only capture a snapshot in time, as device use continues to grow in popularity. FARS/CRSS data on pedestrian device use or involvement in pedestrian crashes is not complete (NCSA, 2023b).

Engineering and Roadway Design

The countermeasures described in this guide relate primarily to educational and enforcement measures aimed at improving knowledge and preventing behaviors that contribute to crashes. Roadway design and engineering also impact road user behavior, both pedestrian and drivers, affecting safety for pedestrians. The Safe System Approach (U.S. DOT, 2022) recognizes the integrated role of different measures, including roadway design, in creating a safe, welcoming environment for all road users. The Safe System Approach recognizes the vulnerability of road users, especially for those unprotected by a vehicle and seeks to employ layers of protection that include safer roads to prevent serious and fatal crashes. The U.S. DOT's (2014) national pedestrian safety action plan focuses significant attention on built environment research and countermeasures.

Data/Surveillance

Practitioners and researchers need high-quality data to both identify problems and to evaluate countermeasure effectiveness. Three primary types of data are needed for a more complete picture of pedestrian safety:

- Safety/outcome data that describes crash events or reports surrogate measures.
- Exposure data that describes the amount of activity in a place or by a group.
- Contextual data that describes the environment in which travel occurs and can provide insight into potential risk factors associated with crashes.

This document's focus on safety data should not minimize the importance of exposure data or contextual data. Exposure is a crucial aspect of analyzing crash risks because, all other factors being equal, greater exposure will increase the chance of a crash. High crash figures may simply reflect high pedestrian activity. Alternatively, a corridor or intersection with low crash figures may be a result of actual or perceived danger that dissuades people from using the facility.

Crashes are currently viewed as the most objective and reliable measurements of road safety. However, there are challenges with crash data, such as human error in reporting, unreported crashes, and the length of time it often takes for crashes to be entered into a database (Carter et al., 2017). Only traffic-related crashes involving motorists are reported to authorities and most States have a minimum threshold of injury or property damage for the police department to file crash reports.

Police-reported crash data, when recorded completely, often has details on pre-crash maneuvers, crash dynamics, and crash locations. These details allow researchers to analyze the causes and correlations of crashes more effectively and to help agencies identify targets for treatment. Since 2014 NCSA has used the crash typing framework Pedestrian and Bicycle Crash Analysis Tool (PBCAT)[7] to describe the events and maneuvers that preceded fatal bicyclist and pedestrian crashes (i.e., the crashes included in FARS). In 2021 FHWA released an updated version of PBCAT, PBCAT3, that improves user functionality and offers crash typing logic that supports coding consistency and objectivity. This new version complements the data that States currently collect. It is important to consider on-site field review of behaviors and site-specific characteristics before determining which engineering or behavioral countermeasures are appropriate (Zegeer, Sandt, & Scully, 2008). Another pedestrian and bicycle crash typing schema is the Location-Movement Classification Method, which provides detail about pedestrian or bicyclist's position relative to the roadway or intersection and theirs and the vehicle's movements preceding a crash. This crash typing helps identify what measures could be applied in specific locations to reduce crashes (Schneider & Stefanich, 2016).

While crash types are informative, crash type studies do not capture all the conditions that can lead to injury or death for people walking. Predominant crash types may differ by geographies, injury severity, area type, lighting context, infrastructure facilities, vehicle fleet characteristics, and populations using the facilities. Enforcement and safety norms may also affect crash types (Saleem et al., 2018). Prevalent crash types have been found to change over time, even when study methods and areas were consistent (Preusser et al., 2002).

Another consideration when analyzing crash data are that pedestrian crashes (as well as bicycle crashes) tend to be underreported. Underreporting of traffic-related crashes on road rights-of-way likely decreases as the crash severity increases because police are likely to be called to injury and fatal crashes, and the pedestrian is more likely to be transported or seek treatment at a healthcare facility. Many States may not require reporting nor collect off-road or private-road crash records. Non-roadway crashes may, however, constitute a significant portion of pedestrian-related crashes with motorists. In several studies, parking lot and driveway-related crashes represented up to 15% to 25% or more of all *reported* pedestrian crashes (Stutts & Hunter, 1999a; Thomas & Levitt, 2014). Many people in the United States and worldwide suffer from falls, including falls incurred while avoiding collisions with motorists (Stutts & Hunter, 1999a, 1999b; Sciortino et al., 2005; Methorst et al., 2017). Many more roadway and non-roadway crashes go unreported. Research is needed to better understand the extent and causes of non-roadway pedestrian crashes and effective countermeasures. NHTSA's Non-Traffic Surveillance (NTS; www.nhtsa.gov/crash-data-systems/non-traffic-surveillance; NCSA, 2023a) monitors and reports on not-in-traffic-related motor vehicle deaths.

Hospital and EMS data can be an important form of safety data, as not all crashes involve police response. These data are usually more accurate than police reported crash data, especially for determining crash severity outcomes. They also may include more information about the nature of an injury and crash than police reports, but rarely include detailed location data. Health-related datasets are often deidentified, which makes it challenging to link them with other datasets (i.e., police-reported crash data). Sometimes linkage is possible by working with individual States or after negotiating data agreements. One source of data is through the National Emergency

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[7] *PBCAT: Pedestrian and Bicycle Crash Analysis Tool, version 3*. (n.d.). https://pbcat3.org/

Medical Services Information System (nemsis.org), the national system used to collect, store, and share EMS data from the U.S. States and Territories. It is a collaborative system to improve prehospital patient care through the standardization, aggregation, and utilization of point of care EMS data at a local, State, and national level. Some data on NEMSIS are publicly available and other data can be obtained through requests.

Surrogate measures of safety can be used to identify crash potential, even when a crash has not occurred or been reported. The most common surrogates are conflicts/near misses measured as a sudden change in speed or trajectory/path and observed behaviors such as driver yielding, driver speed, pedestrian use of crosswalk, and more. User perceptions or rankings by roadway users or expert groups can be used in setting performance measures or safety ratings for roadways. The choice of surrogate safety indicators should be context dependent (Johnsson et al., 2018).

Crash and injury data is often the only available form of safety data, but in a small area (or short duration of time) there may not be enough data for proper analysis. Observing interactions and near misses on local streets may be an effective means of understanding where interventions are needed (Cloutier et al., 2017). Research has linked walking (and bicycling) behavior to perceptions of safety, and if certain locations feel unsafe, there may be no pedestrian traffic. Thus, measuring suppressed trips is also important for gaining a more complete understanding of safety problems (Ferenchak & Marshall, 2019).

Considerations for Improving Data

Improving data on pedestrian transportation is a critical need. A research roadmap developed for the AASHTO Council on Active Transportation calls "improving data on pedestrian and bicyclist fatalities" a high priority (Dill et al., 2021). While crash data is the main source of safety data, a comprehensive nonmotorized safety analysis often means being able to access a wide array of data from sources and disciplines. Key to achieving better understanding of safety is improving police reported crash data, improving exposure data, and increasing the frequency of travel surveys.

A consensus report by the Safe States Alliance provides an overview of pedestrian injury surveillance data that could supplement State level crash data or bolster analyses of safety (Injury Surveillance Workgroup 8, 2017). Fatality and injury data and (primarily) proxy measures of exposure from a variety of sources can be tailored to local needs and used in analyses to understand crashes in greater detail and context.

Emerging Issues

Relevant emerging issues for people walking are related to changes to the vehicle fleet and emergent transportation modes that surround pedestrians. Many sources have documented that light trucks (SUVs and pickups) make up an increasing proportion of the vehicle fleet. These vehicle types, on average, weigh more and have more power than other passenger vehicles so the average force involved in crashes with pedestrians has steadily increased (Hu & Klinich, 2012; Hu & Cicchino, 2018). The emergence of transportation network companies (TNCs) that hire drivers as contractors who drive their personal vehicles may offer some benefits for pedestrians in the form of first-last mile connections to transit, but they likely generate more vehicle miles and vehicle trips, and their curbside activity may create more exposure to conflicts (Erhardt et al., 2019; Barrios et al., 2018).

Vehicle automation has the potential to profoundly affect pedestrian and bicyclist safety; but what is known about the current level of automation reveals that detection technologies are insufficient (AAA Foundation, 2019). However, if automated technologies improve, especially their pedestrian detection capability, then a safety benefit is possible for people walking. A 2017 NHTSA report estimated the safety benefits of Pedestrian Crash Avoidance/Mitigation (PCAM) systems (Yanagisawa et al., 2017). The study used FARS and GES data to reconstruct real crashes and performed tests for two specific pedestrian-vehicle collision scenarios and found an estimated range of 10% to 78% for crash avoidance effectiveness in both scenarios. Current testing is largely limited to a research environment involving light vehicles and measuring the systems' capabilities to detect a pedestrian in the road ahead. Combs et al. (2019) analyzed approximately 5,000 pedestrian fatalities from FARS and found that under research assumptions, automated detection technologies may prevent 30% to 90% of pedestrian fatalities when failure to detect is the primary causal factor. The authors caution that their findings are not necessarily exclusionary of other causal factors and that the estimated benefits may not be realized in all circumstances and equitably for all roadway users. A future with connected and automated vehicles (CAVs) will not only affect mobility, but it will reshape the built environment, so Shay et al. (2018) call for more research to investigate their safety and equity impacts (access, land use, etc.) on pedestrians and walkability. A discussion guide from the Pedestrian and Bicycle Information Center synthesizes existing literature on the safety impacts of CAVs and introduces 10 key challenge areas (Sandt & Owens, 2017).

Little is known about the effects of e-scooters on pedestrian safety. Most e-scooter riders are pedestrians at some point along their trip and they may use pedestrian infrastructure, bicycle infrastructure, or roadway infrastructure depending on their comfort and State or local regulations (Ognissanto et al., 2018). Though data are limited, crashes between e-scooters and pedestrians resulting in injury are rare. Pedestrians, however, report safety concerns involving e-scooter riders being on sidewalks rather than bike lanes or the roadway. There are also some concerns with e-scooter parking taking up sidewalk space or presenting a tripping hazard (Sandt et al., 2022).

Key Resources

- Pedestrian and Bicycle Information Center
    - Toward a Shared Understanding of Pedestrian Safety: An Exploration of Context, Patterns, and Impacts (Sandt et al., 2020).
    - Pedestrian and Bicycle Information Center. (n.d.-b). "Understanding Crashes and Safe Behaviors to Prevent Them" Video Series. www.pedbikeinfo.org/resources/resources_details.cfm?id=5313
    - PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System (n.d.), *Countermeasures*, at www.pedbikesafe.org/PEDSAFE/
    - Pedestrian and Bicycle Information Center. (n.d.-a). Webpage for micromobility includes numerous summary resources including reports developed by PBIC, FHWA, and GHSA: www.pedbikeinfo.org/topics/micromobility.cfm

- NHTSA
    - *Advancing Pedestrian and Bicyclist Safety: A Primer for Highway Safety Professionals* (Brookshire et al., 2016): https://rosap.ntl.bts.gov/view/dot/1982
    - NHTSA's Walk and Bike Safely Curriculum, *For English as Second Language (ESL) Teachers and Learners* (n.d.-a) at www.nhtsa.gov/pedestrian-safety/english-second-language-esl-teachers-and-learners
- FHWA
    - *How to Develop a Pedestrian and Bicycle Safety Action Plan* (Gelinne et al., 2017): https://safety.fhwa.dot.gov/ped_bike/ped_focus/docs/fhwasa17050.pdf
    - *Resident's Guide for Creating Safer Communities for Walking and Biking* (Sandt, Thomas, et al., 2015): https://safety.fhwa.dot.gov/PED_BIKE/ped_cmnity/ped_walkguide/index.cfm
- Reports that summarize national-level pedestrian safety trends (annual/biannual)
    - Smart Growth America's *Dangerous by Design* (Venson et al., 2019) reports analyze FARS data and create rankings of States and metropolitan areas.
    - GHSA's *Pedestrian Traffic Fatalities by State* (Retting, 2021) report offers analysis of FARS data.
    - Benchmarking Report/Benchmarking Project (currently published by the League of American Bicyclists [2020], previously by the Alliance for Biking and Walking) combines data from a variety of sources to document the "state of bicycling and walking" in terms of mode share, safety, health, equity, and more.

The agencies and organizations listed below can provide more information on pedestrian safety and links to numerous other resources.

- NHTSA (n.d.-b): www.nhtsa.gov/road-safety/pedestrian-safety
- FHWA (2023): https://highways.dot.gov/safety/pedestrian-bicyclist
- Pedestrian and Bicycle Information Center (n.d.-c): www.pedbikeinfo.org – a national information center funded by FHWA and NHTSA.
- GHSA (2023): www.ghsa.org/issues/bicyclists-pedestrians
- National Center for Safe Routes to School (2023): www.saferoutesinfo.org
- Smart Growth America (2023) – National Complete Streets Coalition: www.smartgrowthamerica.org/complete-streets
- Safe Kids Worldwide (2023): www.safekids.org/
- Safe Routes National Partnership (n.d.): www.saferoutespartnership.org
- Safe States Alliance (2021): www.safestates.org
- United States Access Board (n.d.): www.access-board.gov
- America Walks (2023): www.americawalks.org
- Association of Pedestrian and Bicycle Professionals (2022): www.apbp.org
- Vision Zero Network (2023): www.visionzeronetwork.org

Pedestrian Safety Countermeasures

Legislation and Licensing

Countermeasure	Effectiveness	Cost	Use	Time
Lower Speed Limits	★★★★	$	High	Varies

Enforcement

Countermeasure	Effectiveness	Cost	Use	Time
High-Visibility Enforcement at Pedestrian Crossings	★★★	$$	Low	Short

Other Strategies for Behavior Change

Countermeasure	Effectiveness	Cost	Use	Time
Pedestrian Safety Zones	★★★★	$$$	Low	Long
Elementary-Age Child Pedestrian Training	★★★	$	Unknown	Medium
Safe Routes to School	★★★	$	High	Medium
Walking School Buses	★★	$	Unknown	Short
Conspicuity Enhancement	★★	$	Low	Medium

Approaches That Are Unproven or Need Further Evaluation

Countermeasure
Child School Bus Training
Communications and Outreach Addressing Impaired Pedestrians
University Educational Campaigns
“Sweeper” Patrols of Impaired Pedestrians
Driver Training
Pedestrian Gap Acceptance Training
Children’s Safety Clubs
Child Supervision

Effectiveness:

★★★★★	Demonstrated to be effective by several high-quality evaluations with consistent results.
★★★★	Demonstrated to be effective in certain situations.
★★★	Likely to be effective based on balance of evidence from high-quality evaluations.
★★	Limited evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.
★	No evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well

Cost to implement:

$$$	Requires extensive new facilities, staff, equipment, or publicity, or makes heavy demands on current resources.
$$	Requires some additional staff time, equipment, facilities, and/or publicity.
$	Can be implemented with current staff, perhaps with training; limited costs for equipment or facilities.

These estimates do not include the costs of enacting legislation or establishing policies.

Use:

High	More than two-thirds of the States, or a substantial majority of communities
Medium	One-third to two-thirds of the States or communities
Low	Less than one-third of the States or communities
Unknown	Data not available

Time to implement:

Long	More than 1 year
Medium	More than 3 months but less than 1 year
Short	3 months or less

These estimates do not include the time required to enact legislation or establish policies.

Legislation and Licensing

Lower Speed Limits

Effectiveness: ★★★★	**Cost:** $	**Use:** High	**Time:** Varies

The goal of reducing motorist travel speeds is to increase reaction time for both drivers and pedestrians to avoid crashes, as well as reduce the severity of pedestrian injuries when these crashes occur. Higher vehicle speeds produce more frequent and more serious pedestrian crashes and casualties, as evidenced by several studies (Leaf & Preusser, 1999; Rosen & Sander, 2009; Tefft, 2011; Martin & Wu, 2018; Thomas et al., 2018). Rosen and Sander (2009) estimated fatality risk curves based on driver impact speeds, ranging from 8% at 31 mph and reaching 50% at about 47 mph. Motorist speed affects pedestrian injury severity and consequently also affects pedestrians' perceptions of whether it is safe to walk. For a more thorough discussion of speed-related issues please see the chapter on Speeding and Speed Management. Reducing and enforcing speed limits is just one tool among many for decreasing travel speeds with the goal of improving pedestrian safety. For more information, see *NCHRP Synthesis 595 Pedestrian Safety Relative to Traffic-Speed Management* (Sanders et al., 2019).

Speed limits are in effect on all road segments in all States. It is important to keep in mind that actual travel speeds often exceed posted or statutory speed limits and that posted speed limits often exceed safe travel speeds. Evidence shows that actual speeds are reduced by only a fraction of the reduction in speed limits—typically 1- to 2 mph speed reduction for every 5-mph speed limit reduction (Elvik et al., 2004). However, even 1- to 2 mph reductions in average speed are estimated to yield substantial fatal and injury crash reductions. Some reasons that travel speeds do not decrease by the same proportion as speed limit reductions, include drivers not noticing the new speed limit, drivers not understanding the safety reasons to reduce speed, drivers speeding out of habit, or continuing to keep up with the speeds maintained by other drivers. For maximum effectiveness, speed limit reductions need to be accompanied by communications and outreach that inform the public and make the case for the speed reduction, and by heightened, visible enforcement (Leaf & Preusser, 1999). Speed limit reductions need to be made compelling through communications strategies (framing the problem); appropriate engineering changes such as road diets, lane narrowing, traffic calming, and roundabouts; and by speed enforcement (including automated). For information on automated enforcement, see the PBIC document *An Overview of Automated Enforcement Systems and Their Potential for Improving Pedestrian and Bicyclist Safety* (Poole et al., 2017). Combinations of these measures can improve road safety and are increasingly used as part of Vision Zero initiatives in many cities in the United States (Kim et al., 2017; Vision Zero Network, 2018). Cities including Boston, New York, Seattle, Minneapolis, and Portland, have implemented the Vision Zero framework to improve pedestrian safety and survival chances by lowering speed limits on roads with a high frequency of multimodal traffic. Case studies and webinars featuring these communities are available on the Vision Zero Network website.

Speed limit reductions can be most effective when introduced to a limited area as part of a visible area-wide change, for example, identifying a downtown area as a special pedestrian-friendly zone through signs, new landscaping or "streetscaping," lighting, etc. As mentioned above, road diets, an FHWA proven safety countermeasure, may be a low-cost way to reduce an overbuilt street that suggests high speeds to drivers and provide more space for walking, bicycling, and for drivers who need to park their vehicles.

If speed limits are routinely ignored, then enforcing speed limits may be a more effective strategy than attempting to change them. Blomberg and Cleven (2006) reported on demonstration programs in two cities in which speed limit enforcement, combined with engineering changes and extensive publicity, reduced both average speeds and the number of excessive speeders in residential neighborhoods. One attempt to scale up a similar program to a large city (Philadelphia) met with challenges in garnering community involvement and increasing enforcement due to a State restriction on using radar to enforce speeds, and seemed to have limited success in reducing injuries (Blomberg et al., 2012). However, speed reductions were observed on 17 of 24 corridors, 6 of which had pavement treatments simulating traffic calming devices. As with many evaluations of countermeasures for pedestrian safety, pedestrian crashes were too few to achieve measurable effects.

Use:

High, in the sense that all public roads have a speed limit and speed limit enforcement is widely employed, even if it is not with the express purpose of improving pedestrian safety.

Effectiveness:

Reduced speed limits with enforcement can reduce vehicle speeds and all types of crashes and crash severity. However, the measure of effectiveness for most studies of speed limit reductions or enforcement operations is speeds, not crashes or severity of injuries. An example of a crash-based study is an evaluation of "slow zone" treatments in London, England, which found a reduced risk of crash severity for pedestrians when urban speed limits are low (e.g., 20 mph) (Li & Graham, 2016). Since the association of pedestrian injury with speed trends strongly suggests that pedestrian injuries and crashes will be reduced if travel speeds are reduced, and pedestrian crashes can be a relatively rare event compared to other motor vehicle crashes. Most studies examine changes to average speeds, 50th percentile speeds, 85th percentile speeds, or excessive speeding. In January 2017 the City of Boston lowered speed limits on city streets to 25 mph from 30 mph. The speed reductions were heavily publicized on traditional and social media (Hu & Cicchino, 2020). An analysis of vehicle speeds during the months of September-November 2017 found statistically significant reductions in the odds of motorists exceeding 25 mph (2.9% lower), 30 mph (8.5% lower), and 35 mph (29.3% lower) on Boston streets compared to streets in a nearby control city. The effect of enforcement was not studied in this analysis; however, the city had installed speed limit and speed feedback signs at certain locations (Hu & Cicchino, 2020). Research conducted in Canada suggests that speed limit reductions may not affect excessive speeding behaviors (Heydari et al., 2014). Both studies reinforce the importance of looking at measures of speed, not just over/under the speed limit.

Cost:

Simply changing speed limits is low-cost, only requiring updating speed limit signs or, where few signs exist, adding some new ones. Combining speed limit changes with communications and outreach, enforcement, and engineering changes is significantly more expensive.

Time to implement:

Depending on the scope of the program, the time can be very short, or it can take several months to more than a year, especially if legislative changes are needed.

Other considerations:

Speed limit changes exist in the context of other, unchanged speed limits. The normal expectation is that there is an overall consistent approach to speed-limit setting. Where, for safety, some speed limits need to be reduced in a manner inconsistent with other speed limits, there must be clear and visible reminders that distinct conditions exist that justify the lower limits. Also, speed limit changes can be more effective if there is public buy-in, which involves a clear understanding of the reasons for the change.

Enforcement

High-Visibility Enforcement at Pedestrian Crossings

Effectiveness: ★★★	**Cost:** $$	**Use:** Low	**Time:** Short

The purpose of enforcement strategies is to increase compliance with the traffic laws that are most likely to improve the safety of pedestrians in areas where crashes are happening or most likely to happen due to increased pedestrian and motorist exposure. While this section focuses on enforcement of driver and pedestrian behavior at pedestrian crossings, it is reasonable to assume that enforcement of other risky driving behaviors such as speed, distraction, impairment, red-light running, etc., improve the safety of people walking.

Before designing and implementing a pedestrian safety enforcement campaign, agencies should engage local stakeholders to help determine if law enforcement offers an appropriate intervention for the safety problems of concern. An increasing body of research has demonstrated the racial disparities in policing, specifically related to traffic stops (Baumgartner et al., 2018; Epp et al., 2017; Pierson et al., 2020). For example, analysis of more than 100 million traffic stops in the United States showed that Black motorists were stopped 40% more frequently than white drivers (Pierson et al., 2020).

Traffic enforcement is most effective when it is highly visible and publicized, to reinforce the required behavior and to raise the expectation that failure to comply may result in legal consequences. Enforcement campaigns should be aimed at drivers and pedestrians, starting with the communications and outreach efforts that announce, describe, and publicize the traffic safety campaign through community meetings, media coverage, social media, mass emails, and signage (NHTSA, 2014). Many pedestrian safety enforcement efforts are crosswalk operations that use plainclothes officers as pedestrians crossing the street, typically with one or two uniformed officers observing for violations and another giving warnings or writing citations.

A coordinated program of targeted enforcement should involve a range of support activities, such as communications and outreach to notify the public of the campaign; training law enforcement officers on enforcement procedures and pedestrian and crosswalk laws; and educating prosecutors and judges so they understand the purposes of the campaign and are prepared for the increase in citations (NHTSA, 2014). Training for prosecutors and judges can help build the case for enforcement of traffic laws and planned enforcement operations with appropriate follow-up throughout the judicial system. A pilot study in North Carolina found that once more stringent prosecution was publicized, the court case load did not increase as feared, as more drivers paid their citations automatically (Hunter et al., 2001).

It is important to teach law enforcement personnel the basics of pedestrian safety and targeted enforcement techniques. In an early phase of North Carolina's *Watch for Me NC* program, an evaluation of a one-day workshop for 118 officers found that participating officers scored 24% higher on knowledge surveys about pedestrians and driver yielding laws after taking the workshop (Sandt, LaJeunesse, et al., 2015). Only 14% of participating officers reported having taken a pedestrian and bicycle law course before. States such as Texas, New York, and Florida are offering quick training and resources in the form of videos that can be shown during roll-call meetings. These videos are typically accessible through YouTube.

Common Resources:

- NHTSA's *Pedestrian Safety Enforcement Operations: How-To Guide* (2014b) offers law enforcement agencies a resource for setting up staged crosswalk enforcement operations. www.nhtsa.gov/sites/nhtsa.dot.gov/files/812059-pedestriansafetyenforceoperahowtoguide.pdf
- *The Role of Law Enforcement in Supporting Pedestrian and Bicyclist Safety: An Idea Book* (2020) shares examples and ideas of how law enforcement can address pedestrian and bicyclist safety including real-world examples and resources. https://rosap.ntl.bts.gov/view/dot/49827

Use:

The use of HVE at pedestrian crossing is low. Enforcement is largely a local option, and often is integrated into other police duties, so special enforcement efforts are difficult to isolate and track. Several localities (including Chicago; Detroit; Miami; Pinellas County, Florida; and Raleigh/Durham, North Carolina) and States such as New Jersey and New Mexico have implemented training for law enforcement officers and conducted targeted enforcement efforts for pedestrian safety.

Effectiveness:

Crash-based studies of pedestrian safety enforcement operations are rare. Most studies evaluate changes in the behavior that the enforcement campaign was designed to deter/modify. The Watch for Me NC education and enforcement program, which is described in more detail under the countermeasure "Pedestrian Safety Zones," conducted initial evaluations using motorist yielding as the measure of effectiveness (Sandt, Marshall, et al., 2016), while a later evaluation analyzed pedestrian crashes in the 29 North Carolina counties with active programs. It is important to note that WFMNC implementation varied within and across counties. The crash-based analysis found a statistically significant 12.8% reduction in pedestrian crashes along with a 21.7% reduction in nighttime crashes and a 9.5% reduction in the "failed to yield" crash type (Saleem et al., 2018).

In Gainesville, Florida, a before/after study with a comparison group examined the effects of sustained, enhanced HVE of motorist yielding to pedestrians, combined with publicity and other community outreach (e.g., flyers given to stopped drivers, information sent home with school children, social norming feedback signs, and earned and paid media) (Van Houten, Malenfant, Blomberg, et al., 2013; Van Houten, Malenfant, Huitema, & Blomberg, 2013). Driver yielding rose throughout the one-year study period, which included four, 2-week waves of enforcement, along with the other activities. Four of the six enforcement sites observed significant increases in yielding at the end of the period with a fifth experiencing a positive trend. The one location that did not observe an increase was on a university campus with an already high baseline rate of yielding. Yielding also increased at the comparison sites, although not by the same degree. Driver awareness of the enforcement, especially awareness of the feedback signs that displayed site-specific and citywide yielding averages, also increased to a high level (from 13% at baseline to 78% at the end of the year). A follow up study 4 years after the HVE program ended found that yielding behavior actually increased at both the enforcement (8% increase) and comparison sites (20% increase) after the program ceased (Van Houten et al., 2017). The study authors hypothesize that the intervention, especially the social norming component, created a "tipping point" for positive motorist behavior whereby a small change tipped the balance of the system and resulted in widespread change. Earlier, Van Houten and Malenfant (2004) had found more modest increases in driver yielding to pedestrians in response to a single wave of targeted police enforcement at crosswalks on two corridors in Miami Beach, Florida. A study attempting to replicate the Gainesville findings in Ann Arbor, Michigan, also observed more substantial improvements at treatment sites than at generalization sites in the short-term, although a long-term follow-up is still needed (Van Houten et al., 2018).

Researchers also adopted a social norming approach in addition to HVE, education, and some low-cost engineering improvements during an 18-month effort in St. Paul, Minnesota (Morris et al., 2019). Weekly average yielding at treatment sites grew from as low as 26% in the baseline period to 78% during the final phase, while generalization sites grew from 31% to 61%. Researchers also noted a decrease in threat passes at both site types, which was a secondary measure of effectiveness for the program.

Law enforcement officials in Detroit, Michigan, implemented two pedestrian-oriented enforcement campaigns at Wayne State University to educate the campus community on proper use of crosswalks and the importance of obeying signals through the issuance of warnings (Savolainen et al., 2011). The study saw pedestrian violations (walking outside the crosswalk or against the signal) reduced from 17% to 27% immediately after the campaign, with sustained reductions of from 8% to 10% several weeks after active enforcement ceased. Pedestrian compliance was also associated with the presence, quality, and location of pedestrian facilities (including pedestrian signals, bus stops, crosswalks, and convenient crossing opportunities).

Cost:

The cost of the enforcement is a direct function of the size of the effort, the amount of enforcement, and associated supplies, ranging from vehicle operating costs to equipment such as speed measurement devices or alcohol test machines. If overtime is used to increase enforcement, costs would be higher. Free or low-cost training of enforcement officers on data driven focused efforts at the local level, can enhance both the cost and time spent to educate and enforce those laws and pedestrian and motorist behaviors most likely to influence serious injury or fatalities to pedestrians.

Time to implement:

The time to implement HVE at pedestrian crossings is short. However, special training to ensure safe and consistent crosswalk enforcement operations may be needed, and periodic data analysis conducted to ensure potential high crash locations are targeted for safety behaviors that influence the safety of pedestrians, including speed and distraction. Developing a plan that coordinates law changes, environmental changes, or support communications and outreach with enforcement activities will take longer.

Other Strategies for Behavior Change

Pedestrian Safety Zones

Effectiveness: ★★★★	**Cost:** $$$	**Use:** Low	**Time:** Long

The pedestrian safety zone concept was developed in a joint effort study by NHTSA and FHWA (Blomberg & Cleven, 1998). The idea is to strive for large decreases in pedestrian crashes and injuries by targeting education, enforcement, and engineering measures to geographic areas and audiences where significant portions of the pedestrian crash problem exist. Pedestrian safety zone programs can target a full range of pedestrian crash problems within a limited geographic area or focus on types of problems that make up a large portion of the problem within a limited area.

Use:

Pedestrian zone programs noted in early research were implemented in only a handful of cities. Since then, more programs have been implemented.

Effectiveness:

Properly designed and implemented pedestrian zone programs have been shown effective in reducing crashes and injuries for older pedestrians (Blomberg & Cleven, 1998), for impaired pedestrians (Blomberg & Cleven, 2000), and for child and adult pedestrian crashes in Miami-Dade County (Zegeer, Blomberg, et al., 2008; Zegeer, Henderson, et al., 2008). Surrogate measures of safety have also yielded promising results (Morris et al., 2019).

Blomberg and Cleven (1998) implemented and analyzed the first pedestrian safety zone program. Crash data in Phoenix, Arizona, were analyzed to identify areas where older pedestrian crashes occurred, and "zones" were drawn around the high-incidence areas. The countermeasures developed for crashes involving older pedestrians included lengthening the signal timing to allow more time to cross the street, providing communications and outreach to both drivers and pedestrians living near the crash zones, and enhanced enforcement. The result was a significant reduction in crashes and injuries involving older pedestrians in the target areas.

In Miami-Dade County, a comprehensive application of the pedestrian safety zone strategy identified high crash zones and then the characteristics of those crashes were further analyzed within the zones (Zegeer, Blomberg, et al., 2008). The four zones, comprising less than 1% of the total land area of the County, accounted for about 20% of the total number of collisions (Zegeer, Henderson, et al., 2008). Further analyses identified high child involvement in crashes in some areas, young adult involvement in others (particularly at night), and older adult involvement on certain corridors. During and following the program implementation, there was an 8.5% to 13.3% reduction in pedestrian crash rates compared to control groups (Zegeer, Blomberg, et al., 2008).

A more recent example in the vein of Phoenix and Miami-Dade comes from a St. Paul effort that involved the three Es plus a social norming approach aimed at improving motorist yielding to pedestrians (Morris et al., 2019). The phased approach implemented over 18 months included distributing education material, conducing four waves of HVE, social norming feedback signs that displayed site-specific and citywide yielding averages, different installations of the in-street yield sign (MUTCD R1-6), and a before-after survey. The 16 study sites were marked crosswalks at unsignalized locations on 30 mph roads; 8 sites were treatment sites that received HVE and a low-cost engineering treatment. Researchers hypothesized that changing motorist behavior hinges on the ability to convince people that a problem exists (i.e., pedestrian crashes) and inviting them to be a part of the solution using coordinated education material and the feedback signs, both of which were deployed citywide, not just at the study sites. Ultimately, weekly average yielding at treatment sites grew from as low as 26% in the baseline period to 78% during the final phase, while generalization sites grew from 31% to 61%. Multi-threat passing was also a surrogate safety measure of interest for the St. Paul research team. At the baseline, multi-threat passing was observed at 11.86% of crossing, but after program implementation this passing declined to 3.17% (Morris et al., 2020). The team also observed that higher speeds are associated with more multi-threat passes.

The Pedestrian Safety Initiative in Montgomery County, Maryland, also employed all three Es focused on 10 areas with high incidence of pedestrian crashes (Dunckel et al., 2014). After 3 years of the program, descriptive statistics showed a 43% reduction in pedestrian collisions in the targeted areas, but the study also reported that non-high incidence areas that received traffic calming treatments without the targeted education and enforcement efforts saw an even greater decrease in crashes. The lack of control sites and more complex statistical analysis make it hard to isolate the effect of the program.

Watch for Me NC (WFMNC) and *Smart Street NJ* are two programs that almost rise to the level of pedestrian safety zones because of their efforts to combine education and enforcement interventions at high crash locations, and in the case of *Watch for Me NC*, incorporate engineering measures at a subset of sites. WFMNC is a long-running program that targets motorist, bicyclist, and pedestrian behavior and has demonstrated improvements in pedestrian safety. It started in 2012 with four pilot communities and over the course of 6 years (2012 to 2017) came to include 41 communities from 29 North Carolina counties. Activities have included paid media, earned media, law enforcement training, enforcement operations, and community action planning, but their implementation has varied across time and across communities. A pre-post study of 16 sites in WFMNC communities found that treatment sites that received enhanced law enforcement activities *and* low-cost engineering improvements saw statistically significant improvements in motorist yielding (4 to 7%) while comparison sites did not experience change (Sandt, Marshall, et al., 2016). A later study employed a crash-based analysis that included all 29 counties with participating communities. The study found a statistically significant 12.8% reduction in pedestrian crashes along with a 21.7% reduction in nighttime crashes and a 9.5% reduction in the "failed to yield" crash type (Saleem et al., 2018). Smart Street NJ was conducted in two phases (2013 and 2016) across nine communities in New Jersey (Gonzales, 2017). Researchers evaluated the program by examining three proxy measures before and immediately after implementation: pedestrian compliance with crossing/crosswalk signs and signals, driver yielding/stopping at red or stop signs, and drivers yielding to pedestrians during green signals. Researchers observed statistically significant improvements in non-compliant behaviors; however, the results for the three different behaviors were mixed across sites.

Cost:

Pedestrian zone programs require up-front analysis and planning, countermeasure development and tailoring, and implementation.

Time to implement:

Long. A pedestrian zone program can take several months of concentrated activity before countermeasures can be implemented. More comprehensive programs, such as in Miami-Dade, may be years-long programs involving data analysis and on-site evaluations, lining up partners, and identifying, implementing, and evaluating countermeasures.

Elementary-Age Child Pedestrian Training

Effectiveness: ★★★	**Cost:** $	**Use:** Unknown	**Time:** Medium

The purpose of elementary school pedestrian training is to equip school-age children with knowledge and practice to enable them to walk safely in environments with traffic and other safety hazards. A consensus from reviews is that practical training—that is, learning by doing with reinforcement of correct behaviors—is the most effective way for children to learn traffic safety skills (Bruce & McGrath, 2005; Dragutinovic & Twisk, 2006; Percer, 2009; Schwebel, Barton et al., 2014). The need for experiential learning is especially key for younger children who lack the capacity to generalize concepts and need to practice in environments with real objects that are as close as possible to those they will experience (Dragutinovic & Twisk, 2006). And for any age to move beyond the stage of developing knowledge, children need lots of opportunities to practice so that they can move beyond the associative stage of cognitive development and devote their mental resources to problem-solving, which is when a skill becomes autonomous.

Classroom education may be enhanced by using outdoor simulation, three-dimensional models, games, or other interactive learning methods such as with computer games and models, particularly in adult-led and small-group activities. These methods do not replace real-world practice but evidence from a few studies suggests that interactive training with opportunities for feedback, correction, and practice (more than one session) may lead to more lasting behavior improvements (Tolmie et al., 2005; Albert & Dolgin, 2010). Increasingly, researchers are exploring virtual reality (ranging from a 3-D environment or headsets to smartphones and tablets), as a tool for pedestrian safety training (Schwebel & McClure, 2014; Schwebel, Combs, et al., 2016; Morrongiello et al., 2018; Schwebel et al., 2018).

A couple of studies have tried to identify the demographic, age, and developmental factors most associated with risky decisions related to crossing the road (Barton & Schwebel, 2007; Congiu et al., 2008). As expected, younger ages were associated with unsafe crossing decisions while children who had some experience with independent walking were less likely to make incorrect decisions. However, the research is less clear about the age at which educational and training interventions may be most effective. More information about effectiveness is detailed below.

Common Resources:

- NHTSA's Child Pedestrian Safety Curriculum (n.d.-c) features five lesson plans for each grade group K-1, 2-3, and 4-5 with developmentally appropriate lessons and messages. Lessons address standards of learning and are accompanied by caregiver tip sheets (available in English and Spanish), skills practice exercises, instructor guide, and student tests to evaluate knowledge change. www.nhtsa.gov/pedestrian-safety/child-pedestrian-safety-curriculum
- The North Carolina DOT's (2019) adaptation of NHTSA's Child Pedestrian Safety Curriculum is called *Let's Go NC!* It includes the same type of material, but for walking and bicycling with the addition of videos. www.ncdot.gov/divisions/integrated-mobility/safety/lets-go-nc/Pages/default.aspx
- Pedestrian Safer Journey (n.d.) by FHWA provides separate video-based training modules for child pedestrians 5 to 9, 10 to 14, and 15 to 18, and teachers' material including discussion guides. www.pedbikeinfo.org/pedsaferjourney/index.html

- *Teaching Children to Walk Safely as They Grow and Develop: A Guide for Parents and Caregivers* by the National Center for Safe Routes to School (n.d.) includes learning objectives and tips for caregivers of children 4 and older. http://guide.saferoutesinfo.org/graduated_walking/index.cfm
- *Stop and Look and Listen with Willy Whistle* by NHTSA (2011) for children grade K-2 emphasizes looking left-right-left before crossing. www.youtube.com/watch?v=-idpfcP6bY4
- *Getting There Safely* by NHTSA (2014) for children grades 3 to 6 emphasizes critical thinking with walking around traffic. www.youtube.com/watch?v=ATyNXDMvBuE

Use:

Unknown. Education and training material are widely available, but not necessarily implemented as part of a systematic or national program. With schools being called on for a wider variety of services and narrower set of teaching requirements, finding time to add child traffic safety modules may be difficult. Newer technologies and information formats may help expand the reach of training information but does not eliminate the need for knowledgeable trainers or educators with an interest in teaching road safety topics.

Effectiveness:

Child pedestrian training programs have been shown to increase knowledge, but long-lasting behavior improvements may be harder to achieve, and no studies have been able to use crash or injury data to demonstrate the effectiveness of an education or training program (Dragutinovic & Twisk, 2006; Schwebel, Barton, et al., 2014). There are several ways to consider the effectiveness of a program: Evaluators may focus on the impact by age group, the method of lesson delivery/practice, or the behaviors the program is trying to influence.

The research does not provide a clear answer on the question of which age groups are most receptive to education and training interventions. This is likely due to differences in the design and implementation of programs. For example, an examination of the effectiveness of NCDOT's *Let's Go NC!* program showed an increase in students' self-reported pedestrian knowledge and improved behaviors during supervised crossing situations on simulated streets that was greater for older students (Grade 3-5) compared to younger students (Grade K-2) (Thomas et al., 2017). Earlier evaluations of 5-day and 3-day WalkSafe programs in the Miami school district that used videos, formal curricula, workbooks, and outside simulation activities on an imaginary road on school grounds showed improvements in safety knowledge compared to before (Hotz et al., 2004, 2009). Improvements were more consistent for grades K-3 than for 4 and 5. Actual in-traffic behaviors were also reportedly improved in the short term but did not hold up at 3 months after the program. The *Let's Go NC!* evaluation used a control group while the WalkSafe evaluations did not include controls.

To examine longer-term retention and replicability, researchers in New Jersey implemented a slightly modified version of the WalkSafe program and evaluated more than 1,500 students receiving a one-time per year WalkSafe instruction over 2 years (Livingston et al., 2011). Short- and intermediate-term knowledge retention was observed among all grades, but long-term (i.e., more than a year) knowledge retention was observed only among children moving from 3rd to 4th grade. Knowledge change did not appear to result in improved pedestrian behaviors. The authors concluded that repetition and reinforcement may be needed for long-term knowledge and behavior change, as well as engagement by caregivers. Further demonstrating the importance of repetition, researchers in Detroit studied the effect of retraining (Gates et al., 2010). In the study of 930 students in grades 2 to 7, pedestrian safety training was provided once and then again 7 to 12 months later. Researchers observed street-crossing behaviors before and after the trainings and assessed knowledge change based on pre/post-tests. After the initial training, both test scores and observed behaviors improved, but were only partially sustained. Once retraining occurred, there were increases in test scores, and the cumulative difference (after initial training and retraining) was consistently larger than the impact of initial training alone for both test scores and observational behavioral measures.

To mitigate the risks of conducting pedestrian safety training in a real-world environment, some researchers are turning to virtual reality (VR). To explore the effectiveness of different delivery methods, Schwebel, McClure, and Severson (2014) conducted a randomized control trial to examine three strategies designed to train 7- and 8-year-old children: video/websites, non-immersive virtual reality (VR), and actual street-side training. Pre-test and post-test (immediately after completion and 6 months later) measures were collected for the 231 subjects via assessment of knowledge, behaviors in virtual reality lab, and behaviors in the field. Results showed that VR training resulted in improved pedestrian behavior post-intervention and at follow-up, but the street-side training resulted in even more impressive gains. Children receiving the video/website training showed minimal learning. A different trial suggested that video-based training may be an effective method for conveying knowledge and appropriate behaviors that would allow for a form of experiential learning while still in the classroom (Arbogast et al., 2014). However, neither before (baseline) nor long-term behavioral observations were conducted. Schwebel and McClure (2014) also used their clinical trial data to test additional hypotheses about knowledge change in relation to behavior change and found that children who received training via videos/websites gained safety knowledge, but their behavior measured in the lab and in the field did not improve, while children who received street-side training showed improvement in knowledge *and* behavior that was retained over a 6-month period. The authors conclude that perhaps pedestrian safety knowledge and behavior are independent constructs that should be considered separately for research and training purposes or that their measures were too disparate, so they encourage replication in future research.

A review and meta-analysis of prior behavioral interventions identified that crossing safely at midblock locations was a behavior that may have been particularly resistant to educational interventions (Schwebel, Barton, et al., 2014). In addition to examining the behaviors that interventions have targeted, researchers also analyzed the type of intervention. They confirmed that individual or small group trainings are generally effective (Tolmie et al., 2005; Albert & Dolgin, 2010). They also reported that 4- and 5-year-olds trained by adults in groups of 3 or 4 using a playmat model retained real-world behavioral (street crossing choices) improvement 6 months later compared to peers trained using two other less interactive methods or who received no training.

Since previous research identified mid-block crossings for middle-childhood kids as an especially risky behavior, Schwebel, Shen, and McClure (2016) conducted a within-subjects study of a semi-mobile, semi-immersive virtual pedestrian environment with a small sample of 44 seven- and eight-year-olds over a 3-week period. Students were assessed in a lab setting before they completed six 15-minute lessons in the virtual setting and then they were assessed again in the lab setting. In general, students made more efficient crossings in the after-period, but there were no significant changes in the rate of unsafe crossings. The researchers found that community settings (e.g., school or community center) may be effective for VR, but that more research is needed to determine the ideal duration of training and the effect of repeated feedback.

Thus, numerous studies suggest that knowledge and behaviors of young children may be improved through education and training programs, but that behavior in real-world traffic situations is more likely to be modified if the program incorporates interactive training with opportunities for practice and positive reinforcement (Percer, 2009). In addition to corrective feedback from adult trainers, opportunities for peer collaboration may also contribute to program success (Albert & Dolgin, 2010). Effectiveness of school-based child pedestrian training would also likely be enhanced if it combined child training with emphasis to teachers, parents, and other caregivers on the limits of children and the need for careful supervision, particularly for those younger than 10.

Cost:

Printed material and other supplies are relatively inexpensive and easy to procure. The cost of a program will be higher if it requires a technology that the school district or community group does not already have access to. Often the most important resource is the time of knowledgeable staff members, community partners, etc.

Time to implement:

Short, once a decision is made by a local agency or organization to offer such a program. Time is needed to review the recommended material, work it into the school's existing curriculum, and train instructors. As indicated by the above research, the training needs to be repeatedly implemented to sustain effectiveness.

Other considerations:

- Hammond et al. (2014) found that trainers often modified the training from recommended best practices in a program ("Kerbcraft") developed to provide roadside training for 5- to 7-year-olds in the United Kingdom. This deviation seems to have been towards conserving resources by conducting shorter trainings and introducing more classroom elements than the program recommended. It isn't clear, however, if the adaptations diminish effectiveness, but that is certainly a risk since the modifications have not been evaluated. The other possible implication is that the longer, all-roadside training may not be practical for consistent implementation (Hammond et al., 2014). It is important that whenever programs are modified, however, that the changed program is also evaluated to ensure continued effectiveness.

Safe Routes to School

Effectiveness: ★★★	**Cost:** $	**Use:** High	**Time:** Medium

The goal of Safe Routes to School Programs (SRTS) is to increase the amount of walking and bicycling trips to and from school while simultaneously improving safety for children walking or bicycling to school. SRTS programs are community-based and are intended to be comprehensive in nature. Programs include engineering and enforcement activities to improve traffic safety and to reduce or eliminate risky elements of the traffic environment around primary and secondary schools so children can safely walk or bicycle to school. Programs may also include education of children, school personnel, parents, guardians, community members, and law enforcement officers about safe walking and bicycling behavior and safe driving behavior around pedestrians and bicyclists.

SRTS efforts typically include a combination of Es to improve pedestrian and bicycle safety through encouragement, engineering, education, and enforcement. Programs can also include evaluation, engagement, and equity considerations. As of June 2020 the Safe Routes Partnership recommends a 6E framework that does not include enforcement. A 2018 systematic review of published evaluations of SRTS programs found that encouragement was the most common "E," represented as an intervention approach in 14 of the 22 reviewed articles (Buttazzoni et al., 2018).

Education and training can be effective in teaching children and their caregivers:

- how to evaluate and choose the safest routes for walking or bicycling to and from school,
- what safe behaviors are associated with walking and biking,
- instilling the need to practice and model safe behaviors when walking, biking, or driving around children walking/biking to school,
- how to use common engineering treatments to enhance their safety (sidewalks, crosswalks),
- the need to adhere to crossing guard direction, and
- to abide by traffic laws, especially in and around school zones.

See the countermeasures Elementary-Age Child Pedestrian Training, Reduce and Enforce Speed Limits, and Enforcement Strategies for additional information. Safety is a key concern in the decision to participate in SRTS and associated programs (Safe Routes to School Partnership, n.d.). Improvements to the road infrastructure with traffic calming measures, improved walking and biking facilities, policies to support active transportation, and community engagement and mobilization are key to addressing safety concerns.

The CDC identified SRTS programs as one of eight non-clinical, context-based, community-wide interventions that have the potential to improve population health. See CDC's Health Impact in 5 Years (HI-5) strategies for health transformation: www.cdc.gov/policy/hst/hi5/index.html. Walking or biking to school has additional benefits to students' health. Studies have found an association between active transport to school and lower BMIs as well as higher performance on standardized tests (Active Living Research, 2015).

Use:

With the establishment of the national SRTS program in 2005 all 50 States and the District of Columbia initiated SRTS programs. As of January 31, 2017, some $1.06 billion out of the $1.147 billion in SAFETEA-LU funds apportioned to local and statewide SRTS programs had been allocated. At that time 19,378 schools, representing an estimated 7.6 million students, had received funding, or were slated to receive funds for SRTS programs. Historically, approximately 68% of award recipients were classified as Title 1 (low-income) schools, a finding that is relevant because areas with lower median income are over-represented in bicyclist- and pedestrian-related crashes (McArthur et al., 2014). From 2005 to 2012 nearly 14,000 schools received SRTS funding (McDonald, 2015).

For a brief history of the SRTS program including funding, see www.saferoutespartnership.org/safe-routes-school/101/history.

Effectiveness:

It is established that SRTS programs can lead to increases in walking and bicycling to school (McDonald et al., 2014; Stewart et al., 2014), but as with other comprehensive programs, it is challenging to design a rigorous evaluation that could disentangle the effects of engineering improvements from other interventions and demonstrate a safety improvement. In terms of mode share, McDonald et al. (2014) examined 801 treatment and control schools in 3 States and District of Columbia and found a relative change of 31% in the proportion of students walking and bicycling to school after 5 years of participating in a SRTS program.

Studies that have examined SRTS-funded engineering improvements, without consideration of programmatic elements, have found injury reductions. In New York City, researchers analyzed 10 years of crash data and found that the annual rate of pedestrian injury decreased 33% for school-age children and 14% for all other ages in Census tracts that received SRTS projects compared to no change in rates for other Census tracts (specifically during typical school travel times during) (Dimaggio & Li, 2013). Since schools were chosen for treatment because of high crash rates, it is possible that some of the crash reductions observed were due to a natural tendency for crashes to return toward an "average" level. In California, researchers looked at 75 constructed countermeasures at 47 schools and compared changes in crashes within a 250-foot buffer around each treatment to crashes beyond the 250-foot buffer, but within a quarter mile of the school. They found a statistically significant decrease in all pedestrian-vehicle crashes, but the decrease for 5- to 18-year-olds was not statistically significant (Ragland et al., 2014).

Some studies have documented dramatic decreases in child pedestrian injuries in geographies with active SRTS programs or other comprehensive pedestrian safety programs, but these evaluations did not include control sites, mention potential changes in exposure, or perform statistical analysis beyond reporting descriptive statistics. For example, a 15-year review of the WalkSafe program in Miami-Dade County, Florida, noted that trauma data reveal a 78% decrease in pediatric injuries during the lifespan of the pedestrian education program (Delouche et al., 2019) and an examination of a pedestrian safety initiative in Montgomery County, Maryland, noted a 79% decrease in pedestrian crashes around SRTS schools (Dunckel et al., 2014). In the latter, the 79% finding is only noted in the abstract and a graphic, it is not described in the main body of the article. Another study looked at pedestrian and bicyclist crashes involving children in 18 States before and after 2008 (the year with the highest frequency of SRTS awards given to States in the study period) and compared to crashes involving adults during the same time (DiMaggio et al., 2016). The authors found a reduction in injury and fatality risk in school-age children compared to adults but acknowledge that examining data at the State-level did not allow them to separate the effects of SRTS from other trends.

Cost:

Education and encouragement activities associated with SRTS may be low cost and may also be eligible for grant funding through the State, and perhaps other sources. Activities formerly eligible under Federal SR2S funding are now eligible under the Transportation Alternatives Set-Aside program outlined in the Bipartisan Infrastructure Law, but funding priorities are established by each State. State contacts may be located on the Safe Routes Partnership website (www.saferoutespartnership.org/safe-routes-school/srts-program/state-contacts), or search individual States' DOT websites for information about TAP and SR2S funding. NCSRTS provides downloadable material for State and local SRTS programs.

Time to implement:

Once the school or district has decided to implement a SRTS program, a range of material, including an online step-by-step guide on getting started, is available from NCSRTS. Programs funded through State DOTs typically require applications on a funding cycle and can take significantly longer to implement. The NCSRTS found that schools that were able to increase the percentage of students walking or bicycling to school were more likely to have a leader within the school to promote SRTS, frequent events to reinforce walking or biking to school, strong parental support, and supportive policies (NCSRTS & FHWA, 2015).

Walking School Bus

Effectiveness: ★★	**Cost:** $	**Use:** Unknown	**Time:** Short

Walking school buses use volunteer adults, usually parents, to walk a group of students on a specific route to and from school, collecting or dropping off children on the way. Walking school buses have fixed routes, pick-up and drop-off times, and stops. The CDC recommends one adult for every six children in the group; however, twice as many adults may be needed to supervise younger children (National Center for Safe Routes to School & Pedestrian and Bicycle Information Center, 2006).

A focus group study in the United Kingdom revealed six factors that influenced parents' decision-making about walking school buses (Nikitas et al., 2019). Safety was a major concern, and included concerns about road safety (e.g., crossing intersections, speeding vehicles) and stranger danger (e.g., unfamiliar chaperones). Other concerns included uncertainties about logistics, health (e.g., air pollution), emotional needs (e.g., spending time with child when taking them to school), trust (e.g., trust in chaperone, trust in child to behave responsibly), and education (e.g., child may not be aware of road dangers).

Active involvement from communities, schools, and State policymakers are central to the development and maintenance of walking school bus programs (Turner et al. 2013; Pérez-Martín et al., 2018). Particularly, the presence of programs such as Safe Routes to School and school crossing guards, is associated with increased school-organized walking school buses (Turner et al., 2013). Promotional activities such as educational campaigns and policies supporting a comprehensive agenda towards increasing active transport to schools are prerequisites to effective walking school bus programs (Yang et al., 2014). There are two comprehensive resources that can help parents, school staff, and community members plan, launch, and maintain a walking school bus:

- The Walking School Bus Program: Combining Safety, Fun and the Walk to School by The National Center for Safe Routes to School & Pedestrian and Bicycle Information Center (2006): http://guide.saferoutesinfo.org/pdf/wsb_guide.pdf
- Step by Step: How to Start a Walking School Bus at Your School by the Safe Routes Partnership and California Department of Public Health (n.d.): www.saferoutespartnership.org/resources/toolkit/step-step

Use:

One study of U.S. elementary schools found that from 2008 to 2010, the percentage of schools organizing walking school buses increased from 4.2% to 6.2% (Turner et al., 2013). As of September 2021 the total extent of the use of walking school buses is unknown. Localities with active programs include Apex, North Carolina, Seattle, Washington, and El Monte, California.

Effectiveness:

In a study of fourth grade students from eight low-income schools in Houston researchers examined the impact of walking school buses on several pedestrian behaviors (Mendoza et al., 2012). Researchers found these students were five times more likely to cross at the intersection or crosswalk (rather than midblock locations) as opposed to children at schools without walking school buses. An evaluation of a walking school bus program in Seattle found a modest increase in most student safety crossing behaviors after the implementation of the program, but safe crossing behaviors remained low overall (Johnston et al, 2006).

In terms of mode shift, a pilot study of walking school buses conducted in Spain found that after a 13-week program involving 55 children, 43% of the participants had partially or completely changed their mode of school transportation from automobile to walking (Pérez-Martín et al., 2018). This finding is relevant because in addition to the health benefit of walking, there may be a safety benefit from the reduction in motor vehicle trips near schools.

Cost:

Walking school buses could cost as little as $500 per school year (PedNet Coalition, 2014).

Time to implement:

Walking school buses could be improved with support from local or State policies, and promotional activities. Once these are in place, planning and implementing the program could take 3 months (Moening et al., 2016).

Conspicuity Enhancement

Effectiveness: ★★	**Cost:** $	**Use:** Low	**Time:** Medium

The purpose of enhancing conspicuity for pedestrians is to increase the opportunity for drivers to see and avoid pedestrians, particularly when it is dark, since this is when 77% of pedestrian fatalities occur nationally (NCSA, 2023c). A conspicuous object is one that is not only *visible* but that *stands out* from the surrounding environment and commands attention. Rogé (2017) proposed that conspicuity can be sensory or cognitive. Sensory conspicuity is the ability to detect and distinguish an object in the landscape. Cognitive conspicuity relates to the whether the object is expected to be in the environment and can be seen and simultaneously understood.

A review of research about visual factors relevant to pedestrian-motorist crashes found that the challenges motorists face in detecting pedestrians include changes in vision during twilight hours and at night, headlamp glare, and age-related decline in visual function (Tyrrell et al., 2016). Motorists underestimate their visual limitations and often do not adjust their speed appropriately. Pedestrians also tend to overestimate their own visibility, wrongly assuming if they can see vehicles, vehicles must see them (Karsch et al., 2012). Research has demonstrated that conspicuity is greatly enhanced at night when pedestrians are in motion and use retroreflective clothing, especially on their extremities, but no studies have linked the use of the visibility aids to a decrease in crashes (Kwan & Mapstone, 2006). It is important to note that conspicuity enhancement is unlikely to overcome risky behaviors like motorist distraction (Szubski et al., 2019).

Retroreflective materials (materials that reflect light such as from car headlights back toward the source) are built into many shoes, including children's and athletic shoes. Other accessories, such as arm or leg bands, gloves, vests, and caps are available from sporting goods stores and other vendors. Light sources, including strobes and other flashing lights, are also available. Many have been designed for bicyclists but are applicable to pedestrians. The difficulty with these devices is that the user must decide in advance to take and use them. See bicyclist conspicuity measures for more information. Bright colored and fluorescent clothing may also help to improve daytime conspicuity for pedestrians in some environments, but most research has focused on bicyclists and there may be differences in effectiveness for these groups.

Educational efforts could include a focus on being visible at night and in the daytime and making use of the conspicuity aids described in this section. Devices designed to be semi-permanently fastened to children's clothing can be provided to parents through schools, group activities, or health care providers. Light sticks and reflective bands can be supplied with new cars or distributed by automobile clubs or insurance companies for use during vehicle breakdowns.

Use:

Retroreflective materials are used regularly in athletic-type shoes, occasionally in backpacks and jackets, and minimally in other clothing.

Effectiveness:

Widespread use of retroreflective materials would increase the ability of drivers to detect pedestrians at night in time to avoid crashes. Pedestrians wearing good retroreflective materials, particularly materials that highlight a person's shape and moving extremities (i.e., wrists and ankles), or widespread use of active (flashing) lights can be detected hundreds of feet farther than can pedestrians in normal clothing, even with low-beam illumination (Koo & Huang, 2015; Karsch et al., 2012; Zegeer et al., 2004). A study in a controlled (closed road) environment also validated that pedestrians are detected more readily when they wear reflective elements on their moving body parts rather than attached to the torso (Tyrrell et al., 2009).

Adding electroluminescent (EL) garments to other retroreflective clothing also improves pedestrian conspicuity at night. EL garments are patches that produce light on their own that can be attached to clothing. They are visible regardless of angle and do not require another source of light to be visible in the dark. A nighttime on-road evaluation found that the addition of EL garments resulted in motorists reacting sooner to pedestrians farther outside the vehicle's headlight light beam (Fekety et al., 2016). Increasing pedestrian's visibility with retroreflective and EL garments provided the greatest benefits to pedestrians in situations when vehicles are approaching pedestrians from a curve or when vehicles' headlights are turned off.

Cost:

The cost to provide retroreflective materials is low if such supplementary materials are distributed in quantity and added to existing programs. Such items as reflective wrist and ankle bands are available commercially. To develop new programs promoting use of conspicuity materials would require more planning and start-up time and costs would also depend on communications strategies.

Time to implement:

Promoting increased conspicuity may require development of targeted messages and a publicity strategy.

Approaches That Are Unproven or Need Further Evaluation

Child School Bus Trainings

The purpose of school bus training for children is to teach school-age children how to safely approach, board, disembark, and walk away from school buses. Basic training for children who ride school buses is provided as part of the normal school routine. Additionally, education about safety behaviors of adults in school zones and around school buses can be reinforced as part of Back-to-School night, in school bulletins, or other communications with families. NHTSA has a refresher training course for school bus drivers and NHTSA's Child Pedestrian Safety Curriculum includes a module on safety around school buses.

There are no evaluation studies showing reductions in crashes or injuries. These outcomes are difficult to demonstrate because minimal, basic training is very widespread and the choice to adopt a stronger curriculum would be confounded with any number of other factors.

Communications and Outreach Addressing Impaired Pedestrians

Communications and outreach to reduce impaired-pedestrian crashes can be directed at a wide variety of audiences, including law enforcement, drivers, alcohol servers and vendors, civic and neighborhood leaders, faith-based communities, universities, and friends and family of likely impaired pedestrians. Impaired pedestrians are also a target audience, of course. However, they are viewed as a difficult audience for communications and outreach to have a meaningful effect on their behavior because their decision-making is compromised. Some of the countermeasures proposed for impaired drivers discussed in the chapter on Alcohol-Impaired Driving, such as responsible beverage service training and alternative transportation, are also appropriate for impaired pedestrians.

The available evaluation data conclude that the countermeasure alone is not effective. Blomberg and Cleven (2000) evaluated a zone-based program in Baltimore that included public service announcements, posters, flyers, and interventions aimed at alcohol-impaired pedestrians and found a 22% decrease in crashes among males 30 to 59. However, this intervention was part of a comprehensive program that included engineering measures and law enforcement involvement.

University Educational Campaigns

This countermeasure involves conducting educational campaigns targeted at new students and staff that may be unfamiliar with walking and driving in the campus environment. A university campus may offer an opportune setting to reach a well-defined target audience of drivers and pedestrians about the risks of unsafe behaviors. Potential educational messages include right-of-way rules and the importance of yielding right-of-way (pedestrians, bicyclists, and drivers), being visible and predictable at both day and night times and during inclement weather (pedestrians and bicyclists), avoiding distractions (pedestrians, bicyclists, and drivers), and speed control (drivers and potentially bicyclists). Partnerships may include campus public safety offices, student health and wellness programs, city/county public safety agencies, injury prevention agencies, parking and transportation services, transit agencies, and student groups.

This countermeasure has not been systematically examined. There is insufficient evaluation data available to determine the effectiveness of the countermeasure. The results of a survey conducted as part of a campaign provide insight into the issues that could be addressed through a campaign, as well as through engineering improvements (Johns Hopkins Center for Injury Research and Policy, 2015; Pollack et al., 2014).

"Sweeper" Patrols of Impaired Pedestrians

The purpose of this countermeasure is to keep alcohol-impaired pedestrians off the streets until they no longer have high BACs. This measure is intended to reduce the exposure of these at-risk pedestrians to traffic and can also address other social issues such as public intoxication and crime. One approach involves police "sweeper" squads and "support on call" programs involving taxis and trained escorts to get intoxicated people home or to a detoxification center. Such programs typically reach only a fraction of those people who need the services.

This countermeasure has not been systematically examined. There is insufficient evaluation data available to determine the effectiveness of the countermeasure.

Driver Training

The purpose of pedestrian safety-related driver training is to increase the sensitivity of drivers to the presence of pedestrians and their shared responsibility as drivers to prevent crashes and enhance the safety of all road users, including pedestrians. Specifications for driver education curricula, typically a State requirement, can be adjusted to include more specific information on pedestrians as part of the traffic environment, right of way laws for drivers and pedestrians in relation to one another, high risk behaviors in relation to pedestrian/motorist crash types, and key ways drivers can avoid being involved in such crashes.

Driver training alone has not been shown to reduce overall crash rates. However, driving skill begins with knowledge education and then practice in relation to all other types of traffic, including pedestrians.

Pedestrian Gap Acceptance Training

The purpose of pedestrian gap acceptance training is to help pedestrians learn to make better road crossing decisions, which may reduce the incidence of crossing-related injuries and fatalities. This can include video-based training and feedback geared towards improving pedestrian judgment of speed or distance of oncoming traffic (Hunt et al., 2011; Dommes & Cavallo, 2012).

This countermeasure has been examined in few research studies. While there is some evidence that certain approaches may lead to limited positive outcomes, there is insufficient evaluation data available to determine the effectiveness of the countermeasure.

Environmental treatments such as allowing sufficient time for the pedestrian crossing in signal timing, median refuges, and careful attention to sidewalk accessibility issues are also important to older pedestrians who may have declined mobility. A pre-post study of crash data at sites with and without pedestrian countdown signals (PCS) found that PCS were found to be associated with a significant 32% reduction in all crashes and a 65% reduction in crashes involving people 65 and older (Kwigizile et al., 2016).

Child Supervision

The primary purpose of this countermeasure is to increase caregiver supervision of children when they are exposed to traffic, or when they are nearby direct access to traffic. Caregiver involvement is an effective means for shaping children's behaviors (Percer, 2009). The State can require such training for teachers, day care workers, and others licensed to care for children. The programs can also be made available to parents, babysitters, or other caretakers through parent-teacher organizations, faith-based organizations or places of worship, medical providers, or even direct mail or internet access. One of the ways to market these programs may be to demonstrate to parents the amount of supervision their child/children need (and effective training). Rivara et al. (1989) and Dunne et al. (1992), for example, have shown that parents consistently overestimate the ability of children younger than 9 or 10 to negotiate in traffic. An observational study of young children in parking lots found that 90% of all children were out of arm's length of an accompanying adults at some point (Rouse & Schwebel, 2019). Adults should actively supervise children and not assume that their presence will be adequate to ensure safer behavior.

This countermeasure has not been systematically examined.

Children's Safety Clubs

This countermeasure involves sponsoring safety clubs in which caregivers can enroll their children as young as age 3. Children then regularly receive books or other print or electronic media that provide instruction to both the child and caregivers about safe walking practices. A primary purpose of children's safety clubs is to help caregivers become more involved in educating young children about safe walking practices. An equally important objective of safety clubs is for caregivers to recognize children's limits and capabilities, and to understand their obligation to provide adequate supervision and control (Gregersen & Nolen, 1994). Safety clubs are more common in Europe and have not been adopted broadly in the United States.

This countermeasure has been examined in a small number of research studies. It is up to caregivers of young children to use material appropriately and a lack of control makes it difficult to monitor or assess results. The research suggests that this countermeasure does not translate into crash and injury reductions (Dragutinovic & Twisk, 2006; Gregersen & Nolen, 1994; West et al., 1993).

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10. Bicycle Safety

Overview

Bicyclists,[8] like motorcyclists, are not safeguarded by occupant protection measures found in passenger vehicles and face comparatively high exposure to injury risks in crashes on the roadway. In the absence of separate bike lanes, trails, or paths, bicyclists may be required to operate foot or low-powered electric bicycles on the roadway with vehicles. Bicyclists are also more susceptible to outdoor elements such as weather and road surface conditions (Reish, 2021). Rising bicyclist and pedestrian fatalities have prompted urgent calls from the National Transportation Safety Board (NTSB) and NSC in recent years (NTSB, 2019; Road to Zero, 2021). The number of bicyclists killed in traffic crashes has been steadily trending upwards since 2010. From 2010 to 2021, bicyclist fatalities ranged from 623 to a high of 966 with a yearly average of 800 (NCSA, 2022; Stewart, 2023). For the last 5 years (2017 to 2021), the yearly average has been 883 people on bicycles killed in police reported traffic crashes (NCSA, 2022; Stewart, 2023). Bicyclists accounted for 2.2% of total traffic fatalities in 2021 (Stewart, 2023).

Characteristics of the bicyclist fatalities during 2021 include (NHTSA, 2023):

- *Roadway location:* The majority (62%) of bicyclist fatalities took place at non-intersection locations.
- *Land Use:* Bicyclist fatalities tend to occur in urban areas more than rural areas, with urban fatalities accounting for approximately 85% of bicyclist fatalities. The proportion of bicyclist fatalities occurring in urban areas increased from 69% in 2011 to 85% in 2021.
- *Vehicle Type:* Collisions with light trucks (which includes SUVs, pickups, and vans) were responsible for the highest proportion of bicyclist fatalities (46%).
- *Time/Light condition:* Over half (56%) of bicyclist fatalities occur in dawn, dusk, or night-time conditions; the highest proportion (21%) of fatal crashes on weekdays occur from 6 p.m. to 8:59 p.m.; the highest proportion (23%) of fatal crashes on the weekend also occur from 6 p.m. to 8:59 p.m.
- *Sex:* 86% of the bicyclists killed and 81% of those injured were male.
- *Age:* The average age of cyclists killed was 49.

Bicyclist injuries remain consistently, disproportionately high. In 2021 an additional estimated 41,615 bicyclists were injured. Over the last 5 years, estimated injury-only crashes averaged about 45,400 yearly.

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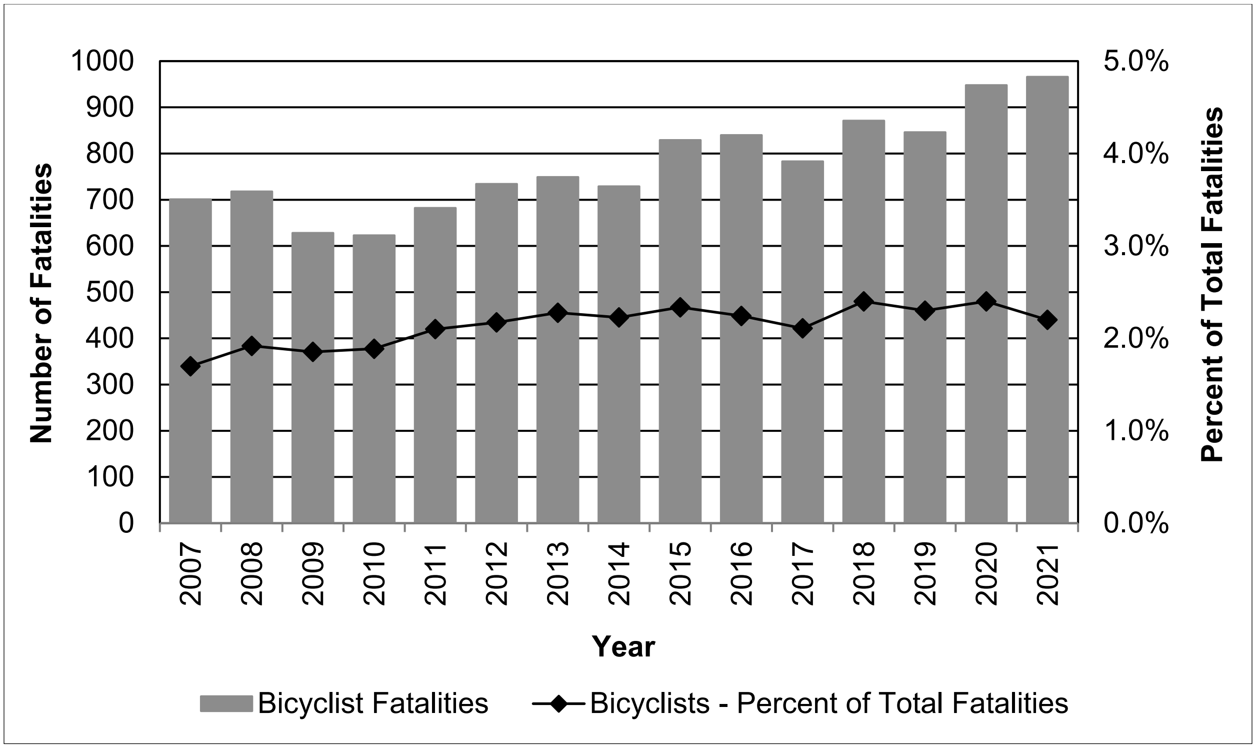
[8] NHTSA's National Center for Statistics and Analysis defines pedalcyclists as bicyclists and other cyclists including riders of two-wheel, nonmotorized vehicles, tricycles, and unicycles powered solely by pedals. Throughout this document, "bicyclists" includes riders of these other types of cycles.



Source: NHTSA (2023)

Figure 10-1. Bicyclist Fatalities, 2007 to 2021

The absolute number of crashes, without a measure of the volume of people riding bicycles, is an imperfect indicator and does not tell the whole story of bicycle safety. For example, while the number of crashes is higher in urban areas, this does not mean that the rate of crashes is high in comparison to the rate in other contexts. An analysis of crash rates that used National Household Travel Survey (NHTS) data to calculate fatality rates based on the estimated number of people riding bicycles identified the most dangerous regions for walking and bicycling and the safest regions for walking and bicycling (Schneider et al., 2017). The study authors concluded that many of the safest regions had central cities that have been nationally recognized for investing in bicycle and pedestrian infrastructure and programs.

Bicycling Trends

People travel by bicycle to work, to school, for social and family/caretaking trips, and for recreation, among other reasons. The growth in use of bicycles, and electric bicycles in particular during the COVID-19 pandemic has led to sharp increases in bicycling in some communities, and has resulted in expanded ranges of trip purposes, abilities, and experience of people riding bicycles on public roadways.

Buehler and Pucher (2021) reviewed available data to assess the impacts of the COVID-19 pandemic on the use of bicycles. Travel monitoring sources such as Streetlight and EcoCounter report an estimated 12% to 16% growth of bicycle use in 2020. Bicycle traffic on many off-road, recreational multi-use trails and greenways grew significantly. However, some locations saw a reduction in bicycling as commuting to work was reduced or where general lockdowns were in place.

Longer-term trends indicate only slight changes in bicycling rates in the United States. According to the National Household Travel Survey, from 2001 to 2017 the overall percentage point change in cycling generally was negligible. Significant shifts in who is bicycling has shifted, however. There was an increase among adults 25 to 64, those with higher educational attainment, and among those living in households without a car or in neighborhoods with higher residential density. There was a decline in cycling rates for children and adolescents 5 to 15, for those living in rural areas or areas with lower population densities, and among those in households with higher car ownership (Buehler et al., 2020).

Estimates from the American Community Survey, conducted by the U.S. Census Bureau, suggest that the number of U.S. workers of all ages who travel to work by bicycle increased from 0.4% of workers in 2000 to an average of 0.6% of workers for the 2008-to-2012 period (McKenzie, 2014). The share of workers that "usually traveled to work" by bicycle increased at a faster rate than any other mode of travel. In 2016 the number of workers who biked to work remained at 0.6% of all surveyed workers (McKenzie et al., 2017). Current American Community Survey data shows that the percentage mode share of people bicycling to work declined to 0.5% by 2020 (U.S. Census Bureau, 2020).

The topic of bicycling volume (sometimes generally referred to as mode share or exposure) is intertwined with safety. The complex and non-linear relationship between crashes and volume highlights the fact that the absolute number of crashes is often an imperfect indicator of danger for people on bicycles, and thus, why strategies focused on increasing mode share and improving safety are often considered in tandem (i.e., Safe Routes to School programs).

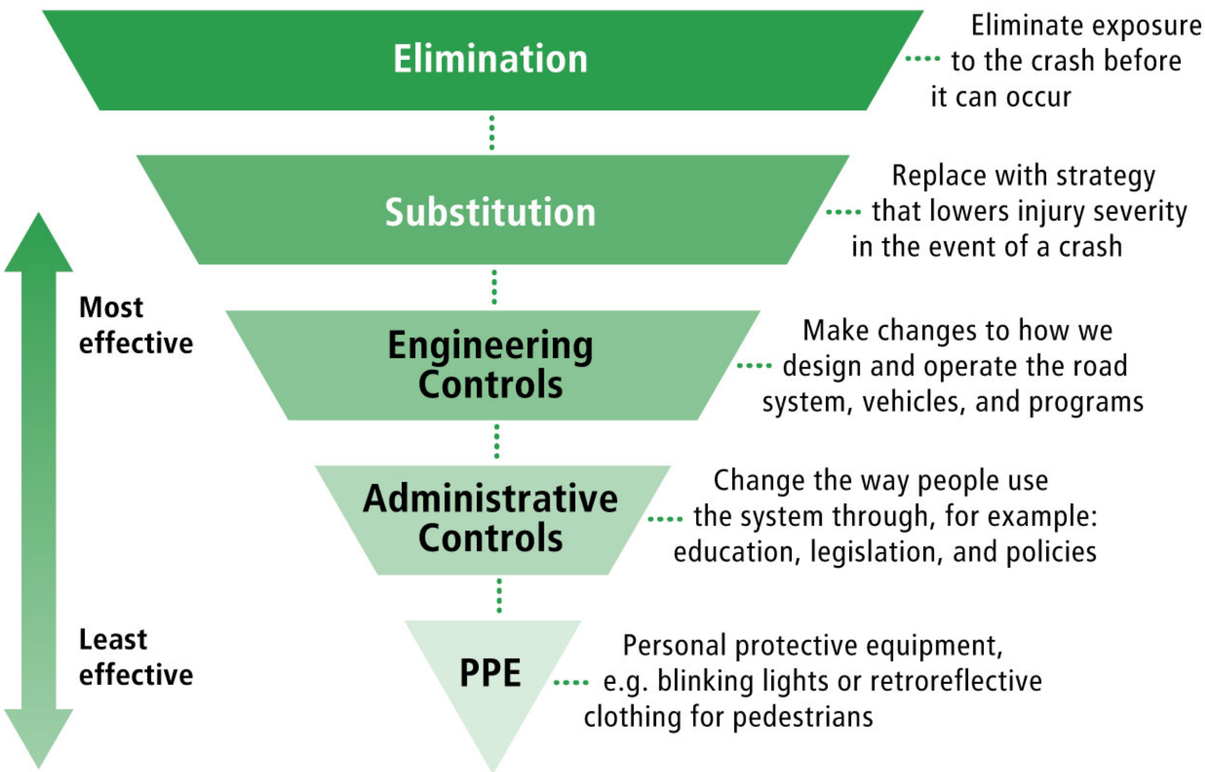
The phrase "safety in numbers" describes the phenomenon whereby the risk to an individual bicyclist of being seriously injured decreases as the number of people bicycling increases. A recent meta-analysis of motorist-pedestrian or motorist-bicyclist injury crashes estimated that there is safety in numbers for both pedestrians and bicyclists (Elvik & Bjørnskau, 2017). By their estimate, if the number of pedestrians or bicyclists doubles (100% increase), the increase in crashes is expected to be 41%. A subsequent expanded meta-analysis determined that the safety in numbers effect may be stronger for pedestrians than bicyclists, and the safety benefit may stem from overall increases in numbers of bicyclists and improvements in motorist-bicyclist interactions at the population level (Elvik & Goel, 2019). However, a recent literature review of studies on the subject of "safety in numbers" found that despite numerous efforts to quantify it, the exact mechanism that produces this effect is unclear (Kehoe et al., 2022).

A focus on systematically improving infrastructure in tandem with road users' safe behaviors is important to increasing population-level safety (measured as a reduction in population-wide fatalities and injuries) and people on bicycles or bicycling mode share. Safety improvements with increases in bicycling will reduce individual risk. A recent resource titled *Understanding and Using New Pedestrian and Bicyclist Fatalities* is focused on education strategies around newer and innovative bicycle facilities (Jackson et al., 2022).

Understanding the Problem

Due to the complexities of the transportation system and how humans interact within it, risks to road users outside the vehicle can exist in unexpected ways (Naumann et al., 2019, 2020). Collaborative planning, engineering, vehicle regulation, road user safety enforcement and education and technology-based strategies are all needed to reduce latent risks. Bicyclist behavior is not only a product of the characteristics of the individual bicyclist but is also sensitive to greater influences of the socio-ecological environment, from the characteristics of the roadway to the nature of the trip or destination, to the degree of social acceptance for bicycling in the community. Finding solutions requires thinking beyond specific site properties or individual road user actions. Creating a safer environment in which people on bicycles and drivers of motor vehicles can safely interact while at the same time ensuring that persistent structural inequities are not perpetuated demands a systemic focus.

Bicyclists are especially vulnerable to crash energies in a collision with a motor vehicle. The most effective means of protecting them is to eliminate conflict with motor vehicles. The Hierarchy of Controls diagram, adapted from workplace safety practices, illustrates safety mitigation strategies from most effective to least effective. Proactively eliminating high level risks at the population level, while addressing systemic inequities, such as the process by which bicycle facility investments are prioritized in some areas of communities and not others, is more effective for more people than a focus on individual protective measures.



Source: Sandt et al., 2020

Figure 10-2. Hierarchy of Controls for Traffic Safety

Separated bicycling infrastructure, which removes the risk of a collision with a motor vehicle for people on bicycles, is an example of an elimination strategy. A key substitution strategy is one of mode shift – replacing car trips with bicycling or walking trips reduces exposure of all road users to motor vehicle traffic and reduces kinetic energy (crash forces) in the system, thereby mitigating injury severity if a crash occurs. Engineering controls are efforts to impact driver and other road user behavior through vehicle design and roadway infrastructure. Examples include methods that mitigate driver speed or increase visibility of vulnerable road users, such as trimming roadside vegetation. Crash and injury mitigation methods such as targeted efforts to manage speed, reduce distraction and impairment, and addressing aggressive or risky driving behaviors can be critical for improving bicyclist safety. These efforts can be tackled through administrative controls, by way of policy, legislation, enforcement, or other behavior change programming. Personal protective equipment such as active lighting and bicycle helmets are important individual measures for protecting people on bicycles.

Gaining a better understanding of the diverse experiences of people walking and bicycling and how risks and outcomes may vary across populations is crucial to identifying, prioritizing, and implementing safety interventions. Inequitable investment in safe bicycle facilities has resulted in less safe built environment conditions for some populations. In a review of more than 7,000 bicyclist crashes in California's San Francisco Bay Area, among five racial/ethnic groups, Black bicyclists were involved in the most crashes per person per distance traveled (Barajas, 2018). The crash rate per person per distance traveled for Black bicyclists was nearly eight times that of white bicyclists; the rate for Hispanic bicyclists was 2.5 times greater than that of white bicyclists. In Washington State, an analysis of bicycle collisions along main street highways (State routes that also function as main streets for local residents) found that low-income areas and communities with large minority populations have a higher probability of collisions involving a motor vehicle (Moudon & Kang, 2017). A study conducted for the Florida Department of Transportation concluded the built environment in low-income communities put people on bicycles at greater risk of being struck by motorists (Dumbaugh et al., 2020).

Tailoring of program delivery may be needed to address diverse populations, such as recent immigrants who may not be familiar with U.S. traffic laws, the U.S. traffic environment, or who may not speak or read English. Behavior on a bicycle can be a factor of age and ability. People who ride bicycles come in all ages with many levels of knowledge, skill, perception, and judgment. Children, who are at different stages of cognitive development, have less experience with the roadway environment, are less aware of their limitations, and are especially prone to errors that may place them in dangerous situations (Almeida et al., 2016; Hamann & Peek-Asa, 2013; Plumert & Schwebel, 1997; Schwebel & McClure, 2014). Older adults riding bicycles may experience reductions in vision, hearing, agility, balance, speed, and strength (Tournier er al., 2016). People living with disabilities who may also be riding bicycles or adaptive bicycles may face challenges navigating certain roadway locations, though research on the safety needs for those bicycling with disabilities is lacking (MacArthur et al., 2020). Agencies should select countermeasures to address problems identified within communities or common to a high-risk group within a community, such as older adults, people experiencing homelessness, or children. Moreover, educational and enforcement programs must take these factors into account and be designed to target specific concerns and the knowledge, skills, and behavioral attributes of these different groups of riders.

The countermeasures described in this report relate primarily to legislative, policy, program, and enforcement measures aimed at improving the knowledge and behaviors of road users to prevent or mitigate the severity of crashes but are not intended to be used in isolation or absent a continued focus on the entire transportation system and the environment surrounding people on bicycles.

Countermeasure selection for improving bicyclist safety will require collaboration across agencies and disciplines. Reducing or eliminating exposure to known risky situations through comprehensive behavioral and environmental countermeasures (without necessarily discouraging bicycling) via strategies such as reducing motor vehicle volumes and creating physical space for all road users, will have the greatest impact on bicyclist safety over the long term.

Roadway and urban design

The importance of road design and the built environment in fostering safer user behaviors is supported by a body of research, and it is essential to consider context when planning countermeasures. Infrastructure countermeasures can be informed by knowledge and expertise present in SHSOs. Agencies can participate in road safety audits and provide valuable insights to help identify where communities should target engineering resources to improve safety.

Most fatal bicyclist crashes occur in urban areas, where more people are riding bicycles (NCSA, 2022). In urban areas, there are many locations with high potential for conflicts, and motor vehicle traffic is moving on roads primarily designed for cars. The presence of intersections, driveways, shops, or apartment blocks, for example, can create conflicts and higher, more concentrated traffic volumes (Monsere et al., 2017). A review found relationships between overall crash numbers and motorist maneuvers such as turning, overtaking, opening a door, or pulling out from parking spaces, so roadway environments where more of this is taking place could be riskier for bicyclists (Prati et al., 2018). A comprehensive approach, involving partnerships with State or local roadway engineers, that uses a combination of effective engineering, enforcement, and educational measures may have the best chance of achieving desired crash reductions.

Driver Behavior

A focus on driver behavior, such as reducing motor vehicle speeds, is an important step in improving safety for all road users, especially people on bicycles. Likewise, decreasing risky behaviors such as aggressive driving, distraction, and impairment will also positively effect bicyclist safety. Bicyclists, as unprotected or vulnerable road users, are more susceptible to crash forces than motorists who are protected by the safety features installed in motor vehicles. In some extreme cases, motorists exhibit aggressive behavior towards bicyclists, based on their beliefs or perceptions about the bicyclist. While this behavior is not common, it does represent a threat to people on bicycles using the road and may play a role in overall safety outcomes (Piatkowski et al., 2017).

Speed

A majority of bicycling fatalities occur at non-intersection locations and speed is frequently a factor in these fatalities due to the kinetic energy involved when a faster, heavier vehicle strikes a slower moving bicyclist (Cushing et al., 2016). Research has shown the likelihood of a bicycle crash being fatal increases substantially when vehicle speeds exceed 20 mph (Cushing et al., 2016). A study conducted in Sweden indicated that in urban areas a reduction in posted speeds from 50 to 60 km/h to 30 to 40 km/h (~31 to 37 mph to 19 to 26 mph) lowered the risk of a serious injury in bicycle/motor vehicle collisions (Isaksson-Hellman & Töreki, 2019). See more in the chapter on Speeding and Speed Management.

Motorist Overtaking

Motorist overtaking crashes are the most common fatal crash type for bicyclists in both urban and rural areas (Thomas et al., 2019). Studies have used instrumented motor vehicles, instrumented bicycles, or other video data to measure motorist passing distances and have found relationships between passing distances and variables related to roadway configuration, traffic conditions, and motorist and bicyclist characteristics. A recent evaluation of HVE campaigns showed improved overall passing distances and a reduction in passing distance violations (Blomberg et al., 2022).

Impairment

People who drive motor vehicles while impaired pose a great danger to people on bicycles. In 2020 of the 930 crashes resulting in a bicyclist fatality, 125 of those crashes involved an alcohol-impaired motor vehicle driver (NCSA, 2022). In 2020 34% of all crashes resulting in a bicyclist fatality involved alcohol consumption by *either* the motorist or the bicyclist (NCSA, 2022).

Distraction

The risk of a crash may be increased due to inattention or distraction, by either the cyclist or driver. While impaired driving and riding have been an ongoing challenge, emerging problems include the use of cell phones, media players, or other electronic devices while riding or driving. Feng et al. (2018) used naturalistic driving data from instrumented motor vehicles to examine events where motorists passed bicyclists and found that approximately 7.8% motorists in passing events were actively engaged with using their cell phones and that those motorists conceded less space to bicyclists than non-distracted motorists. For a bicyclist, this means that 1 in 13 passing events may involve a cell phone distracted driver.

Literature searches do not identify any studies that have evaluated laws or programs aiming to reduce distracted riding. A survey of bicyclist attitudes and behaviors indicates that 21% of bicyclists use an electronic device on at least some of their bicycle trips, with 9% indicating they use a device during nearly all their trips (Schroeder & Wilbur, 2013). An observational study of 1,974 bicyclists in Boston, Massachusetts, found that 31.2% of riders were distracted, however the distractions were defined very broadly as wearing earbuds or headphones (17.7%) and having an object or mobile phone in their hand or on the handlebars (13.5%) (Wolfe et al., 2016). Currently, there is a lack of information about the impact of distracted bicycling on bicyclist safety (Mwakalonge et al., 2014).

Vehicle Design

Some studies have focused on the role of motor vehicle type and design in the event of a crash. Ackery et al. (2012) found that larger motor vehicles—especially freight trucks and SUVs—were overrepresented in bicycle crashes compared to other vehicle types. In an examination of national and State level crash data, Hu and Cicchino (2022) found that minivans, large vans, pickups, and SUVs collectively had higher likelihood of being involved in certain types of crashes involving pedestrians. Increased involvement of heavier vehicles can lead to greater injury severity and is an important consideration when implementing speed management and driver behavior strategies.

Mandatory Helmet Laws

Helmets are important protective gear that can reduce injury severity from single-vehicle crashes and from collisions with motor vehicles. There is a large body of research on the protective effects of helmet use, but there is currently not consensus on whether mandatory helmet use laws are the most effective means of increasing the use of helmets and ensuring population-wide access to the protection that bicycle helmets offer. Research has shown that community-based interventions such as helmet promotion accompanied by free helmets has proven effective at increasing helmet use while addressing inequitable access to helmets (Owen et al., 2011).

Several meta-analyses conducted over the past 2 decades have concluded that bicycle helmets are effective at reducing head injuries among bicyclists involved in falls or crashes with a motor vehicle (Attewell et al., 2001; Elvik, 2013; Høye, 2018b; Olivier & Creighton, 2017; Thompson et al., 1999). The most recent meta-analysis found that the use of bicycle helmets reduced head injuries by 48%, serious head injury by 60%, traumatic brain injury by 53%, face injury by 23%, and the total number of killed or seriously injured bicyclists by 34% (Høye, 2018b). A study that examined emergency room visits of children that had bicycle-related injuries found that unhelmeted children were more likely to sustain injuries (40% versus 25.7%), meet the trauma activation criteria (45.5% versus 16.8%), and be admitted to the hospital (42.4% versus 14.9%). Overall, injury severity was worse with unhelmeted children, and these children were significantly more likely to have brain injuries, skull fractures, and facial fractures (Michael et al., 2017).

It is likely that bicycle helmets have a larger effect in single bicycle crashes than in bicycle crashes with motor vehicles (Høye, 2018a). A small study examining medical data from a set of cycling fatalities found helmets could have a positive (lifesaving) effect in bicycle-only crashes, but often would not have prevented the fatality in high-energy crashes with motor vehicles or trains, often due to the difference in momentum (Bíl et al., 2018). Swedish researchers applied a systems approach to investigating bicycling fatalities, and an analysis of police-reported crashes, medical records, autopsy reports, accident analyses and witness statements, estimated that helmets could have saved 46% of the non-helmeted riders (Kullgren et al., 2019). Examination of bicyclist injuries across seven Seattle area hospitals did not find an association between risk of serious injury and helmet use. However, they did find a strong relationship between motor vehicle involvement in the crash and injury severity. Though fatalities were rare events in the data used for this study, the authors did find an association between helmet use and fatal injury, with nonhelmeted riders being more likely to die than helmeted riders (Rivara et al., 2015). Motor vehicle involvement similarly increased likelihood of a fatality. Helak et al. (2017) looked at outcomes as reported in the National Automotive Sampling System – General Estimates System (NASS – GES) and found no significant differences in police reported injury severity if the rider was wearing a helmet versus not wearing a helmet.

While helmet use is important for preventing serious head injuries among all ages, some jurisdictions are concerned *mandatory* helmet use legislation for all ages will discourage bicycling, perpetuate existing inequalities in access to helmets, or lead to inequitable enforcement of the law. Disparities in access and means to obtain helmets have been observed. A study measuring racial disparities following a helmet law found that helmet use among Black high school students increased less than among their white counterparts, and that these disparities persisted over time (Kraemer, 2016). Exploration of trauma registry data showed that among children under age 16 who were admitted to a trauma center, non-helmeted children were more likely to be Black or insured by Medicaid (Gulack et al., 2015). Selective enforcement of bicycle-related minor violations such as mandatory bicycle helmet laws, especially against low-income people and people of color is a concern. Officers may use issuing bicycle-related citations as an excuse to stop, question, or search people, which may lead to reduced ridership among groups who feel especially likely to be targeted (Brown, 2021; National Association of City Transportation Officials [NACTO], 2016). Given that increased riding provides health benefits, some agencies prefer to use encouragement in lieu of a law to increase helmet use by adults.

Data/Surveillance

Practitioners and researchers need high-quality data to both identify problems and to evaluate countermeasure effectiveness. Three primary types of data are needed for a more complete picture of bicyclist safety:

- Safety/outcome data that describes crash events or reports surrogate measures.
- Exposure data that describes the amount of activity in a place or by a group.
- Contextual data that describes the environment in which travel occurs and can provide insight into potential risk factors associated with crashes.

This document's focus on safety data should not minimize the importance of exposure data or contextual data. Exposure is a crucial aspect of analyzing crash risks because, all other factors being equal, greater exposure will increase the chance of a crash. High crash figures may simply reflect high bicycling activity. Alternatively, a corridor or intersection with low crash figures may be a result of actual or perceived danger that dissuades people from using the facility.

Since 2014 NHTSA's NCSA has used the crash typing framework PBCAT to describe the events and maneuvers that preceded fatal bicyclist and pedestrian crashes (i.e., the crashes included in FARS). An updated version of PBCAT (PBCAT3) that improves user functionality and offers crash typing logic to support coding consistency and objectivity, has been released, it can be found at https://pbcat3.org. The new version complements the data that States currently collect. It is important to consider on-site field review of behaviors and site-specific characteristics before determining which engineering or behavioral countermeasures are appropriate (Zegeer et al., 2009). Another pedestrian and bicycle crash typing schema is the Location-Movement Classification Method, which focuses on where the person was and which direction the person was heading relative to the motor vehicle at the time of the crash (Schneider & Stefanich, 2016).

Another consideration when analyzing crash data are that bicyclist crashes (as well as pedestrian crashes) tend to be underreported. Underreporting of traffic-related crashes on road rights-of-way likely decreases as the crash severity increases because police are likely to be called to injury and fatal crashes, and the bicyclist is more likely to be transported or seek treatment at a healthcare facility. Many States may not require reporting nor collect off-road or private-road crash records. Non-roadway crashes may, however, constitute a significant portion of bicyclist-related crashes with motorists. In several studies looking at pedestrian and bicyclist crashes, parking lot and driveway-related crashes represented up to 15% to 25% or more of all *reported* pedestrian crashes (Stutts & Hunter, 1999; Agran, 1990).

Hospital and EMS data, such as NEMSIS (https://nemsis.org/), can be an important form of safety data, as not all crashes involve police response. These data are usually more accurate than police reported crash data, especially for determining crash severity outcomes. They also may include more information about the nature of an injury and crash than police reports, but rarely include detailed location data. Health-related datasets are often deidentified, which makes it challenging to link them with other datasets (i.e., police-reported crash data). Sometimes linkage is possible by working with individual States or after negotiating data agreements.

Crash and injury data is often the only available form of safety data, but in a small area (or short duration of time) there may not be enough data for proper analysis. Some have turned to using naturalistically observed traffic interactions, or "near-misses", as proxy data to supplement crash data. Near misses are interactions that could have been crashes but were avoided. These near-misses can reveal patterns that might lead to potential risky situations. A combination of crash data and near-miss observations may be an effective means of understanding where interventions are needed (Cloutier et al., 2017). Research has linked bicycling (and walking) behavior to perceptions of safety, and if certain locations feel unsafe, there may be no bicycle traffic. Thus, measuring suppressed trips is also important for gaining a more complete understanding of safety problems (Ferenchak & Marshall, 2019). Last, collecting input from the local residents, safety practitioners, and law enforcement or public works can enhance understanding of safety concerns in a particular location.

More importantly, as mentioned above, in most areas of the country, measures of exposure are lacking. Exposure to traffic and crashes is affected by the number of trips as well as where, when, and for how long a bicyclist rides. The lack of data accounting for the percentage of people on bicycles riding in various situations means we are not able to calculate a rate of crashes for any one location at any given time. This not only hinders full understanding of how bicyclist safety is affected by the built environment, roadway infrastructure, or traffic conditions, but makes comparing safety and risk across the transportation network challenging.

Classifying Crash Types

Bicycle crashes can be classified into types based on bicyclist and motor vehicle pre-crash actions and the location of the crash. Nationally, common bicyclist crash types can be grouped into broad categories: motorist overtaking crashes, turning crashes, and failure to yield crashes. A recent examination of bicyclist crash types also noted a higher frequency of wrong way and sidewalk crashes among young people on bicycles, suggesting that perhaps these riders were not comfortable riding in existing roadway conditions (Thomas et al., 2019). It is important to note that 23% of bicyclist fatalities in 2021 involved hit-and-run drivers; that is, for nearly one-fourth of fatalities, investigators and researchers may never know the condition and characteristics of the driver or the vehicle involved (NHTSA, 2023). Many other factors such as historical and ongoing investment in the built environment, alcohol impairment, traffic speed, larger and more powerful vehicles, etc., may increase the risk of certain crash types and the risk of injury.

Considerations for Improving Data

Improving data on bicycling transportation is a critical need. A research roadmap developed for AASHTO's Council on Active Transportation calls "improving data on pedestrian and bicyclist fatalities" a high priority (Dill et al., 2021). While crash data is the main source of safety data, a comprehensive nonmotorized safety analysis often means being able to access and integrate a wide array of data from sources and disciplines. Key to achieving better understanding of safety is improving police reported crash data, improving exposure data, and increasing the frequency of travel surveys.

A consensus report by the Safe States Alliance provides an overview of pedestrian injury surveillance data that could supplement State level crash data or to bolster analyses of safety for bicyclists and pedestrians (Injury Surveillance Workgroup 8, 2017). Fatality and injury data and (primarily) proxy measures of exposure from a variety of sources can be tailored to local needs and used in analyses to understand crashes in greater detail and context.

Emerging Issues

Other Bike Types

Powered bikes and standing scooters are gaining popularity, particularly in urban and suburban communities and through shared ride programs. Docked bikeshare systems increased in number from 2015 to 2019, and the number of dockless bike and e-scooter share systems have been growing rapidly since 2017 (Bureau of Transportation Statistics, 2022). Docked bikeshare has a strong safety record so far, with just two fatalities in over 88 million bike share trips from 2010 to 2016 (Fischer & Retting, 2017). Dockless bike and e-scooter share crash records are not publicly available.

Electric bikes (e-bikes) provide greater speeds, terrain fitness, and hill-climb assistance that can enable bicyclists to commute farther. E-scooters are often used in dense urban communities for short rides. While many of the behavioral safety issues between traditional bicycles and other forms of micromobility are similar, there are differences that may require additional attention.

In the United States limited research has shown that e-bike users generally do not differ from conventional bicycle riders in terms of safety behaviors (Langford et al., 2015). The speed of a person on an e-bike might be slightly higher, and it's possible for drivers to misjudge the speed of a person on an e-bike. While most e-bike riders have ridden a standard bicycle previous to owning an e-bike, they may be ridden on different routes, and for different purposes such as carrying children or additional cargo, which may result in different behavior for some riders (MacArthur et al., 2018).

Many e-scooter crashes are single-vehicle crashes that happen on the sidewalk or on roadway locations where the pavement conditions are poor or unsuitable for e-scooter riding (Cicchino et al., 2021). Like bicyclist and pedestrian crashes, when a motor vehicle is involved in a crash with an e-scooter, injury outcome for the e-scooter rider is likely to be worse. Riders of e-scooters often cite the fear of being injured in a collision with a motor vehicle, due to lack of safe places to ride (Sandt et al., 2022).

Quantifying safety issues is challenging with these forms of transportation since underreporting may be common. Specifically, incident and crash reporting is seldom specific enough to indicate these bike types, with e-bike crashes often recorded as bicycle crashes, and e-scooters often recorded as pedestrian crashes. While understanding related to e-scooter safety is growing, many municipalities are not systematically tracking injuries of people riding e-scooters (Sandt et al., 2022).

Emerging technology

Connected and automated motorist assistance technologies, infrastructure-based technologies, and cooperative safety devices represent an opportunity to enhance road safety for those outside the vehicle as well as for those inside of it. While these technologies have promise, many are still in development, and challenges must be resolved to ensure people walking and bicycling maintain their right to the use of public space safely. Many of the components within these technologies are still evolving and improving their capacity to precisely identify people on bicycles. Connected technologies could add an additional layer of protection for people on bicycles by alerting drivers to their presence but would require broad adoption to be effective. However, as technological tools to improve safety become more available, it is important to consider equity implications associated with deployment.

Innovative approaches

Implementing a safe system approach requires not only collaboration across disciplines but also entails testing new and innovative cross cutting strategies for road safety. The below approaches have yet to be evaluated, but agencies wishing to test them could provide valuable examples and lessons learned on these novel approaches.

Several States have implemented the "Idaho Stop" rule, which allows people on bicycles to treat stop signs as yield signs. The intention of this law is to adapt a traffic control device devised for motor vehicles to the needs of bicyclists. The person on a bicycle must slow and yield to oncoming traffic but is not required to come to a full stop. Since people on bicycles are traveling at slower speeds, and have a better view of the road environment, this maneuver is somewhat intuitive. Rigorous research on the safety implications of Idaho Stop has not been conducted, but an analysis of crashes in States where the law is in place there showed no adverse safety implications (Bike Delaware, n.d.; Meggs, 2010). A report looking at the impact of bicyclist specific traffic safety laws on crashes noted that data to conduct a rigorous analysis of the effects of the Idaho stop were not available (Jackson et al., 2021).

Many towns have installed temporary or permanent Traffic Gardens to teach bicycle safety to children. Traffic Gardens, also known as safety towns or safety villages, are miniature safety courses where children can safely practice riding a bicycle and following the rules of the road but also where they can engage in free play while gaining an understanding of being safe in traffic and interacting with the built environment. Traffic Gardens can include roads, sidewalks, traffic control devices, crosswalks, and more. In some instances, Traffic Gardens consist of painted lines on asphalt, and more elaborate versions can include small buildings and paved streets (Goffman, 2021).

In recent years vulnerable road user laws have been implemented in at least 5 States, and other States have provisions addressing activities such as harassment of vulnerable road users. The laws are intended to increase awareness and protection of people who are not in vehicles, and often apply harsher penalties for drivers when a crash or action involves vulnerable road users. Specifics of this type of legislation appear to vary in their approach, and evaluation of such laws was not identified in the literature search (McLeod, 2013).

In some States local agencies conduct bicyclist and pedestrian safety assessments along with members of the public and interagency partners. These assessments provide an opportunity for SHSOs to collaborate with community members to identify safety concerns and develop comprehensive strategies to address them. In California this approach has been in place under the Complete Streets Safety Assessments Program. One region in California has also been piloting a campaign called "Go Human" that includes a Kit-of-Parts with which local practitioners can set up temporary demonstration projects that show how roads can be improved to address certain safety issues.

Key Resources

The agencies and organizations listed below can provide more information on bicyclist safety and links to numerous other resources.

- National Cooperative Highway Safety Research Program: *A guide for reducing collisions involving bicycles* (Raborn et al., 2008)
- FHWA: *A resident's guide for creating safer communities for walking and biking* (Sandt et al., 2015)
- NHTSA: Advancing pedestrian and bicyclist Safety: *A primer for highway safety professionals* (Brookshire et al., 2016)
- PBIC: *Discussion guide for automated and connected vehicles, pedestrians and bicyclists* (Sandt & Owens, 2017)
- U.S. DOT: *Primer on safe system approach for pedestrians and bicyclists* (Goughnour et al., 2021)
- PBIC: *Understanding crashes and safe behaviors to help prevent them video series* (PBIC, 2020)
- NHTSA: *The role of law enforcement in supporting pedestrian and bicyclist safety: An idea book* (Blank et al., 2020)
- *Making bicycling equitable: Lessons from sociocultural research* (McCullough, et al., 2019)
- BIKESAFE: *Bicycle countermeasure selection system* (Sundstrom & Nabors, 2014)

Data Resources

- The Pedestrian and Bicycle Crash Analysis Tool software is available to assist jurisdictions in typing bicycle-motor vehicle crashes and developing a database that contains information on pre-crash maneuvers as well as other crash factors. FHWA recently updated PBCAT.
- The League of American Bicyclists: The Benchmarking Project collects publicly available data on bicycling and walking. The report is updated regularly. (League of American Bicyclists, n.d.-a)
- National Pedestrian and Bicycle Safety Data Clearinghouse www.pedbikedata.org

Bicycle Safety Countermeasures

Legislation and Licensing

Countermeasure	Effectiveness	Cost	Use	Time
Bicycle Helmet Laws for Children	★★★	$	Medium	Short
Universal Bicycle Helmet Laws	★★★	$	Low	Short
Active Lighting Laws	★★	$	High	Varies
Motorist Passing Bicyclist Laws	★	$	Medium	Short
Lower Speed Limits	★★★★	$	High	Varies

Enforcement

There are no countermeasures in this category.

Other Strategies for Behavior Change

Countermeasure	Effectiveness	Cost	Use	Time
Promote Bicycle Helmet Use with Education	★★★	$$$	Unknown	Medium
Safe Routes to School	★★★	$	High	Short
Bicycle Safety Education for Children	★★	$	Unknown	Short
Cycling Skills Clinics, Bike Fairs, Bike Rodeos	★	$	Unknown	Short

Approaches That Are Unproven or Need Further Evaluation

Countermeasure
Rider Conspicuity Laws
Driver Training
Bicycle Safety Education for Adult Cyclists
Share the Road Awareness Campaigns

Effectiveness:

★★★★★	Demonstrated to be effective by several high-quality evaluations with consistent results.
★★★★	Demonstrated to be effective in certain situations.
★★★	Likely to be effective based on balance of evidence from high-quality evaluations.
★★	Limited evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.
★	No evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.

Cost to implement:

$$$	Requires extensive new facilities, staff, equipment, or publicity, or makes heavy demands on current resources.
$$	Requires some additional staff time, equipment, facilities, and/or publicity.
$	Can be implemented with current staff, perhaps with training; limited costs for equipment or facilities.

These estimates do not include the costs of enacting legislation or establishing policies.

Use:

High	More than two-thirds of the States, or a substantial majority of communities
Medium	One-third to two-thirds of the States or communities
Low	Less than one-third of the States or communities
Unknown	Data not available

Time to implement:

Long	More than 1 year
Medium	More than 3 months but less than 1 year
Short	3 months or less

These estimates do not include the time required to enact legislation or establish policies.

Legislation and Licensing

Bicycle Helmet Laws for Children

Effectiveness: ★★★	**Cost:** $	**Use:** Medium	**Time:** Short

The purpose of bicycle helmet laws for children is to increase bicycle helmet use, thereby reducing the number of severe and fatal head injuries to children involved in bicycle crashes. A substantial amount of research has examined the efficacy of helmets for minimizing head injuries for bicyclists, and these studies have generally concluded that helmets are important for reducing head injuries. However, research has not reliably shown that legislation and enforcement of helmet laws consistently and equitably lead to increased helmet use.

Legislation effectiveness is enhanced when combined with supportive publicity and education campaigns or programs. See, for example, Rivara et al. (1998), Kanny et al. (2001), Rodgers (2002), and Sandt et al. (2015). The practical effect of bicycle helmet laws is to encourage parents to require their children to use helmets (and educate parents to serve as role models to wear a helmet).

Inequitable enforcement and ticketing must be avoided if helmet laws are enacted. Law enforcement and other safety officials can reinforce the need to wear a helmet through positive interactions, free, or discounted helmet distribution programs (combined with proper helmet fitting), or other positive incentives for helmet use. Publicizing helmet laws and child/parent education on helmet fitting and the importance of wearing a helmet every ride may enhance effectiveness. Educational programs have been shown to increase knowledge about proper use of helmets.

Use:

Mandatory bicycle helmet laws for children are in place in 21 States and the District of Columbia (IIHS, 2022). All of these mandatory bicycle helmet laws cover child bicyclists younger than 18.

Effectiveness:

Two systematic reviews found that legislation may be effective at increasing helmet use (Karkhaneh et al., 2006; Macpherson & Spinks, 2008). Two of three controlled studies reported reductions in head or traumatic brain injury following legislation (Macpherson & Spinks, 2008). The degree of improvement varied but there was a lack of evidence to determine whether enforcement, supporting publicity, and helmet distribution efforts explain some of the variation (Karkhaneh et al., 2006; Macpherson & Spinks, 2008). There was a non-significant trend toward a greater overall increase in helmet use in communities with laws covering all cyclists compared to those covering only children, and effects were larger among children (Karkhaneh et al., 2006). Dennis et al. (2010) also found self-reported helmet use was highest in a province with a law covering all ages, next highest in a province with a law covering children up to 18, and lowest in a province with no law. However, in a study comparing 10 years of injury data from the Trauma Registry database in localities with and without helmet laws for children, Williams et al. (2018) found no change in helmet use after new legislation but did note that communities with helmet laws had higher rates of helmet use among young bicyclists, though those communities generally also had higher incomes.

A survey of adults across the United States conducted by the CDC found that children who lived in States with child helmet legislation were more likely to wear a helmet (51% of respondents reported that their child always wears a helmet, and 21% self-reported their child never wears a helmet) than those in States that did not have a child helmet law (40% always and 35% never) (Jewett et al., 2016). In addition, the strongest predictor of child helmet use was adult helmet use. Parents who reported always wearing helmets were 40% more likely to report that their youngest child always wore a helmet than parents who did not always wear helmets.

The effectiveness of helmet legislation in reducing head injuries is challenging to assess because of the difficulty of controlling for other safety measures that may differ across jurisdictions, and for exposure to crashes of different severities across people in case control studies. Two studies from Canada have found somewhat mixed results. Karkhaneh et al. (2013) found that legislation targeting those under 18 had a beneficial effect on child, adolescent, and adult bicyclists hospitalized for head injury in the province of Alberta, Canada. Helmet use increased from 75% to 92% among children, from 30% to 63% among adolescents, and from 52% to 55% among adults (Karkhaneh et al., 2011). A national study compared trends in provinces with and without legislation. Despite lower injury rates in provinces with helmet laws than in those without, the effect could not be solely attributed to the introduction of the laws (Dennis et al., 2013). However, the study also found that one province that implemented a law covering all ages, not just children, did have a significantly lower injury rate trend for the period covered by the law.

Costs:

A helmet law should be supported with appropriate communications and outreach to parents, children, schools, pediatric health care providers, and law enforcement. NHTSA has a wide range of material that can be used to educate and promote the use of a helmet every ride, demonstrate helmet effectiveness, and educate and demonstrate how to properly fit a helmet.

Time to implement:

A bicycle helmet law can be implemented as soon as the appropriate legislation is enacted. Enacting local ordinances may take less time than enacting statewide legislation. To develop custom communications and outreach, train law enforcement officers on implementing the law, or start a helmet distribution or subsidy program in support of the law may require a medium-to longer-term effort.

Other considerations:

- *Inequitable enforcement:* It is important to consider equity implications of the enforcement of helmet laws and existing disparities in helmet use by youth cyclists of lower socioeconomic status. In one study, which was limited to one urban elementary school, lack of access to bicycle helmets was the most cited barrier to helmet use (Pierce et al., 2014). As mentioned above, community-based interventions such as helmet promotion accompanied by free helmets have proven effective at increasing helmet use (Owen et al., 2011).

Universal Bicycle Helmet Laws

Effectiveness: ★★★	**Cost:** $	**Use:** Low	**Time:** Short

The purpose of bicycle helmet laws is to increase bicycle helmet use, thereby reducing the number of severe and fatal head injuries resulting from bicycle crashes. Bicycle helmets, when worn properly, reduce head injuries in the event of a crash. Research has not reliably shown that legislation and enforcement of helmet laws consistently and equitably lead to increased overall helmet use.

Use:

No States have yet enacted laws requiring adults to wear bicycle helmets. There are local jurisdictions in the United States that require people of all ages to wear helmets when bicycling.

Effectiveness:

A 2018 systematic review synthesizing the evidence on the effectiveness of helmet laws on increasing helmet use found mixed results. Generally, research points to an association between increases in helmet use and helmet legislation, particularly among youth, but authors found methodological limitations to some studies and suggested that more research was needed to examine the impacts of helmet laws (Porter 2018) more comprehensively. Several studies (two studies from Canada, and one from New York City) show helmet laws for all ages produce higher helmet wearing rates than laws covering only children (Dennis et al., 2010; Høye, 2018a; Karkhaneh et al., 2006; Puder et al., 1999). A longitudinal study in Nova Scotia, Canada, found that increased enforcement (through issuing summary offense tickets) along with education efforts were associated with a 25% increase in helmet use following legislation (Huybers et al., 2017). Another Canadian study examining national-level health survey data found evidence of increased helmet use after all-ages helmet laws were implemented, though data was unavailable to control for concurrent efforts that accompanied the legislation like environmental changes, ongoing outreach, helmet giveaway campaigns, etc. (Carpenter & Warman, 2019).

Dennis et al. (2013) found some indication that all ages helmet laws in Canadian provinces correlated with fewer head injuries as a ratio of all bicycle injuries than no helmet law or a law covering only youth, but when they considered trends around general helmet use, built environment changes and other environmental factors, they were unable to isolate the effects of the legislation on the reduction of head injuries.

Analyses of the impacts of statewide helmet legislation in solely U.S. contexts are not available. Seattle, Washington, located in King County, was the largest municipality in the United States with an all-ages helmet law. Researchers compared traumatic injury rates from King County, which, prior to its repeal in 2022, had a mandatory all ages helmet law in place since 1994, to traumatic injury rates from Seattle, where a mandatory helmet law went into effect in 2003. Results are inconclusive on the direct impacts of the helmet legislation in Seattle. In both the city and the county, overall incidences of adult bicyclists admitted to a Level IV trauma center for 24 hours continued an upward trend, and there was no significant change in the proportion of bicyclists with head injuries in either jurisdiction. There was a small decrease in *severe* head injury but only as a proportion of all head injuries for bicyclists in Seattle and in King County. It is difficult to pinpoint the introduction of a helmet law in Seattle as the sole cause of increased helmet use, as awareness and outreach campaigns were simultaneously taking place in the city, and the data showed similar increases in helmet use for hospitalized cyclists in King County over the same time period (Kett et al., 2016).

Costs:

Minimal costs could be incurred for informing and educating the public and providing training for enforcement personnel.

Time to implement:

A universal helmet use law can be implemented as soon as the law is enacted.

Other considerations:

- *Inequitable enforcement:* Mandatory helmet laws introduce the possibility of inequitable enforcement. While the literature search uncovered few academic studies about traffic stops and racial disparities in citations related to *bicycling* infractions, journalistic investigations in cities including Seattle, New York, and Chicago have documented that Black and Latino bicyclists receive a disproportionate share of bicycling-related tickets (in terms of ridership or population). In a longitudinal study looking at police data in Tampa, Mitchell and Ridgeway (2018) found evidence of racial disparity in bicycle stops relative to census and bicycle crash data. In 2021 King County, Washington, repealed its countywide helmet law due to findings of inequitable enforcement of the law (Kroman, 2022).
- *Shared Micromobility Programs and Helmets:* In cities implementing bike share programs, complementary helmets may increase helmet use among bike share riders. An observational study in Vancouver, Canada, where helmet legislation has been enacted since 1996 and where the bike share system provides helmets along with their bicycles, found that a significantly lower proportion of bike share riders wore helmets than personal-use bicycle riders (15% fewer) (Zanotto & Winters, 2017). However, the gap in helmet use is much smaller than in other cities (i.e., 30-48% gap for Toronto, Boston, New York, Washington, London, and Montreal) where bike share companies do not provide complementary helmets.
- *Helmet standards:* All helmets sold in the United States must pass minimum testing standards for head protection (“impact attenuation”), requirements to prevent helmets coming off in a crash, peripheral vision tests and other requirements developed by the Consumer Product Safety Commission (CPSC). More information is available on the CPSC website (CPSC, 2022.).
- *Buying, fitting, and replacing helmets:* Most importantly, helmets must fit properly, be worn properly, and be worn every time in order to offer the desired protection. NHTSA, the League of American Bicyclists, and Safe Kids Worldwide provide tips on helmet fitting and other guidance on riding safely in traffic (Safe Kids Worldwide, 2019; NHTSA, n.d.; NHTSA, 2012; League of American Bicyclists, n.d.-b). Virginia Tech tests and ranks bicycle helmets based on impact performance (Virginia Tech Helmet Lab, n.d.).

Active Lighting Laws

Effectiveness: ★★	**Cost:** $	**Use:** High	**Time:** Varies

Overall, active lighting improves detection and recognition of bicyclists by motorists. In a controlled trial experiment, Danish researchers found that flashing lights used during daylight hours decreased the number of daytime bicyclist crashes during the experiment time period (Madsen et al., 2013). Absent safe infrastructure, bicyclist safety on public roads after dark is affected by a variety of factors inherent to the transportation system. Motorists may underestimate their visual limitations in darkness and fail to adjust their own speeds appropriately. Changes in vision during twilight hours and at night, headlamp glare, and age-related decline in visual function are among the challenges to bicyclist detection faced by motorists (Tyrrell et al., 2016; Wood et al., 2014). Detection may also be affected by driver expectations for seeing people on bicycles in the road environment, potentially related to the Safety in Numbers effect (Elvik, 2017; Tin Tin et al., 2015). Crashes after dark are also influenced by driver factors such as fatigue and alcohol consumption (Tyrell et al., 2016). Unfortunately, it is unlikely that any form of conspicuity can overcome the challenge of driver distraction (Szubski et al., 2019).

Use:

Most States have laws requiring use of active lights and reflectors on bikes ridden at night. Some State laws have specific requirements for the power of the light, i.e., ability to see the light at a certain distance of feet ahead. Some laws, such as in Oregon, require bicycle lighting not only at night, but also in other less than favorable conditions.

There is no data on how frequently active lighting is used among those who bicycle after dark. Nearly three-fourths of U.S. survey respondents who reported having ridden in the dark indicated they took some measures, either using a bike headlight or reflective/fluorescent gear or clothing, to make themselves more visible (Schroeder & Wilbur, 2013).

Effectiveness:

Evidence is unavailable about the effectiveness of laws requiring use of active lighting at increasing use. There is some indication that active visibility aids, such as lights, improve detection more effectively than passive visibility aids (Kwan & Mapstone, 2009).

Costs:

Moderate costs are involved for communications and outreach and for law enforcement training to enforce active lighting laws.

Time to implement:

Brochures and flyers for a bicycle safety education campaign highlighting conspicuity can be created quickly. Often an extra line or two about rider conspicuity can be added to existing educational material or reinforced at community events. Several months can be taken up by designing, producing, and implementing the communications and outreach and law enforcement training for enforcing active lighting laws.

Motorist Passing Bicyclist Laws

Effectiveness: ★	**Cost:** $	**Use:** Medium	**Time:** Short

The purpose of bicyclist passing laws is to require motor vehicle drivers to overtake people on bicycles with a legally defined minimum amount of clearance space between the vehicle and the cyclist. This helps to reduce the likelihood of a sideswipe, and to reduce the chance of a close encounter that could potentially destabilize or divert the course of a bicyclist and cause a crash. Given the high rate of crashes that occur when the driver of a motor vehicle passes a person on a bicycle, it is important to tackle this motorist-bicyclist interaction. However, the research has shown mixed results from current implementations of motorist passing laws.

Use:

As of September 2021 there were 35 States and the District of Columbia known to have enacted bicyclist passing laws requiring drivers to leave a space of 3 feet or more when passing cyclists (National Conference of State Legislatures [NCSL], 2022). Pennsylvania and New Jersey require at least 4 feet for passing, and South Dakota requires at least 3 feet for roads with a speed limit of 35 mph or less and at least 6 feet for roads with a speed limit greater than 35 mph. North Carolina requires at least 2 feet for passing and permits passing a bicyclist in a no-passing zone if the motorist leaves a clearance of at least 4 feet. Delaware, Kentucky, Nevada, Oklahoma, and Washington require the motorist to change lanes to pass a cyclist on roads with lanes in the same direction. Eight other States have laws requiring motorists to pass at a safe distance and speed but are usually not more specific.

Effectiveness:

There is some empirical data suggesting that these laws may change driver behavior. A naturalistic observational study of driver passing behavior in Michigan measured vehicle passing distance in five jurisdictions having 3 feet (1 city), 5 feet (3 cities), and no enacted (1 city) passing laws (Van Houten et al., 2018). The results showed that drivers maintained a significantly greater separation distance when they overtook bicyclists in sites with 5-feet laws, compared to sites with 3-feet or no law. Roadway infrastructure also influences passing behaviors. Roads with paved shoulders, wider roads, and greater number of lanes were associated with greater separations between drivers and bicyclists. Shared use lanes led to closer passing, as did passing situations with larger vehicles. Research by Mackenzie and Evans confirm the finding that road environment influences motorist passing distances (Evans et al., 2018; Mackenzie et al., 2019). In an evaluation of a passing law enacted in Baltimore, Maryland, Love et al. (2012) similarly found that environmental and social factors such as lane width, bicycle infrastructure, cyclist identity, and street type influenced passing distance. The study reported low compliance with the passing law and little to no enforcement of the law by area police. The authors concluded that interventions such as driver education, signage, enforcement, and bicycle infrastructure changes (such as bike lanes and Complete Streets designs) are needed to influence driving behavior and to increase motorist compliance with the motorist passing law. An evaluation of HVE campaigns in two cities showed that concentrated education and outreach coupled with enforcement resulted in higher average passing distances and a decrease in violations of the passing laws (Blomberg et al., 2022).

Bicycle passing laws can be difficult to enforce because it is a challenge to measure the exact distance between bikes and vehicles. Police in Chattanooga and Austin use devices called C3FTs,[9] a handlebar mounted ultrasonic device, to measure when a vehicle passes a police bicycle with less than 3 feet of distance (Davis, 2017; Goodyear, 2015). Devices such as these can offer valuable, accurate information to help make passing laws enforceable.

It is unclear whether motorist passing laws lead to a reduction in crashes. An analysis of 18,534 bicyclist fatalities from 1990 to 2014 in the United States failed to find any significant safety effect for bicyclists in States where Motorist Passing laws were implemented (Nehiba, 2018). A study looking at the impacts of bicyclist safety laws on crashes identified an association between safe passing laws and a reduction in crashes, but authors noted that the crash reduction effect was temporary. Current research has not been able to determine why such laws do not produce lasting safety improvements (Jackson et al., 2021).

Van Houten et al. (2018) note that no research has been conducted on public education around motorist overtaking laws and regulations. In addition, no studies around motorist passing laws have examined the question of speed while passing.

Costs:

Moderate costs could be incurred for informing and educating the public and providing training for enforcement personnel.

Time to implement:

A bicyclist passing law can be implemented as soon as the law is enacted.

[9] A trademarked name meaning "see 3 feet" manufactured by Codaxus LLC, Austin, Texas.

Lower Speed Limits

Effectiveness: ★★★★	**Cost:** $	**Use:** High	**Time:** Varies

The speed of motor vehicle traffic has a clear impact on bicyclist safety (Helak et al., 2017; Peden et al., 2004). The goal of reducing motorist travel speeds is to increase reaction time for both drivers and bicyclists to avoid crashes, as well as reduce the severity of bicyclists' injuries when these crashes occur. Reducing and enforcing speed limits is just one tool among many for decreasing travel speeds with the goal of improving bicyclist safety.

Speed limit reductions can be most effective when introduced to a limited area as part of a visible area-wide change, for example, identifying a downtown area as a special biking-friendly and walking–friendly zone through signs, new landscaping or "streetscaping," lighting, etc. Road diets, an FHWA proven safety countermeasure, may be a low-cost way to reduce an overbuilt street that suggests high speeds to drivers and provide more space for walking, bicycling, and for drivers who need to park their vehicles.

If speed limits are routinely ignored, then enforcing speed limits may be a more effective strategy than attempting to change them. Blomberg and Cleven (2006) reported on demonstration programs in two cities in which speed limit enforcement, combined with engineering changes and extensive publicity, reduced both average speeds and the number of excessive speeders in residential neighborhoods. One attempt to scale up a similar program in Philadelphia met with challenges in garnering community involvement and increasing enforcement due to a State restriction on using radar to enforce speeds, and seemed to have limited success in reducing *pedestrian* injuries (Blomberg et al., 2012).

Use:

High, in the sense that all public roads have a speed limit and speed limit enforcement is widely employed, even if it is not with the express purpose of improving bicyclist safety.

Effectiveness:

Reduced speed limits with enforcement can reduce vehicle speeds and all types of crashes and crash severity. However, the measure of effectiveness for most studies of speed limit reductions or enforcement operations is speeds, not crashes or severity of injuries. Most of the research on the impact of speed reduction on vulnerable road user safety has focused on pedestrians. In Australia, an evaluation of crash data from two cities indicated that speed reduction was associated with a decrease in crash rates, but the effect was not the same in both locations, and incompleteness of available data meant it was impossible to perform robust statistical tests on the observed results (Kamruzzaman et al., 2019). Swedish researchers evaluated injury severity outcomes from crash data in Sweden, and results showed that people on bicycles had a much lower risk of severe injury at 30 to 40 kph (roughly 20 to 25 mph) compared to 50 to 60 kph (roughly 30 to 35 mph) (Isaksson-Hellman & Töreki, 2019).

Cost:

Simply changing speed limits is low-cost, only requiring updating speed limit signs or, where few signs exist, adding some new ones. Combining speed limit changes with communications and outreach, enforcement, and engineering changes is significantly more expensive.

Time to implement:

Depending on the scope of the program, the time can be very short, or it can take several months to more than a year, especially if legislative changes are needed.

Other considerations:

- Speed limit changes exist in the context of other, unchanged speed limits. The normal expectation is that there is an overall consistent approach to speed-limit setting. Where, for safety, some speed limits need to be reduced in a manner inconsistent with other speed limits, there must be clear and visible reminders that distinct conditions exist that justify the lower limits. Also, speed limit changes can be more effective if there is public buy-in, which involves a clear understanding of the reasons for the change.

Other Strategies for Behavior Change

Promote Bicycle Helmet Use With Education

Effectiveness: ★★★	Cost: $$$	Use: Unknown	Time: Medium

The purpose of bicycle helmet education and promotion is to increase use of helmets and thereby decrease the number of severe and fatal brain injuries to bicyclists involved in crashes. This countermeasure involves conducting single events or extended campaigns to promote helmet distribution and use among children and adults. Studies have found disparities in helmet use among young people based on race or socioeconomic status, suggesting a lack of access to a helmet is a significant hindrance (Gulak et al., 2015; Kraemer, 2016).

Promotions can target various barriers to helmet use, including absence of a helmet, child and families' lack of understanding of the importance of helmet use, cost of helmets, and negative attitudes or beliefs about helmet use. Programs that provide helmets can include sponsoring organizations and often involve law enforcement and schools to deliver helmets, fit the helmets, and teach proper fitting and use. Promotions can be conducted through single events or extended campaigns to promote helmet distribution and use.

Helmet promotions should include adults. Expanding helmet promotions to adults requires an expansion in focus, and perhaps different sponsors. However, adding adult-oriented riding tips may increase the appeal of the program. Other adult-oriented strategies should also be included, such as peer-based interventions on a college campus (Buckley, et al., 2009).

Regardless of the target audience, bicycle helmet promotions must include instruction on how to properly fit the helmet and the importance of wearing helmets on every trip. Programs might also need to target differences in tendency to adopt helmet use for different riding purposes (recreational versus commuting), or riders who identify as only one type of rider (Kakefuda et al., 2009). All bicyclists could benefit from using resources that demonstrate how helmets work to reduce injury. Moreover, further efforts are needed to encourage parents and authority figures (e.g., law enforcement officers, school officials and staff, and health-care professionals) to reinforce and model desired behaviors in children including the use of a properly fitted bicycle helmet every ride (Maitland, 2013). Trained and skilled cyclists may also be more likely to adopt helmet use (Kakefuda et al., 2009), so adult bicycle training programs that incorporate the importance of helmet use may help increase wearing by adult riders. A U.S. survey of attitudes toward bicycling and walking indicates that about 34% of respondents who had ridden a bicycle in the past year used a helmet for all or nearly all their rides (Schroeder & Wilbur, 2013).

Use:

Most States have conducted bicycle helmet promotions for children within the last few years, although only a few have ongoing or regular programs. Some States have conducted bicycle helmet promotions for a general audience.

Effectiveness:

Bicycle helmets are proven to reduce injuries and fatalities. Helmet promotions are successful in getting more helmets into the hands of bicyclists. Rouzier and Alto (1995) describe a comprehensive program of presentations, media coverage, messages from doctors to patients, as well as low-cost helmet availability, which significantly increased helmet purchases and use for all ages. A peer-led, social marketing program on a medium-sized college campus also raised observed helmet use, at least for the short term (Ludwig et al., 2005). A school-based injury-reduction program targeting 13- and 14-year-olds incorporating opportunities for instruction, demonstration, rehearsal, feedback, social reinforcement and practice was associated with a 20% increase in observed rate of helmet use among this challenging target age group at 6 months follow-up (Buckley et al., 2009).

A Cochrane systematic review and meta-analysis of twenty-two studies evaluating non-legislative helmet promotion programs aimed at children under 18 found the odds of observed helmet wearing were significantly greater among those receiving the interventions (Owen et al., 2011). The study found the more effective programs were community-based (rather than aimed at people), provided free rather than subsidized helmets, and were set in schools. A Canadian program, Operation Headway, involving enforcement of bike helmet legislation, education, rewards for wearing and economic penalties for non-wearing, and provision of helmets to low-income groups was evaluated by Lockhart et al. (2010). The researchers found the program increased wearing rates (based on observations pre- and post-intervention), increased knowledge and commitment to wearing a helmet, saw greater public awareness of the law through media tracking, and improved relationships between police and the public (based on anecdotal evidence). A related theme of these studies is that population-wide, multifaceted, integrated, and repeated prevention programs are needed, which should include distribution of free helmets and safety information and strategies to increase peer and parental pressure.

Programs that increase proper use of helmets would be expected to reduce injuries in the event of a bicycle crash.

Costs:

Some States provide free or discounted helmets to some children (or parents if requested). The cost for underwriting large numbers of helmets can be high, including supporting communications and outreach material. Helmets that meet safety requirements can be purchased for under $20. When considering the costs of providing helmets, agencies should consider the benefits. A NHTSA summary of helmet laws reported that “every dollar spent on bicycle helmets saves society $30 in indirect medical and other costs” (NHTSA, 2008). Purchase of large quantities of helmets by businesses, hospitals, or through partnerships with merchants for example can also lower the cost per helmet and make free or subsidized distribution of helmets to at-risk segments of the population more feasible.

Time to implement:

A good campaign, including market research, material development, and message placement, will require at least 6 months to plan and implement.

Safe Routes to School

Effectiveness: ★★★	**Cost:** $	**Use:** High	**Time:** Short

SRTS is a comprehensive program that incorporates a set of interventions to improve safety. The goal of SRTS programs is to increase the number of students bicycling and walking to and from school while simultaneously improving safety for children bicycling or walking to school. SRTS programs are community-based and need to prioritize diversity and inclusion. Programs include education of children, school personnel, parents, community members, and law enforcement officers about safe bicycling and walking behavior and safe driving behavior around pedestrians and bicyclists. More importantly, programs can implement engineering activities to improve traffic safety and risky elements of the traffic environment around primary and secondary schools so children can safely bicycle or walk to school.

Education and training can be effective in teaching children and their caregivers how to evaluate and choose the safest routes for walking or bicycling to and from school, what safe behaviors are associated with walking and biking, and instilling the need to practice and model safe behaviors when walking, biking or driving around children walking/biking to school, how to use common engineering treatments to enhance their safety (sidewalks, crosswalks), the need to adhere to crossing guard direction, and to abide by traffic laws, especially in and around school zones. Safety is a key concern in the decision to participate in SRTS and associated programs (Safe Routes Partnership, n.d.). Improvements to the road infrastructure with traffic calming measures, improved walking and biking facilities, policies to support active transportation, and community engagement and mobilization are key to addressing safety concerns.

The CDC identified SRTS programs as one of eight non-clinical, context-based, community-wide interventions that has the potential to improve population health (CDC, n.d.)

SRTS is an opportunity to partner with agencies that can influence planning decisions such as school siting and land uses near schools, and who prioritize the health, social well-being and self-efficacy of young people.

Use:

With the establishment of the national SRTS program, all 50 States and the District of Columbia initiated SRTS programs. From 2005 to 2012 nearly 14,000 schools received SRTS funding (McDonald, 2015). As of 2015 some 17,400 schools, representing 6.8 million students, had received funding or were slated to receive funds for SRTS programs. Importantly, 68% of award recipients were classified as Title 1 (low-income) schools, a finding that is relevant because areas with lower median income are over-represented in bicyclist- and pedestrian-related crashes (McArthur et al., 2014). The number of SRTS programs in the country is currently undetermined, but a survey by the Safe Routes Partnership received input from over 400 SRTS programs (Zimmerman & Lieberman, 2020).

Effectiveness:

It is established that SRTS programs can lead to increases in walking and bicycling to school (McDonald et al., 2014; Stewart et al., 2014), but as with other comprehensive programs, it is challenging to design a rigorous evaluation that could disentangle the effects of engineering improvements from other interventions and demonstrate a safety improvement. Comprehensive SRTS efforts can include built environment, education, encouragement and enforcement interventions to improve safety. Commitment to build environment improvements and ongoing program support can lead to greater increases in biking and walking and improved safety overall. Long term changes can be influenced by incorporating infrastructure and school siting strategies into local planning processes (McDonald et al., 2014). SRTS programs can remain effective for decades because of the lasting engineering component (Muennig et al., 2014). For SRTS implementations that have centered on site-appropriate engineering changes; results have shown behavioral improvements for pedestrians, bicyclists, and motorists (Center for Health Training, n.d.).

While no bicycle-specific safety studies have been reported, overall safety improvements have been demonstrated for SRTS programs in regional studies. A study that looked at pedestrian and bicyclist injury and fatality data from 18 States over 16 years (1995 to 2010) associated SRTS with a 23% reduction in pedestrian/bicyclist injury risk and a 20% reduction in pedestrian/bicyclist fatality risk in school-age children compared to adults from age 30 to 64 (DiMaggio et al., 2016). On a State-by-State basis, only 4 (Florida, Maryland, New York, South Carolina) of the 18 States showed a statistically significant risk reduction in child pedestrian/bicyclist injury, while the remainder showed no effect. Another study found a 60% decrease in the number of pedestrians involved in car crashes after the implementation of SRTS in Miami-Dade County. Similarly, school-aged injury rates in New York City decreased by 44% in census tracts with SRTS interventions relative to those without interventions (NCSRTS & FHWA, 2015). The NCSRTS found that schools that were able to increase the percentage of students walking or bicycling to school were more likely to have a leader within the school to promote SRTS, frequent events to reinforce walking or biking to school, strong parental support, and supportive policies (NCSRTS & FHWA, 2015).

Because funds are limited for SRTS programs, prioritizing the allocation of funding across schools in a State can help improve the overall effectiveness of SRTS programs by focusing on those schools that are most likely to experience the greatest safety benefits.

Costs:

Activities associated with SRTS may be low cost and may also be eligible for grant funding. Grants are administered by each State’s SRTS coordinator. Significant material and resources can be accessed at no cost.

Time to implement:

It is short for education and encouragement, but measurable results take ongoing engagement. Programs funded through State DOTs, including engineering/infrastructure components typically require applications on a funding cycle and can take significantly longer to implement. State SRTS contacts can be found here: www.saferoutespartnership.org/safe-routes-school/srts-program/state-contacts

Bicycle Safety Education for Children

Effectiveness: ★★	**Cost:** $	**Use:** Unknown	**Time:** Short

The purpose of ongoing bicycle education is to teach children basic bicycle handling skills, traffic signs and signals, how to ride on streets with traffic present, proper helmet use, bicycle safety checks, and bicycle maintenance. As part of a regular school curriculum, education can reach every student, but providing training outside of school settings such as through parks and recreation departments, community centers, or faith-based organizations may be more feasible in some circumstances. Community-based programs could also provide greater flexibility in tailoring a program to meet the needs of specific target groups. It is critical to emphasize the importance of pairing bicycle skills training with other interventions like built environment changes that can reduce the risk of bicycle-related injuries in children.

Young children are just learning about traffic. They have little experience with which to anticipate and interpret potential traffic hazards, and limited abilities to reason and react. Their brains are still developing, and they lack the maturity and judgment needed to negotiate traffic safely and to limit risk-taking behaviors (Schwebel et al., 2012). They are also less skilled at riding than older children or adults. Many children under 10 have difficulty accurately judging the speed and movements of motor vehicles and may require adult supervision.

Bicycle safety training and education may be incorporated into life-long, comprehensive traffic safety education, with components assembled from NHTSA or comparable programs. Much bicycle safety education material target children in grades K-8, though some are aimed at younger children. Bikeology, an on-bicycle skills curriculum specifically designed for professional physical education teachers and recreation specialists, is suited for teaching middle to high school students of varying abilities and with special needs (American Alliance for Health, Physical Education, Recreation and Dance, 2014).

NHTSA has produced publications on how to properly fit a bicycle helmet (n.d.), rules of the road, presentations to generate peer to peer discussion on safe walking and bicycling, and games to educate children and parents on bicycle safety. This information is available on NHTSA's Bicycle and Traffic Safety Marketing pages. Bicycle Safer Journey is an updated series of web-based training videos and discussion guides targeted for bicyclists 5 to 9, 10 to 14, and 15 to 18 years old. The material is available on the Pedestrian and Bicycle Information Center website (www.pedbikeinfo.org/bicyclesaferjourney/).

Use:

The use of school-based programs, which is at the discretion of local school districts, is unknown, but some localities are introducing bicycling as a physical activity class taught by experienced teachers. In-school education and training are frequent parts of local SRTS programs. In addition to programs offered by teachers and school personnel, local bicycling coalitions sometimes offer age-appropriate bicycle training within a school setting.

Effectiveness:

Both short lecture-based programs and more extensive programs with on-bicycle training can increase children's knowledge of laws and safe behaviors (Hatfield et al., 2019; Hooshmand et al., 2014; Lachapelle et al., 2013; Richmond et al., 2014; Thomas et al., 2005), bicycling confidence (van Lierop et al., 2016), or observed behaviors in an educational context (Ducheyne et al., 2013) but whether this translates into adoption of the safe behaviors or a reduction in crashes is less certain. Practitioners should keep in mind the developmental limitations in children, and the distinction between knowledge gain and behavior change. If well-implemented, bicycling education programs have the potential to increase participation in bicycling, improve individual bicycling confidence, and improve overall motor skills. Programs can also emphasize the importance of protective safety equipment and good bicycle maintenance practices (Ellis, 2014; Hatfield et al., 2019; Hooshmand et al., 2014; Lachapelle et al., 2013; Mandic et al., 2018; Thomas et al., 2005; van Lierop et al., 2016)

A review of evaluations of 13 educational programs (without legislation enactment) among children and youth found that educational programs were effective at increasing observed helmet use. Most programs also offered discounted or free helmet distribution. Meta-analyses found the odds of observed helmet wearing to be more than 2 times higher than at baseline or among the non-intervention group, but results were quite varied across the different studies (Royal et al. 2007). The authors were unable to tease apart differences in programs that might contribute to different outcomes other than whether they were community-based or school-based, and whether or not they offered free or reduced-priced helmets. Community educational programs that provided free helmets were reported to be more effective than programs set in schools or that provided only an opportunity to purchase a discounted helmet, although the latter types also increased use. School-based programs also tended to obtain best results among the younger participants. Three of the studies found helmet use benefits persisting at 9- to 12-month follow-up, although evidence is still lacking regarding longer-term (1 year or more). Based on the evidence of effectiveness of helmets at preventing head-injuries when worn, injury-reduction benefits would be expected from programs that increase proper use of helmets. Crash reduction benefits of educational programs have not been conclusively demonstrated (Richmond et al., 2014). Evidence is lacking as to whether programs might have any unintended effects such as reducing amounts of riding or conferring overconfidence in one's riding skills.

Costs:

Coalitions may be paid by their associated State to provide training, or otherwise use SRTS funds if money is still available, or if SRTS funding at the State is being maintained. Teachers can provide education using NHTSA's free material, but training, administration, and supervision of a comprehensive program could increase costs somewhat.

Time to implement:

Short, for existing material; medium, to develop and disseminate a training curriculum with material.

Other considerations:

- *Sample curricula:* Some examples of curricula are the Bicycle Transportation Alliance in Portland, and the Hawaii Bicycling League (Thomas et al., 2005). The *Let's Go NC! – Pedestrian and Bicycle Safety Curriculum*, which was based on the NHTSA child pedestrian curriculum, provides educational material for training safe road use skills in children (www.ncdot.gov/initiatives-policies/safety/lets-go-nc/Pages/default.aspx). The *Kids on Bikes* program offers a collection of community-based resources in many localities including bike libraries, summer bike camps, and safe biking education (https://kidsonbikes.net/).

Cycling Skills Clinics, Bike Fairs, Bike Rodeos

Effectiveness: ★	**Cost:** $	**Use:** Unknown	**Time:** Short

Cycling skills clinics, bicycle safety fairs, and bicycle rodeos are local events often run by law enforcement, school personnel, or other civic and volunteer organizations. There may be permanent "neighborhood" layouts where the rodeos are conducted, and the events may be scheduled as part of the elementary and middle school curriculum. Their purpose is to teach children on-bicycle skills such as starting, stopping, weaving to avoid objects, the meaning of traffic signs and signals, some traffic laws and how to ride defensively in various traffic conditions. The intent of these types of activities is to introduce or reinforce bicycle safety concepts learned in a classroom with actual on-bike practice and application. Events can also include discussions and examples of proper bicycle helmet fitting. Skills clinics for children should be part of a more comprehensive program of traffic safety education and training, parent education, and other efforts.

NHTSA collected many examples of these across the country and created a guide of best practices. NHTSA's Cycling Skills Clinic Guide (NHTSA, 2011) aids first time or seasoned organizers in how to set-up a clinic, stations to choose based on their audience, station set-up, and teaching tools for volunteers).

Use:

Although the extent of use is unknown, they are increasingly implemented as part of Safe Routes to School projects and as part of pedestrian and bicycle safety efforts.

Effectiveness:

While cycling skills clinics or rodeos can result in increases in knowledge and skills, a review of the research literature does not reveal any studies that document crash and injury reduction, at least not in isolation. One program of comprehensive education for preschool children and their parents, that included a skills and safety rodeo, led to a doubling of helmet use (Britt et al., 1998; Rivara & Metrik, 1998). Some studies have found that single event bike rodeos did not lead to increases in knowledge or improvements in behaviors or attitudes (Macarthur et al., 1998); thus, bike rodeos need to be part of a larger, more comprehensive program. See Rivara and Metrik (1998) for a more in-depth discussion.

Costs:

A one-time clinic or rodeo can be operated with volunteers at minimal cost. A permanent rodeo facility could cost thousands of dollars. Associated costs may include bicycle and helmet rentals, but many communities have bicycle coalitions that have purchased these resources and bring them in trailers to scheduled events or have children or community members bring their own.

Time to implement:

A one-time clinic or rodeo can be organized in a few months. Implementing a permanent program with a facility may take up to a year or longer.

Approaches That Are Unproven or Need Further Evaluation

Rider Conspicuity Laws

The purpose of a rider conspicuity law is to increase use of conspicuity aids such as reflective accessories or high-visibility clothing. Improving bicyclist conspicuity is intended to make bicyclists more visible to motorists and to enable motorists to see and avoid collisions with bicyclists. Overall, conspicuity measures may improve detection and recognition of bicyclists by motorists, (Kwan & Mapstone, 2009). Prati examined crash data from Italy after a law was passed requiring bicyclists to wear high-visibility clothing and found no evidence of a relationship between the legislation and a change in crashes (Prati, 2018).

A comprehensive approach to improving bicyclist conspicuity should include improving the ambient roadway lighting and creating safe and predictable places spaces for bicyclists to ride, where drivers expect to see them (Raborn et al., 2008). While it is possible that improvements in conspicuity may have a small effect on driver detection of cyclists, it may not prevent crashes. Agencies are instead encouraged to consider how to separate pedestrians and bicyclists from the risk of motor vehicles as with a Safe System Approach.

Driver Training

The purpose of bicyclist safety-related driver training is to increase the sensitivity of drivers to the presence of people on bicycles and their shared responsibility as drivers to prevent crashes and enhance the safety of all road users, including bicyclists. Specifications for driver education curricula, typically a State requirement, can be adjusted to include more specific information on vulnerable road users including pedestrians as part of the traffic environment, right of way laws for drivers and people on bicycles in relation to one another, high risk behaviors in relation to bicyclist/motorist crash types, and key ways drivers can avoid being involved in such crashes.

Driver training alone has not been shown to reduce overall crash rates. There is no evidence indicating that this countermeasure is effective. However, driving skill begins with knowledge education and then practice in relation to all other types of traffic, including bicyclists.

Lifelong traffic safety education that includes bicycle training might also provide motorists with a greater understanding of bicyclist characteristics and needs and how to safely share the road. Computer-based training programs, such as the Risk Awareness and Perception Training (RAPT) and SAFE-T, can be used to train bicyclist anticipation and hazard mitigation skills to young drivers (Pollatsek et al., 2006; Pradhan, et al., 2006; Yamani et al., 2014, 2016). These programs present potential conflict situations to drivers in safe driving simulator settings (e.g., bicyclist passing situation, passing a bicycle with no lights in low light) and help in training and evaluating safe driving skills.

Bicycle Safety Education for Adult Cyclists

This measure is unlikely to be effective in reducing crashes without comprehensive and sustained efforts to improve the cycling environment.

A review of the effects of bicycle training programs on adults found that only a few studies of mixed quality existed, and none of them examined the safety benefits of these programs (Sersli et al., 2019). Nachman and Rodriguez's (2019) evaluation of adult classroom-based bicycle education reinforces past findings that adult bicycling education can influence self-perception and knowledge of the rules of riding a bicycle on public roads, but the study did not evaluate the connection to safety.

Several bicycle groups offer bicycle education to adults (and youth) including both classroom and on-bicycle training to help cyclists of varying levels enhance their knowledge of traffic laws and rules of the road and skills to ride safely and more comfortably in traffic. The oldest and most well-known is the League of American Bicyclists (LAB, n.d.-b).

Share the Road Awareness Programs

The purpose of Share the Road programs is to increase drivers' awareness of bicyclists' rights and the need for mutual respect of bicyclists on the roadway. Campaign education efforts are intended to improve the safety of all road users, including bicyclists and to enhance the understanding and compliance with relevant traffic laws. Currently, some cities and States are specifically changing their Share the Road signs to indicate that bicyclists may occupy the full lanes. This is because Share the Road is perceived differently by different users and not always in its intended way to encourage motorists to look out for and drive safely around bicyclists.

Limited evidence suggests that Share the Road signs can have positive effects on drivers' lane position and speed when passing bicyclists but does not indicate that the signs lead to increased lateral passing distance of bicyclists by drivers. Kay et al. (2014) conducted field studies examining drivers' passing behavior on a rural two-lane highway before and after the installation of "Share the Road " signs. The presence of the sign did not significantly increase lateral passing distance when a driver was passing a person on a bicycle, and lateral passing distances were also dependent on the passing vehicle type, whether there was traffic in the opposing lane and the lane position of bicyclist. Fewer drivers traveled in the rightmost lane position after the signs were installed, and drivers also reduced the vehicle speed by an average of 2.5 mph when passing bicyclists in the presence of the sign. LaMondia and Duthie (2012) found some positive safety effects based on the presence of "Share the Road" signage, but it is unclear whether these effects would be present in any road context, as they only tested four-lane arterial roads in urban locations.

A survey, drawn from a convenience sample of close to 1,800 respondents, indicates that "Share the Road" signage may be less effective than a "Bicycles May Use Full Lane" sign in conveying the message to motorists that people on bicyclists may use the travel lane (Hess & Peterson, 2015). The understanding of a "Share the Road" sign was different for those whose primary commute mode was "other" compared to those who responded that they primarily commuted in a motor vehicle. At least one State has discontinued use of "Share the Road" signage (Hess & Peterson, 2015).

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11. Drowsy Driving

Overview

Drowsy driving is a prevalent safety concern resulting from lifestyle patterns. In 2021 some 684 people were killed in crashes involving a drowsy driver, representing 1.6% of all motor vehicle traffic crash fatalities (Stewart, 2023). Drowsy driving was reportedly involved in 1.8% of fatal crashes from 2017 to 2021 (NHTSA, 2023). Until recently, attention and research on drowsiness has primarily concentrated on commercial truck drivers, but the problem is far more widespread. In 2014 more than one-third of 444,306 respondents 18 and older in the United States reported sleeping less than 7 hours a day—the minimum sleep duration recommended for optimal well-being (Liu et al., 2016). The 2017 AAA Traffic Safety Culture Index found that more than 40% of 2,613 drivers reported getting less than 6 hours of sleep a night in a typical week (AAAFTS, 2018).

Understanding the Problem

Drowsy driving can cause drivers to be less responsive to driving events in a way that potentially increases the risk of crashing (Lyznicki et al., 1998). In one study, participants with sleep deprivation were worse at lane keeping than participants with no sleep deprivation. The effect was greater in the morning even on short drives (Caponecchia & Williamson, 2018). The AAAFTS aimed to quantify the relationship between sleep deprivation and crash risk (Tefft, 2016). A sample of 4,571 crashes that occurred from July 2005 to December 2007 in the United States was analyzed using a case-control design. Elevated crash risk was associated with fewer number of hours of sleep in the 24 hours before a crash. Drivers who reported less than 4 hours, 4 to 5 hours, 5 to 6 hours, and 6 to 7 hours of sleep were associated with a 11.5, 4.3, 1.9, and 1.3 times increase in crash rate, respectively, than drivers who reported sleeping at least 7 hours of sleep in the past 24 hours. In addition, the study also estimated that changes from normal sleep patterns can elevate drivers' crash risk. Overall, drivers who averaged 4 to 5 hours of sleep daily were estimated to have 5.4 times the crash rate of drivers who averaged 7 or more hours of sleep (Tefft, 2016).

NHTSA surveyed 4,010 drivers in 2002 and found 11% reported that they had nodded off while driving during the past year (Royal, 2003). Of those who nodded off, 66% said they had 6 or fewer hours of sleep the previous night. A 2020 study found that nearly all drivers (95%) believe it is unacceptable to drive while excessively drowsy, yet 17.3% admitted to having driven while too tired to easily keep their eyes open in the past 30 days (AAAFTS, 2021).

A CDC analysis of the Behavioral Risk Factor Surveillance System phone survey across 19 States and the District of Columbia found that about 4% of 147,076 respondents reported falling asleep while driving at least once in the past 30 days (Wheaton et al., 2013). This proportion was consistent with a different sample of over 90,000 U.S. residents surveyed in 2011 and 2012 (Wheaton et al., 2014). A meta-analysis of 17 international studies published from 1993 to 2014 reported that drivers who self-reported experiencing sleepiness while driving were at more than twice the risk of being involved in a motor vehicle crash compared to drivers who reported no such instances (Bioulac et al., 2017).

Age, gender, and other risk factors play a role in driving while drowsy. Studies have found that young drivers and male drivers were more likely than older drivers and female drivers to have dozed off at the wheel (Tefft, 2010; Royal, 2003; Wheaton et al., 2013; Wheaton et al., 2014). Drowsy driving was also found to be more prevalent among binge drinkers and those that seldom or never used seat belts while in a car (Wheaton et al., 2014), which suggests that drowsy driving may be more prevalent among drivers who engage in other risky behaviors.

Drowsy driving does not just occur late at night; about one-quarter of those drivers who admit to nodding off say the most recent incident occurred in the afternoon (noon to 5 p.m.) (Royal, 2003). Additionally, drowsy driving is not limited to long trips—roughly half of the drivers who nodded off had been driving for an hour or less. A driving simulator study conducted in Australia identified another vulnerable group of fatigue-prone drivers—regular commuters (Caponecchia & Williamson, 2018).

Driver drowsiness is a critical issue for commercial drivers. About 14% of truck drivers reported a near-crash due to drowsiness according to a 2012 survey by the National Sleep Foundation (NSF, 2012). FMCSA, in partnership with Transport Canada and several Canadian Provinces, created the North American Fatigue Management Program (NAFMP) to research and educate against fatigued driving (FMCSA, 2016). FMCSA regulates drowsiness in commercial drivers through hours of service regulations, driver logs, and inspections; starting December 2017 the use of electronic logging devices (ELDs) was made mandatory for commercial bus and truck drivers (FMCSA, 2015). NHTSA has also developed a prototype drowsy driver warning system that appears promising in reducing drowsiness among drivers of heavy vehicles (Blanco et al., 2009; Brown et al., 2014).

Drowsy driving may result from lifestyles that include insufficient or irregular sleep (shift workers, for instance) or from medical conditions beyond a driver's immediate control. For example, a recent CDC study in 29 States found that people in certain occupational groups—production, healthcare support, healthcare practice, food preparation, protective services, and some transportation services—were more at risk for having short sleep duration of less than 7 hours each day (Shockey & Wheaton, 2017). Moreover, studies indicate that drivers themselves are poor judges of the performance decrements that result from drowsiness (Powell & Chau, 2011). A change in the social perception of sleep and public awareness about the risks of drowsy driving are necessary to change a driver's decisions to drive when drowsy (Higgins et al., 2017).

In 2015 NHTSA hosted a forum bringing together the traffic safety and sleep science communities called *Asleep at the Wheel: A Nation of Drowsy Drivers* (Higgins et al., 2017). The objective was to address drowsy driving through an interdisciplinary approach. As a result of the Forum, NHTSA released the *Drowsy Driving Research and Program Plan* in 2016 and, later, *Asleep at the Wheel: A National Compendium of Efforts to Eliminate Drowsy Driving* (NHTSA, 2017). Together, the publications describe projects quantifying the drowsy driving problem. Additionally, they also examine various efforts to build public awareness and education, develop policy; explore efforts at identifying high-risk populations, and look at advancing vehicle technology and infrastructure as countermeasures (Higgins et al., 2017; NHTSA, 2016; NHTSA, 2017).

Other Federal agencies are also concerned about the drowsy driving problem. The NTSB reported that about 36 major transportation investigations from 2001 to 2012 identified fatigue as a potential cause or contributing factor; this included approximately 14 highway incident investigations (Fischer, 2016; Marcus & Rosekind, 2017). The NTSB added "human fatigue" as an issue in its *Most Wanted List of Transportation Safety Improvements* in 2016 (Fischer, 2016).

Behavioral strategies for drowsy driving focus on removing some of the underlying causes or promoting awareness of the risks. Drowsy driving that is related to a driver's job may be reduced through employer policies and programs. Drowsy driving caused by medical conditions, such as obstructive sleep apnea, or by drugs or medications may be addressed through policies, communications, and outreach. Similarly, communications and outreach may be useful in raising awareness of specific drowsiness issues among certain high-risk populations. However, few studies have examined whether the standard behavioral countermeasures of laws, enforcement, and sanctions (which are used successfully for alcohol impairment, seat belt use, aggressive driving, and speeding) are effective for drowsy drivers.

There are a variety of environmental and vehicular strategies to address drowsy driving. Rumble strips, both on the shoulder and the centerline, have demonstrated their effectiveness in preventing crashes associated with inattention or drowsiness (Persaud et al., 2016). Other roadway improvements, such as wide and visible edge lines, more easily visible road signs, and better lighting at night can help drivers who are not fully alert, particularly due to sleepiness. These strategies are not discussed further in this chapter because they do not fall under the purview of SHSOs.

Data/Surveillance

Even though estimates from crash data provide a useful picture of the risk of driver drowsiness (Tefft, 2016), it is often difficult to determine whether drowsy driving contributed to a crash. Like distracted driving, drivers may be reluctant to admit they dozed off following a crash. Data estimates that 2% to 20% of annual traffic deaths are attributable to driver drowsiness, according to the NHTSA *Drowsy Driving Research and Program Plan* (NHTSA, 2016). However, researchers have inferred the existence of additional drowsy-driving crashes by looking for correlations with related factors such as the number of passengers in the vehicle, crash time and day of week, sex of the driver, and crash type. A study by the AAAFTS, using data from 1999 to 2013, found that driver drowsiness may have contributed to 6% of all crashes and 21% of fatal crashes (Tefft, 2014). Using the number of fatal crashes in 2021 (39,508) and percentage of driver drowsiness that may have contributed to these fatal crashes (21%), this estimate suggests that more than 8,300 people may have died in drowsy-driving-related motor vehicle crashes across the United States in 2021.

Naturalistic driving studies (NDSs) may help us understand the associations between driver drowsiness and crash risk. One recent study by the AAAFTS used the Strategic Highway Research Program 2 (SHRP2) NDS data to estimate the prevalence of driver drowsiness immediately before a crash (Owens et al., 2018). Drowsiness was assessed as the percentage of time a driver's eyes were closed. A total of 701 crashes were examined. Estimates show that drowsiness may have been a contributing factor in 8.8% to 9.5% of all crashes examined and in 10.6% to 10.8% of crashes that resulted in air bag deployment, significant property damage, or injury (Owens et al., 2018).

Emerging Issues

Vehicular strategies that hold promise for reducing crashes among drivers who are drowsy include collision avoidance technologies such as lane departure warning, crash-imminent braking, and forward collision warning, and vehicle-to-vehicle and vehicle-to-infrastructure communications technologies (IIHS, 2012; IIHS, 2014). Such technologies, once available only in luxury brands, are now offered in many new vehicles.

Additionally, in-vehicle technologies are available and being further developed to detect driver drowsiness by monitoring driver performance and then warning drivers (Brown et al., 2014; May & Baldwin, 2009; Papadelis et al., 2007; Sahayadhas et al., 2012). When first introduced, driver State monitoring systems (DSMs) were activated only when a certain ADAS was activated. DSMs can now be used independently of ADAS. Manufacturers of such systems use a variety of techniques to monitor the driver such as pressure on the steering wheel and number of lane departures. More sophisticated systems monitor eye blinks. Although SHSOs are limited in their ability to implement this technology, it is promising in that it provides a potential measure of the behavioral effectiveness of programmatic-based strategies to reduce drowsy driving.

Key Resources

For information about the contribution of drowsy driving to crashes, see the following.

- AAAFTS:
    - Prevalence of drowsy-driving crashes: Estimates from a large-scale naturalistic driving study (Owens et al., 2018).
    - Prevalence of motor vehicle crashes involving drowsy drivers, United States, 1999-2013 (Tefft, 2014).
    - Acute sleep deprivation and risk of motor vehicle crash involvement (Tefft, 2016).

For more information about drowsy driving countermeasures, see:

- GHSA: Wake up call! Understanding drowsy driving and what States can do (Fischer, 2016).
- NHTSA: Drowsy Driving Research and Program Plan (NHTSA, 2016).
- NHTSA: Asleep at the wheel: A National compendium of efforts to eliminate drowsy driving (NHTSA, 2017).

For drowsy driving laws, see the following.

- Governor’s Highway Safety Administration: *Drowsy driving* (GHSA, n.d. -b)

Drowsy Driving Countermeasures

Legislation and Licensing

Countermeasure	Effectiveness	Cost	Use	Time
Graduated Drivers' Licensing Intermediate License Nighttime Restrictions	★★★★★	$	High	Medium

Enforcement

There are no countermeasures in this category.

Other Strategies for Behavior Change

Countermeasure	Effectiveness	Cost	Use	Time
Employer Programs	★★	Varies	Unknown	Short
School Start Times	★★	Varies	Low	Long

Approaches That Are Unproven or Need Further Evaluation

Countermeasure
Communications and Outreach on Drowsy Driving
Education Regarding Medical Conditions and Medications
General Driver Drowsiness Laws

Effectiveness:

★★★★★	Demonstrated to be effective by several high-quality evaluations with consistent results.
★★★★	Demonstrated to be effective in certain situations.
★★★	Likely to be effective based on balance of evidence from high-quality evaluations.
★★	Limited evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.
★	No evaluation evidence, but adheres to principles of human behavior and may be effective if implemented well.

Cost to implement:

$$$	Requires extensive new facilities, staff, equipment, or publicity, or makes heavy demands on current resources.
$$	Requires some additional staff time, equipment, facilities, and/or publicity.
$	Can be implemented with current staff, perhaps with training; limited costs for equipment or facilities.

These estimates do not include the costs of enacting legislation or establishing policies.

Use:

High	More than two-thirds of the States, or a substantial majority of communities
Medium	One-third to two-thirds of the States or communities
Low	Less than one-third of the States or communities
Unknown	Data not available

Time to implement:

Long	More than 1 year
Medium	More than 3 months but less than 1 year
Short	3 months or less

These estimates do not include the time required to enact legislation or establish policies.

Legislation and Licensing

Graduated Driver Licensing Intermediate License Nighttime Restrictions

Effectiveness: ★★★★★ **Cost:** $ **Use:** High **Time:** Medium

Driving at night is associated with a higher fatal crash risk than during the day for teen drivers (McCartt & Teoh, 2015), and may pose greater risks of drowsy driving. Several studies suggest that drivers 16 to 24 years old are somewhat more likely than other age groups to drive while drowsy (Royal, 2003; Wheaton et al., 2014). An NCHRP guide for reducing crashes involving young drivers describes the key provisions of GDL systems, including nighttime restrictions (Goodwin et al., 2007). The IIHS and the GHSA have summarized State GDL laws (GHSA, n.d.-a; IIHS, 2022). These summaries are updated monthly. See the Young Driver Chapter for a complete discussion of GDL for beginning young drivers.

Other Strategies for Behavior Change

Employer Programs

Effectiveness: ★★ **Cost:** Varies **Use:** Unknown **Time:** Short

Drowsy driving can be linked to the characteristics of a person's job. Shift workers are one employment group at high risk for drowsy-driving crashes. This includes people who work long or irregular hours or who work at night. There are different types of shift work that contribute to drowsiness, including displaced work hours, roster work, and rotating shift work (Åkerstedt, 2019). Of these three types, the Sleep Foundation finds that rotating shift work is the most problematic (Pacheco & Singh, 2022). Professions such as medical workers, manufacturing, and first responders are jobs that include shift work (Stutts et al., 2005; Pacheco & Singh, 2022).

Those in the medical field can be at risk for higher crash rates, including nurses, interns, and EMS and support staff. Barger et al. (2005) studied medical interns, who frequently work extended shifts of 24 hours or more, by collecting monthly reports from 2,737 interns. Barger and colleagues found that medical interns were 2.3 times more likely to report a crash and 5.9 times more likely to report a near miss after an extended shift than a shorter shift. Each extended shift in a month increased the monthly risk of a crash during the commute from work by 16%. In one driving simulator study, anesthesiology residents were found to have significant increases in reaction times, attention lapses, impairments in speed and lane position maintenance, and increased risk of collisions after 6 consecutive night shifts (Huffmyer et al., 2016).

NHTSA's *Fatigue in EMS Project* aimed at providing evidence-based guidelines to manage fatigue in EMS personnel. The recommendations included the use of sleepiness survey instruments to measure and monitor fatigue, limiting shifts to a maximum of 24 hours, access to caffeine as a countermeasure (although they cautioned against excessive caffeine consumption), allowing personnel the opportunity to nap while on duty, and education and training of EMS personnel to prevent and mitigate fatigue-related risks (Martin-Gill et al., 2018; Patterson et al., 2018; Patterson & Robinson, 2019).

Commercial drivers are also at risk for drowsy-driving crashes. One study of 96 truck drivers found that safety critical driving events were associated with a sleep pattern of shorter sleep duration, less sleep from 1 a.m. to 5 a.m., and sleep in the early stages of the non-work period preceding the work-related driving (Chen et al., 2016). There are many ways States can work with trucking companies to address drowsy driving. In general, work culture, adherence to hours of service rules, and employer-provided interventions and education can help address drowsy driving, including testing for medical conditions. One study found that treating obstructive sleep apnea in drivers was cost effective for trucking companies overall. Aside from reducing crash risk, it lowered overall health care expenses by $550 a month for each driver (Gurubhagavatula & Sullivan, 2019).

Even those who might not fall under one of the categories mentioned above are at risk for drowsy driving. In 2008 the NSF conducted a survey of 1,000 U.S. residents who were employed full time. Those who work 50 or more hours per week were three times as likely to report driving drowsy on a weekly basis compared to those who work 30 to 40 hours per week (Swanson et al., 2012).

There are a few organizations engaging in employer program outreach. NSF provides material for publicizing Drowsy Driving Prevention Week and information on managing shift work schedules (Pacheco & Singh, 2022). NHTSA and the National Center on Sleep Disorders Research (NCSDR) produced a comprehensive workplace education program for shift workers called *Wake Up and Get Some Sleep*. It includes information on sleep habits and, in particular, drowsy driving. Program material includes a video, posters, brochures for workers and their families, tip cards, a PowerPoint training session, and an administrator's guide (NHTSA/NCSDR, 1998).

Use:

No summary of current programs exists.

Effectiveness:

There are few studies of the effectiveness of drowsy driving employer programs, and it is unknown the extent to which any drowsy driving programs have been evaluated by the employers implementing them.

The NHTSA/NCSDR program was tested by more than 20 U.S. companies and was well received by workers and management, but its effect on crashes was not evaluated (Stutts et al., 2005).

A study by Adamos and Nathanail (2019) evaluated an intervention educating Greek truck drivers about strategies to alleviate drowsy driving and then monitoring them to see if they applied this knowledge using GPS and self-report. Using data collected before and after the program, they found that knowledge of strategies for decreasing crash risk increased but behaviors did not change.

In sum, there is insufficient evaluation data available to determine the effectiveness of the countermeasure for knowledge acquisition or, more importantly, producing behavior change. The Adamos and Nathanail (2019) study demonstrates the difficulty of implementing an intervention that results in real behavior change.

Cost:

NHTSA and the National Center on Sleep Disorders Research program is available at no cost. It is not known how much private companies spend on education programs. Additional expenses, beyond the programmatic costs, could be added if the employer chooses to use medical condition testing.

Time to implement:

Unknown

School Start Times

Effectiveness: ★★	**Cost:** Varies	**Use:** Low	**Time:** Long

Teens are less experienced at the task of driving, requiring more of their deliberate attention than is the case for experienced drivers (Lansdown, 2002). Several studies suggest that drivers 16 to 24 are somewhat more likely than other age groups to drive while drowsy (Royal, 2003; Wheaton et al., 2014). In a 2006 survey by the NSF (2006), 51% of 552 young drivers (grades 10 to 12) reported driving at least once while drowsy. One countermeasure that could reduce drowsy driving by teens is delaying high school start times.

Adolescents undergo a circadian cycle change known as "phase delay" whereby they experience sleepiness later in the evening and later wake times (Adolescent Sleep Working Group, Committee on Adolescence, & Council on School Health, 2014). The American Academy of Pediatrics recommends that teens get 8.5 to 9.5 hours of sleep per night. However, because of biological processes associated with changes in their circadian cycle in addition to societal factors such as homework and electronic device use, teens go to bed later, making it hard for them to get the full recommended hours of sleep. This leads to chronic sleep loss. In a 2014 policy statement, the American Academy of Pediatrics' Adolescent Sleep Working Group recommended that one countermeasure to this problem is to delay high school start times.

In addition to improvements such as an increased attendance, improved grades, and less daytime sleepiness (Wheaton et al., 2016), research also shows that there is a reduction of teen driver motor vehicle crashes when high school start times are delayed. Danner and Phillips (2008) found that average crash rates for teen drivers in one school district in Kentucky were reduced by 16.5% after the delay in school start time. In a 2011 study done by Vorona et al., 16- to 18-year-olds in one Virginia county with later school start times were less likely to crash than in the neighboring county with earlier school start times. A 2019 study by Foss et al. also showed a decrease in crashes, albeit small, in 16- to 17-year-olds. Finally, a study looking at Fairfax County, Virginia, found a reduction in crashes in 16 to 18-year-old drivers when a 50-minute delay was implemented in high school start times (Bin-Hasan et al., 2020).

Use:

It is unclear how many school districts have or implemented later high school start times. In 2018, the National Center for Education Statistics (NCES) mapped out the average public high school start times throughout the United States. However, it is only a statewide average and does not distinguish the actual high school start times by district (NCES, 2020). Yip et al. (2022) did a meta-analysis and determined that the optimal high school start times were from 8:30 a.m. to 8:59 a.m. Only South Carolina (average start time of 8:34 a.m.) and the District of Columbia (average start time of 8:41 a.m.) fell within the optimal timeframe. In 2019 California mandated that high school begin no earlier than 8:30 a.m. as of July 2022.

Effectiveness:

Delayed high school start times are associated with some reduction in teen driver crashes. However, research completed to date could not determine whether a reduction in teen drowsiness is the main causal mechanism at work (Bin-Hassan et al., 2020; Foss et al., 2019). Further studies are needed to examine the causal relationship between teen drowsiness, crash reduction, and later high school start times.

Cost:

The cost of changing school start times depends on a multitude of factors. The policy change itself is not expensive; it is the cascading effects of the change that may make later start times difficult to implement. Things that may make the change difficult to implement include changing bus schedules and routes, rescheduling after school activities, and other administrative costs. In the case of Fairfax County, Virginia, the projected cost was $5 million dollars (Rosenberg, 2015). However, in the case of Edina, Minnesota, they were able to make the changes that resulted in no "additional cost" according to the district superintendent at the time.

Time to implement:

Much like cost, the implementation of changing high school start times would vary throughout the United States and may require policy change at either the local or State level. For example, in 2019 the State of California passed *Pupil attendance: school start time*, Senate Bill No. 328 stating, "The school day for high schools, including high schools operated as charter schools, shall begin no earlier than 8:30." However, in other localities, the change came from the school district superintendent such as in the case of Edina. The time from conception to implementation varied. The California law was signed in October 2019 by the governor and came into effect in July 2022 (*Pupil attendance*), while in the case of Edina, it took 6 months (Rosenberg, 2015).

Approaches That Are Unproven or Need Further Evaluation

Communications and Outreach on Drowsy Driving

States including Iowa, Texas, New York, and Utah and national organizations such as NSF have conducted drowsy driving communications and outreach campaigns directed to the public (Fischer, 2016; Stutts et al., 2005). Campaign goals usually include raising awareness of the dangers of drowsy driving; motivating drivers to take action to reduce drowsy driving; and providing information on what drivers can do, either before they start out on a trip or if they become drowsy while driving. The GHSA summarizes public awareness efforts by NHTSA, the AAAFTS, and the AASM in its 2016 report to States (Fischer, 2016). The focus is on the development of evidence-based messages on the risk of driver drowsiness, implementation or enhancement of employer-provided policies and education, and the development of web-accessible awareness material for the general population.

The goal of drowsy driving communications and outreach is to change driver behavior; however, there are substantial obstacles. As discussed in other chapters, communications and outreach by themselves rarely change driving behavior. To have any chance of success, stand-alone campaigns must be carefully pre-tested, communicate health information not previously known, be long-term, and have substantial funding (Williams, 2007).

Drowsy driving messages may compete with other priorities conflicting with a driver getting enough sleep. Focus group discussions with young men and shift workers, two groups at high risk of drowsy driving, supported this conclusion (Nelson et al., 2001). Most shift workers and many young men understood well the risks caused by lack of sleep. Many had crashed or almost crashed after falling asleep at the wheel or had friends who had crashed. But neither their knowledge nor their crash experience changed their sleep habits. They sacrificed sleep for the demands of their work, families, and social lives.

A couple of studies have found messaging to be somewhat effective in the case of drowsy driving. However, the results should be interpreted with caution. In Greece a national communication campaign was implemented in 2008 and 2009 to curb drowsy driving. Titled *Sleep, but not at the wheel*, the campaign was designed to raise awareness of the risks of driving while tired, and to increase knowledge of effective countermeasures to reduce fatigue (e.g., taking short breaks while driving). The campaign included thousands of TV and radio messages, as well as posters and leaflets distributed across the country (Adamos et al., 2013). The study's conclusion was that it raised awareness, but there was no objective measure of behavior change.

In a more recent study, Rahman and Kang (2020) examined the effect of a drowsy driving advisory system on two rural stretches of highway in Alabama. They found that using a combination of messaging in the form of roadside signs before a rest area reduced drowsy driving crashes from pre-intervention levels by 64% in one location. However, the signs were used in combination with the rest stops, so any intervention of this kind would need to be conducted with infrastructure already in place.

The goal of an awareness-raising campaign is to influence the behavior of an individual through information and education. This approach presumes that the audience lacks the information and that simply learning the information will be sufficient to change behavior. However, this approach fails to consider or address the other factors that influence the behavior (e.g., work schedules, family responsibilities, etc.).

Education Regarding Medical Conditions and Medications

Several chronic medical conditions and sleep disorders can potentially compromise sleep and elevate feelings of fatigue (Smolensky et al., 2011). Three disorders, in particular, can cause drivers to fall asleep at the wheel. Insomnia is the subjective experience of having difficulty falling asleep or staying asleep. It affects an estimated 11% of the U.S. population (NSF, 2008). People suffering from insomnia often report daytime sleepiness that interferes with their daily activities. Several studies suggest that people suffering from insomnia are two to three times more likely to be involved in motor vehicle crashes compared to those without insomnia (Smolensky et al., 2011).

Obstructive sleep apnea is a breathing disorder characterized by brief interruptions of breathing during sleep (Punjabi, 2008). By fragmenting nighttime sleep, sleep apnea produces daytime sleepiness. NSF estimates that about 4% of men and 2% of women are affected by sleep apnea. It can be treated by physical or mechanical therapy or by surgery. Research shows that people with sleep apnea are up to six times more likely to be involved in a crash (Teran-Santos et al., 1999). It has been estimated that crashes among people with obstructive sleep apnea cost approximately $16 billion each year (Sassani et al., 2004).

Narcolepsy is a disorder of the central nervous system's sleep-wake mechanism that can cause narcoleptics to fall asleep suddenly at any time (Suni & DeBanto, 2021). It is quite rare, affecting about one person in 2,000 and can be treated with medications. The number of crashes resulting from narcolepsy is not known.

Most cases of obstructive sleep apnea or narcolepsy are undiagnosed and untreated (Stutts et al., 2005; NHTSA, 1998). Indeed, falling asleep at the wheel may be one of the main ways to raise the possibility of a sleep disorder and motivate a driver to seek medical attention (NHTSA, 1998). Once treated, people with obstructive sleep apnea have crash rates that are no higher than the general population (George, 2001).

Aside from the three sleep disorders mentioned above, there are many other medical conditions that can potentially compromise sleep or increase daytime feelings of fatigue such as asthma, chronic obstructive pulmonary disease, and rheumatoid or osteoarthritis.

Many common prescription and over-the-counter medications can also cause drowsiness. One study of the sedative Zolpidem by drivers 70 and older in Alabama found increased at-fault crash rates in women and drivers 80 or older when compared with non-users (Booth et al., 2016). Warning labels on the medications note this and caution users against driving or other activities that could be affected by drowsiness.

The principal countermeasures to address medical conditions and medication effects are (Stutts et al., 2005):

- Communications and outreach on sleep disorders to increase overall awareness of their symptoms, consequences, and treatment.
- Efforts with driver licensing medical advisory boards to increase their awareness of these conditions as they review driver fitness for licensing.
- Efforts with physicians to increase their awareness of these conditions and their potential effects on driving, to treat these conditions as appropriate, and to counsel their patients to take steps to reduce the risk of drowsy driving.

Additionally, it is important that pharmacies and drug makers include patient education about the potentially impairing effects of certain medications on driving (Smith et al., 2018). Prescription labeling by drug makers, as well as incorporation of electronic prompts when dispensing medication, can be other promising opportunities for patient education (Smith et al., 2018). One survey study found that while pharmacists generally provide warnings on sedatives and narcotics to many patients (about 85% of 7,405 people surveyed), fewer people receive warnings on antidepressants (62.6%) and stimulants (57.7%) (Pollini et al., 2017).

Education campaigns can be hard to evaluate due to the difficulty in measuring behavior change. It is unclear from the limited literature that any of these efforts results in people engaging in strategies to minimize the effects of their medical condition or medicine. Raising awareness about the risks is not necessarily the same as teaching mitigation skills and then having people implement them.

General Driver Drowsiness Laws

This countermeasure involves laws that specifically target the issue of drowsy drivers. For example, a law could permit drivers to be prosecuted for vehicular homicide if they have not slept in 24 hours and they cause a crash in which someone is killed.

As of February 2022 New Jersey and Arkansas are the only States with laws explicitly addressing drowsy driving (GHSA, n.d.-b).

Laws that specifically target drowsy drivers are not widely used, and this countermeasure has not been systematically examined. There is insufficient evaluation data available to determine the effectiveness of the countermeasure.

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