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# **TRAFFIC SAFETY IN THE U.S.: RE-EXAMINING MAJOR OPPORTUNITIES**

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16. Abstract <p>This report examines five major road-safety risk factors: exceeding posted speed limits, not using safety belts, driving while intoxicated, nighttime driving, and young drivers. The importance of each of these factors is documented, known effective countermeasures (both policy and technology based) are discussed, and impediments to the implementation of these countermeasures in the U.S. are examined.</p> <p>Based on current understanding of the five major risk factors, and of the available countermeasures, there appear to be a variety of opportunities to make substantial gains in road safety using existing knowledge. The limited implementation of a variety of known countermeasures therefore appears to be inconsistent with high-level, strategic goals to improve road safety.</p> <p>Consequently, a recommendation is made to comprehensively re-examine the balance between the countermeasures discussed in this report and economic, mobility, and privacy concerns. Such a re-examination is likely to result in broad support for these countermeasures, with a consequent major improvement in road safety.</p>					
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## Introduction

### Basic facts

The U.S. was on the forefront of traffic safety for most of the 20<sup>th</sup> century. Unfortunately, that is no longer the case. As pointed out by Evans (2004), “by 2002 the U.S. had dropped from first to 16<sup>th</sup> place in deaths per registered vehicle, and from first to 10<sup>th</sup> place in deaths for the same distance of travel” (p. 408).

The changes in the most basic measure—number of fatalities—over the most recent decade for the U.S. and for 17 other developed countries are shown in Table 1. In the U.S., there was an increase of 5% in road fatalities from 1994 to 2004 (40,716 vs. 42,636). In contrast, during the same period most other developed countries, including all of the 17 comparison countries, experienced substantial reductions in fatalities.

Table 1  
Percentage changes in road fatalities between 1994 and 2004 in the U.S.  
(FARS, 2006a) and 17 other developed countries (IRTAD, 2006).

Country	Change in road fatalities from 1994 to 2004 (%)
U.S.A.	+5
Norway	-8
U.K.	-12
Spain	-16
Australia	-18
Sweden	-19
Italy	-21
Finland	-22
New Zealand	-25
Switzerland	-25
Denmark	-32
Japan	-33
Austria	-34
Netherlands	-38
France	-39
Germany	-40
Portugal	-41
South Korea	-43

Because the increase in the U.S. population was greater than the corresponding increase in road fatalities, there was a slight reduction in terms of the societal burden of road crashes, with the rate per population dropping by 7%. Table 2 compares this change to the changes in the Netherlands (a country with one of the largest drops in total fatalities) and Sweden (a country with a more moderate drop in total fatalities). It turns out that the reductions in the fatality rate per population in these two countries were substantially greater than in the U.S. (41% in the Netherlands and 21% in Sweden), and the absolute rate for 2004 in these countries was substantially lower than that in the U.S.

Table 2  
Road fatality rates for the U.S. (FARS, 2006a) compared to the Netherlands and Sweden (IRTAD, 2006).

Country	Fatalities per 100,000 inhabitants			Fatalities per billion km driven		
	1994	2004	% change	1994	2004	% change
U.S.A.	15.6	14.5	-7	10.7	8.9	-17
Netherlands	8.5	5.0	-41	11.9	7.7*	-35
Sweden	6.7	5.4	-21	9.1	6.3	-31

\* Applicable for 2003.

An argument is sometimes made that the underlying fatality rate per distance driven is already very low in the U.S., and thus further improvements are more difficult to achieve. However, two aspects of the data in Table 2 are not consistent with this argument. First, the 1994 rates per distance driven for the two comparison countries were already similar to that of the U.S. Second, the 2004 rate for the U.S. was the highest among the three examined countries.

Yes, the fatality rate per distance driven in the U.S. dropped between 1994 and 2004—by 17%. However, that compares to reductions of 35% in the Netherlands and 31% in Sweden (see Table 2).

## **Lives lost**

If the U.S. rate per distance driven for 2004 had been the same as that for the Netherlands, there would have been 5,749 fewer U.S. fatalities in 2004. Analogously, using the rate for Sweden there would have been 12,455 fewer U.S. fatalities. Furthermore, Sweden and the Netherlands are not unique. For example, Evans (2004) presents calculations suggesting that between 1979 and 2002 there would have been 200,000 fewer U.S. road fatalities if the U.S. had followed the progress of Great Britain, Canada, or Australia. Evans argues that the current situation in the U.S. is a consequence of undue emphasis on vehicular aspects in general and on mandating air bags in particular (instead of fostering safety-belt laws), and of the unusually powerful role of litigation in the U.S. safety system. His position is that more effort should have been directed toward factors that are under the control of individual drivers, such as using safety belts and reducing alcohol consumption.

## **Opportunities not yet taken**

The present study was designed to examine five factors that could be considered opportunities not yet taken for improving the traffic situation in the U.S.: exceeding posted speed limits, not wearing safety belts, alcohol-impaired driving, visibility problems in nighttime driving, and young driver problems. These five factors could be viewed as lost opportunities because (1) they have garnered almost universal support as being among the major factors in road safety,<sup>1</sup> and (2) several effective policy and technological countermeasures for these factors have been known for years.

To provide an indication of the importance of these five factors, we performed a series of one-way analyses of the 2004 fatal crash data (FARS, 2006). The involvement of these factors is shown as entries one through five in column 2 of Table 3. In comparison, column 3 shows the relevant exposure data for the individual factors.

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<sup>1</sup> For example, WHO (2004) lists all but young drivers among the five key areas for effective intervention. (The fifth area on the WHO list is wearing helmets.)

Table 3  
Involvement of the five selected factors among the 2004 fatally injured drivers  
(FARS, 2006b) and the relevant exposure.

Factor	Involvement of the factor among fatally injured drivers	Exposure (source)
Speeding	29% <sup>1</sup>	Estimates vary greatly by location (e.g., IIHS, 2003)
Not using safety belts	54% <sup>2</sup>	18% (Glassbrenner, 2005)
Intoxicated driving	30% <sup>3</sup>	1-5% of drivers have BAC $\geq$ .1 (Farris et al., 1977)
Nighttime driving	47%/35% <sup>4</sup>	25% of total mileage (NSC, 2004)
Young drivers	11% <sup>5</sup>	4% of total mileage <sup>7</sup> (Massie & Campbell, 1993)
Any of the 5 factors	78%/75% <sup>6</sup>	Total exposure for combinations of factors is unknown

<sup>1</sup>Includes not only driving in excess of posted maximum, but also driving too fast for conditions (FARS variables DR\_CF1 through DR\_CF4 set to 44).

<sup>2</sup>Not using the restraint system (FARS variable REST\_USE).

<sup>3</sup>Driver drinking (FARS variable DR\_DRINK).

<sup>4</sup>47% is applicable for “dark,” “dark but lighted,” and one half of “dawn” and “dusk,” while 35% is applicable if “dark but lighted” is excluded (FARS variable LGT\_COND).

<sup>5</sup>Ages 15 through 19 (FARS variable AGE).

<sup>6</sup>For the values of the factors as specified in footnotes (1) through (5). 78% is applicable if “dark but lighted” is included; 75% is applicable if it is excluded.

<sup>7</sup>Ages 16 through 19.

The last entry in Table 3 presents the results of an analysis that investigated the presence of one or more of the factors in question for the fatally injured drivers: *One or more of the five factors were present for about three quarters of all fatally injured drivers.* (The total exposure for one or more factors is not known. Because these factors are not independent, the total exposure cannot be estimated by the sum of the individual exposures.)

### **Where do we go from here?**

In the sections that follow, for each of the five selected factors, we provide a brief background concerning its importance, review known countermeasures, discuss reasons for lack of progress on implementation of the known countermeasures in the U.S., and provide specific recommendations.

## **Exceeding Posted Speed Limits**

### **Importance of the problem**

In 2003, 13,380 people (31.4% of all road traffic fatalities) were killed in speeding-related crashes in the U.S. (NHTSA, 2004a). The relationship between speed and crashes is not only statistical but also causal (Elvik, 2005). According to the power model (Nilsson, 2004), the risk of injury in an accident increases by the second power of the mean speed, and the risk of a fatal accident increases by the fourth power of the mean speed. Although these effects of speed are primarily a consequence of changes in kinetic energy, the increased difficulty of the driving task with increased speed (e.g., Kallberg & Luoma, 1996) is of importance here as well.

Exceeding the posted speed limit is probably the most common traffic law violation (Elvik & Vaa, 2004). For example, the proportion of drivers exceeding the posted speed limit more than 5 mph (8 km/h) ranged from 10% to 68% on U.S. rural and urban interstates in five states (IIHS, 2003). On urban interstates in four cities with the posted speed limit of 55 mph (88 km/h), the proportion of drivers exceeding the limit by more than 15 mph (24 km/h) ranged from 11% to 78% (IIHS, 2003). These results are in line with the findings from a recent national driver survey (Royal, 2003): More than 60% of drivers admit they drove over the speed limit within the past week.

Speeding is a complex issue, however. For example, determination of whether speeding was involved in a crash is no simple task, which implies that we probably underestimate the number of speeding-related fatalities (e.g., Evans, 2004). This is the case because a crash is considered speeding-related only if a driver is charged with a speeding-related offense, and that requires strong evidence. On the other hand, speeding-related crashes also include behaviors other than exceeding the posted speed limit, for example “driving too fast for conditions” (U.S. DOT Speed Management Team, 2005). Nevertheless, given the above proportions of drivers exceeding the posted speed on U.S. roads and the strong evidence of the effects of speed on accidents and fatalities, it is assumed that the above number of fatalities provides a reasonable estimate for demonstrating the magnitude of the problem. Consequently, exceeding posted speed

limits is a major problem that should be addressed. This is not to say that “racing” or “driving too fast for conditions” are of no importance, but, according to the basics of safe driver behavior, careful and prudent speed is never faster than the posted speed limit (see e.g., State of Michigan, 2004).

## **Known countermeasures**

### *Traditional countermeasures*

Traditional countermeasures cover three broad areas: education, enforcement, and engineering.

*Education.* Driver education is designed to ensure that every licensed driver knows that the posted speed limits should be obeyed. In addition to driver education, information and publicity campaigns regarding the impacts of speed have been used. However, these measures have had no major success. This is the case because lack of information and attitudes towards speed and speed limits are not the main problems. Indeed, the results of a national survey (Royal, 2003) showed that most drivers indicate that it is important to reduce speeding on all types of roads: The highest support was for streets (90%), followed by two-lane roads (86%), non-interstate multilane roads (81%), and multi-lane interstate highways (77%). Almost all drivers (98%) indicated that speeding by others is a threat to themselves and to their family. In addition, only a small minority (8-35%, depending on the road type) stated that the speed limits were too low.

However, drivers do not appreciate that speed is associated with risk in their *own* driving (e.g., Quimby et al., 2004). In particular, driving only slightly above the speed limit is not considered risky or socially unacceptable. Other important factors are that drivers overestimate other drivers’ speed, believe that other drivers think they are driving too slowly, and want to drive like others (Connolly & Åberg, 1993; Åberg et al., 1997). Consequently, there are several complex factors that result in speeding, and thus presenting simple information to drivers cannot solve the problem.

*Enforcement.* Traditional speed enforcement involves police officers, usually in police vehicles. However, only a small proportion of all speeding violations are detected:

More than 70% of drivers admit exceeding the speed limit within a past month, but only 10% report having been stopped within the past 12 months (Royal, 2003). The probability of detection is low because police surveillance is time-consuming and expensive, and there is no reason to assume that public funding for enforcement will increase in the near future. In addition, there are many occasions and sites, such as high-volume roads, where traditional speed enforcement can never operate effectively.

*Engineering.* The basic engineering countermeasure involves road design. Specifically, the design elements of the road should consistently reflect the road category and thus encourage appropriate choice of speed (MASTER, 1999). However, the necessity of other engineering countermeasures, such as speed limits and speed bumps, demonstrate that the design of roads is challenging and does not provide any easy solution to the speeding problem.

#### *Countermeasures with limited or no utilization in the U.S.*

There are two broad approaches that have not yet been used widely in the U.S., namely automated speed enforcement (or speed/safety cameras) and so-called intelligent speed adaptation.

*Automated speed enforcement.* Automated speed enforcement is a system designed to automatically detect vehicles violating speed limits. The main features include a camera and an attached speed-measuring device (typically radar or detector loops). Speed is measured from the police vehicle or from a fixed station. When a vehicle passing such a camera is violating the speed limit, the system photographs the driver and the license plate. The registered owner of the vehicle then receives a ticket in the mail. The responsibility of the owner and respective penalties vary by country.

Automated speed enforcement has been used in about 75 countries around the world, including Europe, Canada, and Australia (Cunningham et al., 2005). Overall, positive effects on speed behavior and safety have been reported. (For a recent review, see Goldenbeld & van Schagen, 2005.) For example, Gains et al. (2005) report that a four-year national safety-camera program in the U.K. reduced excessive speeding,

collisions, casualties, and deaths. Specifically, the proportion of vehicles exceeding the posted limit by more than 24 km/h (approximately 15 mph) fell by 91% at fixed camera sites and 36% at mobile camera sites. In total, 42% fewer people were killed or seriously injured. The cost-benefit ratio was 2.7:1.

Furthermore, in countries where safety cameras are used relatively often, the public generally supports their use: Although drivers in the U.K. estimate that they are more likely than the drivers in any other country in the European Union (EU) to be checked for speeding, they are more in favor of speed cameras (78%) than drivers in the EU on average (66%) (Quimby et al., 2004).

*Intelligent speed adaptation.* Intelligent speed adaptation (ISA) is an in-car technology that warns the driver about speeding, discourages the driver from speeding, or prevents the driver from exceeding the speed limit. Information about the speed limit for a given location is usually identified from an on-board digital map in the vehicle. In terms of intervention, there are three major types of systems (ETSC, 2005): informative (providing visual or audio signal), supportive (increasing the resistance on the accelerator pedal), and intervening (automatically limiting the speed).

In Europe, there are currently several ongoing field evaluations of the speed and safety effects of ISA (PROSPER, 2006). The basic technology required for ISA systems is generally available: More and more vehicles are equipped with a GPS system (either as part of their original equipment or as an aftermarket device), and several informative ISA systems have already reached the market (ETSC, 2005).

Recently, Carsten and Tate (2005) showed that in the U.K. the informative type of ISA system has the potential to reduce fatal accidents by 18%, and the intervening system by 37%. The cost-benefit ratio of each system was more than 5:1. The results of the acceptance studies showed that participants were generally positive about ISA after using it (Carsten, 2002).

However, drivers are more willing to accept an informative or supportive ISA system than an intervening one. Consequently, ETSC (2005) concluded that manufacturers should first offer and promote informative ISAs. In addition, recording

ISAs (i.e., informative ISAs with a recording function) could be used with young drivers in guiding them to remain within the speed limit, and transport companies could use them in their fleet vehicles to ensure quality of their services (Peltola et al., 2004).

One aspect that supports the introduction of automatic speed enforcement and ISAs is that substantial safety improvements could be achieved by measures targeted to reduce not only major but also minor speeding offences. As Kallberg (submitted) shows, there are substantial safety benefits available even below the frequently-applied threshold of 15 km/h (approximately 10 mph). Approximately one half of all injury accidents involving one or more speeding vehicles are attributable to speeding offences not greater than 15 km/h over the posted limit. This finding suggests that enforcement should cover both minor and major speeding.

### **Reasons for non-implementation of known countermeasures in the U.S.**

In spite of positive experiences obtained in other countries, automated speed enforcement has not been used extensively in the U.S. A major obstacle to introducing this effective countermeasure more widely is, presumably, low driver acceptance due to privacy concerns. Legally, the defense is based on the Fourth Amendment to the U.S. Constitution that protects citizens against unreasonable search and seizure by the government.

However, based on a recent survey in North Carolina, this concern has weakened substantially. For example, people involved in focus groups indicated positive attitudes towards this type of enforcement: “If you are in a public place, you cannot complain about privacy. If you are operating a vehicle on a public road and you violate the law, you give up your right to privacy.... I believe that when you put my life in jeopardy, there is no privacy issue” (Cunningham et al., 2005, p. 34). Furthermore, in the U.S. there has been an explosive increase in the use of surveillance cameras in general, and the recent compliance of several phone companies with a request from the government for phone records of ordinary citizens has not created too much furor.

Indeed, Royal (2003) showed that a vast majority (68%) of U.S. drivers think that it is a good idea to use automated enforcement to identify vehicles that are going 20 mph (32 km/h) or more over the speed limit. Furthermore, most agree with the use of automated enforcement in school zones (78%), where it could be hazardous for the driver or officer to stop (69%), where stopping a vehicle could cause traffic congestion (70%), and where there have been many accidents (84%).

Probably the main reason for the absence of ISA in the U.S. is that it is a relatively recent development. An additional potential argument against implementation in the U.S. might be that this approach would not be acceptable to drivers because the system places constraints on speed choice (i.e., constraints on freedom). However, there is no available evidence directly supporting this position. Indeed, the results of Royal (2003) showed that 35% of U.S. drivers feel that speed governors (mechanical devices that limit the maximum speed a vehicle can be driven) are a good idea.

### **Recommendations**

The magnitude of the problem of exceeding posted speed limits is substantial. Recent experience with automated speed enforcement and intelligent speed adaptation in other countries has shown major positive effects (e.g., Evans, 2004; Richter et al., 2005). Therefore, it is recommended that these two general approaches be seriously considered for wider adaptation in the U.S. There is some evidence that U.S. drivers would accept more restrictive speed enforcement. Furthermore, the results from other countries suggest that this support will increase substantially if these countermeasures are introduced in a way that people perceive as targeting their safety (Quimby et al., 2004).

## Use of Safety Belts

### Importance of the problem

The single most effective technology for reducing injury severity in a motor-vehicle crash is the safety belt. Depending upon the vehicle type, Kahane (2000) has estimated that use of three-point safety belts reduces the risk of fatality by 45-60%. Safety belts are only effective, however, if they are used.

Of all the U.S. passenger vehicle occupants killed in 2004, 55% were not restrained by an occupant protection system (NHTSA, 2005d). The problem is more significant when certain subgroups are considered. In 2004, 68% of passenger vehicle occupant fatalities aged 13-15 years were not restrained, and in 69% of pickup truck fatalities, the occupant was not restrained (NHTSA, 2005d). If all passenger vehicle occupants used safety belts, NHTSA (2005d) estimates that 5,839 lives would have been saved in 2004. This equates to about a 14% reduction in motor-vehicle-related fatalities.

Safety belt use in the U.S. reached an all-time high of 82% in 2005 (Glassbrenner, 2005). Despite this achievement, use of safety belts in the U.S. still lags behind many other developed countries. For example, Australia has an estimated use rate of 96% (Australian Automobile Association, 2004), and Sweden and the United Kingdom report 93% use (Swedish Road Administration, 2005; U.K. Department of Transport, 2006). Within the U.S., statewide belt use rates vary from 61% to 95% (Glassbrenner, 2005). Getting the remaining non-users to wear belts could have a significant effect on safety as these unbelted drivers account for 35% more crashes than belted drivers (Luoma, Antov, Rõivas, Skládaná, & Tecl, 2004).

Some groups of motor vehicle occupants are significantly less likely to use safety belts than others. Direct observation studies in the U.S. consistently find that belt use is lower for males (Eby, Molnar, & Olk, 2000); increases with age after the mid-teens (Glassbrenner, 2004); and is quite low for pickup truck occupants (Glassbrenner, 2003) and heavy truck drivers (Knoblauch, Cotton, Nitzburg, Siefert, Shapiro, & Broene, 2003). Use of safety belts also varies by situational factors, with belt use lower on rural than

urban/suburban roads (Glassbrenner, 2004), on local roads than freeways (Eby, Molnar, & Olk, 2000), and during the daytime (Chaudhary, Geary, Preusser, & Cosgrove, 2005).

These patterns suggest that belt use may be influenced by variations in a motor vehicle occupant's perceptions of the risk of traveling while unbuckled. Support for this suggestion comes from the most recent Motor Vehicle Occupant Safety Survey which found that 95% of respondents reported using a belt to prevent injury, while 71% also reported using a belt to avoid receiving a belt citation (Boyle & Vanderwolf, 2004). The same survey found that the most frequently reported reason for non-use was that the respondent was only traveling a short distance and, therefore, not likely to be in crash.

### **Known countermeasures**

#### *Legislation*

Statewide mandatory safety belt use laws began to be enacted in the 1980s at the urging of the federal government, with New York passing the first mandatory safety belt use law in 1984. While these laws were initially unpopular in many states, every state except New Hampshire has now passed a safety belt use law. It is clear that implementation and enforcement of mandatory safety belt use laws increase safety belt use. The increase in the national safety belt use rate from approximately 15% in the early 1980s to the current rate of 82% can be attributed in large part to the introduction of mandatory safety belt use laws (NHTSA, 1999). In general, these laws produce a dramatic increase in safety belt use immediately after implementation, followed by a decline in belt use to a level that remains substantially higher than pre-law levels (Eby, Molnar, & Olk, 2000).

An important component of belt use legislation is the provision that indicates how the law is to be enforced. As states began to discuss adopting safety belt use laws, citizens voiced concerns that these laws were in violation of their individual rights and that these laws could be used by police as a way to harass citizens. To address these concerns, legislators in New Jersey included a "secondary" enforcement provision in their safety belt use law that stated that an officer could issue a safety belt citation only if

the vehicle were stopped for a different violation (Moffat, 1998). By including this provision in their law, New Jersey legislators created a distinction between such secondary and “standard,” or primary enforcement, where an officer can stop a vehicle and cite an occupant solely for failure to use a safety belt (NHTSA, 1999).

Direct observation studies show that states with standard enforcement have use rates that are about 10% higher than states with secondary enforcement (Glassbrenner, 2005). In recognition of this fact, many states that originally had secondary enforcement have begun to enact legislation to strengthen belt use laws to standard enforcement. Changing a law from secondary to standard enforcement can be a significant and cost-effective way for states to increase their safety belt use rate, with increases found to be on the order of 10% to 15% immediately following a change to standard enforcement (Russell, Dreyfuss, & Cosgrove, 1999; Eby, Vivoda, & Fordyce, 2002).

#### *High-visibility enforcement*

Even with standard enforcement, belt use rates in many states are well under 90% (Glassbrenner, 2005). Consequently, NHTSA has sponsored a nationwide high-visibility enforcement campaign called “Click it or Ticket” (CIOT), based on the Selective Traffic Enforcement Program (STEP) model developed in Canada (NSC, 2006). CIOT is a short, but intense, visible safety-belt-enforcement effort alongside a well-publicized media campaign that stresses the presence of enforcement activity. An evaluation of the 2003 campaign found that when compared to pre-CIOT use rates, post-use rates increased in 40 states, decreased in six states, and remained the same in one state (Solomon, Chaudhary, & Cosgrove, 2003).

#### *Reminder systems*

Reminder systems were introduced into vehicles by federal mandate in the early 1970s with a requirement that all new vehicles in the U.S. produce a 4- to 8-second signal if the driver does not use a safety belt after starting the vehicle (Transportation Research Board, 2003). The signal could be a light, a sound, or both. Analysis of belt use before

and after the buzzer-light systems were installed showed no statistical increase in safety belt use (Robertson & Haddon, 1974), as the benign reminder signal was easily ignored.

In 1995, the Swedish Road Administration and Swedish vehicle manufacturers began to examine the potential of improved reminder systems. Following this initial work, the European New Car Assessment Programme (Euro NCAP) developed a reminder system protocol (Euro NCAP, 2006) that defined the minimum acceptable features of an advanced system, including a loud and clear audible signal of at least 90 seconds if the driver is unbelted. An observational study in Sweden has shown that, compared to vehicles without NCAP-protocol-compliant reminder systems, belt use is significantly greater (by as much as 16%) in vehicles with an advanced reminder system (ETSC, 2005). A more advanced reminder system has recently been implemented voluntarily in the U.S. by the Ford Motor Company. Ford's system involves intermittent flashing lights and chimes for five minutes if the driver is not buckled. A direct observation study of patrons arriving at Ford dealerships found that belt use was 5% higher for drivers with the reminder system installed than for those without the system (Williams, Wells, & Farmer, 2002).

### *Interlock systems*

A safety belt interlock system links belt use with some vehicle function, such as the ability to start the vehicle. In 1973, the federal government mandated that all new vehicles sold in the U.S. must be equipped with a safety-belt-ignition-interlock system that prevents the vehicle from starting if the driver and front-right passenger are not using safety belts (Buckley, 1975). Despite the fact that these interlock systems increased safety belt use by as much as 30% (see e.g., Robertson, 1974, 1975), public opposition to them led Congress to rescind the legislation in 1975.

More recently, vehicle manufacturers have begun to evaluate the effectiveness and acceptability of interlocking safety belt use with the ability to use the entertainment or environmental control systems (Eby, Molnar, Kostyniuk, Shope, & Miller, 2004). A nationwide telephone survey of part-time safety belt users in the U.S. found that the

perceived effectiveness of interlocking belt use with either the entertainment and heating/cooling system was high (Eby, Molnar, Kostyniuk, & Shope, 2005). The study also found, however, that most respondents considered these systems to be unacceptable to have in their own vehicle.

### **Reasons for non-implementation of known countermeasures in the U.S.**

Public opposition is the main reason for the lack of implementation, or suboptimal implementation, of each of the discussed countermeasures. Public concerns about harassment have prevented many states from upgrading their mandatory use law to standard enforcement even though research has shown that this change in the enforcement provision does not lead to harassment (Eby, Kostyniuk, Molnar, Vivoda, & Miller, 2004). The recommended high-visibility enforcement technique—safety belt checkpoints—is underutilized in many jurisdictions because of the fear of public complaints regarding invasion of privacy. Reminder systems must be intrusive in order to influence belt use behavior. Thus, public acceptance and effectiveness can be at odds. Vehicle manufacturers will be reluctant to install a system that the public finds unacceptable unless it is federally mandated. While ignition interlocks are clearly the most effective countermeasure, strong public criticism led to their removal from vehicles in the 1970s. The three main reasons cited for opposition to the safety-belt-ignition-interlock system were: technical problems with proper functioning of the system when no front-right passenger was present; safety concerns associated with preventing drivers from rapidly starting a vehicle in the event of an emergency; and the relative ease of disabling the ignition interlocks (Eby, Molnar, Kostyniuk, Shope, & Miller, 2004).

### **Recommendations**

The injury prevention benefits of using safety belts are clear. Governments of states without a standard enforcement belt law should continue efforts to implement this type of law. Nearly 100% belt use could be achieved by a federal mandate that requires all new vehicles sold in the U.S. to have a safety-belt-ignition-interlock system installed.

Given the history of a prior mandate, it is doubtful that the U.S. government will ever require such systems or that auto manufacturers will include them in their vehicles voluntarily. Absent an ignition-interlock system, the U.S. government should mandate the development and installation of advanced safety belt reminder systems, such as the types of systems defined by the Euro NCAP (2006) protocol standards or the type of system proposed by Eby et al. (2005). Alternatively, organizations that evaluate vehicle safety could develop minimum requirements for advanced safety-belt-reminder systems and reward vehicle manufacturers by giving a higher safety rating to vehicles with a qualifying system. This approach, similar to the Euro NCAP approach, would provide vehicle manufacturers with strong motivation to voluntarily install advanced reminder systems.

## **Alcohol-Impaired Driving**

### **Importance of the problem**

In 2004, in the U.S., alcohol-impaired drivers were involved in 14,968 fatal crashes, 168,000 injury crashes, and 247,000 property-damage-only crashes, resulting in 16,694 fatalities and 248,000 injuries (NHTSA, 2005b; 2005c). All told, the economic cost to society for medical care, insurance premiums, lost productivity, and other indirect costs due to alcohol-impaired driving exceeded \$51 billion in 2002 (NHTSA, 2002).

There is clear and abundant evidence linking alcohol-involved driving to the increased likelihood of crash occurrence and severity (Borkenstein et al., 1964; Jurkovich et al., 1993; Maio et al., 1997; Soderstrom, & Eastman, 1987; Traynor, 2005). Alcohol contributes to impaired driving by slowing responses and interfering with the safe execution of driving maneuvers. Furthermore, the effects of alcohol on driving are not limited to its physiological effects on the brain. Psychological characteristics of drivers, such as antisocial personality, aggressiveness, psychopathology, impulsivity, sensation seeking, and biological characteristics relating to alcohol metabolism, appear to act as moderators of the likelihood that alcohol-involved driving will result in a crash (Begg, Langely, & Stephenson, 2003; Eensoo, Paaver, Harro, & Harro, 2005; Furnham & Saipe, 1993; Waller, Hill, Maio, & Blow, 2003). Alcohol consumption pattern also plays a role, with higher consumption contributing to increased likelihood of driving after drinking (Begg et al., 2003). However, contrary to some claims (Evans, 2004), when other factors, including blood alcohol concentration (BAC), are controlled, there is inconsistent evidence linking an alcohol abuse/dependence diagnosis with alcohol-related crash severity (Maio et al., 1997).

Alcohol-impaired driving is also associated with age and sex. Young adults ages 20 to 24 have the highest rates of alcohol-impaired driving and alcohol-involved fatal crashes of any age group. Teenaged drivers are less likely than young adults to drive while impaired by alcohol, and drivers over age 65 have the lowest rates of alcohol-impaired driving. At all ages, men are more likely than women to drive while impaired

by alcohol (NHTSA, 2005c). On the positive side, alcohol-impaired driving and alcohol-involved fatal crashes have been decreasing for the past decade (NHTSA, 2005c).

### **Known countermeasures**

#### *Interventions, programs, and policy*

There are many policy and program measures that reduce heavy alcohol consumption and behaviors that are unacceptably risky when combined with alcohol, such as driving. A few examples of effective programs targeting the person directly are self-help and 12-step programs, such as Alcoholics Anonymous (Davis, Campbell, Tax, & Lieber, 2002; Green, French, Haberman, & Holland, 1991), one-on-one or group Cognitive Behavioral Therapy (Kaminer & Slesnick, 2005), Motivational Interviewing (Heather, 2005), and brief interventions (Blow & Barry, 2000; Mundt et al., 2005). These treatments can target at-risk alcohol consumption in general or alcohol-impaired driving in particular.

An important lesson learned from past public health programs (both failed and successful) is that relevant information is necessary, but not sufficient, to cause behavior change. Effective programs must include an incentive in addition to information so that there is adequate motivation to change behavior. Some of the most effective motivations come from laws, policies, and enforcement. For example, the passage of *per se* laws (laws that declare it illegal to drive above a certain alcohol level, as measured by a blood or breath test) resulted in immediate decreases in alcohol-impaired driving (Ross, 1984), and random breath testing in New South Wales, Australia, produced one of the largest changes (a reduction of 19%) in alcohol-impaired driving specific to a single intervention (Roads and Traffic Authority, 1989). Other factors that can be influenced by policy, laws, and enforcement include alcohol availability, minimum drinking age laws, cost of alcohol, and alcohol sales and advertising (Evans, 2004). Evidence from Finland shows that the imposition and enforcement of severe penalties for alcohol-impaired driving results in substantially fewer drivers exceeding the legal BAC limit (Liikenneturva,

2005). Enforcement is vital to program success, and aggressive enforcement strategies should be considered in the formulation of alcohol-related driving laws and policies.

Another set of countermeasures could deal with curtailing alcohol consumption in general. As pointed out by Evans (2004), an increase in the federal excise tax on alcohol in general and beer in particular (beer represents a majority of all alcohol sales), and a prohibition on beer advertising on TV, would likely lead to major reductions in alcohol consumption. In turn, reductions in alcohol consumption would likely result in reduced frequencies of alcohol-impaired driving.

### *Technological approaches*

Current technology for reducing alcohol-impaired driving includes active and passive breath sensors. Current breath alcohol sensors are reliable and accurate, and provide immediate results (Jacobs, 2003); however, their use in enforcement is limited to BAC testing after police officers have stopped potentially alcohol-impaired drivers. Alcohol detection technology in non-enforcement programs can also deter alcohol-impaired driving.

Alcohol ignition interlocks utilize breath alcohol sensors to confirm that a driver's BAC is below a specified limit before the vehicle can be started. Early interlocks were unreliable, not alcohol-specific, and could be easily circumvented or bypassed (Dalton, 2006). Studies of these early systems found bypass rates as high as 50% (Beirness, 2001; EMT Group, 1990; Frank, 1988; Marques & Voas, 1993; Morse & Elliott, 1990). Current interlocks are more foolproof. Bypass attempts are recorded by sensors, testing is alcohol-specific, "rolling re-tests" are taken while the vehicle is in motion as well as at startup, and some systems require the breath sample to be delivered in a complex pattern of blowing and inhaling (Beirness, 2001; Horizon Interlock, 2006). While these additional measures make it more difficult to bypass the interlock, passengers could provide a negative breath sample during rolling re-tests and confederates could learn to perform the blowing pattern in the same manner as the alcohol offender was taught when the interlock was installed. Remaining loopholes in interlock systems could be

eliminated by coupling alcohol interlocks with other technologies. Biometric technologies (such as iris and retinal recognition, thumb/fingerprint scanners, hand geometry recognition, and facial feature identification) are used regularly in security systems (Automated Identification and Data Capture, 2006). Thumb/fingerprint scanners and iris and retinal recognition are currently the most reliable of these technologies. Interlock reliability could be improved using thumbprint scanners to identify the person holding the interlock mouthpiece, or eye scanners could be combined with the interlock mouthpiece to form a breath sampling device that would allow ignition system engagement only if identity and BAC criteria were met.

Biometric technology could also be combined with smart card technology. Smart cards are identification cards with built-in technology for storing, recording, and/or transferring data, such as a magnetic strip or an embedded microchip (HowStuffWorks, 2006). Smart cards could be programmed to regulate how vehicles perform by delivering instructions to the vehicle's on-board computer. At the 2004 Melbourne Auto Show, Toyota presented a concept car, the Sportivo, which featured smart card regulation of the vehicle's performance (Gray, 2004). If installed in all vehicles, smart cards that included a thumb/fingerprint scanner could be used to identify interlock-sentenced drivers and limit them to using vehicles with an interlock installed.

Deterrence of alcohol-impaired driving in the general population could be achieved by using smart cards that combine thumb/fingerprint identification with a transdermal alcohol sensor to estimate the driver's BAC. While there is current debate about the accuracy, timeliness, and reliability of transdermal alcohol sensors in estimating BAC (Davidson, Camara, & Swift, 1997; Swift, 2000), the feasibility of this approach may be increased by future technological refinements. Alternatively, as is currently proposed in Sweden (Sydney Morning Herald, 2005), all new vehicles could be manufactured with an alcohol interlock installed (Beirness, 2001), requiring all drivers to provide a negative breath sample before driving.

### **Reasons for non-implementation of known countermeasures in the U.S.**

Forty-five states and the District of Columbia (Insurance Institute for Highway Safety, 2005) have interlock laws in place, yet the proportion of offenders mandated to interlock programs remains small. Interlock use remains low in the U.S. for various reasons, including judges' reluctance to sentence offenders to interlock programs (Beirness, 2001; Beirness & Marques, 2004; Voas, Roth, & Marques, 2006); offenders' choice of licensure suspension rather than interlock use (Beirness, 2001); insufficient oversight of interlock-sentenced offenders (Beirness, 2001; Voas et al., 2006); program cost (Beirness, 2001; Beirness & Simpson, 2003; Voas et al., 2006); and low social acceptance of interlocks in the U.S. The future use of alcohol interlocks in the U.S. is heavily reliant on increased societal acceptance of interlocks.

An increase in the federal excise tax on alcohol does not have much support in the U.S. Congress, probably because it could be criticized as another example of "raising taxes." However, as pointed out by Evans (2004), a revenue-neutral change in taxes might turn out to be more acceptable. Finally, a prohibition on TV advertising is objected to most by the alcohol industry.

### **Recommendations**

Alcohol interlocks are highly effective while installed, but once they are removed alcohol-impaired driving offenders typically recidivate rapidly to pre-interlock levels of alcohol-impaired driving (Beck, Rauch, Baker, & Williams, 1999; Rauch et al., 2006; Voas, Marques, Tippetts, & Beirness, 1999). This clearly indicates that while interlocks are effective deterrents of alcohol-impaired driving, they have little rehabilitative capability. Recidivism to alcohol-impaired driving could be directly addressed by tougher policies that require all first-time alcohol-impaired driving offenders to be sentenced to an interlock program. Such a policy was recently put in place in New Mexico (Impaired Driving Update, 2006). Additional legislation requiring automatic sentencing of all repeat offenders to long-term, perhaps permanent, interlock programs would further reduce repeat alcohol-impaired driving offenses.

Alcohol rehabilitation programs could be included in interlock programs. Improvement in the long-term effectiveness of alcohol interlocks could be achieved by installing an interlock in alcohol-impaired drivers' vehicles while they complete a required, shown-to-be-effective, alcohol treatment. Such an interlock system could prevent offenders from alcohol-impaired driving while they are progressing through a program that is likely to enable them to control their drinking and alcohol-impaired driving.

A more rigorous enforcement of existing laws relating to alcohol-involved driving is needed. The most effective tool would be frequent use of roadside random breath testing.

A substantial increase in the federal excise tax on alcohol and a prohibition of alcohol advertising on TV would likely result in a major reduction in general alcohol consumption. One likely consequence of such a reduction in the consumption of alcohol would be a major reduction in alcohol-related crashes.

## Nighttime Driving

### Importance of the problem

Driving at night is substantially riskier than driving during the day. For example, the current fatality rate per 100,000,000 vehicle miles is 2.27 times higher at night than during the day (2.68 vs. 1.18) (NSC, 2004). Given that about 25% of the distance traveled occurs at night (NSC, 2004), if the night rate per vehicle mile had been as low as the day rate, 10,282 deaths (24% of the total of 42,636) would have been prevented in 2004.

As with many major problems that are regarded, at a certain level of analysis, as unified and homogeneous, the problem of increased risk at night can also be viewed as a collection of related but separable mechanisms. For example, nighttime risk is influenced by a number of factors that are not unique to nighttime—including alcohol, fatigue, and the proportion of young drivers. Each of these factors has a stronger influence at night, but also accounts for some amount of risk throughout the day. The defining characteristic of night driving, lack of natural light, is the only major factor that is unique to nighttime.

Recent studies of crash data have been reasonably successful in isolating the component of increased risk at night that is attributable to darkness itself rather than the other factors that vary between day and night (Owens & Sivak, 1996; Sullivan & Flannagan, 2002). For fatal crashes, it appears that about 3,855 fatalities per year in the U.S. can be attributed to darkness, with the largest single component of that total being pedestrians, estimated to be about 2,334 per year (Sullivan & Flannagan, 2001).

In addition to quantifying the overall importance of the darkness of night as a risk factor, this line of research has produced evidence about the nature of that risk, and that evidence corresponds closely to well established circumstances concerning headlighting and driver vision. The primary countermeasure for darkness is vehicle headlighting. It has been recognized for a long time that low-beam headlamps, which are used vastly more often than high-beam headlamps, usually do not provide adequate seeing distance to unexpected, low-contrast objects (most importantly, pedestrians). For example, in

summarizing a variety of studies Perel, Olson, Sivak, and Medlin (1983) estimated that the maximum safe speed with low-beam headlamps was about 70 km/h [45 MPH]. As would be expected from that assessment, the relative risk for fatal pedestrian crashes under dark versus light conditions varies greatly with posted speed limits, being particularly high on higher speed roads (Sullivan & Flannagan, 2001). Such findings suggest that the majority of the safety problem related to darkness involves inadequate seeing distance with typical headlamps.

### **Known countermeasures**

The most obvious, if perhaps impractical, countermeasure for the increased risk of driving at night is to restrict driving to daytime. Although this may be unrealistic as a general solution, it may in fact be reasonable in a variety of ways as a partial solution. Some older drivers, for example, self-restrict their driving at night. Some graduated licensing programs include restrictions on night driving by young drivers. At a societal level, analyses have shown that it would be possible to reduce road crashes by shifting driving toward light hours by means of extended daylight saving time (Coate & Markowitz, 2004; Ferguson, Preusser, Lund, Zador, & Ulmer, 1995). Because such restrictions involve potentially complex changes in drivers' daily activities, it is unclear how much they would reduce the risk of nighttime crashes that are unrelated to darkness itself (such as crashes attributable to alcohol and fatigue). However, it is likely that they would at least reduce darkness-related crashes.

Many options exist to reduce darkness-related crashes at night. Some of these involve improved equipment, and some could be accomplished through education or changes in policy. Because of the dominant role of pedestrians in darkness-related crashes, some of the simplest options involve changes in pedestrian exposure to traffic. For example, if pedestrians stayed out of traffic lanes at night, darkness-related crashes would be greatly reduced. Although it is notoriously difficult to improve safety by attempting simply to increase compliance with safety guidelines, there is some reason to expect that in this particular case it would be effective. This is because pedestrians'

behavior near traffic at night may be influenced to a great extent by a particular misunderstanding about how visible they are to drivers. A line of research extending back through most of the history of driving has demonstrated that pedestrians strongly overestimate the distances at which drivers can see them with typical headlamps (Ferguson & Geddes, 1941; Ferguson, 1944; Shinar, 1984; Tyrrell, Wood, & Carberry, 2004). Public information specifically addressing this misunderstanding might therefore be more effective than general appeals to be more careful at night. In addition to staying out of traffic lanes, pedestrians could reduce their risk by wearing lighter clothing and marking themselves with retroreflective materials or active light sources.

A variety of changes in infrastructure could also reduce pedestrian exposure to traffic at any time of day, or increase pedestrian visibility at night. These include improvements in sidewalks, crosswalks, and separate pedestrian walkways. Improved street lighting, especially by concentrating efforts on areas in which pedestrians are more likely to be encountered, would help.

It has been established that high-beam headlamps are substantially underused, even in situations in which a vehicle is isolated from other vehicles, and there is therefore no cause for concern about glare from high beams (Hare & Hemion, 1968; Sullivan, Adachi, Mefford, & Flannagan, 2004; Mefford, Flannagan, & Bogard, 2006). Current laws never require the use of high beams; they only prohibit their use under certain circumstances. Changes in laws, and public education in general, could promote the use of high beams, which would probably reduce pedestrian crashes at night. Automatic switching between high and low beams is an old idea, but recent improvements in artificial sensing technology offer greatly improved performance. Use of this equipment would probably increase the use of high beams under appropriate circumstances.

The light output of low-beam headlamps is restricted relative to high-beam headlamps because of glare to oncoming drivers. However, it appears to be possible to improve the visibility provided by low beams while still taking into account concerns about glare. For example, although headlamps with high-intensity discharge sources have caused public concern about glare, there is evidence that they actually improve the

situation with respect to the objectively important aspects of glare, as well as providing more light in important areas (Sivak, Flannagan, Schoettle, & Adachi, 2003). Better evidence about the effectiveness of these lamps may increase their acceptance.

Adaptive headlighting may offer improved visibility without creating the glare concerns that have been raised by HID lamps. By changing headlighting in response to roadway, environmental, and traffic conditions, adaptive headlighting offers a more favorable tradeoff between visibility and glare than can be achieved with traditional, fixed headlighting (Sivak, Schoettle, Flannagan, & Minoda, 2005).

Infrared night vision systems have been used on the road for a number of years, and such systems are becoming available on a larger number of vehicles. Technical development of these systems has been rapid, and further improvements appear to be likely. The design of the optimal driver interface for these systems is still unresolved. With an appropriate interface, these systems may be very effective in reducing risk at night (Tsimhoni, Flannagan, & Minoda, 2005).

### **Reasons for non-implementation of known countermeasures in the US**

For the darkness-related portion of nighttime risk, a major reason for not implementing more of the many options that are available may be that the problem was not well understood prior to the recent work that isolated and quantified that component of risk, independent of factors that are only partially related to night, such as alcohol and fatigue. One reason that it required a careful analysis of crash data to recognize this problem may be that the extent and nature of the visibility problem at night, especially the key role of pedestrian detection, is not fully recognized by drivers themselves because of selective degradation of their visual abilities in night driving (Leibowitz & Owens, 1977). Their ability to see in ways that allow them to stay on the road is little changed at the low light levels typical of roads at night, while their ability to detect and recognize objects, such as pedestrians, is strongly diminished. Thus, they may be overconfident about their general ability to see in night driving.

Some, but not all, of the countermeasures for darkness-related risk involve changing low-beam headlamps in ways that would affect the tradeoff between visibility and glare. To some extent, it is necessary to accept more subjective discomfort from headlamp glare in order to achieve better visibility (Flannagan, Sivak, Traube, & Kojima, 2000). Because that tradeoff is a matter of public opinion and public policy, lack of information about the safety benefits of better driver vision at night may have resulted in the current tradeoff represented by low-beam headlamps being less than optimal.

### **Recommendations**

Several of the simple and low-cost countermeasures for darkness-related risk should be implemented. These are encouraging a greater use of high-beam headlamps and better pedestrian behavior at night.

Effective, but more expensive, countermeasures involve changes in infrastructure. Examples include improved street lighting and better separation of pedestrians from other traffic.

There should be further implementation of the improvements in vehicle equipment that could address the darkness-related component of night risk. These include stronger low-beam headlamps and adaptive headlamps.

## Young Drivers

### Importance of the problem

Young drivers have higher rates of fatal crash involvement than any other age group. While in most U.S. states, a license to drive unsupervised requires a driver to be at least age 16, there is some variation, from 14 years and 3 months (with driver education) in South Dakota to 17 years in New Jersey (IIHS, 2006). Insurance companies have for a long time charged higher rates for drivers under age 25, based on their overall poor driving records.

According to the National Highway Traffic Safety Administration (NHTSA, 2005e), 7,709 drivers of motor vehicles (including motorcycles) who were ages 16 to 20 were involved in fatal crashes in 2004 (a rate of 61.8 per 100,000 licensed drivers), among whom male drivers were more than twice as likely to be involved in fatal crashes as female drivers. Drivers ages 21 to 24 had the next highest rate of any age group, at 46.5 per 100,000 licensed drivers, with 6,382 drivers involved in fatal crashes. In this age group, male drivers were more than three times as likely to be involved in fatal crashes as female drivers. In comparison, fatal involvement rates for other age groups ranged from 18.7 for 65- to 74-year-old drivers to 31.0 for 25- to 34-year-old drivers, clearly demonstrating the excess risk presented by drivers 16 to 24 years old.

In 2004, there were 14,977 road fatalities of all ages in crashes involving drivers between 16 and 24 years old, or 35% of the total U.S. fatalities (NHTSA, 2005a), even though drivers under age 25 comprised only 13% of all U.S. licensed drivers (USDOT, 2005). Unfortunately, there has been no substantial decrease in the last decade. Among 15- to 20-year-old drivers, there was only a 1% decrease in involvement in fatal crashes, with fatally injured drivers actually increasing 5% (NHTSA, 2005e). More than half (7,672) of the 2004 deaths involving 16- to 24-year-old drivers were in single vehicle crashes, of which the most common types were rollovers (1,442 deaths) and hitting a tree (1,310 deaths) (NHTSA, 2005a). Finally, unintentional injury is the leading cause of

death for 15- to 24-year-olds, with 70% of those deaths from motor vehicle crashes (10,736) in 2003 (CDC, 2004).

### **Known countermeasures**

#### *Policy*

Several countermeasures have been adopted to address the particular crash characteristics seen among young drivers. Most of these are policy-based. High rates of alcohol-related fatal crashes led to changes in states' minimum legal drinking age laws, and by 1988 all states had raised their drinking age to 21. During the changeover, states with a minimum legal drinking age of 21 were found to have substantially fewer single-vehicle, nighttime (proxy for alcohol-related) fatal crashes among drivers under age 21 (O'Malley & Wagenaar, 1991). By 1998, all states had also adopted lower legal blood alcohol concentration limits for drivers under age 21 ("zero tolerance" laws). During that changeover, states with a zero tolerance law were found to have further decreased their rates of single-vehicle, nighttime fatal crashes (Hingson, Heeren, & Winter, 1994).

By the 1990s, the high rates of teen driver fatal crashes, particularly at night (Williams, 2003), led to the adoption of graduated driver licensing (GDL), which is now in place in most states. GDL programs for drivers under 18 years old vary by state, but typically have three licensure stages: a learner stage requiring extended supervised practice, an intermediate stage of at least six months that allows independent driving only with specific restrictions (night especially), and a full privilege stage following a clean driving record. Several GDL program evaluations have demonstrated reduced crashes among 16-year-olds (Foss, Feaganes, & Rodgman, 2001; Shope, Molnar, Elliott, & Waller, 2001; Shope, & Molnar 2004). The longer learner/supervised driving phase in GDL addresses the presumed need for more practice driving, which was shown to reduce crashes in Sweden (Gregersen, Berg, Engstrom et al., 2000). Ideal GDL programs also include an intermediate stage restriction on carrying teen passengers, which addresses the high fatal crash rates among teen drivers who are carrying passengers (Williams, 2003). Positive results of passenger restriction have been reported from California (Masten & Hagge, 2004). The most comprehensive programs tend to have the greatest benefits

(Chen, Baker, and Li, 2006). Compliance with GDL, however, is less than ideal (Williams, Nelson, & Leaf, 2002).

Other potential policy approaches exist. An older age of driver licensure is one approach. Indeed, in New Jersey, the only state where for years teens had to be 17 to be licensed to drive, teen fatal crash rates were lower than in states with a lower licensing age (Williams, Karpf, & Zador, 1983). In most developed countries other than the U.S., the licensing age is 18 (see e.g., UNECE, 2004). While an older age of licensure does not eliminate novice drivers' crashes that are due to inexperience, it does contribute somewhat to reducing the risk (Elliott, Raghunathan, & Shope, 2002; Maycock, Lockwood, & Lester, 1991). Another policy-related area of concern is the especially low rate of safety belt usage among young drivers and their passengers (McCartt & Northrup, 2004). In states with primary safety belt laws, higher belt use is also seen among teens (McCartt & Northrup, 2004).

Policy and practice in the U.S. do not fully utilize the potential of other existing approaches that could help to reduce young driver fatalities by certain and swift enforcement of behaviors known to lead to crashes. Speed limit enforcement cameras reduce both speeding and the incidence of crashes (Retting & Farmer, 2003; Hess, 2004). Red light running cameras have been shown to reduce intersection violations and crashes (Blakey, 2003; Ruby & Hobeika, 2003). Alcohol sobriety checkpoints are effective but underutilized in the U.S. (Fell, Lacey, & Voas, 2004). Policy approaches such as these would reduce fatalities for drivers of all ages, but offer particular benefit for young drivers because of their higher incidence of the unsafe behaviors involved.

Another countermeasure targets the parents of young, novice drivers, enhancing their awareness of teen drivers' especially high risks in the early months of licensure (Mayhew, Simpson, & Pak, 2003; McCartt, Shabanova, & Leaf, 2003; Waller et al., 2001), and encouraging them to restrict their teen's initial driving, increasing driving privileges only as they are earned. This "Checkpoints Program" promotes parent involvement in teen driving through the use of a parent/teen agreement and monitoring of teens' behavior, and results in increased parental limitations, and decreased risky driving

and traffic violations among teen drivers (Simons-Morton, Hartos, Leaf, Preusser, in press).

### *Technological approaches*

Technological approaches may have a role as countermeasures to the risky driving of some young people. While much of the excess crash risk of the youngest drivers may be due to lack of driving experience and skill, some crash risk among young drivers is likely due to high-risk driving. Electronic stability control, road departure warning systems, and advance crash warning systems might be especially helpful for young drivers because of the prevalence of these types of crashes in this age group. Electronic monitoring devices similar to those used in fleets are available on the market for parents to use to determine the types of driving their teen may be doing. Studies are needed to learn if such an approach has positive benefits. Computer and driver simulation for hazard perception training of novice drivers has potential benefits (Fisher, Laurie, Glaser et al., 2002). Safety belt reminder systems already exist, but technology enhancements might make them more effective (see Use of Safety Belts for details). In-vehicle alcohol sensors, perhaps linked to a smart card license unique to each driver, could also be useful (see Alcohol-Impaired Driving for details).

### **Reasons for non-implementation of known countermeasures in the U.S.**

The main argument against raising the licensing age to be comparable with most other countries is that the U.S. is large, with vast rural areas lacking any public transport. Thus, in much of the country, there are few transportation alternatives to the private automobile. Motor vehicles have allowed important economic and recreational mobility, as well as independence and privacy so deeply embedded in the culture. Even for the youngest drivers, the issue has become one of mobility versus safety (Hirsch, 2003).

Graduated driver licensing has been introduced by most states. However, the types of programs vary widely. Certain aspects known to be especially effective (e.g., longer learner/supervised driving phase and restriction on carrying teen passengers) should be universally implemented.

Countermeasures that target young drivers' speeding, driving while intoxicated, and not wearing safety belts face the same counterarguments as those discussed earlier for the general driving population in the individual chapters dealing with these factors.

Technological countermeasures for the types of accidents in which young drivers are overrepresented (e.g., rollovers) are relatively new. Consequently, we do not yet know whether behavioral adaptation to them differs as a function of driver age and experience.

### **Recommendations**

Effective enforcement (and media coverage) of countermeasures in place, and adoption of new, effective countermeasures are both needed. Young drivers, as well as road users of all ages, would be safer with strong primary belt use laws that are enforced, automated speed and red-light enforcement, sobriety checkpoints, and attention to the licensing system so that unlicensed, suspended licenses, and restricted licenses are carefully monitored.

For the youngest drivers, graduated driver licensing has made a good start, but many states can enhance their programs, as well as compliance with their programs (Williams, 2005). Penalties, such as points on the driving record for particular infractions (as is the case for safety belt non-use), could help. Vehicle choice for novice drivers is also important (Williams, Leaf, Simons-Morton, & Hartos, 2006).

New technological innovations (e.g., electronic stability controls, road departure warnings, and crash warning systems) should be further investigated concerning their benefits to young drivers. Young drivers might be the biggest beneficiaries of these technologies because they target crash scenarios in which young drivers are particularly overinvolved.

Some states have raised the age of independent driving and more states should consider that approach. If fewer teens can drive themselves, though, creative mobility options, that retain some of the private automobile's advantages, must be implemented.

## Discussion

### Connecting goals and reality: Do we have the means?

The National Highway Traffic Safety Administration, in its budget request for fiscal year 2005 (NHTSA, 2004b), set the goal of reducing the fatality rate by the end of 2008 to 1 per 100 million miles traveled (6.2 per billion kilometers). Although this is not as ambitious a goal as the Swedish goal of reducing the rate to zero (Swedish Ministry of Transport and Communications, 1997), achieving the target rate would nevertheless represent a huge improvement in the U.S. traffic safety situation.<sup>2</sup> However, the preliminary rate for 2005—1.46 fatalities per 100 million miles (NHTSA, 2006)—is 1% above the rate for 2004 and is 46% above the target rate for 2008. Thus, the prospects of achieving a rate of 1 fatality per 100 million miles traveled by 2008 appear to be slim.

What would it take to bring the rate down to 1 fatality per 100 million miles traveled? Evidence is clear that we could do a lot by acting decisively on the five factors discussed in this document. For example, according to Evans (2004), “if all the drivers with illegal BAC > 0.08 became marginally legal drivers with BAC = 0.08, this would reduce U.S. traffic fatalities by 34%” (p. 251). Consequently, just by assuring (by stricter enforcement and the use of new technology) that people drive only when legally sober, we would already reduce the rate to below 1 per 100 million miles traveled. Specifically, the rate would be 1.46 times (1 minus 0.34) = 0.96.

Additional major advances in safety would be achieved if we could make sure (again by stricter enforcement and with the use of new technology) that drivers follow the law in terms of wearing safety belts and obeying posted speed limits. For example, according to a recent estimate, a 100% use rate of safety belts for vehicle occupants over age 4 would result in a 14% reduction in fatalities (NHTSA, 2005d).

The elevated risk of nighttime crashes is a consequence of several factors, with darkness being the focus in the present document. Technological and policy countermeasures discussed above can mitigate the effects of darkness, and especially so for nighttime crashes involving pedestrians.

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<sup>2</sup> Road safety strategic plans of many other countries worldwide are included in WHO (2006).

The over-involvement of young drivers in crashes is a consequence of both lower level of skill and increased risk taking. Dealing successfully with the other four factors (speeding, not using safety belts, driving while intoxicated, and nighttime driving) in the context of the entire driving population would address a part of the young-driver problem as well. Additional safety benefits would accrue from young-driver targeted policy and technological countermeasures discussed earlier.

Although we treated the five factors one at a time, they are not independent. For example, some young-driver crashes happen at night, under the influence of alcohol, while speeding, and while not using safety belts. Thus, the total benefits of addressing the five factors would be less than the sum of the individual benefits. Nevertheless, if dealing successfully with alcohol would reduce the rate by 34% and with safety restraints by 14%, then addressing all five factors will necessarily lead to major improvements.

Many important factors in road safety appear to be rather heterogeneous, and thus not amenable to effective simple countermeasures. Fortunately, some of these heterogeneous factors are now known to involve sub-factors that are relatively homogeneous and thus more susceptible to targeted interventions. Let us consider one such example. It is well known that nighttime driving is a multi-faceted factor, and thus unwieldy to deal with: Nighttime does involve darkness, but it also involves increased use of alcohol and increased fatigue. By analyzing the consequences of abrupt changes in ambient illumination during transmissions to and from Daylight Saving Time, several recent analyses (e.g., Sullivan and Flannagan, 2002) were able to isolate the effect of darkness and to identify pedestrian crashes as most susceptible to the influence of darkness. Consequently, specific countermeasures can be recommended to target the darkness/pedestrian connection: increased usage by pedestrians of retroreflective materials, better separation of traffic, improved low-beam headlighting, greater use of high beams, and use of infra-red night vision systems. These countermeasures are targeted in the sense that they mitigate the effects of darkness, but have no influence on the effects of the other main subfactors of nighttime (i.e., alcohol and fatigue).

“Young drivers” is another factor that can be fruitfully broken down into functional subfactors. As indicated above, we know that the increased risk of young drivers is a consequence of both inexperience (resulting in a lower level of skill) and increased risk taking. Consequently, a countermeasure that specifically addresses either the inexperience or risk taking behavior of young drivers is likely to be more effective than a countermeasure targeting young drivers in general.

However, the remaining three factors under discussion are conceptually different: Exceeding the posted speed limits, not wearing safety belts, and driving while intoxicated are transgressions against existing laws. Thus, effective countermeasures would result in drivers obeying the law (by reminding drivers about their transgression, preventing them from transgressing, or preventing them from driving at all). For these three factors, it is not necessary to understand the functional sub-factors. For example, although we know that the effects of alcohol are manifested through worsened perceptual performance and increased risk taking, effective countermeasures would deal with reducing the exposure of driving while intoxicated, and not with mitigating the perceptual or risk-taking consequences of alcohol intoxication.

### **Connecting goals and reality: Do we have the will?**

Our recommended countermeasures involve a blend of improved training, modified policy, increased enforcement, and new technology. However, to rapidly bring about major improvements in traffic safety in the U.S., we need to take major steps. In turn, instituting major changes will require the buy-in of both the society at large and individual drivers.

*Societal buy-in.* From a societal point of view, road crashes are a major health and economic problem. In 2004, road fatalities accounted for 1.8% of all deaths in the U.S. (NCHS, 2006). Furthermore, because road crashes involve a disproportionate number of young people, road crashes account for about 4.4% of disability-adjusted life years in the developed countries (Murray & Lopez, 1996). Road crashes in 2000 were

estimated to cost U.S. society \$230.6 billion (2.3% of the gross domestic product) or \$820 for every inhabitant (Blincoe et al., 2000).

Nevertheless, road crashes are not a high priority for our society. For example, road fatalities do not make headlines unless the crash involves a large number of people (e.g., a bus or a chain collision). In contrast, airline crashes are lead stories despite the fact that in the U.S. flying is substantially safer than driving (Sivak and Flannagan, 2002). However, unless a celebrity is involved, a crash with one fatality is not as compelling a news story as a crash with a large number of fatalities (even though the former occurs much more frequently than the latter).

Another indication that society assigns low priority to road safety is the low federal funding for road-safety research in relation to funding for research on other causes of death (see e.g., IIHS, 2002). This state of affairs might reflect, in part, our cultural bias to be more concerned about certain causes of death than others. For example, there is more societal concern with teen injury due to violence and suicide, even though road crashes are the leading cause of death for 15- to 24-year-olds (NSC, 2004).

*Individual driver buy-in.* From the perspective of an individual driver, driving in the U.S. is a very safe activity, with one fatality per 112 million kilometers driven (FARS, 2006a)—equivalent to one fatality for 146 round trips to the moon. So on most trips, nothing unusual happens. Furthermore, drivers get continuous positive feedback about how well they perform one aspect of the driving task—staying on the road. In contrast, critical events, by their very nature of being rare, cannot generally provide useable feedback—and it is frequently too late (e.g., Leibowitz & Owens, 1977).

Drivers feel that they are in control of the situation (as opposed to being passive, as when being a passenger on a plane, for example). To compound the matter even further, most people think that they are better drivers than the average driver (e.g., Sivak, Soler, & Tränkle, 1989), and consequently believe that being involved in a crash is something that happens only to others.

These considerations suggest that we have an uphill battle to motivate *all* drivers to do everything they can to improve their own safety and the safety of other traffic

participants (e.g., by wearing safety belts, not exceeding speed limits, and not driving when intoxicated). Furthermore, persuading the current nonbelievers will be more difficult than was the case for those who have already been persuaded. However, achieving success with the remaining drivers is not a matter of diminishing returns, but just the opposite. For example, as reviewed by Evans (2004), drivers who do not wear safety belts are also the drivers who are more likely to be involved in crashes and have more severe crashes. Thus, a given percentage change in safety belt use reduces the total fatalities by more as the baseline level increases. Evans (2004) refers to this as the *law of increasing returns*.

### **The heart of the solution**

“At the inquest into the world’s first road traffic death in 1896, the coroner was reported to have said ‘this must never happen again’” (RoadPeace, 2006). Fast forward to the 21<sup>st</sup> century with a cumulative total of over 3 million road fatalities in the U.S. (IIHS, 2002). We can look at our current situation, with many thousands dying every year, and say that it is unacceptable, but do we seriously mean that? If so, we appear to have the opportunity to change things.

We know what to do to substantially reduce road-transportation fatalities. Lack of implementation is the problem. Yes, the known countermeasures do involve some economic, mobility, and privacy costs. But are we, indeed, satisfied with the current cost/benefit balance? Furthermore, are we even aware of what balance we are dealing with? In many instances the economic, mobility, and privacy costs are likely to be much smaller than generally feared.

Our most fundamental recommendation is to re-examine the known countermeasures reviewed in this document in the context of the economic, mobility, and privacy trade-offs involved in their implementation. Our expectation is that a comprehensive understanding of these trade-offs is likely to result in broad support for wider implementation of these countermeasures, leading to major improvement in traffic safety.

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