NCHRP REPORT 622

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Effectiveness of Behavioral Highway Safety Countermeasures

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

N A T I O N A L C O O P E R A T I V E H I G H W A Y R E S E A R C H P R O G R A M

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Effectiveness of Behavioral Highway Safety Countermeasures

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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FOREWORD

By Charles W. Niessner
Staff Officer
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This report presents the findings of a research project to develop a framework and guidance for estimating the costs and benefits of emerging, experimental, untried, or unproven behavioral highway safety countermeasures. This report will be of particular interest to safety practitioners responsible for the development and implementation of the state's Strategic Highway Safety Plan.

In 2006, the U.S. DOT reported 42,642 fatalities and nearly 3 million injuries resulting from highway crashes nationwide. The National Highway Traffic Safety Administration (NHTSA) estimates that highway crashes cost society more than $230 billion a year. To reduce injuries, fatalities, and other costs, billions of dollars are invested every year to engineer and construct improved and safer infrastructure, enforce traffic safety laws, and educate users of the nation's highway system on safe practices.

Each year, hundreds of millions of these dollars are spent on behavioral highway safety countermeasures without sufficient knowledge of their benefits. The lack of sound information on the efficacy and costs of behavioral safety countermeasures such as public awareness campaigns, new safety program start-ups, and enforcement programs impedes effective decision making.

With limited resources and the duty to ensure public accountability in the use of funds available for behavioral highway safety programs, there is a need to provide decision makers with additional information to determine the countermeasures that will result in the greatest reductions of crashes, injuries, and fatalities.

Under NCHRP Project 17-33, "Effectiveness of Behavioral Highway Safety Countermeasures," researchers at the Preusser Research Group, Inc., developed a framework and guidance for estimating the costs and benefits of emerging, experimental, untried, or unproven behavioral highway safety countermeasures.

The researchers reviewed the behavioral countermeasures included in the report: *Countermeasures that Work: A Highway Safety Countermeasure Guide for State Highway Offices*. This report was prepared for the NHTSA by the Governors Highway Safety Association. The 104 countermeasures in the report were divided into four groups: proven to be effective, likely to be effective, unlikely to be effective or the effects are unknown, and known to have negative consequences. Effectiveness estimates were developed for a number of the proven to be effective countermeasures.

The report includes a classification scheme to estimate the effectiveness of countermeasures that are believed "likely" to work but for which evaluation evidence is not yet available, as well as emerging and developing countermeasures that have not yet been fully implemented or evaluated. Guidelines are presented for estimating when countermeasures within each of these classifications are likely to be cost effective.

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SUMMARY

Effectiveness of Behavioral Highway Safety Countermeasures

The goal of this project is to assist states in selecting programs, projects, and activities that have the greatest potential for the reduction of highway death and injury. The specific objectives are as follows:

> Produce a manual for application of behavioral highway safety countermeasures and develop a framework and guidance for estimating the costs and benefits of emerging, experimental, untried, or unproven behavioral highway safety countermeasures.

There are 104 countermeasures in *Countermeasures That Work: A Highway Safety Countermeasure Guide for State Highway Safety Offices* (NHTSA, 2007b). Of these, 34 have been "proven" effective. These countermeasures should be implemented whenever feasible, practical, and politically acceptable. Many involve little direct cost either because the primary effort involves passage of a law (e.g., universal mandatory motorcycle helmet law, bicycle helmet law for children, primary seat belt law, graduated driver licensing) or because they are revenue neutral "user pay" (e.g., alcohol interlock, speed cameras, and red-light cameras). Some countermeasures rated Proven do involve direct costs for their implementation. Benefit/cost calculations indicate that most will produce a positive benefit/cost ratio for most states (e.g., booster seat promotions, sobriety checkpoints, short-term high-visibility belt use enforcement).

Estimated effectiveness for 54 of the 104 countermeasures is rated as Unlikely/Uncertain or Unknown. Three countermeasures have actually been shown to have negative consequences. All of these countermeasures should be avoided at least until more evidence becomes available.

In between the Proven countermeasures and the Unlikely/Uncertain/Unknown, fall 13 countermeasures that are believed "likely" to work but for which evaluation evidence is not yet available, as well as emerging and developing countermeasures that have not yet been fully implemented, let alone evaluated. This report provides the following classification scheme to estimate the effectiveness of these measures:

1. Voluntary action (countermeasures that are designed to train, educate, or request some behavior);
2. Law or regulation (require the behavior);
3. Laws plus enhancements (high-visibility enforcement of the law); and
4. Sanctions and treatments of offenders.

Guidelines are presented for estimating when countermeasures within each of these classifications are likely to be cost effective.

CHAPTER 1

Introduction

A significant part of highway safety program activities is devoted to behavioral countermeasures. These include the entire driver control system—from training and licensing to laws and enforcement and sometimes culminating in fines and sanctions. Given the enormous cost of crashes and the importance of driver behavior in highway loss reduction, it is important that behavioral countermeasures be implemented as effectively as possible.

It is a challenge to accomplish this goal. Driver behavior can be changed, although this is not easily accomplished. Some behavioral countermeasures are effective; others, including some that are popular and widely used, are not effective. There are many complexities in assessing behavioral countermeasures. Some that may not be effective on their own (e.g., certain public information programs) can be an essential feature when combined with other elements. Some programs that may be described the same way (e.g., public information/education programs encouraging bicycle helmet use) can be widely different in ways that make one program effective, another not. Moreover, among measures that are effective, there is a wide range in how much they reduce the problem, depending on the effect size (e.g., a 5% versus a 25% reduction in highway deaths), the size of the population to which the measure applies, and the expected duration of the effect. There also can be wide differences in program costs, both monetary and nonmonetary.

All of these issues, as well as others, are covered in this report. The intention is to develop a roadmap for states, a best practices guide for the use and assessment of behavioral countermeasures. In doing so, all such countermeasures that are used or could be used by states are considered, and information on the cost and/or effectiveness is indicated when available.

Chapter 2 provides background information on countermeasures and Chapter 3 lists behavioral countermeasures by logical groupings in terms of the behavior change approach used. Countermeasures within each group are separated into those that work in terms of reducing the highway safety problem, and those that do not or for which the evidence is uncertain or unknown. In subsequent chapters, the cost benefit parameters for proven effective countermeasures are calculated and analyses of why certain programs work and others do not are presented and draw on behavior change principles derived from the scientific literature.

This report aims to provide states with a framework for an evaluation of their current program in terms of countermeasures in use and those that might be used. The delineation of behavior change principles indicating what works and what does not also provides a means of assessing the likely contribution of emerging, experimental, untried, or unproven behavioral safety measures.

CHAPTER 2

Countermeasures

Behavioral countermeasures considered in this document are derived primarily from *Countermeasures That Work: A Highway Safety Countermeasure Guide for State Highway Safety Offices* (NHTSA, 2007b). The report was intended to include all countermeasures relevant to state programs in the following areas: alcohol-impaired driving, safety belts, aggressive driving and speeding, distracted and fatigued driving, motorcycle safety, young drivers, and elderly drivers. Excluded are measures already in place in every state (e.g., 0.08 blood alcohol concentration [BAC] laws). The original report did not include countermeasures involving pedestrians and bicycles, but they have been added for the 2007 update of that document. The present report includes these countermeasures, with some adjustments (e.g., booster seat promotions, a new type of program, was added).

The effectiveness of each countermeasure listed in *Countermeasures That Work* was assessed in terms of reductions in crashes or injuries, or improvements in some intermediate measure, such as arrests or successful prosecutions. The rating categories were defined as follows:

- Proven—consistent positive evidence from several high-quality evaluations,
- Likely—balance of evidence from high-quality evaluations or other sources,
- Uncertain—limited and ambiguous evidence,
- Unknown—no high-quality evaluation evidence, or
- Varies—different methods of implementing the countermeasure produce different results.

The Varies rating was usually applied when there were discretely different types of approaches in use (e.g., the countermeasure "alcohol sanctions" included license suspension, fines, and jail). These separate actions have been considered individually in this NCHRP report. Considering separate actions individually in other cases has resulted in the elimination of the Varies rating. Otherwise, the Hedlund effectiveness ratings have been retained, with occasional adjustments and updates. For example, *Countermeasures That Work* (NHTSA, 2007b) included studies through June 2006; since that time, there has been enough new information on passenger restrictions for teenage drivers to rate them as Proven.

In total, there are 104 separate countermeasures: 33 in the alcohol area; 13 for young drivers; 11 for occupant restraints; 10 for pedestrians; 9 each for bicycles and motorcycles; 7 for elderly drivers, and 6 each for distracted/fatigued drivers and for aggressive drivers/speeding.

Countermeasures That Work (NHTSA, 2007b) also included information on implementation costs, which is used as a starting point in the present analyses. The cost ratings are defined as follows:

- High—requires extensive new facilities, staff, equipment, or publicity, or makes heavy demands on current resources;
- Medium—requires some additional staff time, equipment, facilities, and/or publicity; and
- Low—can be implemented with current staff, perhaps with training; limited costs for equipment, facilities, and publicity.

Information in *Countermeasures That Work* was presented by topic area (alcohol-impaired driving, safety belts, etc.). This NCHRP report cuts across topic areas. Here, countermeasures are classified according to their behavioral change technique (e.g., education, laws, enforcement). This report also extends the Hedlund work in providing metrics for the countermeasures classified as Proven. That is, where possible, an indication of the effect size of the countermeasure is provided (e.g., 10% crash reduction), as well as the target population and likely duration of the effect. Information on monetary costs, including benefit/cost ratios, is also provided whenever possible.

One problem encountered in conducting this research was that high-quality evidence concerning effectiveness is often lacking. Ideally, for every countermeasure in use, it should be known if it was effective. That is not the case. Of the more than 100 countermeasures considered, about half are rated as Uncertain or Unknown. However, both the uncertains and the unknowns can be assessed in terms of whether they are likely to work, based on the principles derived from those countermeasures known to work and known to be ineffective. This same procedure can be used to gauge the likely contribution of new and untried countermeasures.

CHAPTER 3

Countermeasure Classification

Behavioral change techniques used in highway safety countermeasures basically fall into one of the following four categories:

1. Voluntary action (public information, education, mass media, training);
2. Laws, regulations, policies;
3. Laws plus enhancements (enforcement plus publicity); or
4. Sanctions and treatments (fines, points, jail, alcohol school, license suspension).

Changing Driver Behavior

There are many issues and challenges that need to be considered with respect to changing driver behavior. One issue is that safe driving practices and protective behaviors (such as helmet use) have to be practiced on each trip. Measures that have only a short-term effect with no lasting behavioral change contribute little. Long-term effects are much harder to achieve than immediate ones, and some behaviors are more difficult to implement than others. For example, converting motorcyclists to helmet use requires them to purchase a helmet and always wear it, which may seem uncomfortable and intrusive. Potential users may be opposed to helmet use for intellectual and emotional reasons. In comparison, wearing an already available seat belt, which is less intrusive than a helmet, should be an easy sell.

In general, most people know what they are supposed to do on the highway in terms of safe driving practices; it is not a matter of lack of knowledge. What people actually do, however, is guided by attitudes, motivations, lifestyle factors, and assumptions about risk. Veteran drivers have well-developed habits that pose a challenge to change. Moreover, from risk perception research it is known that in very familiar activities such as driving, there is a tendency to minimize the possibility of bad outcomes as a way of allaying personal concerns (Douglas, 1985). People underestimate risks that are supposed to be under their control, insulating themselves by creating "illusory zones of immunity" around everyday activities (Jasanoff, 1998). This sense of subjective immunity is bolstered by the belief of most people that their own driving skills are superior (Williams, Paek, and Lund, 1995). Crashes happen, but to *other drivers*; the highway safety problem is a problem of the *other driver*. We want those *other drivers* to behave on the highways since they are a threat to us and, in that context, safety messages are for *them*, not us. In general, people have an optimistic bias, thinking that they are less likely than others to suffer misfortunes (Maibach and Holtgrave, 1995). Therefore, it is not surprising that this so-called "third-person effect" is found in a number of health realms. People viewing health messages believe the message is for others, not themselves (Davison, 1983). This is likely to be even more of a factor in regard to highway safety, given the psychological tendency of people to protect themselves by minimizing the possibility of harm to themselves resulting from the everyday activity of driving.

Finally, crashes, especially those that produce injuries, are extremely rare events per mile driven. Speeding, driving while impaired, running red lights, and other dangerous and illegal behaviors generally have no downside. In this sense, drivers are rewarded every time they complete a trip involving these actions. All of these factors, taken together, pose significant barriers to influencing driving behavior.

That said, some groupings can be expected to have more effective countermeasures than others. For example, laws are generally more effective than requesting voluntary actions in terms of producing behavior change; enhanced laws should be more effective than laws alone. Within each of the four categories, however, some countermeasures work and some do not.

Cautions About the Countermeasures

As indicated earlier, one issue in determining the effectiveness of a countermeasure is that one type of program or approach involving that specific countermeasure may work, and another may not. This can happen in all four of the countermeasure groupings. For example, in the laws area, it is possible that a law that works in one state will not work in another, since laws (e.g., seat belt laws, administrative license revocation [ALR] laws) vary in terms of coverage and penalties. In the laws/enhancements area, enforcement programs can vary in intensity and duration, and may be differentially effective. In the treatment/sanctions area, alcohol treatment programs can differ markedly. However, this is most likely to be an issue in the grouping for voluntary actions only where programs promoting a specific action can vary widely, ranging from a passive public information campaign based on materials sent through the mail to multiple face-to-face interactions involving sophisticated behavior change models, and possibly involving other inputs. The latter may work; the former may not.

Another warning concerning effectiveness ratings was raised in *Countermeasures That Work* (NHTSA, 2007b), namely that evaluation studies generally examine and report on high-quality implementations of countermeasures, so that the effectiveness data are likely to show the maximum effect that can be realized. That is, the countermeasure in question may not work, or work as well, with lesser efforts. Also, it should be noted that while a particular approach may not work by itself, it may facilitate acceptance of an approach that will reduce injury (e.g., public information and education [PI&E] may affect public acceptance making passage of a law more likely).

The remainder of this chapter will discuss each countermeasure category in turn, along with the criteria derived that distinguish effective and ineffective countermeasures within that category. Then, each countermeasure within that group will be rated as follows:

- Proven effective;
- Likely to be effective;
- Effectiveness is Unknown/Uncertain/Unlikely; or
- In a few cases, Proven Not to Work.

Countermeasure Categories

Class 1: Voluntary Action

A popular approach in the behavioral field has been to urge people to take appropriate actions through public information, educational programs, mass media, and training used alone. Given the barriers to change discussed earlier, it is not easy to change driver behavior in this manner. This subject is treated extensively in *Public Information and Education in the Promotion of Highway Safety* (Williams, 2007a), which forms the basis for the following discussion.

Most of the countermeasures in the Voluntary Action Group involve communications. Historically, many of these efforts have been of poor quality, consisting of passive messaging, sloganeering, exhorting people to do—or not do—some behavior, and delivered to an undifferentiated audience over the short term. The simplistic assumption is that if individuals are made aware of behaviors that will enhance their personal health or safety and urged to adopt these behaviors, they will do so. Seemingly logical, this sequence of events is unlikely to happen. It is well established that information-only programs are unlikely to work, especially when most of the audience already knows what to do. Therefore, highway safety messages conveyed in signs, pamphlets, brochures, on buttons, etc. may increase awareness of the health issue being addressed and reinforce social values, but are unlikely to have any effect on behavior. Behaviors that are particularly difficult to change, such as getting a motorcyclist to buy and use a helmet, are least likely to be affected by advice or urgings to do so.

Lecture-oriented education programs that are information-only in nature also are likely to be ineffective, as are short-term programs and messages delivered only once or twice. Extreme fear or scare techniques also are likely to have no more than a short-term emotional effect, especially when directed at adolescents.

Programs recommending driver behavior that are more likely to be effective include public information programs that involve careful pre-testing of messages to make sure the message is relevant to the group being addressed and careful delineation of the target group to make sure the messages reach the target group in sufficient intensity over time. These are the aspects involved in successful social marketing programs. In the education arena, some success (mostly in other health areas) has been achieved through programs using theory-based behavior change models, and interactive methods to teach skills to resist social influence through role playing, behavior rehearsal, group discussion, and other means.

However, even high-quality public information and education programs rarely work by themselves to change individual behavior, although their contribution can be critically important when combined with other prevention efforts (e.g., in support of law enforcement or as part of broader community programs). According to the research literature (Williams, 2007a), programs involving voluntary actions that work on their own include those targeting children, whereas programs targeting teenagers or adults are not likely to work. Unlike adults, children do not have well-developed safety behavior patterns and so are more amenable to change. Programs also work that communicate health knowledge not previously known. One example of this is the shift of children from front to rear seats to avoid air bag inflation dangers, a "new" knowledge that was largely driven by public education programs. Programs where the communicator has some control over resources or over the audience also are more likely to be successful. These would include employer programs, parents influencing their children, and alcohol servers influencing patrons. Finally, high-quality public information and education programs that are part of broad-based community programs have also been successful.

The 38 voluntary action countermeasures (the largest group of any of the four categories) are listed below, sorted according to their effectiveness rating. Note that this group also includes three items that research has clearly shown do not work to reduce crashes and, in fact, can increase them: novice driver education (when that education leads to licensure at an age which is younger than would otherwise be the case without the education), skid training for novices, and traffic violator school in lieu of penalties. Regarding the category of Unknown/Uncertain/Unlikely, see Appendix A for the rationale and references to further separate this group into: (+) some basis for thinking that it might work; (0) unknown or no opinion; and (−) some basis for thinking that the countermeasure will not work.

Proven

- School pedestrian training for children;
- Programs to get parents to put children in rear seats;
- Booster seat promotions; and
- Child bicycle helmet promotions.

Likely

- Responsible beverage service and
- Parent guiding teen licensing.

Unknown/Uncertain/Unlikely

- Child pedestrian supervision training for caregivers (+);
- Child safety clubs (+);
- Bicycle education for children (+);
- School-based alcohol education programs to reduce drinking and driving (0);
- PI&E for elderly drivers (−);
- PI&E for low belt users (+);
- Motorcycle education and training courses (−);
- Formal driver education courses for elderly drivers (−);
- Bike fairs, rodeos (+);
- Driver training about sharing the road with bicycles (−);
- Teaching bike rules/safety in driver education (−);
- Education encouraging bicyclists to increase their conspicuity (−);
- Education to encourage pedestrians to increase their conspicuity (−);
- Driver education in regard to pedestrians (−);
- Programs to teach driver awareness about motorcyclists (−);
- PI&E about driver fatigue (−);
- PI&E about distracted driving (−);
- PI&E on sleep disorders for general population and physicians (−);
- Employer programs for shift workers, medical interns (+);
- Alternative transportation for alcohol-impaired drivers (+);
- Designated driver programs (0);
- Motorcycle helmet use promotion programs (−);
- PI&E on drinking and motorcycling (−);
- Education to encourage motorcyclists to increase their conspicuity (−);
- Programs to help police detect impaired motorcyclists (0);
- Communications and outreach regarding impaired pedestrians (−);
- Extreme fear and scare tactics in youth programs, e.g., fake deaths, mock funerals (−);
- High school driver education (not leading to early learning/licensing) (0); and
- School bus training for children (+).

Proven Not to Work

- High school driver education (leading to early learning/licensing);
- Advanced driver education, skid training; and
- Traffic violator school in lieu of penalties.

Class 2: Laws, Regulations, Policies

Many of the demonstrable gains in changing behavior in ways that reduce motor vehicle injuries have come through laws and regulations. The power of laws is illustrated by the abrupt changes in behavior that occur coincident with their introduction. For example, on the day British Columbia's seat belt use law went into effect, belt use was 30 percentage points higher than it had been 24 hrs earlier (Williams and Robertson, 1979).

Not all laws work, however. Laws that work best incorporate elements associated with high deterrent capabilities. That is, they are well known to the public, and they are enforceable laws, based on easily observable behavior and objective criteria (e.g., motorcycle helmet use laws). This leads to the expectation that not complying with the law will result in apprehension and sanctioning. Also advantageous are laws where enforcement is done not only by the police, but by parents (e.g., bicycle helmet laws for children, or graduated licensing laws for adolescents). Department of Motor Vehicles (DMV) rules that have to be followed, and ordinances and other across-the-board policies also are more likely to work. Policies work that force changes that result in positive outcomes. For example, motorcycle helmet laws force riders to wear a helmet.

Laws less likely to work on their own are those that are not well known, or for which the behavior is not easily observable by police and therefore not easily enforced (e.g., open container laws). Laws that apply only to a portion of the population performing the behavior (e.g., motorcycle helmet laws that apply only to young motorcyclists) are difficult to make effective, especially when the penalties are weak. Laws where the criteria are not explicit also are less likely to be successful (e.g., aggressive driving, fatigue, and distracted driving laws).

Proven

- Bike helmet laws for children;
- Graduated driver licensing (GDL);
- Extended learner permit;
- Night restrictions (for young drivers);
- Passenger restrictions (for young drivers);
- Administrative license revocation laws;
- BAC test refusal penalties;
- Primary seat belt law;
- Speed limits;
- Motorcycle helmet laws; and
- Reduced speed limit regarding pedestrians (proven in Europe).

Likely

- Ice cream vendor ordinance;
- Local primary seat belt laws;
- Adult bike helmet laws;
- License renewal policies for elderly drivers; and
- License actions for underage alcohol violations.

Unknown/Uncertain/Unlikely

- General cell phone laws (+);
- Open container laws (0);
- Lower BAC limit for repeaters (+);
- Cell phone laws as part of graduated licensing (+);
- Belt use as part of graduated licensing (+);
- Motorcycle licensing laws, especially in regard to having a valid license (0);
- Belt laws with significant exclusions (0);
- Keg registration laws (0);
- Medical advisory boards for elderly drivers (0);
- Aggressive driving laws (−);
- Driver fatigue and distracted driving laws (−);
- Referral of elderly drivers to licensing agencies (+);
- Licensing screening and testing for elderly drivers (+); and
- Licensing restrictions for elderly drivers (+).

Class 3: Laws Plus Enhancements

If the public to whom the law applies is not aware of the law, or there is little enforcement, or little *perceived* enforcement, positive effects of laws can be diminished or eliminated. Thus, the effects of laws can be enhanced by special enforcement programs, publicity about the law and its enforcement, and—in some cases—by special equipment such as passive alcohol sensors to enhance enforcement. When one or more of these elements is combined with laws that are easily enforceable, success is likely. Success is less likely when laws are not easily enforceable because the criteria for enforcement are vague or the behavior is difficult to observe.

Proven

- Sobriety checkpoints;
- Saturation patrols for alcohol-impaired driving;
- Preliminary breath test devices;
- Passive alcohol sensors;
- Short, high-visibility belt law enforcement;
- Automated enforcement for speed, red light running;
- Mass media support of alcohol enforcement or other programs;
- PI&E supporting enforcement of seat belt laws; and
- Community programs, including age 21 enforcement.

Likely

- Integrated enforcement (alcohol, seat belts, speeding);
- Zero-tolerance enforcement;
- Vendor compliance checks for age 21 enforcement; and
- Sustained seat belt enforcement.

Unknown/Uncertain/Unlikely

- Aggressive driving enforcement (+);
- GDL enforcement (+);
- Enforcement of pedestrian rules targeted to drivers and pedestrians (−);
- Enforcement of bike rules (−); and
- Enforcement against unapproved motorcycle helmets (+).

Class 4: Sanctions and Treatments

Special penalties and treatments also can supplement laws. Sanctions that are well known to violators, have a high probability of being imposed, and have a high degree of intrusiveness (i.e., involve a real amount of money or time) are most likely to work. If there is low intrusiveness, if sanctions are not well known to violators, are unlikely to be applied, or if the penalty is not very meaningful, success is unlikely.

Proven

- Aggressive driving, speeding penalties (e.g., suspension, warning letters);
- Restrictions on plea bargains;
- Court monitoring;
- Mandatory attendance at alcohol treatment;
- Close monitoring of DUIs;
- Alcohol interlocks;
- Brief interventions—alcohol;
- License plate impoundment;
- Vehicle immobilization; and
- Vehicle impoundment.

Likely

- Increased belt use law penalties and
- Simplifying and streamlining DUI statutes.

Unknown/Uncertain/Unlikely

- Vehicle forfeiture (+);
- GDL penalties (0);
- Driving under the influence (DUI) fines (0);
- DUI jail (0);
- High BAC sanctions (+); and
- DWI (driving while intoxicated) courts (+).

Summary

Overall, 45% of the 104 countermeasures are considered effective (33% proven; 12% likely). By comparison, the other 55% are less likely to work. This assessment is based on the fact that evidence for effectiveness is uncertain or unknown and/or the criteria for what is likely to work are not met (52%), or because research indicates that these countermeasures increase crashes (3%).

The following percentage of countermeasures are rated Proven or Likely to work in each class of countermeasures:

- Sixteen percent of Class 1: Voluntary Action;
- Fifty-three percent of Class 2: Laws, Regulations, Policies;
- Seventy-two percent of Class 3: Laws Plus Enhancements; and
- Sixty-seven percent of Class 4: Sanctions and Treatments.

By topic area, there are differences in expected effectiveness. Effectiveness is most likely in the occupant restraint group where 82% of the countermeasures are rated Proven or Likely; followed by alcohol (67%); aggressive driving/speeding (50%); young drivers (38%); bicycles (33%); pedestrians (30%); elderly drivers (14%); motorcycles (11%); and distracted/fatigued drivers (none at this time).

How effective are those countermeasures rated as Proven or Likely? Ideally, for all countermeasures rated as Proven, and for many rated as Likely, it would be possible to derive a numerical estimate of the effect size, the expected percentage reduction in injuries. However, it is not always possible to estimate this number. Of the 47 countermeasures rated as Proven or Likely, about half of the outcomes relate not to reductions in crashes or injuries, but to some intermediate measure (e.g., reductions in recidivism, increases in arrests or convictions, decreased drinking, increases in seat belt use). It is possible to estimate the impact of increases in seat belt use to decreases in injuries, but for many other intermediate measures, there is no credible way to do so. There also are a few cases where the expected effect relates to crashes or injuries, but not enough information is available to extract a numerical estimate of the effect.

In addition to the effect size, there are other important factors in determining the overall impact of any countermeasure. One of these factors is the size of the population affected. For example, a measure affecting the general population can have more impact than one affecting a specific subgroup (e.g., teenage drivers only). Another is the expected duration of the effect. For example, although the effects of laws can vary over time, depending on such factors as the amount of publicity and enforcement, their permanence gives them an advantage compared with programs that are one-time efforts. Duration can also refer to the length of time the positive effects of a policy last on individuals affected, for example, license suspension.

CHAPTER 4

Estimation of Highway Loss

This chapter presents the estimated highway loss associated with the target groups for which countermeasures have been developed. Highway loss can arise from both fatal and nonfatal injury. Property damage is not considered here because it is a relatively small proportion of all loss and is not consistently reported across the states.

Target Group Size—Fatal Injury

The countermeasures reviewed cover differing groups of road users and differing numbers of fatal and injury victims. For instance, some involve nonmotorists (pedestrians and cyclists), others involve alcohol, speed, motorcycles, belt use, teen drivers, etc. The size of each of these target groups varies substantially. Table 1 indicates the number of fatalities associated with each of the target groups and the percentage of all fatalities that each group represents.

Note that the groups are not mutually exclusive. For instance, a single crash could involve a 16-year-old driver, distracted, at night, who had been drinking.

Target Group Size—Nonfatal Injury

Fatalities are only part, and typically not even the major part, of overall highway loss. We estimate, based on Blincoe, Seay, Zaloshnja et al. (2002), that for every motor-vehicle-related fatality, there are 126 associated injuries (of any severity). This figure refers to the overall injury-to-fatality ratio (i.e., 126/1). There is substantial variance in this ratio as a function of the target population. For instance, motorcyclists and pedestrians have different injury-to-fatality (i.e., injury/death) ratios than do occupants of passenger vehicles.

To estimate the injury/death ratio for each target group and then use such ratios to determine target group costs based on the Blincoe et al. report, this ratio was first calculated for each target population based on General Estimates System (GES) data for 2004–2006. The ratio for each subgroup was then divided by the ratio for all persons to provide an adjustment factor. For example, if the GES injury/death ratio for pedestrians was 21/1 and the ratio for all groups combined was 85/1, then the relative size of the injury/death ratio for pedestrians was 0.25 that of the overall group (i.e., 21/1 ÷ 85/1 = 0.25). This proportion (0.25) was then used to adjust the overall injury/death ratio calculated from the Blincoe et al. report (2002). Thus, if the pedestrian injury/death ratio was 0.25 of the overall injury/death ratio in the GES data set, then it was assumed to be 0.25 the overall injury/death ratio in the data used by Blincoe (126/1). Therefore, multiplying 0.25 by 126/1, the overall injury/death ratio from the Blincoe dataset resulted in an adjusted 31/1 ratio, which was used to estimate costs associated with both deaths and injuries. Adjusted ratios for various target groups are shown in Table 2. Taking pedestrians as an example, the final column in the table for adjusted ratios was obtained by determining what proportion of the all persons ratio is comprised of the pedestrian ratio shown in the column for GES ratio relative to all persons (hence: 21/85 = 0.25), and adjusting the Blincoe et al. ratio by that factor to provide the data in the last column ($125.95 \times 0.25 = 31.49$).

The last column of Table 2 indicates the injury/fatality ratio used to estimate the benefits for each Proven countermeasure. Rounding, the first ratio shown is 126/1, which represents the overall ratio calculated across all target groups. The next ratio is 31/1 for pedestrians (used in the previous example). Based on this procedure, motorcyclists have an injury/fatality ratio of 35/1. Both pedestrians and motorcyclists are "unprotected" road users. The result is that these persons are far more likely to sustain fatal injury, as compared with a nonfatal injury, given that a crash has occurred. At the opposite end of the range are child occupants of passenger vehicles. They are highly protected by the car and by the fact that they are often in the back seat, sometimes in a child restraint device. Their injury/fatality ratio is 656/1, indicating that fatal injury in the event of a crash is far less likely than

Table 1. Percentage of fatalities associated with various types of crashes.

Crashes involving	Fatality Analysis Reporting System (FARS) 2006		Description
	No. of fatalities	Percentage of all fatalities	
All persons	42,642	100.00	All motor-vehicle-related fatalities
Pedestrians	4,784	11.22	All pedestrian fatalities
Distracted	4,246	9.96	Fatalities involving distracted drivers (drowsy excluded)
Drowsy	1,344	3.15	Fatalities involving drowsy drivers
Speed	11,518	27.01	Speed related, speed violation, or excessive speed fatalities
Aggressive	11,684	27.40	Fatalities involving speeding, reckless driving, road rage, aggressive driving
Alcohol related	17,602	41.28	Fatalities involving drivers with BAC ≥ .01
Teen drivers	2,291	5.37	Fatalities involving 16- and 17-year-old drivers in passenger vehicles
16-year-old drivers	880	2.06	Fatalities involving 16-year-old drivers in passenger vehicles
Elderly drivers	3,135	7.35	Fatalities involving drivers age 75 and over in passenger vehicles
Motorcycles	4,654	10.91	All motorcyclist fatalities
Nighttime	15,194	35.63	All fatalities occurring between 9 P.M. and 6 A.M.
Child in car	993	2.33	Children 0-12 in passenger vehicles
Front seat occupants	26,715	62.65	Outboard front seat occupant of passenger vehicles ages 13 and up
Bicycles	770	1.81	All bicyclist fatalities

nonfatal injury. All of the remaining target groups fall somewhere between these two extreme values.

Cost of Fatal and Nonfatal Injury

The Blincoe et al. (2002) report estimates the cost of fatalities and injuries of varying severity. Nichols and Ledingham (2008) use Blincoe's 1994 and 2000 base-year figures and interpolate estimates for other years. For the year 2007, Nichols estimates the cost of each fatality at $1,115,820 and the average cost of Maximum Abbreviated Injury Scale (MAIS) 2 to 5 injuries at $2,686,417 (cost of total MAIS 2 to 5 injuries per unit fatality). Using Nichols' method and figures, the average cost of 126 MAIS 1 to 5 injuries per unit fatality was estimated to be $3,780,038 in 2007. This overall cost was then converted to an average cost-per-injury estimate that, combined with the (adjusted) injury/death ratios for the various crash categories, was used to estimate total costs for MAIS 1 to 5 injuries

Table 2. Adjusted fatality-to-injury ratio by crash type.

Crashes involving	GES 2004–2006		Injury-to-fatality ratio	GES ratio relative to all persons	Adjusted ratios
	No. of Injuries	No. of Fatalities			
All persons	7,719,076	90,612	85	Blincoe's ratio: 125.95	
Pedestrians	183,659	8,640	21	0.25	31.49
Distracted	1,951,355	12,315	158	1.86	234.28
Drowsy	276,000	5,464	51	0.59	74.68
Speed	1,812,245	30,628	59	0.69	87.48
Aggressive	1,867,291	30,731	61	0.71	89.84
Alcohol related	600,415	19,008	32	0.37	46.70
Teen drivers	787,101	4,884	161	1.89	238.28
16-year-old drivers	334,031	1,843	181	2.13	267.96
Elderly drivers (75+)	468,402	7218	65	0.76	95.95
Motorcycles	229,522	9,827	23	0.27	34.53
Nighttime	1,290,607	28,915	45	0.52	65.99
Child in car	413,146	931	444	5.21	656.15
Front seat occupants	5,886,027	55,710	106	1.24	156.21
Bicycles	125,599	1,745	72	0.84	106.41

associated with a given number of deaths. For 2007, the estimated cost of each fatality is $1,115,820 and the average unit cost of MAIS 1 to 5 injuries was $30,238, as indicated in Table 3.

The sources of the costs differ depending on whether injuries are fatal. For fatal injuries, 82% of the $1,115,820 is lost productivity, 2% is from medical and emergency service costs, and 15% is from other costs (e.g., legal fees, insurance). For nonfatal injuries (MAIS 1 to 5), 45% of the costs ($30,238) is due to lost productivity, 35% is associated with medical and emergency services, and 20% represents other costs. For any given countermeasure, the percentage of cost savings falling into each category is dependent on the injury-to-fatality ratio. For example, the savings from a pedestrian countermeasure would have lower medical savings because a higher proportion of the victims were fatally injured. Whereas a countermeasure focusing on teens would be expected to have a higher proportion of the savings coming from medical costs as a higher proportion of the victims being "saved" were nonfatally injured.

Note that costs for fatalities after year 2000 were extrapolated from the rate of change from 1994 to 2000 (Blincoe, Seay, Zaloshnja et al., 2002). An alternative method for making this estimation would have been to use changes in the consumer product index from the Bureau of Labor Statistics (www.bls.gov). Using that approach, the estimated cost of a death in 2007 would have been 1.03 times the estimated cost shown in Table 3 (i.e., it would be $1,149.344, rather than the $1,115,820 shown). This latter number would, of course, provide a higher estimate of costs. In the "typical" state with 600 deaths, the costs associated with deaths (alone) would be about $689.7 million, rather than $669.5 million, or an additional $20 million. In this scenario, total costs (deaths and injuries) associated with 600 deaths in the "typical" state would be $2.975 billion, rather than $2.955 billion as estimated in Chapter 5.

Table 3. Estimated costs associated with each death and MAIS 1-5 injury by year.

Year	Cost	
	Average MAIS 1-5	Per unit fatality
1994*	$10,721	$822,330
1995	$12,223	$844,906
1996	$13,724	$867,482
1997	$15,225	$890,059
1998	$16,726	$912,635
1999	$18,228	$935,211
2000*	$19,729	$957,787
2001	$21,230	$980,363
2002	$22,731	$1,002,939
2003	$24,233	$1,025,516
2004	$25,734	$1,048,092
2005	$27,235	$1,070,668
2006	$28,737	$1,093,244
2007	**$30,238**	**$1,115,820**

* Blincoe et al. base years

None of these costs include grief, pain, and suffering. Although enormous, the latter costs are difficult to quantify. Thus, the estimated costs used in this report focus on more direct and measurable costs associated with fatalities and nonfatal injuries. Also, as mentioned previously, property damage (a relatively small portion of overall highway loss) is not included.

In summary, the societal cost of each fatality in 2007 is (conservatively) estimated to be $1,115,820, and the average cost of each MAIS 1 to 5 injury is estimated to be $30,238. These unit estimates are used to determine the total costs of deaths and associated injuries for each subgroup examined in this report. Again, these estimates are likely to be very conservative. The costs of pain, grief, and suffering, for example, are not included. If included, it is likely that they would increase these estimates by approximately 300%.

CHAPTER 5

Estimation of Savings

Savings, or estimated benefits, from any highway safety measure are calculated based on three factors as follows:

1. The number of fatalities and injuries resulting from crashes addressed by the countermeasure (based on number of deaths in the target group and on an estimate of the number of injuries per death avoided),
2. The estimated percentage reduction produced by the countermeasure, and
3. The estimated cost of each fatality and injury avoided.

Dollar values associated with a fatality and dollar values associated with an injury were derived in the last section. This section begins with those dollar values and then relates them to the dollar "savings" that might be derived from the successful implementation of a given countermeasure in the median state as described in the following section.

Median State

There were 42,642 motor-vehicle-related fatalities in the United States in 2006 (NHTSA, 2007a). The median number of fatalities per state was 630. To estimate the costs incurred by a typical state, the researchers assume each state to have 600 fatalities a year and use that assumption as a basis for example calculations. States with 1,200 fatalities per year would multiply all cost/savings estimates by two. States with 300 fatalities per year would divide by two.

Estimates for this "median" or "typical" state are shown in Table 4. This state experiences an overall loss of $2.955 billion dollars per year. That loss, based on the national distribution of fatalities and injuries, is largely accounted for by three target groups: (1) front seat occupants of passenger vehicles; (2) speed; and (3) alcohol-impaired driving. Also shown in Table 4 are dollar savings that could be achieved if crashes represented by each of these respective target groups could be reduced by some specified amount, say 10%, 30%, or 50%. It immediately becomes apparent that, even using our conservative estimates, the costs associated with crashes are very large for any target group. Even small reductions in crashes in a major target group will result in tens of millions of dollars in direct economic savings to the state.

States can increase the precision with respect to the numbers shown in Table 4 by determining the actual number of fatal victims in the state within each target group. For example, instead of taking the national average of 11% of all fatalities being pedestrians, states can use their own number of pedestrian fatalities per year. In order to arrive at a stable estimate for smaller target groups, most states will likely have to calculate an average number of deaths across several years. Two or three years of data should be sufficient for most states; as many as five years may be needed for smaller states.

Countermeasure Effectiveness

The estimated effectiveness of a countermeasure was based on research and evaluation studies for that countermeasure. These effectiveness estimates for 23 Proven countermeasures, along with a brief statement regarding relevant research citations, are detailed in Appendix B. When estimated effects were reported as a range, the lowest estimate of effectiveness was used. For instance, if the fatal and/or injury reduction associated with a given countermeasure as based on three high-quality evaluation studies was 10%, 12%, and 16%, respectively, then the 10% figure was used in the calculation of savings.

Use of the lowest effectiveness number, although perhaps too conservative in some cases, should allow states to make benefit/cost decisions without the need to assume that their implementation would be "exemplary" or "extraordinary" as compared to previously demonstrated effective efforts. States planning an "exemplary" implementation can recalculate their benefit estimates based on the middle or high estimate.

Table 4. Median state fatality and cost estimates.

Target	Cost for example state	Percent of all fatalities	If estimated effectiveness is 10%	20%	30%	40%	50%
			then resulting estimated savings are:				
All fatalities and injuries	$2,954,577,660	100	$295,457,766	$590,915,532	$886,373,298	$1,181,831,064	$1,477,288,830
Fatalities and injuries involving alcohol-impaired drivers	$537,848,587	35.46	$53,784,859	$107,569,717	$161,354,576	$215,139,435	$268,924,294
Alcohol-related involving drivers with previous DWI convictions	$41,509,775	2.74	$4,150,978	$8,301,955	$12,452,933	$16,603,910	$20,754,888
Alcohol-related	$626,096,874	41.28	$62,609,687	$125,219,375	$187,829,062	$250,438,750	$313,048,437
Belt use: unbelted front seat outboard occupant, passenger vehicle	$1,082,328,300	30.89	$108,232,830	$216,465,660	$324,698,490	$432,931,320	$541,164,150
School-aged pedestrians	$3,750,385	0.30	$375,039	$750,077	$1,125,116	$1,500,154	$1,875,193
Unhelmeted bicyclists ages 12 and under	$4,512,100	0.17	$451,210	$902,420	$1,353,630	$1,804,840	$2,256,050
Bicyclists age 12 and under	$4,573,075	0.18	$457,308	$914,615	$1,371,923	$1,829,230	$2,286,538
Unhelmeted bicyclists age 13 and up	$39,572,340	1.52	$3,957,234	$7,914,468	$11,871,702	$15,828,936	$19,786,170
Teen drivers	$268,232,054	5.37	$26,823,205	$53,646,411	$80,469,616	$107,292,822	$134,116,027
Underage drivers with BAC≥.01	$99,061,459	6.53	$9,906,146	$19,812,292	$29,718,438	$39,624,584	$49,530,730
Speed related	$609,535,127	27.01	$60,953,513	$121,907,025	$182,860,538	$243,814,051	$304,767,564
Elderly drivers (75+)	$177,202,538	7.35	$17,720,254	$35,440,508	$53,160,761	$70,881,015	$88,601,269

Estimating the potential cost savings associated with any of the Proven countermeasures (for which an effect size is provided) is a relatively straightforward algebraic calculation when the following parameters are known:

1. The target group size (i.e., the number of fatalities and injuries in crashes addressed by the countermeasure);
2. The estimated effectiveness of the countermeasure (i.e., the percentage reduction produced by the countermeasure); and
3. The estimated dollar value of each fatality and injury avoided.

Example

The first countermeasure shown in Appendix B is School Pedestrian Training for Children. The target population for this countermeasure is pedestrian crash victims, ages 6 to 12. This target group comprised 0.303% of all fatalities (129 of 42,642) in 2006. Based on this proportion, our "typical" state with 600 annual fatalities might expect that 1.82 of its total number of victims would be pedestrians 6 to 12 years of age. Based on the last column of Table 2, the estimated injury/fatality ratio for pedestrians is 31.4/1. Thus, this typical state might expect 57 (MAIS 1-5) injuries annually, in addition to the 1.82 fatalities.

Based on the estimated unit costs of $1,115,820 per fatality and $30,238 per MAIS 1-5 injury (see Table 3), the total cost associated with 1.82 deaths and 57 injuries among child pedestrians would be $3,750,385 per year in this typical state. Again, these estimates should be considered to be conservative. They make no adjustment for pain and suffering and they make no adjustments for age of the victim. The life of an elderly victim, using this estimation procedure, is considered to be equally valuable to that of a child, a teenager, the parent of a child, or anyone else. That is, the costs reported here are averages across all ages.

The results of known evaluations of child pedestrian training (see Appendix B) suggest that such training can reduce child pedestrian injury by about 12%. Applying this effect size as a 12% reduction in the $3,750,385 cost estimate associated with child pedestrian deaths and injuries yields an estimated saving of $450,046.

Can the typical state with 600 fatalities conduct child pedestrian training statewide for $450,046 or less? If the answer to this question is *yes*, then this countermeasure will be cost effective. That is, the benefit will exceed the cost. Even if the answer is *no* on a statewide basis, the state may decide to limit implementation of the countermeasure to those jurisdictions, typically urban, where child pedestrian crashes are most common. This should substantially reduce implementation costs while retaining much of the benefit.

Proven Countermeasures

Similar calculations are possible for 23 of the Proven countermeasures. Such calculations, detailed in Appendix B, are summarized in Tables 5 through 8. The savings possible from these 23 countermeasures for a typical state with 600 fatalities range from $450,046 (for school pedestrian training) to $121,907,025 (for automated enforcement).

Table 5 provides cost-savings estimates for the two Proven voluntary action countermeasures for which crash/death/injury reduction estimates are available. It suggests that an estimated savings of $450,046 would be associated with an effective pedestrian countermeasure and a savings of $6,140,394 would be associated with an effective booster seat program. Note that both of these countermeasures involve children, teachers, and parents. With regard to adult behavior, the literature suggests that education and information can be effective only when it is used in support of some other measure, such as enforcement or sanctions. It is not likely to be effective when it is used alone.

Finally, unless there is some form of mass media communications effort associated with the programs in Table 5, or there is a plan for implementing these countermeasures widely across the state or across the majority of communities within the state, these measures are likely to have only a specific effect. That is, their impact will be limited to those targets where such programs are implemented (e.g., in a specific school or

Table 5. Voluntary actions.

Countermeasures		Target population			Highway loss ($)	Reduction (%)	Savings ($)
Name	Cost*	Description	No. of fatalities	No. of injuries			
School pedestrian training for children	Low	Pedestrians ages 6 to 12	2	57	$3,750,385	12%	$450,046
Booster seat promotions	Medium	Children ages 4 to 8 not in booster seat	4	2,530	$80,794,661	8%	$6,140,394

*Cost column is from NHTSA (2007b).

Table 6. Laws, regulations, and policies.

Countermeasures		Target population			Highway loss ($)	Reduction (%)	Savings ($)
Name	Cost	Description	No. of fatalities	No. of injuries			
Bike helmet laws for children	Medium	Unhelmeted bikers under age 12	1	91	$3,719,434	15%	$557,915
Graduated driver licensing	Medium	16-year-old drivers	12	3,318	$114,143,621	20%	$22,828,724
Extended learner permit	Low	16-year-old drivers	12	3,318	$114,143,621	22%	$25,111,597
Night restrictions	Low	16-year-old drivers nighttime crashes	4	954	$32,816,291	50%	$16,408,146
Passenger restrictions	Low	16-year-old drivers w/ teen passengers	7	1,900	$65,373,165	33%	$21,573,144
Administrative license revocation	High	Impaired drivers	213	9,936	$537,848,587	13%	$69,920,316
Primary seat belt law	Low	Unbelted front seat occupants	185	28,954	$1,082,328,300	7%	$75,762,981
Motorcycle helmet law	Low	Motorcyclists	65	2,261	$141,442,973	20%	$28,288,595
Reduced speed limits (for pedestrian safety)	Low	Pedestrians in 60km/h (37 mph) urban zones	16	489	$32,154,461	25%	$ 8,038,615

community). For these countermeasures to result in a general effect, one that is likely to measurably reduce deaths and injuries, they must be broadly implemented across the state and, a plan for doing so should be considered along with their adoption.

Table 6 lists the nine Proven countermeasures for laws, regulations, or policies. The estimated savings associated with these countermeasures ranges from $557,915 for a child bike helmet law to $75,762,981 for a primary belt law. Each of these measures, if publicized, is likely to result in a general, rather than a specific, effect. That is, each is likely to affect a large portion of the target population across the state and, as such, is likely to produce measurable reductions in deaths and injuries.

These countermeasures have three important advantages. First, implementation of a law can often be done at relatively

Table 7. Laws plus enhancements.

Countermeasures		Target population			Highway loss ($)	Reduction (%)	Savings ($)
Name	Cost	Description	No. of fatalities	No of injuries			
Sobriety checkpoints	High	Impaired drivers	213	9,936	$537,848,587	20%	$107,569,717
Short, high-visibility belt law enforcement	High	Unbelted front seat occupants	185	28,954	$1,082,328,300	3%	$27,274,673
Automated enforcement: speed cameras	High	Speeding drivers	162	14,177	$609,535,127	20%	$121,907,025
Mass media to support alcohol enforcement or other program	High	Impaired drivers	213	100	$537,848,587	13%	$69,920,316
Community program including age-21 enforcement	High	Drinking drivers under age 21	39	1,830	$99,061,459	10%	$9,906,146

Table 8. Sanctions and treatments.

Countermeasures		Target population			Highway loss ($)	Reduction (%)	Savings ($)
Name	Cost	Description	No. of fatalities	No. of injuries			
Aggressive driving: license suspension	Medium	Drivers w/ previous speeding convictions	47	4,250	$181,293,587	17%	$30,819,910
Aggressive driving: individual meetings	Medium	Drivers w/ previous speeding convictions	47	4,250	$181,293,587	8%	$14,503,487
Aggressive driving: group meetings	Medium	Drivers w/ previous speeding convictions	47	4,250	$181,293,587	5%	$9,064,679
Aggressive driving: warning letters	Medium	Drivers w/ previous speeding convictions	47	4,250	$181,293,587	4%	$7,251,743
Mandatory attendance at alcohol treatment programs	Medium	DUI-convicted drivers in alcohol-related crashes	16	767	$41,509,775	7%	$2,905,684
Alcohol interlocks (when installed)	Medium	DUI-convicted drivers in alcohol-related crashes	16	767	$41,509,775	37%	$15,358,617

modest cost. Second, there is some permanence to their impact (i.e., once a safety measure becomes law it tends to remain law). Thus, it is often true that these are one-time costs with benefits seen year after year thereafter. Third, all laws have the potential for general, rather than specific, effects. Unlike an education program (or an unpublicized sanction), for which exposure tends to be limited, laws potentially affect everyone within the jurisdiction covered by them. Two of the requirements for laws to be effective are that they are enforced and that they (both the law and the enforcement) are publicized. Thus, the costs of enforcement and publicity should also be considered when adopting any of these laws.

Table 7 lists the five Proven countermeasures for laws plus enhancements. The estimated savings associated with these countermeasures range from $9,906,146 for community programs including age-21 enforcement to $107,569,717 for sobriety checkpoints and $121,907,025 for automated enforcement. Like laws, each of these countermeasures, if fully implemented and publicized, has a strong potential for providing a general effect and, as such, each is likely to result in measurable reductions in deaths and injuries.

These countermeasures are characterized by a very high payoff. However, they can also involve high implementation costs. For instance, in order for sobriety checkpoints to realize their full potential, they need to be implemented across the entire jurisdiction throughout the year. That is because their implementation needs to convince all (or at least *most*) motorists that they have a very real chance of being arrested should they choose to drink and drive. Available data suggest that drivers resume their typical drinking and driving behavior when checkpoints are discontinued. Still, $107 million is a very large savings for the "typical" state with 600 fatalities, and this countermeasure should receive serious consideration.

Table 8 lists the six Proven countermeasures for sanctions and treatments. The estimated savings associated with these countermeasures range from $2,905,684 for mandatory attendance at alcohol treatment programs to $30,819,910 for license suspensions for poor and aggressive driving records.

CHAPTER 6

Estimation of Cost to Implement Countermeasures

Final decisions as to whether a state may choose to implement a given countermeasure—or not—often will depend on the cost of implementation versus the expected benefit from implementation. Expected benefits are covered in the previous chapter. This chapter will address the issue of cost of implementation.

Cost may be thought of as falling into four general areas: political capital, resource allocation, user pay, and direct cost. Benefit/cost ratios typically are based on the direct cost to the state highway safety office (SHO) of implementing a given countermeasure. However, direct cost is not the only cost. Very often direct cost is not even the most significant cost or consideration when selecting a given countermeasure for implementation.

Political Capital

Each state will make an assessment of what is doable—and not doable—each year in their highway safety plan. This determination becomes a judgment call that can only be made at the state level. Is a mandatory motorcycle helmet law possible given the current legislature? How about a primary seat belt law or an upgrade to the graduated licensing law? What can realistically be accomplished and what initiatives should be given priority? In general, most SHOs work toward a prioritized and limited set of objectives for each legislative session, rather than pursuing an omnibus list of possible new legislative initiatives.

Direct costs associated with passing and implementing legislation, although generally modest, are nonetheless real, and need to be considered as a bill moves forward and passage appears likely. For instance, Oregon estimated that administrative costs associated with implementing their new GDL law were $150,000. They also estimated that the crash reduction benefit to the state of Oregon was nearly $11 million, resulting in a benefit/cost ratio of 73/1. That is, there was a $73 savings for every dollar invested. Benefit/cost ratios of this magnitude would be expected from most of the proven legal and regulatory countermeasures, although such ratios are rarely the deciding factor on whether to pass such legislation.

Political capital also refers to the tolerance and acceptance of the general public for highway safety initiatives. The general population has come to expect holiday crackdowns on drunk driving, speed, and aggressive driving. Would they welcome automated speed enforcement? How about automated speed enforcement around school zones?

Political capital is a real, yet largely nonquantifiable, cost. Most of the law and policy countermeasures listed as Proven and considered effective in the previous section cost little in terms of dollars and their benefit/cost ratios are enormous. Yet, they may require a large amount of political capital and, as such, may be out of reach at this time in some states.

Resource Allocation

States that have prioritized speeding as the number one enforcement issue will not be spending much time on red-light running. There are only so many officers and overtime hours that an enforcement agency can fill. Similarly, if the SHO is inundating media outlets with child safety messages, these same outlets will not also be receptive to a drunk driving campaign at the same time. Or, if SHO staff have been tasked with community outreach, it is not likely that they will also be available for the development of other programs. Similarly, if sister state agencies and nonprofit organizations are being asked to focus on one campaign, they may not be able to assist in other areas as well.

Many of the resources available to a state office are neither renewable nor expandable. They are fixed and, once deployed, will not be available for some other effort in any specified time period. The "cost" of deploying these resources in pursuit of one goal is the potential for missing the opportunity to pursue some other goal. Although these costs are real, like political costs, they are difficult to quantify. Such costs are minimized by deploying these nonrenewable resources in pursuit of those countermeasures that will produce the greatest reduction in highway loss.

A common phrase is: *If I can save one life, it will all be worth it*. Perhaps, but SHOs do not have this luxury. If they deploy a measure that saves one life rather than deploying a measure that could have saved three lives, using the same time and money, then they have, in effect, killed two people.

User Pay

A large proportion of the cost, and—not incidentally—the benefit, for implementing highway safety initiatives is borne by the client or the user of that initiative. Such costs are quantifiable, yet they rarely enter into consideration of whether to implement a selected countermeasure. Parents, not the state, are the ones who most often purchase a child restraint, booster seat, or bike helmet. Convicted drunk drivers are the ones who most often pay for their alcohol assessment, rehabilitation, or vehicle interlock. Only a small proportion of the costs for both child safety and alcohol sanctioning programs are borne by the state. As such, these programs need only marginal effectiveness in order to be very cost effective.

Another source of user pay is the fines that violators pay when convicted of speeding, red-light running, and other violations. Fines that are collected typically go to the state, county, or municipal General Fund. Fees collected are often used to support the court and the rest of the adjudication system. We do not have a tradition of counting General Fund revenue as an offset for the cost of countermeasure implementation. In fact, our tradition is the opposite. We attempt to build a wall between the revenue generated from ticket writing and the agency performing the service. We do not want the public to feel that the police will profit from writing a ticket.

What is the benefit/cost ratio from writing tickets? It may be quite large, particularly if the ticket writing results in more revenue to the General Fund than the agency and adjudication costs associated with the activity. Either way, it is not a number that we generally include in our benefit/cost ratios, nor is it one that we are likely to include in such calculations in the foreseeable future.

Automated speed enforcement and red-light running cameras are a clear exception. Here, we want to know the implementation and operation costs of the systems and we want to know that the fines generated will cover these costs. The expectation is that these systems will be at least revenue neutral. That is, they will generate a sufficient amount of fine revenue to cover their implementation and maintenance costs. If successful, and if they reduce crashes, their benefit/cost ratio will be very large. A Government Accountability Office (GAO) report (2003), found that photo enforcement program revenues were lower than program costs in three jurisdictions, while revenues in two other jurisdictions exceeded program costs. It seems likely that both technologies, automated speed and red-light running, are now sufficiently developed such that a jurisdiction can implement either one as revenue neutral and/or with excess revenue devoted to some worthwhile purpose such as education.

Automated speed enforcement and red-light running have one additional important feature that sets them apart from officer-dependent ticket writing. The fine is assessed against the vehicle, not against the driver. Thus, no drivers will have their drivers license suspended or insurance increased if their vehicle is photographed violating the law. While this effect is not necessarily desirable from a general deterrence point of view, it is an important distinction that has made such programs acceptable in some communities.

Direct Cost

Last, but not least, is the issue of direct cost. That is, countermeasures that consume real dollars from highway safety, enforcement, or other budgets and need to be weighed against benefits to justify the expenditures. Surprisingly, there are relatively few Proven countermeasures that fall into this category. With regard to the countermeasures discussed throughout the remainder of this chapter, cost estimates are drawn from original documents that documented their effectiveness (and costs) and from experience with ongoing programs. These estimates are clearly imprecise and, as such, need to be viewed as only a starting point for planning purposes. Actual cost estimates for a given program implemented in a given state and in a given year have often come primarily from the grants awarded by the states. The following subsections are intended only to outline costs that have been reported in the past, based on existing research reports.

School Pedestrian Training for Children

Most of the available “programs in a box” that are oriented toward a particular grade level are low cost and easy to implement. Per-student costs for school pedestrian training materials range from less than one dollar to two dollars. Statewide coverage for a first-year K-6 program might cost $500,000 to $800,000 for a “typical” state with 600 fatalities. As was suggested earlier, estimated savings from such a program would be $450,046, suggesting that the effort would have a negative return on investment. However, most of the costs outlined are first-year costs which, if amortized over several years, would bring subsequent year costs down to a much lower level. Moreover, the program could be targeted to only those urban areas that have a substantial child pedestrian safety problem, further reducing implementation costs and providing the potential for a positive benefit/cost ratio.

Booster Seat Promotions

It is likely that a comprehensive booster seat program would involve a large number of entities and activities such as the following: a community coalition of agencies and organizations to promote booster seat use; a citizen advisory group of parents and caregivers to provide feedback on campaign messages and materials; development of strategies to ensure community involvement; community education; newspaper articles; organization and group newsletter articles; a booster seat website; tip sheets, brochures, and flyers in multiple languages; a telephone information line for parents; resource kits for preschools and health care providers; radio and TV public service announcements; educational programs to address barriers to booster set use; discount booster seat coupons ($10 off); car seat training program and in-services for health care providers, child care providers and educators, law enforcement, EMS personnel, and advocates.

Direct costs for such an effort, for the typical 600-fatality state, could range from a low of $300,000 (assuming substantial donated time and effort from cooperating agencies) to as much as $800,000 (assuming paid media and coupons to low-income families). As indicated, estimated savings from such a program would be $6,140,394 suggesting that the effort would have a benefit/cost ratio (i.e., return on investment) ranging from 8/1 to 20/1. That is, a return of $8 to $20 would be expected from each dollar invested.

Sobriety Checkpoints

The most recent documented, comprehensive statewide sobriety checkpoint program was implemented in Connecticut in 2003 (Zwicker, Chaudhary, Maloney et al., 2007). The state used paid media in support of a statewide program of sobriety checkpoints. Costs for this program were approximately $1.25 per resident of the state. So, if a typical 600-fatality state had a population of 5 million people, then the program might cost $6.25 million (about $7 million, adjusted for inflation). As computed earlier, estimated savings from such a program would be $107,569,717, resulting in a benefit/cost ratio of 15/1. That is, a return of $15 would be expected from each dollar invested.

Short, High-Visibility Belt Law Enforcement

A comprehensive Click It or Ticket (CIOT) Program has generally included paid media ($300,000 to $500,000); at least one law enforcement liaison to recruit enforcement agency participation ($100,000 per year, minimum); plus enforcement grants to police agencies (possibly $200,000 to $500,000 for an average-size state). Total costs should range from about $600,000 to just over $1 million. As computed earlier, estimated savings from such a program would be $27,274,673 suggesting that the effort would have a benefit/cost return on investment of 27/1 to 45/1. That is, a return of $27 to $45 would be expected from each dollar invested.

Mass Media Supporting Alcohol Enforcement

Eight mass media studies that showed positive effects were reviewed by the Task Force on Community Preventive Services, a group supported by the Centers for Disease Control and Prevention (CDC). Cost information was provided for two of these mass media programs. Based on 1997 U.S. dollars, a Victoria, Australia, campaign cost $403,174 per month in its first 23 months for advertisement development, supporting media, media placement, and concept research. Estimated savings from medical costs, productivity losses, pain and suffering, and property damage were $8,324,532 per month, with $3,214,096 of this being for averted medical costs. Thus, the benefit/cost ratio, as computed from this Australian program, would be approximately 20/1.

In the United States, a six-month campaign was conducted in Kansas. It used paid media (in Wichita) and public service announcements (in Kansas City). Total costs were estimated to be $454,000, and $322,660 in these two cites, respectively. Included were costs for planning and evaluation, message production, and media scheduling. Total savings from averted costs of insurance administration, premature funerals, legal and court expenses, medical payments, property damage, rehabilitation, and employers' losses were estimated at $3,431,305 for the Wichita campaign, and $3,676,399 for Kansas City. The benefit/cost ratio, as computed from these numbers, would be approximately 8/1 for Wichita and 11/1 for Kansas City.

Community Programs Including Age-Twenty-One Enforcement

Massachusetts conducted comprehensive safety programs in six communities beginning in 1988. Each community implemented age-21 minimum drinking age (MDA) enforcement as part of a broader endeavor including efforts to reduce speeding and increase seat belt use. Costs in 1988 dollars were approximately $1 per person per year. Funds were used to pay for a coordinator, added police enforcement, other program activities, and the purchase of materials. In addition, each community included substantial voluntary efforts. What would such a program cost today? It is estimated that approximately $2 to $3 per person would be required and, as computed earlier, estimated savings from such a program would be nearly $10 million. Here, the costs of such an effort would be roughly equal to the savings.

States wishing to pursue such a comprehensive community effort should consider primarily targeting communities that have an identified under-age drinking problem. Such programs are routinely implemented, for instance, in college towns and vacation destinations frequented by young persons. In this way, the program effort and resources are concentrated in communities that would benefit most from an effective program.

Individual Meetings, Group Meetings, and Warning Letters

Benefit/cost evaluations of individual meetings, group meetings, and warning letters have been reported in studies conducted by the California DMV. These studies suggested that all three approaches may be cost effective, although the warning letter consistently provides a higher benefit/cost ratio than the other two approaches. Although the warning letter produces the smallest reduction in crashes (4% versus 5% for group meetings and 8% for individual meetings) it can be implemented at the lowest cost.

It is estimated that a warning letter program can be implemented at a cost of approximately $2 per letter. The typical 600-fatality state might issue approximately 200,000 speeding tickets per year. Thus, if a warning letter was sent to every violator, the cost of the program would be approximately $400,000. The benefit (see Appendix B) is estimated at $7,251,743 for a benefit/cost ratio of approximately 36/1. The cost of a group meeting program is estimated at approximately $30 per attendee, and the cost of an individual meeting is estimated at $100. Thus, neither of these two approaches would be particularly cost effective if applied to every speed violator. Likely because of these higher costs, states have generally reserved these intensive interventions for multiple offenders.

CHAPTER 7

Using this Guide

The overall goal of this project is to help states allocate their money effectively. This chapter summarizes the information developed thus far into guidelines for doing so, as follows:

1. It is critically important to focus on countermeasures that have been *proven to be effective* (i.e., Proven countermeasures); that can be accomplished within existing financial and political constraints; and that will provide the greatest benefit/cost return on invested resources.
2. It is appropriate to examine those countermeasures that are judged *Likely to be effective, even though there may not yet be firm evidence* that they reduce crash injury. Some of these may be quite appropriate for inclusion in your highway safety plan, although it may be necessary to conduct additional evaluations of their effectiveness, since currently available data are not definitive.
3. To the extent possible, a state should avoid countermeasures that are unlikely to be effective or for which the effects are unknown (i.e., Unknown/Uncertain/Unlikely effective countermeasures). This will be quite a challenge since nearly half of the 104 listed countermeasures are in this category. To the extent countermeasures in this group are considered, priority should be given to those with plus (+) ratings, indicating there is some basis suggesting they may work, although not enough to place them in the Likely group.
4. It is important to stay away from measures that are known to have negative consequences (i.e., those Proven Not to Work). This may also be difficult due to commonly accepted views of such actions (e.g., providing driver education as a more expedient way to license young novice drivers).
5. A state may want to explore newly developing, innovative countermeasures that are untried. Guidelines are suggested for how to assess such new countermeasures.

1. Identify Proven Injury Reducing Countermeasures That Can Be Implemented

There are 23 countermeasures that are rated as Proven and for which injury reduction estimates are available (see Appendix B). Any of these measures that have not yet been implemented in a given state should be considered first for inclusion in a state's highway safety plan. The countermeasures in this Proven classification are as follows:

1. School pedestrian training,
2. Booster seat programs,
3. Bike helmet law for children,
4. Motorcycle helmet use law,
5. Primary seat belt law,
6. Short, high-visibility belt law enforcement,
7. GDL,
8. Extended learners permit,
9. Night restrictions for young novice drivers,
10. Passenger restrictions for young novice drivers,
11. Administrative license revocation,
12. Mass media in support of alcohol (or other) enforcement,
13. Mandatory attendance at alcohol treatment programs,
14. Sobriety checkpoints,
15. Alcohol safety interlocks,
16. Multi-component community programs to address underage drinking,
17. Speed cameras (automated speed enforcement),
18. Red-light cameras (automated red-light enforcement),
19. License suspension,
20. Individual meetings for traffic violators,
21. Group meetings for traffic violators,
22. Warning letters for traffic violators, and
23. Reduced speed limits (for pedestrian safety).

It is recognized that it may not be feasible to implement some of these measures at the present time. There may be political, legal, or financial constraints that make current implementation difficult, if not impossible. Alternatively, implementation may not be possible at the present time because the likely quality or intensity of activity that your state can provide is not sufficient to fully implement the countermeasure.

For example, in the Voluntary Action Group, booster seat promotions and parent management programs are rated as Proven, but this rating is based on programs that are of very high quality. Successful programs in these areas have been quite sophisticated, involving techniques associated with more effective PI&E programs (e.g., interactive methods, inputs from multiple sources, long-term programs, financial incentives, etc.). Lesser-quality programs that are short term, or that are based on didactic approaches or posters in schools, for example, are not likely to increase booster seat use, or to influence parents to better manage their teenagers' driving practices. In general, every PI&E program proposed, whether it is used alone or in conjunction with other measures, needs careful formative evaluation and development to ensure that it is of sufficiently high quality and that it is based on behavior change principles.

There is a second-level judgment to be made as well. PI&E programs that work tend to have high development and implementation costs, and one consideration in funding such programs is whether or not they are intended to be repeated. For example, a booster seat program run one time in one community may increase use, but can it be repeated and/or sustained, and is it a program that other communities can adopt? This is somewhat of a Catch-22 situation, because in order to work, such a program may have to be so extensive and thorough (with associated costs) that it is outside the reach of other communities. On the other hand, there are more modest PI&E programs for children, such as the Willy Whistle program for teaching young children how to cross streets, that have modest costs associated with them and could readily be applied in school systems across the state. Still, it should be remembered that the savings associated with effective programs are substantial and that high-cost programs that produce substantial effects can be a stimulus for other such programs. There have been demonstration programs, for example, that have had high costs but that have also become models for other, often large-scale, effective efforts. For example, the seat belt enforcement program in Elmira, New York, was a high-cost effort, but it demonstrated that vigorous enforcement of belt use laws could be done with high public acceptance. This paved the way for the North Carolina CIOT Program and eventually led to the nationwide launch of high-intensity belt use enforcement programs (i.e., the national CIOT mobilizations).

Another issue that must be considered in selecting Proven countermeasures is how long the program must be maintained to be effective or cost effective. This is a major consideration for some of the programs in the Laws Plus Enhancements Group. For example, sobriety checkpoints are a proven technique, but to work they have to be sustained over time. If checkpoints are run for just a short period of time, such as during a single holiday period, they are likely to have little or no long-term effect. Short-term media bursts to supplement laws also have very limited effects.

In establishing an effective countermeasure program (and selecting countermeasures for that program), it is also important to take advantage of favorable trends. Graduated licensing provides a good example of a trend that is both popular and effective at the present time. Research is now available that has established the importance of the core elements of graduated licensing (extended learner permit, night and passenger restrictions, are all rated Proven). Some states do not have these provisions or have weak versions of them. Establishing or upgrading the key provisions of GDL is an important step forward. Because of the current trend of activities and public support, this may be an opportune time for a state to assess and upgrade its novice driver GDL program.

Some countermeasures are both highly cost effective and highly controversial. Automated speed and red-light enforcement provides a case in point, especially in reference to speed cameras. Controlling high speeds is an important goal, and speed cameras are a proven countermeasure in accomplishing this goal. It is important to note, however, that community programs involving camera technology can be designed in ways that are publicly acceptable. Such programs exist in Scottsdale, Arizona; Charlotte, North Carolina; and Montgomery County, Maryland, and can be used as models. General guidelines also are available for conducting speed-control programs that are effective and acceptable, using such techniques as focusing on "extreme" speeders and speeding in school zones (Harsha and Hedlund, 2007).

Some highly effective countermeasures simply may not be possible given existing state law or political climate. Sobriety checkpoints, for instance, are not legal in some states, and a motorcycle helmet law or a primary seat belt law simply may be out of reach given the current legislature.

The result of this process will be the selection of Proven countermeasures for inclusion within the state's highway safety plan that can be accomplished within the political, legal, and financial conditions that currently exist within the state. In addition, to be effective, the state must recognize that these countermeasures must share two characteristics: (1) that they can be implemented; and (2) that they can be implemented to the level necessary to achieve crash and injury reduction.

Implementation, in some cases, need not be statewide. Urban jurisdictions will have a greater need for pedestrian countermeasures than their rural counterparts; rural areas may be more concerned with speeding than are urban areas; college communities will be more concerned with underage drinking than other parts of the state. Problem identification (i.e., identification of the who, what, when, where, and why of any particular target group of fatal and nonfatal injuries) should be used to cost effectively deploy programs.

2a. Use Countermeasures That Are Likely To Be Effective

Thirteen of the 104 countermeasures are listed as Likely to be effective. Each of these countermeasures fits within the effectiveness guidelines for its classification (i.e., Voluntary Action; Laws; Laws Plus Enhancements; or Sanctions and Treatments Groups). This means that, based on what has been seen with other similar countermeasures, these countermeasures should be effective, if properly or fully implemented. These Likely to be effective countermeasures include the following (references are provided in Appendix C):

1. Responsible beverage service;
2. Parent guiding teen licensing;
3. Ice cream vendor ordinances;
4. Local primary seat belt laws or ordinances;
5. Adult bicycle helmet laws;
6. License renewal policies for elderly drivers;
7. License actions for underage alcohol violations;
8. Integrated enforcement (e.g., alcohol, seat belts, speeding);
9. Zero-tolerance enforcement;
10. Vendor compliance checks for age-21 enforcement;
11. Sustained seat belt enforcement;
12. Increased belt use law penalties; and
13. Simplifying and streamlining DUI statutes.

Each of these Likely countermeasures has been implemented in one or more jurisdictions in the past and most have been evaluated with positive results. However, the evaluations of these countermeasures have typically focused on intermediate measures of effectiveness (e.g., number of bicycle helmets distributed, number of drinks served, number of arrests, increases in seat belt use, etc.), often within limited areas of a state or community. These countermeasures may be presumed to be effective, although the full benefit they provide as measured by injury reduction is not fully established.

It is suggested that Likely countermeasures be considered side by side with Proven countermeasures for which benefit information is not available. Both tend to positively impact some intermediate measure of highway safety that should, eventually, reduce injury.

2b. Consider Proven Countermeasures with No Effectiveness Estimates

There are some countermeasures that are Proven yet the evaluation evidence does not provide estimates of crash reduction. These countermeasures are discussed and referenced in Appendix D.

1. Speed limits,
2. BAC test refusal penalties,
3. Saturation patrols for alcohol-impaired driving,
4. Preliminary breath test devices,
5. Passive alcohol sensors,
6. Restrictions on plea bargaining,
7. Court monitoring,
8. Brief interventions (alcohol),
9. Vehicle immobilization,
10. Vehicle impoundment,
11. Close monitoring of DUIs,
12. PI&E supporting belt law enforcement, and
13. Child bicycle helmet promotions.

Speed limits, or more particularly, "rational speed limits," can limit the number of speed violators and reduce the variance between vehicles traveling at the fastest speeds and vehicles traveling more slowly on a particular stretch of road. This will make speed-related crashes less likely. However, there is no direct formula for creating a crash reduction estimate. Moreover, for most jurisdictions, the number of miles of roadway for which rational speed limits are applicable is limited. Therefore, statewide implementation of this countermeasure is not possible. This should be viewed as a local countermeasure.

As indicated, the next four countermeasures on the list shown above all deal with increasing the arrest rate of drinking drivers and/or collecting more complete evidence. Each of these should be thought of as enhancements to the process of finding, arresting, and prosecuting offenders. Obviously, improvements in the process are desirable and this process has strong general deterrence potential. However, as above, there is no direct formula for creating a crash reduction estimate.

The next group of six countermeasures on the list deal with increasing the probability of conviction and the severity of sanction for drinking drivers. Certainty and severity of sanction are the desirable goal. However, again, there is no direct formula for creating a crash reduction estimate from these countermeasures.

Child bicycle helmet promotions increase use to varying degrees, but do not yield estimates of injury reductions. Similarly, PI&E in support of belt law enforcement can increase use but does not readily convert to injury reductions.

Decisions to implement these countermeasures will need to be made without direct estimates of their potential crash reduction benefits. Many will play an important role in the development of a highway safety plan. However, final decisions will need to be made on identified need for process improvements and judgment as to how these measures may be used to fill those needs.

3. Avoid Countermeasures with Unknown and Unlikely Effectiveness

Many of the Unknown/Uncertain/Unlikely countermeasures are in the Voluntary Action Group. The education and information approach that characterizes these countermeasures is popular. This group involves more than one-third of all the countermeasures. It has, by far, the highest percentage of countermeasures of unproven effectiveness (84%).

Many voluntary action programs have long been known to be ineffective, but their popularity remains. Exhorting people to take some preferred health action for their own benefit is easy to do and gives the appearance of doing something important for society; sometimes these efforts are referred to as feel-good programs. A somewhat cynical appraisal of this situation was presented by Stone (1989, p. 891), who noted that ". . . health education is cheap, generally uncontroversial, and safe: if it works, the politicians take the credit, and if it does not, the target population takes the blame." In this context, the following conclusions of Williams (2007a, p. 9) bear repeating:

> Never assume that a PI&E program will be successful. In fact, most PI&E programs do not lead to a measurable reduction in crashes or injuries. . . . Never assume that a PI&E program will do no harm. Some well-meaning educational programs, albeit a very few, actually lead to more crashes and injuries. Moreover, the implementation of a program that does not work will limit the amount of resources available for programs that can make a difference.

Avoidance of ineffective countermeasures is by no means limited to the voluntary action group, but applies to the other three groups as well. Passing laws that have limited public acceptability or that are not readily enforceable are two examples. Enforceability is a key issue. Much current attention in the United States has been given to distracted, fatigued, and aggressive driving. However, enacting laws against these behaviors, although it may be a popular approach, is likely to have little effect because they are difficult for police to enforce.

Laws against hand-held cell phones constitute a separate distracted driving issue. General cell phone laws are listed as having uncertain impact. The behavior is observable by police, but the evidence indicates minimal decreases in use unless the law is enforced (McCartt, Hellinga, and Geary, 2006). However, research has indicated that the distraction is the cell phone call itself, not whether it is hands free or hands on.

States choosing to implement countermeasures in the Unlikely/Unknown group need to emphasize those listed with plus (+) ratings. Whatever the choice, states will need to conduct a comprehensive evaluation and take corrective action at the first sign of trouble. Again, resources spent for measures that do not work will limit the resources available for things that will work.

4. Do No Harm

Some programs with potentially negative effects (Proven Not to Work) have become popular. For instance, programs that teach teenagers advanced driving maneuvers, typically how to handle skids. The logic here is that standard driver education courses generally concentrate on basic driving skills. However, it is known that graduates of these courses are prone to being involved in crashes that reflect driving inexperience (e.g., running off the road and not being able to recover) so it is important to teach new drivers skills that will help them avoid these types of crashes. That is the premise, but research in Scandinavia and the United States has found that skid courses have a negative effect. Drivers who take these courses—especially young males—have more crashes than untrained drivers (Jones, 1993; Glad, 1988). This is perhaps because of the age factor. That is, drivers who get this training may become overconfident and drive more aggressively, showing off to their friends, etc. (see Williams and Ferguson, 2004). Despite these research findings, skid courses offered by manufacturers, police organizations, and others have proliferated in recent years in the United States.

Another example is offering traffic violator school, *in lieu of fines and points on the license*. The "in lieu of" qualifier is important here. These schools have not been shown to provide a safety benefit that outweighs the benefits provided by traditional "fine and point" sanctions (Peck and Gebers, 1991; McCartt and Solomon, 2004). School *in addition to* fines and points is a different matter and can be effective.

A third example is driver education that speeds the process of young driver licensing or programs that provide a "time discount" for their completion (i.e., earlier licensure for those who have taken driver education). Speeding the licensure process and therefore increasing exposure to crashes at an early age has, repeatedly, been shown to increase the number of young driver crash involvements (Vernick, Li, Ogaitis, et al., 1999; Roberts, Kwan, and Cochrane Injuries Group, 2006; Mayhew, 2007). Any "value added" that the completion of driver education may provide does not outweigh the negative effects of licensing teens at a younger age.

Selection of Countermeasures

The relative effectiveness of various countermeasures and countermeasure groups has been described, along with considerations regarding their selection. This information should be considered by HSOs in the development of their highway safety plans. The next step is to actually select countermeasures from these lists of potential countermeasures. One way to begin is to first identify total highway loss, as well as the proportion of that loss represented by each target group for which a Proven countermeasure can be implemented.

Table 9 shows the total fatal and nonfatal highway loss for a typical 600-fatality state. This table represents national averages.

Table 9 can, and probably should, be generated specifically for your state based on your fatality data. Small states should average the last 5 years; large states might use the last 3 years. The advantage to averaging across several years is that it provides a more statistically stable estimate for each target group. The disadvantage associated with using too many prior years, however, is that the further back in time a state goes, the less representative the numbers will be of its current situation. This is particularly important if the state has recently implemented an important, potentially impacting countermeasure, such as a primary belt law, the effects of which are only apparent for the recent past (e.g., the last 18 months).

Even if a state does not use its own data averaged across the last few years, it will still need to scale Table 9 to reflect its annual number of fatalities. Thus, if a state has 1,200 fatalities per year, then all of the figures in Table 9 need to be doubled. States with 300 fatalities need to cut the figures in Table 9 by half. Scaling is easily accomplished by taking your number of fatalities (say 450); dividing by 600 (450/600 = 0.75); then multiplying this number (0.75) times every dollar estimate in the table. Similarly, a state with 750 fatalities would get a multiplier of 1.25 (750/600 = 1.25).

The next step, after the dollar estimates in Table 9 have been adjusted for your state, is to array the potentially viable countermeasures against the respective target groups.

Twenty-three Proven countermeasures are described in Appendix B, along with percent crash reduction estimates. Each has an intended target group and each indicates the expected effectiveness when fully and properly implemented. Simply array the countermeasures against the appropriate target group; then go to the last column in the table (total highway loss) and multiply the total by the expected level of effectiveness. The result is the expected benefit for your state. For example, alcohol-impaired drivers cost the typical 600-fatality state $537,874,321 per year. Sobriety checkpoints that are implemented across the state for the full year, with full media support, would be expected to provide a 20% injury reduction. Multiply 20% by $537,874,321 (or your state's adjusted total cost of deaths and injuries) to calculate the estimated savings, which in this case is $107 million.

Sobriety checkpoints were selected as the first example since they are one of the most expensive countermeasures a state might consider. Proven countermeasures that can be implemented at relatively less cost include child bike helmet law, GDL, extended learner permit, night restrictions,

Table 9. Fatal and nonfatal highway loss for typical 600-fatality state.

Crashes involving	Fatal injuries	Nonfatal injuries	Type of highway loss		
			Fatal	Nonfatal	Total
All persons	600	75572	$669,492,000	$2,285,140,088	$2,954,632,088
Pedestrians	67	2116	$75,110,214	$63,971,882	$139,082,096
Distracted	60	13997	$66,663,455	$423,239,815	$489,903,270
Drowsy	19	1412	$21,101,197	$42,704,002	$63,805,199
Speed	162	14178	$180,836,003	$428,711,216	$609,547,219
Aggressive	164	14770	$183,442,252	$446,600,914	$630,043,166
Alcohol related	248	11583	$276,723,360	$350,234,416	$626,957,776
Alcohol impaired	213	9937	$237,404,168	$300,470,153	$537,874,321
Teen drivers	32	7681	$35,969,377	$232,263,878	$268,233,255
Age-16 drivers	12	3318	$13,816,260	$100,328,595	$114,144,855
Elderly drivers	44	4232	$49,220,426	$127,978,295	$177,198,721
Motorcycles	65	2245	$72,528,300	$67,871,854	$140,400,154
Nighttime	214	14109	$238,550,290	$426,621,478	$665,171,767
Child in car	14	9168	$15,590,393	$277,215,254	$292,805,648
Front seat occupants	376	58720	$419,433,394	$1,775,583,025	$2,195,016,419
Bicycles	11	1153	$12,089,228	$34,859,723	$46,948,950

passenger restrictions, license suspension, and warning letters. Countermeasures that can be implemented at comparatively little direct cost to the state (e.g., offender-pay countermeasures) include mandatory attendance at alcohol treatment, alcohol interlocks, and red-light running cameras. All of these efforts should be given serious consideration in the development of a state highway safety plan. Cost benefit ratios for these countermeasures, if calculated, would be enormous.

Next, there are several countermeasures for which the benefit/cost ratio measured in terms of dollars is large but that may be difficult to implement given the current political climate. These countermeasures include universal mandatory motorcycle helmet law, primary seat belt law, speed cameras, and reduced speed limit. Each of these countermeasures, if not already in place, should be implemented as soon as it is feasible to do so.

Several countermeasures fall between these two cost extremes. These include child pedestrian training, booster seat promotions, high-visibility enforcement, ALR, mass media in support of alcohol enforcement, community programs for under age 21 enforcement, individual meetings, and group meetings. For each of these, it will be necessary for a state to estimate its own costs for “fully” implementing these programs. Once the costs have been estimated, the benefit/cost ratio can be estimated using the expected effectiveness (shown in Appendix B) and the cost data shown in Table 9.

A state may conclude that it would be better served by implementing a program on a regional basis instead of statewide. All of the benefit and implementation cost numbers can be scaled accordingly just by entering the total number of deaths for that region, relative to those of the “typical” state (to get an estimate of total costs) and then entering the number of deaths for the targeted population in the region involved. Programs that may fall into this category of regional or sub-group implementation include child pedestrian safety (urban), red-light running (urban and suburban), community under age-21 enforcement (college towns), and reduced speed limit for pedestrians (urban).

This exercise will result in a series of countermeasures that the state intends to include in its highway safety plan. At least some of these countermeasures will be accompanied by benefit/cost estimates. Other countermeasures may be implemented with little cost or on a user-pay basis such that the benefit/cost ratio is not relevant.

Note that all of the selected countermeasures—Proven, Proven without injury reduction estimates, and Likely—can be assessed with respect to the target groups listed in Table 9. Measures attempting to deal with a large target group will be favored, other things being equal, over measures dealing with a much smaller target group.

Shift in Strategy

It should be noted that the above strategy for countermeasure selection differs from current guidelines. Currently, the recommended approach is to (1) conduct problem identification, (2) identify priority areas, (3) formulate goals and objectives for each priority area, then (4) select countermeasures that will lead to the accomplishment of those goals.

The present analysis suggests that this is not the optimal approach. Specifically, it is highly likely that there will be no effective and cost-effective countermeasures available to achieve significant impact in some program/problem areas. Even if a potentially effective countermeasure is available, it may not be possible to implement that countermeasure at this time. For instance, it may not be possible at this time to enact a universal mandatory helmet law for all motorcycle riders. Or, in your state it may not be possible to conduct sobriety checkpoints. Similarly, speed cameras, a primary seat belt law, or restrictions on plea bargaining may not be viable options at this time.

The present analysis suggests that the availability of effective/cost-effective countermeasures that can realistically be implemented at this time is a major limiting factor. Highway safety plans should attempt to avoid objectives that are unattainable, given current technology and political climate. Rather, they should focus funds and other resources primarily on those objectives that can be addressed. Therefore, the strategy recommended in this document is for the state to (1) conduct problem identification (as above), (2) identify priority areas (as above), (3) identify cost-effective countermeasures that *can* be implemented, and then and only then (4) formulate realistic objectives based on the expected effectiveness of the identified countermeasures.

Consider, for instance, the objectives of the health care delivery system, which includes doctors, hospitals, medical insurance companies, etc. This system is presented with a range of medical conditions. Some of these conditions can be treated, given current technology, and some cannot. The objective of the system is to treat those that can be treated. The best that can be accomplished for the remainder is to attempt to deal with the symptoms since the underlying problem can not be solved given current medical technology. The limiting factor is the availability of a course of treatment. Although the desire may be to cure everyone, the system can only realistically cure those medical conditions that are treatable now, at this time, in this place, with available technology.

Similarly, although highway safety professionals may wish to save everyone, they can only realistically deal with those deaths and injuries for which there is an available countermeasure that can be implemented in their state, at this time. This list of effective countermeasures is the limiting factor and, as such, it is the driving consideration in the development of a highway safety plan.

New and Emerging Countermeasures

The final highway safety plan will leave some target groups that are not well addressed by the selected countermeasures. This could lead to the possibility that the state may have an interest in pursuing countermeasures that are not yet fully developed, let alone implemented and evaluated. Such new countermeasure development may take the form of an unsolicited proposal from some vested constituency or it may result from innovative efforts from staff or perhaps serendipitous effects from other ongoing efforts.

The potential impact of new and emerging countermeasures should immediately be assessed by first classifying them as: Voluntary Action; Laws, Regulations, Policies; Laws Plus Enhancements; or Sanctions and Treatments. Then, applying the same principles as we have for known existing countermeasures, the state can estimate how the implementation of such countermeasures is likely to affect the fatality, injury, and cost aspects of its traffic safety problem. Some of the most important characteristics, requirements, and opportunities associated with the above listed categories are as follows:

- Voluntary Action
  - Must be of high quality and intensity;
  - Works best when:
    - Targeting children;
    - Allowing communicator some control over audience;
    - Communicating new knowledge; and
    - Serving as part of some larger community-based effort.
- Laws, Regulations, Policies
  - Must be well known to the public;
  - Must be enforceable, based on easily observable and objective criteria; and
  - Must apply to entire targeted population, not to just a subset of the population.
- Laws Plus Enhancements
  - Enhancement must be well publicized;
  - May involve special equipment to aid officers, prosecutors, probation officers, etc.; and
  - Generally involves intense selective and concentrated enforcement.
- Sanctions and Treatments
  - Sanction must be well known to violators;
  - There must be an immediacy and certainty to imposition of the sanction; and
  - There should be a high degree of intrusiveness to the violator (either through penalty or extent of mandated treatment).

New countermeasures that fit with the above guidelines and/or are similar in design to countermeasures that are known to be effective are much more likely to work than measures that do not conform to these guidelines. Note that the majority of countermeasures that have ever been tried have not stood the test of time. Most have not met their objectives. Some have had negative consequences. States implementing new and untried efforts must evaluate progress and take corrective action including halting those countermeasures that are not producing the desired behavioral change. It is important to redeploy resources to effective programs as soon as possible.

Conclusion

This report has focused on moving resources from ineffective and/or marginally effective countermeasures to those with the largest benefit/cost payoff. Sometimes, there are other goals and objectives that need to be considered for at least a portion of available highway safety dollars.

It may be found, for instance, that a particular countermeasure is not likely to work alone, nor will it enhance the impact of another measure, but it could aid in the recruitment of additional advocates and, as such, facilitate adoption of something that does work. One example is the networking and outreach that occurred just prior to the enactment of seat belt use laws. There is little evidence that such activity measurably increased seat belt use, but there are indications that it led to the public awareness and acceptability of seat belt laws before and after enactment. Perhaps the "take one" pamphlet, police overtime, or out-of-state training (and associated travel) should be funded, if it is not very expensive and if it will help cement ties between highway safety and some other key agency.

There will always be a fine line between implementing Proven countermeasures, satisfying key constituencies, and developing new countermeasures to meet emerging issues. This guide focuses on Proven strategies in the hope that states will shift resources *as much as is reasonably possible and prudent* to countermeasures that work and away from countermeasures that don't work or are unlikely to work given our current understanding of behavioral change strategies.

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APPENDIX A

Unknown/Uncertain/Unlikely Countermeasures

Countermeasures shown in the text as Unknown/Uncertain/Unlikely were further rated as: + some basis for thinking they should work; – some basis for thinking they will not work; and 0 unknown whether or not they will work. The main criterion for this rating was the research evidence. There may be no research evidence at all, there are cases where the weight of evidence tips the scale toward a + or – rating, and there are cases where the available research evidence does not allow a judgment. The second criterion, used in the absence of research evidence, involved whether the countermeasure has characteristics associated with successful or unsuccessful measures. For example, in the Voluntary Action Group, programs targeting children would be considered likely to work.

Voluntary Action

+ Child pedestrian supervision training for caregivers (research lacking; has characteristics associated with successful programs).
+ Child safety clubs (the mostly European research base does not have clear-cut findings; has characteristics associated with successful programs) (West, Sammons, and West, 1993; Gregersen and Nolen, 1994; Dragutinovic and Twisk, 2006).
+ Bicycle education for children (research lacking; has characteristics associated with successful programs).
0 School-based alcohol education programs to reduce drinking and driving (insufficient evidence from research; does not have characteristics associated with successful programs) (Stewart, 1999; Elder, Nichols, Shults et al., 2005; Shope, Elliott, Raghunathan et al., 2001; D'Amico and Fromme, 2002).
– PI&E for elderly drivers (no relevant evaluations; does not have characteristics associated with successful programs).
+ PI&E for low belt users (weight of evidence suggests the high-quality programs can increase belt use) (Solomon and Chaffe, 2006).
– Motorcycle education and training courses (weight of research evidence suggests no effects on crashes) (Mayhew and Simpson, 2001; Ivers, in progress).
– Formal driver education courses for elderly drivers (weight of evidence suggests no effects on crashes) (Owsley, McGwin, Phillips et al., 2004; Kua, Korner-Bitensky, Desrosiers et al., 2007).
+ Bike fairs, rodeos (no relevant research; has characteristics associated with successful programs).
– Driver training about sharing the road with bicycles (no relevant research; does not have characteristics associated with successful programs).
– Teaching bike rules/safety in driver education (no relevant research; does not have characteristics associated with successful programs).
– Education encouraging bicyclists to increase their conspicuity (no relevant research; does not have characteristics associated with successful programs).
– Education to encourage pedestrians to increase their conspicuity (no relevant research; does not have characteristics associated with successful programs).
– Driver education in regard to pedestrians (no relevant research; does not have characteristics associated with successful programs).
– Programs to teach driver awareness about motorcyclists (no relevant research; does not have characteristics associated with successful programs).
– PI&E about driver fatigue (no relevant research; does not have characteristics associated with successful programs).
– PI&E about distracted driving (no relevant research; does not have characteristics associated with successful programs).

- – PI&E on sleep disorders for general population and physicians (no relevant research; does not have characteristics associated with successful programs).
- + Employer programs for shift workers, medical interns (insufficient research; has characteristics associated with successful programs).
- + Alternative transportation for alcohol-impaired drivers (weight of evidence suggests positive effects) (Lacey, Jones, and Anderson, 2000; Rothschild, Nastin, and Miller, 2006).
- 0 Designated driver programs (research evidence inconclusive; does not have characteristics associated with successful programs) (Ditter, Elder, Shults et al., 2005).
- – Motorcycle helmet use promotion programs (no relevant research; does not have characteristics associated with successful programs).
- – PI&E regarding drinking and motorcycling (no relevant research; does not have characteristics associated with successful programs).
- – Education to encourage motorcyclists to increase their conspicuity (no relevant research; does not have characteristics of successful programs).
- 0 Programs to help police detect impaired motorcyclists (no relevant research; facilitates the enforcement process).
- – Communications and outreach regarding impaired pedestrians (no relevant research; does not have characteristics associated with successful programs).
- – Extreme fear and scare tactics in youth programs (no relevant research; has characteristics thought not to be associated with successful programs) (Elliott, 2005; DeJong and Wallack, 1999).
- 0 High school driver education (not leading to early learning/licensing).
- + School bus training for children (no relevant research; has characteristics associated with successful programs).

Laws, Regulations, and Policies

- + General cell phone laws (mixed research evidence, short-term effects that may or may not last depending on enforcement and publicity; has characteristics associated with successful laws) (McCartt, Hellinga, and Geary, 2006; McCartt and Hellinga, 2007).
- 0 Open container laws (scant evidence; does not have characteristics associated with successful laws) (Stuster, Burns, and Fiorentino, 2002).
- + Lower BAC limit for repeaters (weight of evidence suggests positive results) (Hingson, Heeren, and Winter, 1998; Jones and Rodriguez-Iglesias, 2004).
- + Cell phone laws as part of graduated licensing (limited research evidence).
- + Belt use as part of graduated licensing (limited research evidence) (Goodwin, Wells, Foss et al., 2006).
- 0 Motorcycle licensing laws, especially in regard to having a valid license (some limited evidence that programs can increase licensure) (Braver, Kufera, and Volpini et al., 2007).
- 0 Comprehensive belt laws versus laws with significant exceptions (no relevant research, e.g., on extent to which belt laws that cover rear passengers increase belt use; does not have characteristics associated with successful laws).
- 0 Keg registration laws (positive but inconclusive evidence they reduce crash rates; does not have characteristics associated with successful laws) (Grube and Stewart, 2004).
- 0 Medical advisory boards for elderly drivers (no relevant studies; some likelihood that medical advisory boards can assist licensing agencies in evaluating people with medical conditions/functional limitations affecting driving ability).
- – Aggressive driving laws (no relevant research; does not have characteristics associated with successful laws).
- – Driver fatigue and distracted driving laws (no relevant research; does not have characteristics associated with successful laws).
- + Referring elderly drivers to licensing agencies (limited research; likelihood that states establishing and publicizing referral procedures will increase referrals).
- + Elderly licensing screening and testing (limited research; likelihood that model guidelines can identify with reasonable accuracy those whose driving should be curtailed) (Staplin and Lococo, 2003; Staplin, Lococo, Gish et al., 2003).
- + Elderly licensing restrictions (weight of evidence suggests restrictions lower crash risk) (Vernon, Diller, Cook et al., 2001).

Laws Plus Enhancements

- + Aggressive driving enforcement (weight of evidence suggests positive effects) (McCartt, Leaf, Witkowski et al., 2001; NHTSA, 2002; Stuster, 2004; Davis, Bennink, Pepper et al., 2006).
- + GDL enforcement (weight of evidence suggests positive though limited effects) (Goodwin, Wells, Foss et al., 2006).
- – Enforcement of pedestrian rules (for both drivers and pedestrians; limited research); one study showed no effect on driver yielding; does not have characteristics associated with successful programs (Britt, Bergman, and Moffat, 1995).
- – Enforcement of bike rules (for both bikers and drivers) (no relevant research; does not have characteristics associated with successful programs).

+ Enforcement against unapproved motorcycle helmets (no relevant research; has characteristics associated with successful programs).

Sanctions and Treatments

+ Vehicle forfeiture (no relevant research; has characteristics associated with successful sanctions).
0 GDL penalties (limited unsupportive research; does not have characteristics associated with successful sanctions) (Goodwin and Foss, 2004; Williams, 2007b).
0 DUI fines (limited evidence suggests no effects in reducing alcohol-impaired driving) (Century Council, 2003).
0 DUI jail (weight of evidence suggests no positive effects) (Wagenaar, Zobek, and Williams, 2000).
+ High BAC sanctions (limited evidence suggests positive effects on recidivism) (McCartt and Northrup, 2004).
+ DWI courts (results are mixed, some positive, some not) (Guerin, 2002).

APPENDIX B

Effectiveness Estimates for Twenty-Three Proven Countermeasures

Class 1: Voluntary Action

School Pedestrian Training for Children: Estimated effect 12% reduction in child pedestrian injuries (Blomberg, Preusser, Hale et al., 1983); applicable population: elementary school pedestrians; effects limited unless program is ongoing (low cost).

The effect of this countermeasure is an estimated 12% reduction in child pedestrian injuries. Its primary target is school-aged children, which we define as children between 6 and 12 years of age. The pedestrian fatality-to-injury ratio will be used in all calculations.

School-aged pedestrian fatalities represent 0.3% of all fatalities, resulting in an estimated 2 fatalities per state. As there are an estimated 31 injuries per fatality, the example state is estimated to have 57 child pedestrian injuries per year, for a total estimated cost of $3,750,385. School pedestrian training for children has an estimated 12% reduction in injuries, resulting in savings of $450,046.

Table B1. Estimated savings for school pedestrian training countermeasure.

Total fatalities	42,642
Child pedestrian fatalities (U.S.)	129
% total fatalities (U.S.)	0.303%
Median fatalities (state)	600
Est. child ped. fatalities (state)	1.82
Pedestrian Death-to-Injury Ratio	31.43

ESTIMATED SAVINGS FOR AN EXAMPLE STATE					
		No.	**$ Fatalities**	**$ Injuries**	**$ Total**
	Fatalities	1.82	$ 2,025,338		
School pedestrian training	Injuries	57		$ 1,725,047	$ 3,750,385
Reduction	Loss reduced by:	12%			
	Fatalities	1.60	$ 1,782,298		
	Injuries	50.2		$ 1,518,041	$ 3,300,339
	Savings				**$ 450,046**

Booster Seat Promotions: Effect varies according to type of program and baseline use. Programs have involved education directed at children, parents, or physicians, delivered through traditional channels or via home visits; plus discounts for booster seat purchase. Increases in booster seat use have been reported: from 61 to 75%, 0 to 22%, 43 to 67%; 13 to 26% (Ehiri, King, Ejere et al., 2006). Durbin, Elliott, Winston et al. (2003) estimate a 59% reduction in injury for children in a booster seat rather than an adult seat belt; applicable population: children ages 4-8 not traveling in booster seats; effects limited to duration of program (medium cost).

Booster seat promotions increase use by 13% and the effect of putting children in booster seats rather than adult seat belts is an estimated 59% reduction in injuries. Thus, this countermeasure reduces injuries by an estimated 8%. Its primary target is children between 4 and 8 not traveling in booster seats in passenger vehicles. The child occupant fatality-to-injury ratio will be used in all calculations.

Children 4 to 8 not traveling in booster seats represent 0.6% of all fatalities, resulting in an estimated 4 fatalities per state. As there are an estimated 656 injuries per fatality, the example state is computed to have 2,530 injuries per year, for a total estimated cost of $80,794,661. Booster seat programs have an estimated 8% reduction in injuries, resulting in savings of $6,140,394.

Table B2. Estimated savings for booster seat programs countermeasure.

Total fatalities	42,642
Fatals child occ age 4-8 not in seat	274
% total fatalities	0.643%
Median fatalities (state)	600
Est. children occ. 4-8 fatals (state)	3.86
Child occupants death-to-injury ratio	656.15

ESTIMATED SAVINGS FOR AN EXAMPLE STATE

		No.	$ Fatalities	$ Injuries	$ Total
	Fatalities	3.86	$4,301,881		
Booster seat programs	Injuries	2,530		$76,492,780	$80,794,661
Reduction	Loss reduced by:	8%			
	Fatalities	3.56	$3,974,938		
	Injuries	2,337.4		$70,679,328	$74,654,266
	Savings				**$ 6,140,394**

Class 2: Laws, Regulations, Policies

Bike Helmet Laws for Children: Grant and Rutner (2004) estimate a 15% reduction in child bicyclist fatalities attributable to bike helmet laws; applicable population: child bikers under age 12; permanent effects (medium cost).

The effect of this countermeasure is an estimated 15% reduction in fatalities. Its primary target is bicyclists under the age of 12. The bicyclist fatality-to-injury ratio will be used in all calculations.

Cyclists under age 12 not wearing a helmet represent 0.1% of all fatalities, resulting in an estimated 1 fatality per state. As there are an estimated 106 injuries per fatality, the example state is computed to have 91 injuries per year, for a total estimated cost of $3,719,434. Bike helmet laws for cyclists under age 12 have an estimated 15% reduction in fatalities, resulting in savings of $557,519.

Table B3. Estimated savings for child bike helmet law countermeasure.

Total fatalities	42,642
Bicyclists under 12, no helmet	61
% total fatalities	0.143%
Median fatalities (state)	600
Est. child cyclist fatalities (state)	0.86
Cyclist death-to-injury ratio	106.41

ESTIMATED SAVINGS FOR AN EXAMPLE STATE

		No.	$ Fatalities	$ Injuries	$ Total
	Fatalities	0.86	$ 957,718		
Bike helmet law for children	Injuries	91		$ 2,761,716	$ 3,719,434
Reduction	Loss reduced by:	15%			
	Fatalities	0.73	$ 814,060		
	Injuries	77.6		$ 2,347,459	$ 3,161,519
	Savings				**$ 557,915**

Graduated Driver Licensing (GDL): For three-stage systems, 20-40% reduction in crashes (Shope, 2007; Baker, Chen, and Li, 2007); applicable population: 16-year-old drivers; permanent effects (medium cost).

The effect of this countermeasure is an estimated 20% reduction in crashes involving 16-year-old drivers. Its primary target is 16-year-old drivers. The 16-year-old driver fatality-to-injury ratio will be used in all calculations.

Sixteen-year-old drivers are involved in 2% of all fatalities, resulting in an estimated 12 fatalities per state. As there are an estimated 268 injuries per fatality, the example state is computed to have 3,318 injuries per year, for a total estimated cost of $114,143,621. GDL has an estimated 20% reduction in crashes, resulting in savings of $22,828,724.

Table B4. Estimated savings for GDL countermeasure.

Total fatalities	42,642				
Fatalities involving 16 y/o driver	880				
% total fatalities	2.064%				
Median fatalities (state)	600				
Est. fatals inv. 16 y/o drivers (state)	12.38				
Death-to-injury ratio inv 16 y/o driver	267.96				
ESTIMATED SAVINGS FOR AN EXAMPLE STATE					
		No.	$ Fatalities	$ Injuries	$ Total
GDL – 3 stages	Fatalities	12.38	$13,816,260		
	Injuries	3,318		$100,327,361	$114,143,621
Reduction	Loss reduced by:	20%			
	Fatalities	9.91	$11,053,008		
	Injuries	2,654.3		$80,261,889	$ 91,314,897
	Savings				$ 22,828,724

Extended Learner Permit: Reduction of 22-33% in 16-year-old crashes if minimum permit age 16 and 6-month minimum holding period (Agent, Steenbergen, Pigman et al., 1998; Ulmer, Ferguson, Williams et al., 2001; Mayhew, Simpson, Desmond et al., 2003); applicable population: 16-year-old drivers; permanent effects (low cost).

The effect of this countermeasure is an estimated 22% reduction in crashes involving 16-year-old drivers if the minimum permit age is 16 with a 6-month minimum holding period. Its primary target is 16-year-old drivers. The 16-year-old driver fatality-to-injury ratio will be used in all calculations.

Sixteen-year-old drivers are involved in 2% of all fatalities, resulting in an estimated 12 fatalities per state. As there are an estimated 268 injuries per fatality, the example state is computed to have 3,318 injuries per year, for a total estimated cost of $114,143,621. The extended learner permit has an estimated 22% reduction in crashes, resulting in savings of $25,111,597.

Table B5. Estimated savings for extended learner permit countermeasure.

Total fatalities	42,642				
Fatalities involving 16 y/o driver	880				
% total fatalities	2.064%				
Median fatalities (state)	600				
Est. fatals inv. 16 y/o drivers (state)	12.38				
Death-to-injury ratio involving 16 y/o driver	267.96				
ESTIMATED SAVINGS FOR AN EXAMPLE STATE					
		No.	**$ Fatalities**	**$ Injuries**	**$ Total**
Extended learner permit	Fatalities	12.38	$13,816,260		
	Injuries	3,318		$100,327,361	$114,143,621
Reduction	Loss reduced by	22%			
	Fatalities	9.66	$10,776,683		
	Injuries	2,588		$ 78,255,342	$ 89,032,024
	Savings				**$ 25,111,597**

Night Restrictions: On average, 50% reduction in nighttime crashes (9 P.M. to 6 A.M.) (Williams, 2007b); applicable population: 16-year-old drivers; permanent effects (low cost).

The effect of this countermeasure is an estimated 50% reduction in nighttime crashes (9 P.M. to 6 A.M.) involving 16-year-old drivers. Its primary target is 16-year-old drivers. The 16-year-old driver fatality-to-injury ratio will be used in all calculations.

Nighttime fatalities involving 16-year-old drivers represent 0.6% of all fatalities, resulting in an estimated 4 fatalities per state. As there are an estimated 268 injuries per fatality, the example state is computed to have 954 injuries per year, for a total estimated cost of $32,816,291. The nighttime (9 P.M. to 6 A.M.) restrictions have an estimated 50% reduction in nighttime crashes, resulting in savings of $16,408,146.

Table B6. Estimated savings for night restrictions countermeasure.

Total fatalities	42,642
Fatalities involving 16 y/o drivers in nighttime crashes	253
% total fatalities	0.593%
Median fatalities (state)	600
Estimated fatalities involving 16 y/o drivers in nighttime crashes (state)	3.56
Death-to-injury ratio involving 16 y/o drivers	267.96

ESTIMATED SAVINGS FOR AN EXAMPLE STATE

		No.	$ Fatalities	$ Injuries	$ Total
Night restrictions (9 P.M. to 6 A.M.)	Fatalities Injuries	3.56 954	$3,972,175	$28,844,116	$32,816,291
Reduction	Loss reduced by: Fatalities Injuries	50% 1.78 477.0	$1,986,087	$14,422,058	$16,408,146
	Savings				**$16,408,146**

Passenger Restrictions: About a 33% reduction in 16-year-old fatal crashes in which teen passengers are injured or killed (Williams, 2007b); applicable population: 16-year-old drivers, permanent effects (low cost).

The effect of this countermeasure is an estimated 33% reduction in 16-year-old driver fatal crashes in which a teen passenger was injured or killed. Its primary target is 16-year-old drivers with teen passengers. The 16-year-old driver fatality-to-injury ratio will be used in all calculations.

Table B7. Estimated savings for passenger restrictions countermeasure.

Total fatalities	42,642
Fatalities involving 16 y/o drivers with teen passengers	504
% total fatalities	1.182%
Median fatalities (state)	600
Est. fatalities involving 16 y/o drivers with teen passenger (state)	7.09
Death-to-injury ratio involving 16 y/o drivers	267.96

ESTIMATED SAVINGS FOR AN EXAMPLE STATE

		No.	$ Fatalities	$ Injuries	$ Total
Passenger restrictions	Fatalities Injuries	7.09 1,900	$7,912,949	$57,460,216	$65,373,165
Reduction	Loss reduced by: Fatalities Injuries	33% 4.75 1,273.2	$5,301,676	$38,498,345	$43,800,020
	Savings				**$21,573,144**

Fatalities involving 16-year-old drivers with teen passenger(s) represent 1% of all fatalities, resulting in an estimated 7 fatalities per state. As there are an estimated 268 injuries per fatality, the example state is computed to have 1,900 injuries per year, for a total estimated cost of $65,373,165. The passenger restrictions have an estimated 33% reduction in the above described crashes, resulting in savings of $21,573,144.

Administrative License Revocation Law: Reduction of 13-15% in alcohol-related crashes (Wagenaar, Zobek, and Williams, 2000; Ross, 1987, 1991; Zador, Lund, and Weinberg, 1989; Voas and Tippetts, 1999); applicable population: alcohol-impaired drivers; permanent effects (high cost).

Table B8. Estimated savings for administrative license revocation countermeasure.

Total fatalities	42,642				
Fatalities involving alcohol-impaired drivers	15,121				
% total fatalities	35.460%				
Median fatalities (state)	600				
Estimated alcohol-impaired related fatalities (state)	212.76				
Alcohol-related death-to-injury ratio	46.7				
ESTIMATED SAVINGS FOR AN EXAMPLE STATE					
		No.	**$ Fatalities**	**$ Injuries**	**$ Total**
Administrative license revocation	Fatalities Injuries	212.76 9,936	$237,404,168	$300,444,419	$537,848,587
Reduction	Loss reduced by: Fatalities Injuries	13% 185.10 8,644.3	$206,541,626	$261,386,645	$467,928,271
	Savings				**$ 69,920,316**

The effect of this countermeasure is an estimated 13% reduction in alcohol-related crashes. Its primary target is alcohol-impaired drivers (BAC ≥ .08). The alcohol related fatality-to-injury ratio will be used in all calculations.

Fatalities involving alcohol-impaired drivers represent 35% of all fatalities, resulting in an estimated 213 fatalities per state. As there are an estimated 47 injuries per fatality, the example state is computed to have 9,936 injuries per year, for a total estimated cost of $537,848,587. Administrative license revocation law has an estimated 13% reduction in crashes, resulting in savings of $69,920,316.

Primary Seat Belt Law: Reduction of 7-8% in fatalities (Farmer and Williams, 2005; Chaudhary and Solomon, under review); applicable population: front seat occupants in passenger vehicles; permanent effects (low cost).

Table B9. Estimated savings for primary seat belt law countermeasure.

Total fatalities	42,642				
Front seat occupants unbelted	13,173				
% total fatalities	30.892%				
Median fatalities (state)	600				
Estimated front seat occupant fatalities (state)	185.35				
Front seat occupants >13 death-to-injury ratio	156.21				
ESTIMATED SAVINGS FOR AN EXAMPLE STATE					
		No.	**$ Fatalities**	**$ Injuries**	**$ Total**
Primary seat belt law	Fatalities Injuries	185.35 28,954	$206,819,992	$875,508,308	$1,082,328,300
Reduction	Loss reduced by: Fatalities Injuries	7% 172.38 26,927.1	$192,342,593	$814,222,726	$1,006,565,319
	Savings				**$ 75,762,981**

The effect of this countermeasure is an estimated 7% reduction in fatalities. Its primary target is unbelted front seat outboard occupants of passenger vehicles (age 13 and up). The front seat occupant fatality-to-injury ratio will be used in all calculations.

Unbelted front seat occupants age 13 and over represent 31% of all fatalities, resulting in an estimated 185 fatalities per state. As there are an estimated 156 injuries per fatality, the example state is computed to have 28,954 injuries per year, for a total estimated cost of $1,082,328,300. Primary seat belt law has an estimated 7% reduction in fatalities, resulting in savings of $75,762,981.

Motorcycle Helmet Use Law: Reduction of 20-40% in fatalities (GAO, 1991); applicable population: motorcyclists; permanent effects (low cost).

The effect of this countermeasure is an estimated 20% reduction in fatalities. Its primary target is motorcyclists. The motorcyclist fatality-to-injury ratio will be used in all calculations.

Table B10. Estimated savings for universal helmet use law countermeasure.

Total fatalities	42,642				
Motorcyclists (all)	4654				
% total fatalities	10.914%				
Median fatalities (state)	600				
Est. motorcyclist fatalities (state)	65.48				
Motorcyclist death-to-injury ratio	34.53				
ESTIMATED SAVINGS FOR AN EXAMPLE STATE					
		No.	**$ Fatalities**	**$ Injuries**	**$ Total**
Universal helmet use law	Fatalities Injuries	65.48 2,261	$73,069,175	$ 68,373,798	$ 141,442,973
Reduction	Loss reduced by: Fatalities Injuries	20% 52.39 1,809.0	$58,455,340	$ 54,699,038	$ 113,154,379
	Savings				**$ 28,288,595**

Motorcyclists represent 11% of all fatalities, resulting in an estimated 65 fatalities per state. As there are an estimated 35 injuries per fatality, the example state is computed to have 2,261 injuries per year, for a total estimated cost of $141,442,973. Universal helmet laws for motorcyclists have an estimated 20% reduction in fatalities, resulting in savings of $28,288,595.

Reduced Speed Limit: Reduction of 25-30% in pedestrian fatalities associated with a reduction in speed limit from 60 km/h to 50 km/h in urban areas (Fieldwick and Brown, 1987; Preston, 1990; Walz, Hoefliger, and Fehlmann, 1983); applicable population: pedestrians of all ages in urban areas; permanent effects (low cost).

Table B11. Estimated savings for reduced speed limit countermeasure.

Total fatalities	42,642				
Ped. fatalities in 60km/h urban zones	1,106				
% total fatalities	2.594%				
Median fatalities (state)	600				
Estimated pedestrian fatalities in 60 km/h urban zones (state)	15.56				
Pedestrian death-to-injury ratio	31.43				
ESTIMATED SAVINGS FOR AN EXAMPLE STATE					
		No.	**$ Fatalities**	**$ Injuries**	**$ Total**
Reduced speed limit	Fatalities Injuries	15.56 489	$17,364,527	$14,789,935	$32,154,461
Reduction	Loss reduced by: Fatalities Injuries	25% 11.67 366.8	$13,023,395	$11,092,451	$24,115,846
	Savings				**$ 8,038,615**

The effect of this countermeasure is an estimated 25% reduction in pedestrian fatalities when urban speed limit is reduced from 60 km/h to 50 km/h. Its primary target is pedestrians in urban areas with a speed limit of 60 km/h. We define urban areas with speed limits between 35 mph and 40 mph as the target zones. The pedestrian fatality-to-injury ratio will be used in all calculations.

Pedestrian fatalities in the target zones represent 3% of all fatalities, resulting in an estimated 16 fatalities per state. As there are an estimated 31 injuries per fatality, the example state is estimated to have 489 urban pedestrian injuries per year, for a total estimated cost of $32,154,461. Reducing speed limits from 60 km/h to 50 km/h in urban areas has an estimated 25% reduction in pedestrian fatalities, resulting in savings of $8,038,615.

Class 3: Laws Plus Enhancements

Sobriety Checkpoints: Reduction of 20% in alcohol-related fatal and injury crashes (Elder, Shults, Sleet et al., 2002); applicable population: alcohol impaired; effects only for duration of checkpoints (high cost).

The effect of this countermeasure is an estimated 20% reduction in alcohol-related fatal and injury crashes. Its primary target is impaired drivers (BAC ≥ .08). The alcohol-related fatality-to-injury ratio will be used in all calculations.

Fatalities involving alcohol-impaired drivers represent 35% of all fatalities, resulting in an estimated 213 fatalities per state. As there are an estimated 47 injuries per fatality, the example state is computed to have 9,936 injuries per year, for a total estimated cost of $537,848,587. Sobriety checkpoints have an estimated 20% reduction in crashes, resulting in savings of $107,569,717.

Table B12. Estimated savings for sobriety checkpoints countermeasure.

Total fatalities	42,642				
Fatalities involving alcohol-impaired drivers	15,121				
% total fatalities	35.460%				
Median fatalities (state)	600				
Estimated alcohol-impaired-related fatalities (state)	212.76				
Alcohol-related death-to-injury ratio	46.7				
ESTIMATED SAVINGS FOR AN EXAMPLE STATE					
		No.	**$ Fatalities**	**$ Injuries**	**$ Total**
Sobriety checkpoints	Fatalities	212.76	$237,404,168		
	Injuries	9,936		$300,444,419	$537,848,587
Reduction	Loss reduced by:	20%			
	Fatalities	170.21	$189,923,334		
	Injuries	7,948.8		$240,355,535	$430,278,870
	Savings				**$107,569,717**

Short, High-Visibility Belt Law Enforcement: Increase of 4-6 percentage points in belt use; applicable population: unbelted front seat occupants; effects primarily while program is ongoing (high cost).

The effect of this countermeasure is an estimated increase of 4 percentage points in belt use. NHTSA estimates that for every 1-percentage-point increase in belt use, an additional 270 lives are saved (2004 data). If belt use were to increase by 4 percentage points, 1,070 lives would be saved. Based on 2004 FARS data, this would represent a 2.52% decrease in fatalities. The primary target for this countermeasure is unbelted front seat outboard occupants (13 and over in passenger vehicles). The front seat occupant fatality-to-injury ratio will be used in all calculations.

Unbelted front seat occupants age 13 and over represent 31% of all fatalities, resulting in an estimated 185 fatalities per state. As there are an estimated 156 injuries per fatality, the example state is computed to have 28,954 injuries per year, for a total estimated cost of $1,082,328,300. Short, high-visibility law enforcement has an estimated 3% reduction in fatalities, resulting in savings of $27,274,673.

Table B13. Estimated savings for short, high-visibility belt law enforcement countermeasure.

Total fatalities	42,642				
Unbelted front seat occupants fatalities	13,173				
% total fatalities	30.892%				
Median fatalities (state)	600				
Est. unbelted front seat occupant fatalities (state)	185.35				
Front seat occupants >13 death-to-injury ratio	156.21				
ESTIMATED SAVINGS FOR AN EXAMPLE STATE					
		No.	**$ Fatalities**	**$ Injuries**	**$ Total**
Short, high-visibility belt law enforcement	Fatalities Injuries	185.35 28,954	$206,819,992	$875,508,308	$1,082,328,300
Reduction	Loss reduced by: Fatalities Injuries	3% 180.68 28,224.3	$201,608,129	$853,445,498	$1,055,053,627
	Savings				**$ 27,274,673**

Automated Enforcement for Speed, Red Light Running: Speed cameras: on average, 20-40% reduction in crashes, based on studies in Canada, Australia, and Europe (Pilkington and Kinra, 2005); red-light cameras: 16% reduction in all injury crashes, 24% reduction in right-angle crashes, no significant increase in rear-end crashes (Aeron-Thomas and Hess, 2005); applicable populations: drivers running red lights or speeding; permanent effects where used (high cost).

The effect of this countermeasure (speed cameras) is an estimated 20% reduction in crashes. Its primary target is speed-related crashes. The speed-related fatality-to-injury ratio will be used in all calculations.

Table B14. Estimated savings for speed cameras countermeasure.

Total fatalities	42,642				
Speed-related fatalities	11,518				
% total fatalities	27.011%				
Median fatalities (state)	600				
Est. speed-related fatalities (state)	162.07				
Speed-related death-to-injury ratio	87.48				
ESTIMATED SAVINGS FOR AN EXAMPLE STATE					
		No.	**$ Fatalities**	**$ Injuries**	**$ Total**
Speed cameras	Fatalities Injuries	162.07 14,177	$180,836,003	$428,699,124	$609,535,127
Reduction	Loss reduced by: Fatalities Injuries	20% 129.65 11,342.0	$144,668,803	$342,959,299	$487,628,102
	Savings				**$121,907,025**

Speed-related fatalities represent 27% of all fatalities, resulting in an estimated 162 fatalities per state. As there are an estimated 87 injuries per fatality, the example state is computed to have 14,177 injuries per year, for a total estimated cost of $609,535,127. Speed cameras have an estimated 20% reduction in crashes, resulting in savings of $121,907,025.

Mass Media Supporting Alcohol Enforcement (Top-Line Programs): Reduction of 13% in alcohol-related crashes, with the caution that this is based on top-line programs (Elder, Shults, Sleet et al., 2002); applicable population: alcohol-impaired drivers; effects while program ongoing (high cost).

The effect of this countermeasure is an estimated 13% reduction in alcohol-related crashes (note that this estimate is based on top-line programs only). Its primary target is alcohol-impaired drivers (BAC ≥ .08). The alcohol-related fatality-to-injury ratio will be used in all calculations.

Fatalities involving alcohol-impaired drivers represent 35% of all fatalities, resulting in an estimated 213 fatalities per state. As there are an estimated 47 injuries per fatality, the example state is computed to have 9,936 injuries per year, for a total estimated cost of $537,848,587. Mass media supporting alcohol enforcement has an estimated 13% reduction in crashes, resulting in savings of $69,920,316.

Table B15. Estimated savings for mass media support of alcohol enforcement countermeasure.

Total fatalities	42,642				
Fatalities involving alcohol-impaired drivers	15,121				
% total fatalities	35.460%				
Median fatalities (state)	600				
Estimated alcohol-impaired-related fatalities (state)	212.76				
Alcohol-related death-to-injury ratio	46.7				
ESTIMATED SAVINGS FOR AN EXAMPLE STATE					
		No.	**$ Fatalities**	**$ Injuries**	**$ Total**
Mass media supporting alcohol enforcement	Fatalities Injuries	212.76 9,936	$237,404,168	$300,444,419	$537,848,587
Reduction	Loss reduced by: Fatalities Injuries	13% 185.10 8,644.3	$206,541,626	$261,386,645	$467,928,271
	Savings				**$ 69,920,316**

Community Programs Including Age-21 Enforcement: Reduction of 10-25% in crashes, based on a study by Holder, Gruenewald, Ponicki et al. (2000), who found that single-vehicle nighttime crashes decreased 10-11% more than in comparison communities, and a study by Hingson, McGovern, Howland et al. (1996), where there was a 25% greater reduction in fatal crashes in study communities than in the rest of Massachusetts (programs were vastly different but both incorporated age-21 enforcement); applicable population: alcohol users under age 21; effects while program ongoing (high cost).

Table B16. Estimated savings for community programs countermeasure.

Total fatalities	42,642				
Fatalities involving drivers <21, BAC ≥.01	2785				
% total fatalities	6.531%				
Median fatalities (state)	600				
Estimated fatalities involving drivers <21, BAC ≥.01 (state)	39.19				
Alcohol-related death-to-injury ratio	46.7				
ESTIMATED SAVINGS FOR AN EXAMPLE STATE					
		No.	**$ Fatalities**	**$ Injuries**	**$ Total**
Community programs including age-21 enforcement	Fatalities Injuries	39.19 1,830	$43,725,323	$55,336,136	$99,061,459
Reduction	Loss reduced by: Fatalities Injuries	10% 35.27 1,647.0	$39,352,791	$49,802,522	$89,155,313
	Savings				**$ 9,906,146**

The effect of this countermeasure is an estimated 10% reduction in crashes. Its primary target is drivers under 21 with BAC ≥ .01. The alcohol-related fatality-to-injury ratio will be used in all calculations.

Fatalities involving drivers under 21 with BAC ≥ .01 represent 7% of all fatalities, resulting in an estimated 39 fatalities per state. As there are an estimated 47 injuries per fatality, the example state is computed to have 1,830 injuries per year, for a total estimated cost of $99,061,459. Community programs including age-21 enforcement have an estimated 10% reduction in crashes, resulting in savings of $9,906,146.

Class 4: Sanctions and Treatments

Aggressive Driving/Speeding Penalties: Crash reduction effects for license suspension 17%, individual meetings 8%, group meetings 5%, and warning letters 4% (Masten and Peck, 2004); applicable population: apprehended traffic violators; effects while sanctions are in force, may not last (medium cost).

These countermeasures' primary target is apprehended traffic violators. For this project, we will define the target as drivers with previous speeding convictions since data regarding previous aggressive driving convictions are not available in FARS.

License Suspension (Medium Cost)

The effect of this countermeasure is an estimated 17% reduction in crashes. Its primary target is drivers with previous speed convictions involved in aggressive-driving-related crashes. The aggressive driving fatality-to-injury ratio will be used in all calculations.

Aggressive-driving-related fatalities involving drivers with previous speed convictions represent 8% of all fatalities, resulting in an estimated 47 fatalities per state. As there are an estimated 90 injuries per fatality, the example state is computed to have 4,250 injuries per year, for a total estimated cost of $181,293,587. License suspension has an estimated 17% reduction in crashes, resulting in savings of $30,819,910.

Table B17. Estimated savings for license suspension countermeasure.

Total fatalities	42,642
Fatalities involving aggressive drivers with prev. speed conv.	3,362
% total fatalities	7.884%
Median fatalities (state)	600
Est. fatalities involving prev. speed conv. (state)	47.31
Aggressive driving death-to-injury ratio	89.84

ESTIMATED SAVINGS FOR AN EXAMPLE STATE					
		No.	**$ Fatalities**	**$ Injuries**	**$ Total**
License suspension	Fatalities Injuries	47.31 4,250	$52,784,393	$128,509,194	$181,293,587
Reduction	Loss reduced by: Fatalities Injuries	17% 39.26 3,527.4	$43,811,047	$106,662,631	$150,473,678
	Savings				**$ 30,819,910**

Individual Meetings (Low Cost)

The effect of this countermeasure is an estimated 8% reduction in crashes. Its primary target is apprehended traffic violators involved in aggressive-driving-related crashes. The aggressive driving fatality-to-injury ratio will be used in all calculations.

Aggressive-driving-related fatalities involving drivers with previous speed convictions represent 8% of all fatalities, resulting in an estimated 47 fatalities per state. As there are an estimated 90 injuries per fatality, the example state is computed to have 4,250 injuries per year, for a total estimated cost of $181,293,587. Individual meetings have an estimated 8% reduction in crashes, resulting in savings of $14,503,487.

Table B18. Estimated savings for individual meetings countermeasure.

Total fatalities	42,642				
Fatalities involving aggressive drivers with prev. speed conv.	3,362				
% total fatalities	7.884%				
Median fatalities (state)	600				
Est. fatalities involving prev. speed conv. (state)	47.31				
Aggressive driving death-to-injury ratio	89.84				
ESTIMATED SAVINGS FOR AN EXAMPLE STATE					
		No.	**$ Fatalities**	**$ Injuries**	**$ Total**
Individual meetings	Fatalities Injuries	47.31 4,250	$52,784,393	$128,509,194	$181,293,587
Reduction	Loss reduced by: Fatalities Injuries	8% 43.52 3,909.9	$48,561,642	$118,228,458	$166,790,100
	Savings				**$ 14,503,487**

Group Meetings (Medium Cost)

The effect of this countermeasure is an estimated 5% reduction in crashes. Its primary target is apprehended traffic violators involved in aggressive-driving-related crashes. The aggressive driving fatality-to-injury ratio will be used in all calculations.

Aggressive-driving-related fatalities involving drivers with previous speed convictions represent 8% of all fatalities, resulting in an estimated 47 fatalities per state. As there are an estimated 90 injuries per fatality, the example state is computed to have 4,250 injuries per year, for a total estimated cost of $181,293,587. Group meetings have an estimated 5% reduction in crashes, resulting in savings of $9,064,679.

Table B19. Estimated savings for group meetings countermeasure.

Total fatalities	42,642				
Fatalities involving aggressive drivers with prev. speed conv.	3,362				
% total fatalities	7.884%				
Median fatalities (state)	600				
Est. fatalities involving prev. speed conv. (state)	47.31				
Aggressive driving death-to-injury ratio	89.84				
ESTIMATED SAVINGS FOR AN EXAMPLE STATE					
		No.	**$ Fatalities**	**$ Injuries**	**$ Total**
Group meetings	Fatalities Injuries	47.31 4,250	$52,784,393	$128,509,194	$181,293,587
Reduction	Loss reduced by: Fatalities Injuries	5% 44.94 4,037.4	$50,145,174	$122,083,734	$172,228,908
	Savings				**$ 9,064,679**

Warning Letters (Medium Cost)

The effect of this countermeasure is an estimated 4% reduction in crashes. Its primary target is apprehended traffic violators involved in aggressive-driving-related crashes. The aggressive driving fatality-to-injury ratio will be used in all calculations.

Aggressive-driving-related fatalities involving drivers with previous speed convictions represent 8% of all fatalities, resulting in an estimated 47 fatalities per state. As there are an estimated 90 injuries per fatality, the example state is computed to have 4,250 injuries per year, for a total estimated cost of $181,293,587. Warning letters have an estimated 4% reduction in crashes, resulting in savings of $7,251,743.

Table B20. Estimated savings for warning letters countermeasure.

Total fatalities	42,642
Fatalities involving aggressive drivers with prev. speed conv.	3,362
% total fatalities	7.884%
Median fatalities (state)	600
Est. fatalities involving prev. speed convictions (state)	47.31
Aggressive driving death-to-injury ratio	89.84

ESTIMATED SAVINGS FOR AN EXAMPLE STATE					
		No.	**$ Fatalities**	**$ Injuries**	**$ Total**
Warning letters	Fatalities	47.31	$52,784,393		
	Injuries	4,250		$128,509,194	$181,293,587
Reduction	Loss reduced by:	4%			
	Fatalities	45.41	$50,673,018		
	Injuries	4,079.9		$123,368,826	$174,041,844
	Savings				**$ 7,251,743**

Mandatory Attendance at Alcohol Treatment Programs: Reduction in alcohol-related crashes, 7-9% on average (Wells-Parker Banger-Drowns, McMillen et al., 1995); applicable population: DUI-convicted population; effect duration unknown (medium cost).

The effect of this countermeasure is an estimated 7% reduction in alcohol-related crashes. Its primary target is drivers with previous DWI convictions involved in alcohol-related crashes (i.e., BAC ≥ .01). The alcohol-related fatality-to-injury ratio will be used in all calculations.

Alcohol-related fatalities involving drivers with previous DWI represent 3% of all fatalities, resulting in an estimated 16 fatalities per state. As there are an estimated 47 injuries per fatality, the example state is computed to have 767 injuries per year, for a total estimated cost of $41,509,775. Alcohol treatment programs have an estimated 7% reduction in crashes, resulting in savings of $2,905,684.

Table B21. Estimated savings for alcohol treatment program countermeasure.

Total fatalities	42,642
Alcohol-related fatalities involving drivers with previous DWI	1,167
% total fatalities	2.737%
Median fatalities (state)	600
Est. alcohol-related fatalities inv. drivers with prev. DWI (state)	16.42
Alcohol related death-to-injury ratio	46.7

ESTIMATED SAVINGS FOR AN EXAMPLE STATE					
		No.	**$ Fatalities**	**$ Injuries**	**$ Total**
Alcohol treatment program	Fatalities	16.42	$18,322,245		
	Injuries	767		$23,187,530	$41,509,775
Reduction	Loss reduced by:	7%			
	Fatalities	15.27	$17,039,688		
	Injuries	713.2		$21,564,403	$38,604,090
	Savings				**$ 2,905,684**

Alcohol Interlocks: Reduction of 37-90% in recidivism (Willis, Lybrand, and Bellamy, 2004; Beirness and Marques, 2004); applicable population: DUI convicted population; duration of effect limited to period when interlock is present (medium cost).

The effect of this countermeasure is an estimated 37% reduction in recidivism. Its primary target is drivers with previous DWI convictions involved in alcohol-related crashes. The assumption is that 37% of previously convicted drivers with an installed alcohol interlock system would not drink and drive, and thus would not be involved in alcohol-related crashes. The alcohol-related fatality-to-injury ratio will be used in all calculations.

Alcohol-related fatalities involving drivers with previous DWI represent 3% of all fatalities, resulting in an estimated 16 fatalities per state. As there are an estimated 47 injuries per fatality, the example state is estimated to have 767 alcohol-related injuries per year, for a total estimated cost of $41,509,775. Alcohol interlocks for convicted DWI drivers have an estimated 37% reduction in recidivism, resulting in savings of $15,358,617.

Table B22. Estimated savings for alcohol interlock countermeasure.

Total fatalities	42,642
Alcohol-related fatalities inv. drivers with previous DWI	1,167
% total fatalities	2.737%
Median fatalities (state)	600
Est. alcohol-related fatalities inv. drivers with prev. DWI (state)	16.42
Alcohol related death-to-injury ratio	46.7

ESTIMATED SAVINGS FOR AN EXAMPLE STATE

		No.	$ Fatalities	$ Injuries	$ Total
Alcohol interlock	Fatalities	16.42	$18,322,245		
	Injuries	767		$23,187,530	$41,509,775
Reduction	Loss reduced by:	37%			
	Fatalities	10.34	$11,543,014		
	Injuries	483.1		$14,608,144	$26,151,158
	Savings				**$15,358,617**

APPENDIX C

Countermeasures Likely to Work

Voluntary Action

Responsible beverage service (Shults, Elder, Sleet et al., 2001; Holder, Gruenewald, Ponicki et al., 2000)
Parents guiding teen licensing (Simons-Morton, 2007)

Laws, Regulations, Policies

Ice cream vendor ordinance (Hale, Blomberg, and Preusser, 1978)
Local primary seat belt laws (NHTSA, 2007b)
Adult bike helmet laws (Ginsberg and Silverberg, 1994; Robinson, 1996; Scuffham, Alsop, Cryer et al., 2000)
License renewal policies (Morrisey and Grabowski, 2005) for drivers 85 and older with in-person renewal
License actions for underage alcohol violations (Ulmer, Ferguson, Williams et al. 2001)

Laws Plus Enhancements

Integrated enforcement (Jones, Joksch, and Lacey, 1995; Hingson, McGovern, Howland et al., 1996)
Zero-tolerance enforcement (Jones and Lacey, 2001)
Vendor compliance checks for age-21 enforcement (Stewart, 1999)
Sustained seat belt enforcement (Hedlund, Preusser, and Shults, 2004; Glassbrenner, 2005)

Sanctions and Treatments

Increased belt use law penalties (Houston and Richardson, 2006)
Simplifying and streamlining DUI statutes (no references but has obvious potential for producing a more effective and efficient DUI control system)

APPENDIX D

Proven Countermeasures With No Crash or Injury Reduction Calculations

Voluntary Action

Child bicycle helmet promotions: (Wood and Milne, 1988; Bergman, Rivara, Richards et al., 1990; Van Houten, Van Houten, and Malenfant, 2007). All studies based on high-quality community programs.

Laws, Regulations, Policies

BAC test refusal penalties: Produces fewer refusals (Zwicker, Hedlund, and Northrup, 2005), which may increase DUI convictions.

Speed limits: Clear evidence that raised speed limits on high-speed roads increase fatalities; lowered speed limits reduce fatalities (TRB, 2006).

Laws Plus Enhancements

Saturation patrols for alcohol-impaired driving: Increase arrests (Greene, 2003; Century Council, 2003), although number estimates not available; no studies of effects on crashes.

Preliminary breath test devices: Increase arrests to unknown extent; effect on crashes unclear (Century Council, 2003).

Passive alcohol sensors: Increase arrests at checkpoints and possibly increase general deterrence (Kiger, Lestina, and Lund, 1993; Ferguson, Wells, and Lund, 1995); effects on crashes unclear.

PI&E supporting enforcement of seat belt laws: Paid advertising increases belt use. Solomon, Ulmer, and Preusser (2002) found that belt use increased by 8.6% in states that used paid advertising extensively in their enforcement campaigns, 2.4% across four states that used limited paid advertising, and 0.5% in states that used no paid advertising.

Sanctions and Treatments

Restrictions on plea bargains: Convictions are increased, recidivism may also be reduced (NTSB, 2000). No numerical estimates available.

Court monitoring: Cases less likely to be dismissed, more likely to be guilty judgments (Shinar, 1992); more studies needed to derive numerical estimates.

Close monitoring of DUIs: There are many types, e.g., intensive supervision, home confinement with electronic monitoring, dedicated detention facilities, individual judicial oversight. Reductions in recidivism, numerical estimates not established (Voas and Tippetts, 1990; Lapham, Kapitual, C'de et al., 2006; Jones, Wiliszowski, and Lacey, 1996).

Brief interventions—alcohol: Reduces drinking and self-reported driving after drinking (D'Onofrio and Degutis, 2002; Moyer, Finney, Swearingen et al., 2002; Wilk, Jensen, and Havighurst, 1997); some evidence of crash reductions (Dill, Wells-Parker, and Soderstrom, 2004).

License plate impoundment: Reduces recidivism; numerical estimates not established.

Vehicle immobilization, vehicle impoundment: Reduces recidivism; numerical estimates not established (Voas, Tippetts, and Taylor, 1997, 1998; DeYoung, 1997, 1998).

Abbreviations and acronyms used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation