Motor Vehicle Injury Prevention

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— Contributors—

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Where We Are

Dimensions of the Problem

With about 500 million cars and commercial vehicles in use worldwide, more than half a million people die each year in motor vehicle crashes. In the United States alone, motor vehicle crashes have killed 2.8 million people since 1900 — more than twice the number of Americans killed in all U.S. wars since 1775. Motor vehicle crashes are the leading cause of death among U.S. citizens for all age groups from 1 through 34 years of age (1); the third most significant cause of years of potential life lost, after heart disease and cancer (2); and the leading cause of work-related deaths. At current rates, approximately 1 of every 70 babies born will eventually die in a motor vehicle crash.

The risk of premature death is only one dimension of this public health hazard. In the United States each year, crashes are responsible for more than 500,000 hospitalizations and 4.8 million nonhospitalized injuries (2). Motor vehicle crashes are the major cause of serious head and spinal cord injuries leading to permanent disabilities; they account for one-third to one-half of all serious head injuries, and an estimated 30% to 60% of all spinal cord injuries (2). At current rates, approximately 3 of every 100 babies born will eventually suffer a disabling injury in a motor vehicle crash.

The economic impact of crash-related injuries is often overlooked. The estimated economic cost to the Nation from motor vehicle crashes in 1985 exceeded $75 billion. The injury-related costs were $48 billion, of which $12 billion were for direct medical and rehabilitation costs, $19 billion for indirect productivity costs associated with morbidity, and $17 billion for indirect productivity costs associated with mortality (2).

In view of these burdens, the benefits to be derived from reducing crash-related injuries are great indeed. They include reductions in costs of emergency department visits, hospitalization, rehabilitation, home care, public assistance, productivity losses, and pain and suffering among injured persons and their loved ones. In these times of fiscal constraint, with an urgency to address the appropriate allocation of dollars, it is prudent for society to think of the unseen as well as the seen victim. In the words of Dr. Harvey Fineberg, Dean of the Harvard University School of Public Health, who spoke at the 1988 Joseph W. Mountin Lecture at the Centers for Disease Control (CDC):

> Many people will remember the names and faces of those babies who are presented on television or in newspapers as needing a liver transplant. But how many people ever think about the baby in the automobile accident who died and whose liver becomes the liver that is available for the transplant? Can we discern if the life of the baby in the automobile is any less precious than that of the baby who is in need of the transplant? (3)

Motor vehicles are integral to our lifestyles, and the number of vehicle-miles traveled yearly per person continues to grow. From 1965 to 1990, motor vehicle mileage for the U.S. population increased more than 133%, from under 900 **billion** to over 2.1 **trillion** miles per year (Figure 1). Vehicle miles of travel are expected to continue to increase throughout the 1990s. In 1989, there were 24,300 fewer deaths than there would have been if the 1980 rate had continued undiminished (National Highway Traffic Safety Administration (NHTSA) press release, November 1990).

Efforts to predict the magnitude of the highway safety problem more than 10 years into the future have been notoriously unsuccessful. In the past, many analysts forecast increases in the annual highway death toll from the 40,000 to 50,000 range to the 60,000 to 80,000 range. Such projections have usually assumed steady annual increases in vehicle-miles of travel and a constant death rate per mile of travel. In fact, the death rate (per 100 million vehicle-miles traveled (VMT)) has declined from 15.6 in 1930 to 5.1 in 1960, and to 2.1 in 1990 (Figure 1).

Factors that may depress the mileage death rate in the 1990s include

- A decrease in the relative size of the teenage driving population.
- Increased population density and urbanization.
- Further reductions in alcohol consumption and alcohol-involved crashes.
- Further increases in occupant restraint use.
- Vehicle safety improvements, including airbags and side impact protection.
- Decreasing use of motorcycles and increasing use of motorcycle helmets.
- Roadway improvements.

Factors that may inflate the mileage death rate include

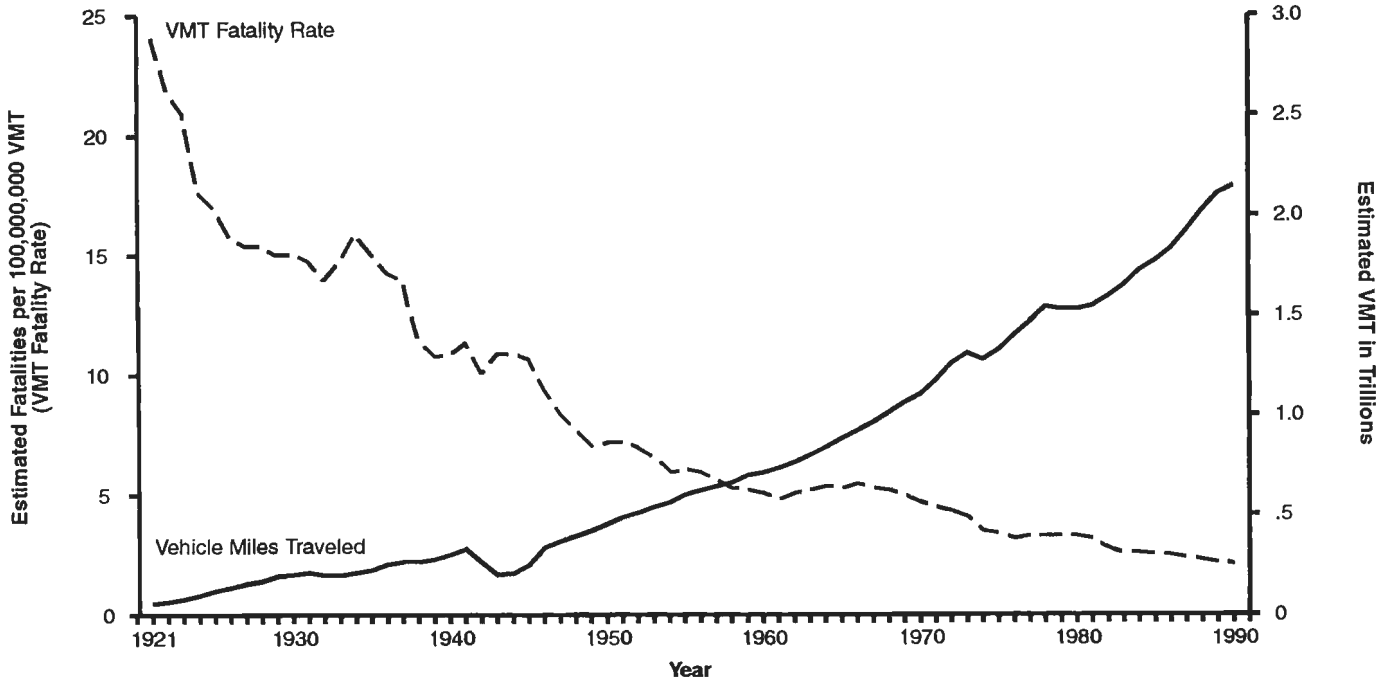
- An increase in the number of elderly drivers, passengers, and pedestrians.
- Continued increases in vehicle speeds, including speeds on rural interstate highways following the implementation of 65 mph speed limits (4).
- More vehicle downsizing and sales of small cars in response to gas prices and pressures for improved fuel economy.
- Continued increases in large truck and trailer weights.

Unless major new intervention programs are implemented, the annual U.S. death toll from motor vehicle crashes probably will remain in the 40,000 to 50,000 range over the next few years.

This paper is entitled "Motor Vehicle Injury Prevention," but it is not intended to be exclusionary or limiting, and where applicable, the concepts discussed should be applied to the prevention of injury associated with all common road vehicles, including nonmotorized

Figure 1

Vehicles Miles Traveled (VMT) and Traffic Fatality Rates, United States, 1921-1990



Sources: 1921-1974 National Center for Health Statistics, Centers for Disease Control, and State Accident Summaries

1975-1990 National Center for Statistics and Analysis, National Highway Traffic Safety Administration

vehicles, such as bicycles. In this paper, the terms highway safety, motor vehicle injury prevention, road safety, roadway safety, and traffic safety are, in general, used interchangeably.

Cost-Effective Prevention Opportunities

Motor vehicle injury prevention is a sound investment of scarce public health and highway safety dollars. Health economists have compared the estimated costs per life (and life year) saved by numerous public health programs. Such studies have consistently concluded that traffic safety programs are more cost effective than almost all other kinds of public health interventions. For example, Graham and Vaupel (5) found that the median cost per life year saved for selected National Highway Traffic Safety Administration (NHTSA) programs was over 100 times less than for selected occupational and environmental health programs. Similar findings have been reported by Schwing (6), Bailey (7), and Morrall (8).

The cost-effectiveness of regulatory actions also varies tremendously, reflecting the poor allocation of society's resources for reducing risk. An example of this variation appears in the Federal Budget for Fiscal Year (FY) 1992: on the average, spending $2 million regulating cancer risks posed by wood preserving chemicals prevents one cancer case every 2.9 million years, whereas the same amount spent on highway safety saves at least one life in just a few years (9). The evidence suggests that our limited public health resources could lower costs and save more lives if they were reallocated to favor more traffic safety investments.

If traffic safety programs reduce the number or severity of injuries, they can produce economic savings. Motor vehicle injuries account for 9% of all nonhospitalized injuries, but they account for 22% of all injury-associated hospitalizations, 32% of all injury-associated fatalities, 31% (or $48.7 billion) of the total lifetime costs of injuries in the United States (2), and more than 25% of all uncompensated hospitalization charges. Expressed in 1985 dollars, the average lifetime cost per person injured by a motor vehicle exceeds $9,000 (2), and the average cost per fatal injury exceeds $350,000 (2). These cost estimates include only medical costs and losses in economic productivity. When dollar values are added for pain and suffering and other quality-of-life factors, the costs are frequently 10 times greater than these estimates (10). The U.S. Department of Transportation (DOT) currently uses $1.5 million for the dollar value per life when conducting cost-benefit analyses; this value includes some consideration for pain and suffering.

The results of cost-benefit analyses of motorcycle helmets, child safety seats, and airbags suggest that the economic savings in terms of medical and rehabilitation costs far exceed the cost of these protective devices. For many highway safety programs, the economic savings have been estimated to exceed program costs (see Table 1) (11-20).

No Single Magic Solution

As with many diseases that affect large numbers in the population, no single magic bullet — technological or behavioral — will eliminate the problem of motor vehicle injury. Over the past 4 decades, numerous interventions in motor vehicle and highway safety have contributed incrementally to reductions in the likelihood of injury in the United States. These countermeasures have included public awareness, education, and incentive programs; legal proscriptions; innovative vehicle and equipment designs; improved roadways, enhanced emergency medical services (EMS) systems; new acute care technologies at trauma centers; and modernized rehabilitation programs. A multifaceted approach has been necessary because of the complexity and array of significant traffic problems that contribute to morbidity and mortality on our roads.

In September 1990, as part of a "management-by-objectives" planning process, Secretary of Health and Human Services, Louis Sullivan introduced 298 health objectives for the Nation (21). A complete list of objectives relating to motor vehicle injury control appears in Appendix A. The wide range of issues reflected in the following summary of the relevant objectives illustrates that no single strategy will solve the problem of motor vehicle injuries:

- Reduce the rate of motor-vehicle crash deaths per VMT.
- Reduce serious nonfatal head injuries.
- Reduce nonfatal spinal-cord injuries.
- Reduce secondary disabilities associated with injuries of the head and spinal cord.
- Increase use of active and passive restraints.
- Increase helmet use by motorcyclists.
- Extend laws on safety-belt and motorcycle-helmet use to all states for all ages.
- Reduce deaths caused by alcohol-related motor vehicle crashes.
- Reduce per capita alcohol consumption.
- Extend administrative license suspension and revocation laws (or other effective programs) to all states.
- Enact and enforce laws that reduce access to alcoholic beverages by minors.
- Restrict alcoholic beverage promotions that are focused principally on young audiences.
- Extend blood alcohol concentration (BAC) tolerance levels of .00% for drivers under the age of 21 to all states.

All of the recommendations in this paper that address the Year 2000 Objectives are so noted in the text. The panel's recommendations, however, extend beyond the focused Year 2000 Objectives listed in Appendix A.

Table 1

Highway Safety Improvements With The Highest Benefit-Cost Ratios

1974-1989

Rank	Construction Classification	Percent Reduction in Injury Rates After Improvements			Benefit-Cost Ratio
		Fatal Injury	Nonfatal Injury	Fatal and Nonfatal Injury	
1	Illumination	47	22	22	9.5
2	New Median Barrier	66	6	9	4.8
3	Upgrade Bridge Rail	75	32	36	4.1
4	Upgrade Guardrail	40	8	10	4.1
5	Traffic Signs	28	8	8	3.6
6	Remove Obstacles	50	23	24	3.6
7	New Traffic Signals	52	20	21	3.5
8	Upgrade Median Barrier	45	27	27	3.3
9	Impact Attenuators	33	35	35	2.7
10	Improve Minor Structure	35	20	21	2.5

Source: (20)

Notes: 1. Revised project cost indices were used to convert the original construction cost of each project to 1987 dollars. The indices are used to counter the effect of inflation when comparing the benefit-cost ratio of safety projects implemented in different years. The indices are based on information provided in a Federal Highway Administration (FHWA) publication entitled "Price Trends for Federal-Aid Highway Construction," Second Quarter 1989.

2. Costs (in 1986 dollars) of $1,500,000 per fatality and $11,000 per injury were used in calculating the benefit-cost ratio of highway safety improvement projects. These costs are based on the findings of a 1986 FHWA research contract entitled "Alternative Approaches to Accident Cost Concepts."

Factors that Transcend Motor Vehicle Injury

The solutions to the problem of motor vehicle injury do not lie solely in the realm of either traffic safety or public health. Many behaviors and risk factors are associated with both traffic safety trends and larger, societal issues. Illustrative behaviors and risk factors include impaired driving, risk taking, age, and literacy.

Impaired Driving

The traffic safety community has long recognized the association of alcohol and other drugs with serious motor vehicle crashes, and during the last decade, public awareness has risen considerably. Citizen advocacy groups demanded greater attention to the morbidity and mortality attributable to impaired driving. Enforcement and sanctions are necessary to combat impaired driving, but a more comprehensive approach must be taken if significant progress is to be made in preventing impaired driving.

In 1988, the Surgeon General's Workshop on Drunk Driving was convened as the first major national public health effort to take a comprehensive approach to alcohol-impaired driving (22). The workshop's origins in the public health community and its attention to the effects of alcohol on motor vehicle safety constituted an important and growing link among the alcohol, health, and transportation communities.

The workshop addressed enforcement and judicial procedures, but it also examined the pricing and availability of alcohol, the advertising and marketing of alcohol, and transportation and alcohol service policies. Changes in each of these areas have the potential to reduce alcohol consumption and minimize its deadly and costly effects on individuals and society. This comprehensive approach to impaired driving has triggered some opposition. However, it is unlikely that we will substantially reduce impaired driving until and unless we (a) reduce problem drinking, drug use, and total per capita alcohol consumption, and (b) modify many commonly accepted current practices such as granting licenses to drinking establishments that can be reached only by private transportation and allowing the alcoholic beverage industry to sponsor events targeted at audiences who are below the minimum drinking age.

Specific recommendations regarding alcohol are addressed in the section titled "Program Successes," and in "How We Get There," page 129, under "Corporate America."

Driver Attitudes and Risk Denial

The risk of involvement in a fatal crash is often expressed in terms of fatalities per VMT. Today, the motor vehicle crash fatality rate is less than 2.1 per 100 million VMT. As Figure 1 shows, this rate represents a dramatic decrease in rates from earlier years and reflects improvements in many aspects of traffic safety. The decline in the fatality rate, however, obscures the tremendous variation in **relative** risk. For example, an 18-year-old male is over nine times more likely to be involved in a fatal crash than a 40-year-old male. Drivers whose

BAC levels are $\geq$ .10% are more than 12 times as likely to be involved in a fatal crash as a sober driver (23). The use of safety belts, the vehicle's weight and speed, and even the type of road on which a driver is traveling, all combine to affect a driver's relative risk. Some aspects of relative risk have been minimized through improvements in the safety features of roads and vehicles. However, driver behavior and actions also play an important and often decisive role in either increasing or decreasing relative risk.

Many motor vehicle crashes can be classified into one of two groups: crashes that are the result of aggressive, reckless driving, and crashes that are the result of lapses in judgment by otherwise attentive, responsible drivers (24). Vehicle and roadway design can potentially help good drivers avoid crashes, but a reckless driver can overcome built-in safety features by driving irresponsibly.

Aggressiveness is a behavior issue related to the individual driver, individual motivation, and peer pressures. Drivers who routinely take irresponsible risks with their vehicles must be reached in order to reduce traffic casualties. This may require early education and training of children before they get driving privileges (25), and careful review of television and film portrayals of heroes who unrealistically avoid the consequences of reckless driving and speeding. Aggressive driving is a critical factor in injuries among adolescents and has been associated with other risk-taking behaviors (26). These issues warrant further study, as do various behavior-based interventions (27).

Age

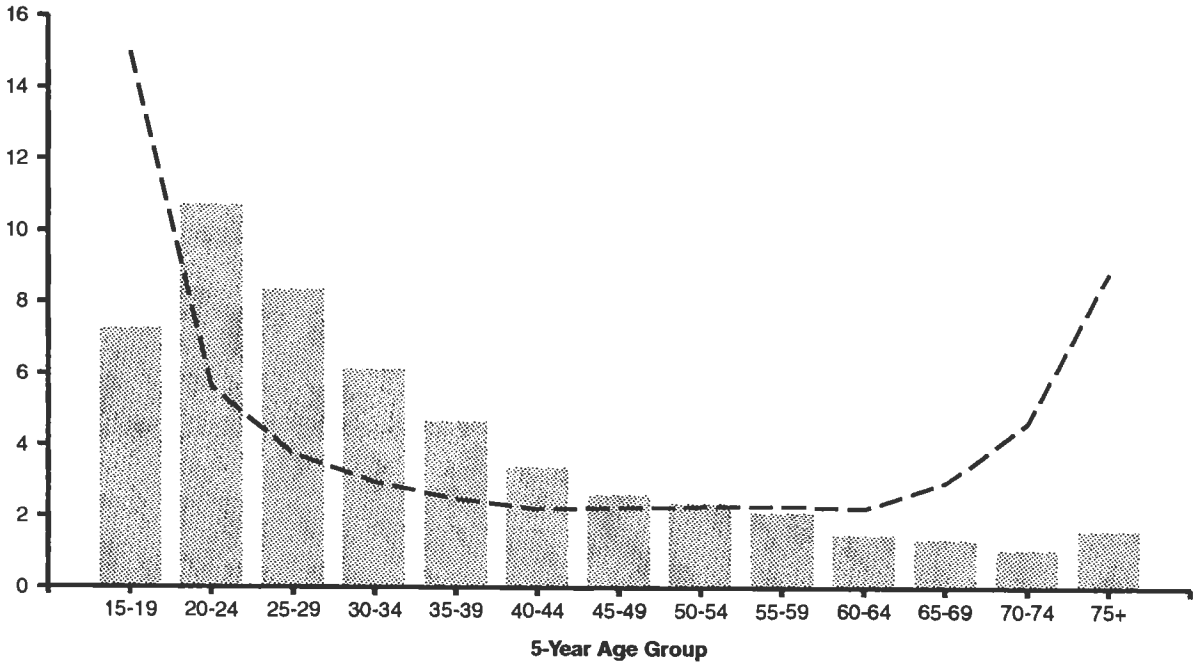
Age is one of the most powerful risk factors for motor vehicle injury, in part because it relates to alcohol consumption, aggressive behavior, and driver capabilities (26). Raising the minimum age of licensure has been proposed as one solution to the higher crash risk of young drivers. This would not reduce any crash risk due to inexperience in driving, but would reduce appreciably the risk due to immaturity and to exposure.

Although age per se should not be used as a criterion for denying a license at the other end of the age continuum, the risk of crash per mile driven increases after age 65, and markedly so after age 75 (Figure 2). Increased age is also associated with higher probability of serious or fatal injury in a crash of given severity (28, 29). However, continued mobility may be a factor in maintaining the health and psychological well-being of the elderly (30), and mobility needs should be balanced with safety concerns.

The changing demographics of our population herald increases in the older driving population and decreases in the younger driving population. Changing demographics will require broad societal attention to developing appropriate alternative transportation systems for older people no longer able to drive and to urban planning that enables older people to meet their needs with reduced exposure to traffic.

Figure 2

Driver Involvement in Fatal Crashes and Fatal Involvement Rates by Age, United States, 1983



Source: Transportation Research Board (28), based on data from the 1983-1984 Nationwide Personal Transportation Study, Federal Highway Administration/ National Highway Traffic Safety Administration/Urban Mass Transportation Administration, and data from the Fatal Accident Reporting System, National HighwayTraffic Safety Administration

Literacy

A causal relationship between literacy and driving performance has not been proven, but the two appear to be related. Literacy is clearly related to socioeconomic status. In one state, applicants taking the oral version of the knowledge test to obtain a driver's license had more crashes and in older vehicles, when other relevant factors were considered (31). Addressing such a fundamental problem might augment highway safety efforts to reduce injuries.

Research Successes

Successes in motor vehicle injury prevention have not come easily, but when they have, they have usually been based on advances in scientific knowledge of the causes of injury and the methods of injury reduction. These advances in driver, vehicle, and highway safety have been achieved by years of scientific research, development, testing, and evaluation.

Between 1966 and 1982, improvements in motor vehicle safety resulted in the saving of at least 90,000 lives and the prevention of hundreds of thousands of injuries (32-34). Each year selected vehicle safety programs save more than 4,000 lives and prevent more than 150,000 injuries (11-19). These numbers are expected to increase substantially as airbags, safety belts, and side impact improvements come into more widespread use.

State safety belt use laws save an estimated 3,600 lives each year (35, 36). An estimated 1,100 lives each year have also been saved (37) as states have passed and enforced "Age 21" minimum drinking age laws (38) and have taken other similar measures based on research to prevent alcohol impaired driving (39, 40). Roadway safety research has been another contributor to saving lives and preventing injuries (Table 1). These various safety features are based on research conducted or supported by various government agencies, automotive manufacturers, and automotive suppliers (41).

Despite the effectiveness of traffic safety programs, federal safety research funds have not been sufficient for studying vehicle crashworthiness, crash avoidance, highway safety, and driver behavior; hence there has been a reduction in the number of scientists and engineers with expertise in traffic safety working in the field. Several universities and research organizations that once were productive contributors to the advances in motor vehicle safety no longer engage in safety research. Private sector research on safety has also struggled. As a result, insufficient funds have kept new researchers from entering the field.

A comparison of federal research investments indicates that motor vehicle injury research is a relatively neglected field. In FY87, the NHTSA research budget was $39.8 million, and the total federal expenditure for injury-related research was $160 million. By comparison,

the FY87 budget obligation for the National Cancer Institute was $1.4 billion, and $930 million for the National Heart, Lung, and Blood Institute (42).

The NHTSA FY90 research and development (R&D) budget for motor vehicle safety of $32.4 million amounted to about $619 per death. Compared with the annual costs to society that are associated with motor vehicle injuries, this reflects about six cents invested per $100 in economic costs to society, or about $17 per life year lost because of motor vehicle fatalities. When the Federal Highway Administration (FHWA) R&D budget for safety of about $6 million and CDC funds of about $2 million earmarked for motor vehicle injury prevention research are included, the total amounts to about $41 million (42). This amounts to $21 per life year lost to motor vehicle injuries in contrast to federal R&D spending of $86 per life year lost to cardiovascular diseases and $195 per life year lost to cancer. Per life year lost, the federal R&D expenditures for motor vehicle injury represent less than one-ninth of those for cardiovascular disease and cancer.

With better funded research programs and trained researchers, the Nation can continue the scientifically based motor vehicle safety progress reflected in current effective interventions, such as vehicle occupant protection, safety legislation, public education, and law enforcement. These interventions are already saving many thousands of lives each year, and they prevent many more thousands of serious injuries.

Program Successes

Motor vehicle injury prevention is a promising and exciting field because significant program successes have already been proven. These successes are encouraging, but more work needs to be done in each of the critical areas described below.

Occupant Protection

It is estimated that among front seat passenger-vehicle occupants over 4 years of age, safety belts saved more than 4,800 lives in 1990, almost 3,000 of which were related to belt use laws (43). In 1988, surveys indicated that belt use in states with belt laws averaged about 50%, but varied widely from state to state, from 68% in Hawaii to only 27% in Tennessee (44). Belt use is generally lower in states without belt laws, but those states also show substantial variance in belt use (45, 46). It is estimated that if only 70% of all vehicle occupants had been protected by safety belts in 1990, another 3,750 lives could have been saved (43). As safety belt use becomes a common practice and supplementary airbags become more widely available, many more lives will be saved (Appendix A, Objective 9.12).

When combined with public education, enforcement, and incentives, belt use laws can significantly increase belt use rates and reduce injuries (47, 48). An analysis of Fatal Accident Reporting System (FARS) data from 1975 through 1986 revealed that among

occupants of cars in 24 jurisdictions with safety belt use laws, total crash fatalities were 6.6% lower than the number forecast from previous trends (49). In several of these jurisdictions, downward shifts in the number of fatalities were linked to the month of the law's onset (49). By August 1991, 42 states, the District of Columbia, and Puerto Rico had enacted safety belt use laws. Safety belt use laws that allow for primary enforcement empower law enforcement officers to stop drivers for a belt use violation alone, whereas secondary enforcement laws require that a vehicle must first be stopped for some other traffic violation before citing the driver for a belt use violation. Whereas laws that allow for primary enforcement have no additional costs, states in which primary enforcement laws have been implemented have higher safety belt use rates than states with secondary enforcement or no laws (50, 51).

Further reductions in injury may result from implementation of the proposed Occupational Safety and Health Administration (OSHA) rule that would require employers to ensure use of safety belts and airbags among their employees when driving on-the-job (52). Such a rule could also have a spillover effect, increasing the use of safety belts off-the-job.

Child safety seats and adult belts on children have been credited with saving more than 1,300 infants' and toddlers' lives between 1982 and 1990 (36). However, 460 more lives could have been saved in 1990 if **all** children under 5 years of age had been restrained in child safety seats on every trip. Programs that enhance motivation to use child safety seats (53, 54), extend access to child safety seats, and educate parents regarding the need for and proper use of safety seats are needed (55). Although the cost of child seats can be prohibitive for some families, the effectiveness of child seat loaner programs should be evaluated, and liability issues that hinder such programs should be resolved.

Vehicle seat and safety belt designs that better accommodate child safety seats are also needed (Appendix A, Objective 9.12). Child safety seats should be designed to decrease the high frequency of misuse and failure.

In addition to encouraging safety belt and child safety seat use, laws and enforcement are needed to prevent the dangerous practice of passengers (particularly children) riding unrestrained in the cargo areas of pickup trucks.

Motorcycle Safety

From 1979 through 1990, more than 51,000 motorcyclists died from motorcycle-related injuries; more than half of these deaths involved head injury (56). It is estimated that motorcycle helmets have saved more than 5,000 lives since 1984 (57). However, death is the outcome for only 1% of motorcyclists injured severely enough to receive medical care (58). Deaths represent but a small fraction of the head injury problem presented by motorcycle crashes.

In states where motorcycle helmet use laws are in place, helmet use in observational studies exceeds 99%. In states without helmet use laws, use is about 44% among all motorcyclists (59) and considerably lower among those fatally injured in motorcycle crashes (Table 2). As with safety belt use, helmets are less frequently used by those fatally injured in crashes (24). Studies indicate a relatively high use of public funds in medical and rehabilitation costs by those injured in motorcycle crashes (60, 61).

TABLE 2
Fatalities Involving Nonuse of Motorcycle Helmets and Safety Belts and Estimate of Lives Saved Per Year with Helmet and Safety Belt Use United States, 1987

	1990 Fatalities Without Use		Annual Estimated Lives Saved		
	In States With Use Laws	In States Without Use Laws	In States With Use Laws	If 70% Use Nationwide	If 100% Use Nationwide
Helmets	380	1,269	450	777	1,110
Belts	19,515	2,989	4,302	8,592	15,275
Total			4,752	9,369	16,385

Source: (57, 59)

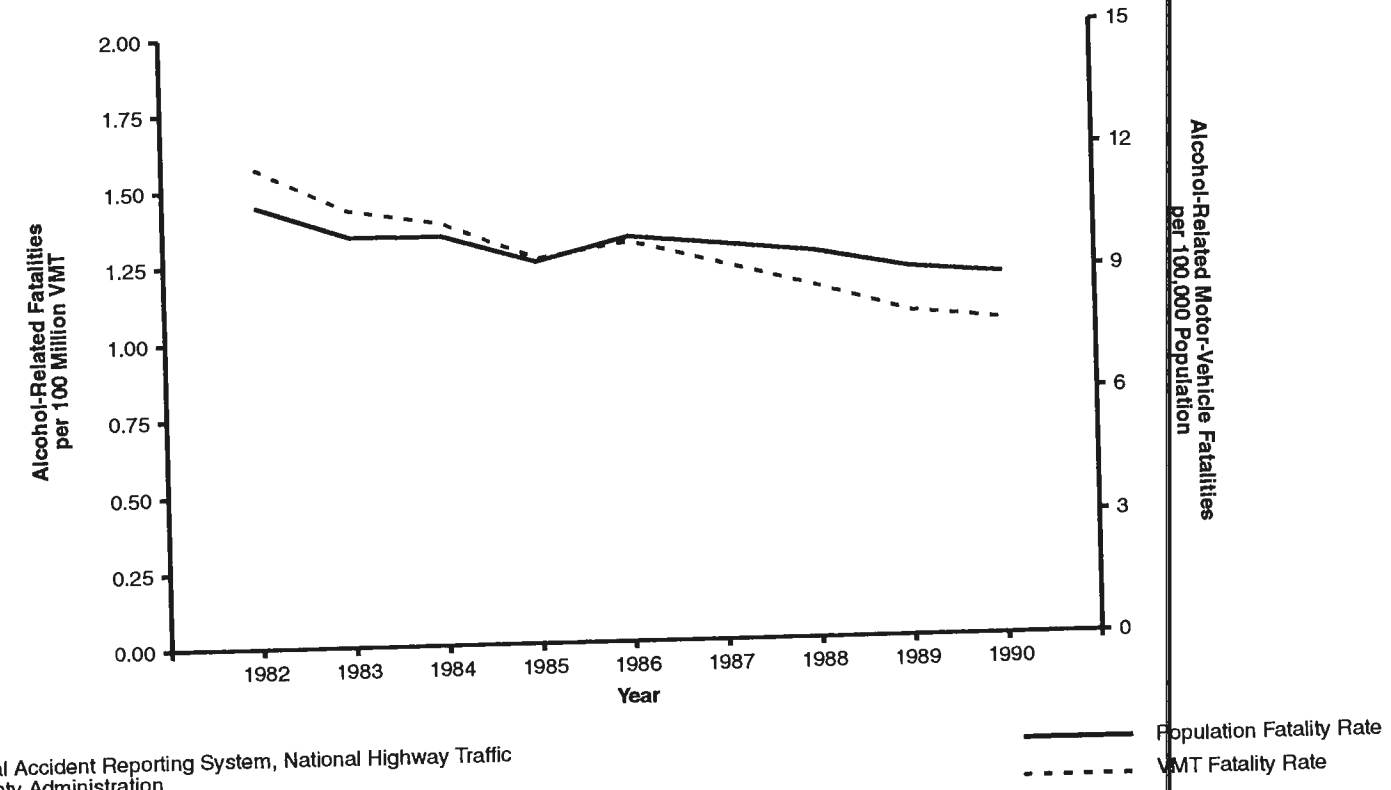
As of mid-1991, only 24 states and the District of Columbia had helmet use laws that pertained to riders of all ages. Much can be gained if all states adopt and enforce all-rider helmet use laws (Appendix A, Objective 9.14). In addition, all states should enact and enforce laws that require all motorcycle operators to obtain a motorcycle operator license. In 1989, 41% of motorcycle fatalities occurred among unlicensed or improperly licensed operators (61).

Impaired Driving

Despite recent progress, alcohol and drug use continue to be major highway safety problems (Figure 3 and Appendix A, Objective 4.1). An estimated 47% of traffic fatalities in 1987 would have been prevented if alcohol-related deaths could have been completely eliminated; this means between 20,000 and 24,000 fewer deaths annually (62). In 57% of all fatal crashes in 1982, either a driver or a pedestrian had a detectable BAC. This figure was 50% in 1990; over 22,000 persons were killed in alcohol-related crashes in 1990. In addition, the results of several studies have shown drugs in the bloodstream of 10% to 22% of injured drivers, often in combination with alcohol (63). The extent to which these substances contribute to the circumstances of such crashes warrants further study.

Figure 3

Alcohol-Related Motor Vehicle Fatality Rates by Vehicle Miles Traveled (VMT) and by Population, United States, 1982-1990



Source: Fatal Accident Reporting System, National Highway Traffic Safety Administration

The enforcement of minimum drinking age laws is one way of reducing young drivers' access to alcohol. As the Year 2000 Health Objectives for the Nation (21) and the Surgeon General's Workshop report (22) also note, an important element of enforcing these laws is to cite those who sell or serve alcohol to minors, in addition to citing minors who illegally purchase alcohol (Appendix A, Objective 4.16). Other approaches to restricting minors' access to alcohol include restricting or controlling the availability of alcohol in settings where young people constitute the majority of the audience and restricting alcohol beverage companies' sponsorship of collegiate, athletic, and motor sports events.

Alcohol consumption among both minors and adults can also be affected by raising taxes on alcoholic beverages (64, 65). The Pricing and Availability Panel of the Surgeon General's Workshop calculated that a weighted alcohol price increase of 33.6% may yield 19% to 25% reductions in motor vehicle fatalities, or between 8,400 and 11,000 fatalities annually (22, 66). Even if only a fraction of this level is attained, increasing taxes may be appropriate.

Minimum drinking age laws saved over 1,100 lives in 1988 (39), and appear to have had sustained effects in several states (67, 68). A study of high school seniors and young adults found that higher minimum drinking ages were associated with lower levels of alcohol use across a number of demographic variables (69). Significantly lower levels of alcohol use persisted as high school youth moved into their early twenties, suggesting that these laws can lead to lasting changes in consumption patterns among both the target under-21 group and in the over-21 age group as the target population ages.

Administratively imposed license revocation (ALR) laws for drivers with BACs above the legal level of intoxication (administrative per se laws) are another example of laws effective in reducing impaired driving (Appendix A, Objective 4.15). The contribution of alcohol to impaired vision, perception, judgment, and reaction time warrants a reduction in the legal BAC limit to .08% for adults 21 years of age and older and to .00% (zero tolerance) for persons under the age of 21 (70). (By convention, .02% is the level applied to indicate .00% BAC, in order to allow for instrument error.) If impaired drivers perceive that the likelihood of being cited for impaired driving (at lower BAC levels) is relatively high, they might be more cautious about drinking and driving. However, reducing BAC limits to .04%, as recommended in the Year 2000 Health Objectives for the Nation, would place a burden on the enforcement of laws concerned with drinking and driving ("driving under the influence" (DUI)), enforcement that is already insufficient. The panel recognizes this trade-off, but notes that stricter BAC limits are needed. There is also a need for vigorous enforcement of DUI laws at any BAC level, including citation of persons who often are not cited for DUI because they are transported for emergency medical treatment.

Although all states have DUI laws, there is considerable room for improvement. More than half the states do not have an open container law, and many states lack administrative license penalties, mandatory BAC tests for drivers killed or injured in crashes, anti-plea bargaining statutes, and preliminary breath tests. In addition, access to alcohol treatment and to rehabilitation programs is limited both in terms of absolute numbers of program positions

available and in terms of prohibitive monetary costs to those seeking treatment. Some progress has been made in understanding the value and effectiveness of these countermeasures, but additional policy research and analysis are needed to develop the most cost-effective approach.

Motor Vehicle Safety Standards

Motor vehicle safety standards that have led to vehicle improvements such as enhanced side impact protection, improved steering assemblies, and high penetration-resistant windshields have saved an estimated 5,160 lives each year from 1975 to 1985 (71), as shown in Table 3. Implementing other specific known vehicle improvements for passenger cars (Table 4a) and light trucks (Table 4b) would save an estimated 1,300 lives and prevent approximately 10,000 injuries annually. To evaluate and implement these improvements further, we need more sophisticated test procedures, improved measuring devices, and more research in biomechanics.

Table 3

Annual Number of Lives Saved and Injuries Prevented by Vehicle Safety Improvements

Improvement	Number of Lives Saved	Number of Injuries Prevented
Instrument Panel Padding	550	8,000
Head Restraints	Unknown	64,000
Steering Assemblies	1,300	24,000
Windshields	Unknown	47,000
Door Retention	400	Unknown
Side Protection	480	9,400
Brake Improvements	320	27,000
Occupant Protection (light trucks and vans)	2,000	Unknown
Total	5,160	155,100

Source: (71)

Table 4a

Annual Benefits from Selected Vehicle Safety Improvements to Passenger Cars

Program	Target Population		Potential Reductions	
	Fatalities	AIS 2-5* Injuries	Fatalities	AIS 2-5* Injuries
Improve occupant restraints and vehicle structures to meet current occupant protection standards in full frontal crashes up to 40 mph	1,170	1,980	230	400
Improve occupant restraints and vehicle structures to meet current occupant protection standards in offset frontal crashes up to 30 mph	1,640	26,400	330	5,280
Improve vehicle hoods to reduce the risk of pedestrian head injuries	320	1,790	27	30
Upgrade existing standards to improve head to upper interior impact protection	4,000	22,000	400	2,200
Total	7,130	52,170	987	7,910

Source: (35)

*The Abbreviated Injury Scale (AIS) is a commonly used system for assessing injury severity. For any of six designated body regions, an AIS score of 1 denotes minor injury, 2 moderate injury, 3 serious injury, 4 severe injury, and 5 critical injury. The system is used to code single injuries and is the foundation for methods to assess multiply injured patients with more precise definitions of what these levels of injury constitute for each body region (72).

Table 4b

Annual Benefits from Selected Vehicle Safety Improvements to Light Trucks

Program	Target Population		Potential Reductions	
	Fatalities	AIS 2-5* Injuries	Fatalities	AIS 2-5* Injuries
Improve occupant restraints and vehicle structures to meet current occupant protection standards in full frontal crashes up to 40 mph	370	270	70	50
Improve occupant restraints and vehicle structures to meet current occupant protection standards in offset frontal crashes up to 30 mph	740	3,600	150	720
Improve vehicle hoods to reduce the risk of pedestrian head injuries	35	230	3	1
Upgrade existing standards to improve head to upper interior impact protection	600	4,600	60	460
Develop dynamic side impact test requirements for light trucks	215	5,800	50	1,300
Total	1,960	14,500	333	2,531

Source: (35)

*The Abbreviated Injury Scale (AIS) is a commonly used system for assessing injury severity. For any of six designated body regions, an AIS score of 1 denotes minor injury, 2 moderate injury, 3 serious injury, 4 severe injury, and 5 critical injury. The system is used to code single injuries and is the foundation for methods to assess multiply injured patients with more precise definitions of what these levels of injury constitute for each body region (72).

There are numerous other examples of estimated savings attributable to motor vehicle safety devices and laws:

- Voluntary safety belt use saved 4,580 lives in 1989 and 19,360 lives from 1984 through 1989 (43).
- Safety belt use laws saved 3,660 lives in 1989 and 14,190 lives from 1984 through 1989 (43).
- Child safety seats saved 240 lives in 1989 and 1,140 lives from 1984 through 1989 (43, 73).
- Motorcycle helmets saved 530 lives in 1989 and 4,120 lives from 1984 through 1989 (43).
- Motorcycle helmet use laws saved 290 lives in 1989 and 2,180 lives from 1984 through 1989 (43).
- Minimum drinking age laws saved 1,090 lives in 1989 and 5,560 lives from 1984 through 1989 (43).

Roadway Safety Improvements

Enhancing the physical highway environment can have a significant, positive impact on highway safety. This is illustrated by the lower fatality rates on the Interstate Highway System; this system separates opposing traffic, limits access, eliminates crossing traffic, and is designed to meet higher safety standards than do other roads. Interstate highways have a crash fatality rate that is about half the national average. Sections of interstate highways constructed after 1967, when the concept of providing clear roadsides for all interstates was adopted, have generally had two-thirds the crash fatality rate of older sections of interstates. The system of highways with the lowest design standards, local and collector roads, continues to report a crash fatality rate about 25% higher than the national average for all roads (74).

Highway safety improvements have proven particularly effective at specific "high accident locations." Federal Aid Highway Safety Improvement projects implemented by the states since 1974 have saved over 55,000 lives (over 3,400 lives per year) and have prevented more than 1 million serious injuries (10). Examples of these types of improvements include traffic signs, better illumination, guardrail upgrades, obstacle removal, and crash cushions. On average, these improvement projects have returned over four dollars in safety benefits for every dollar expended on project costs (see Table 1, page 82, benefit-cost ratios.)

A new concept that holds great promise involves a comprehensive interdisciplinary approach to reducing crashes in "high accident corridors." In the corridor strategy, physical improvements to the highway are combined with enforcement, public awareness, and EMS programs. The combined effect of the different approaches appears to yield a far greater payoff in crash reduction than would be expected had the programs been undertaken separately (71). Interdisciplinary efforts may be an innovative and productive future safety strategy. Evaluation research is the key to determining which combination of interdisciplinary efforts would be most beneficial.

Where We Want To Be

Research Directions

Crash Avoidance Research

Crash avoidance research addresses improvements in vehicle safety by reducing the frequency of crashes, crash severity, or both. A variety of factors contribute to crashes. "Driver error" is one contributing factor to most crashes (75). The sources of driver error are varied, covering fatigue, impaired driving, innate sensory or motor deficiencies (in some cases age-related), poor judgment or inexperience, speeding or other traffic law violations, inattention, and information detection or processing deficiencies. These human factors are frequently exacerbated by weather, road conditions, vehicle maintenance, and other factors.

To address the full range of issues, growth in crash avoidance research should be accompanied by growth in applications-oriented human factors research. A scientific framework should be established that allows researchers to understand the role of the driver in crashes. While not meant to be exhaustive, the following areas are representative of those areas that should be pursued:

Driver-Machine Interaction

Research is required to assess the impact of vehicle design parameters on operator performance. This can include research to evaluate the response of drivers to a variety of vehicle modifications, including warning systems, lights, information displays, controls, handling characteristics, and various performance feedback systems. Development and wide use of the center-mounted brake light are an example of a driver-machine human factors approach.

Intelligent Vehicle Highway Systems Research

Intelligent Vehicle Highway Systems (IVHS) is an emerging field that systematically applies advanced technology to the driver-vehicle-roadway system. IVHS crash avoidance systems build on advances in electronics, computers, and communications and artificial intelligence technologies. These technologies can alert drivers to impending dangers or lapses in attention and judgment. By assisting drivers with the driving task, IVHS systems can compensate for some of the errors and risk denial that lead to crashes.

The IVHS initiative seeks to improve safety, driver convenience, and system capacity, and to reduce congestion, emissions, and fuel consumption. Since over 60% of nonrecurring delays on freeways are the result of crashes or disabled vehicles, improvements in crash avoidance capabilities will lead to improvements in both safety and traffic flow. With IVHS,

step-function increases in road capacity and safety — rather than incremental percentage improvements — are possible. Instead of merely managing worsening conditions, IVHS has the potential for solving transportation problems.

The research ranges from the development and evaluation of advanced technology systems to policy research, such as analyses of the public's willingness to accept these technologies, and their social and legal ramifications. The ultimate success of IVHS depends on matches between the technology and the capabilities and limitations of drivers who will use it. Unless attention is paid to the driver-vehicle interface, expectations may not be achieved, and safety benefits could be undermined because drivers are confused or overloaded by the information that is intended to help them.

Highway Design Research

There is compelling evidence that improved highway design contributes to the reduction in frequency and severity of crashes. The Nation's highway network includes almost 4 million miles of roads. Research to optimize this system's design features, ranging from signs and pavement markings to highway geometry, should have a major payoff in safety. The Federal Highway Administration (FHWA) currently recommends further human factors research on sign reading, overhead illumination, and traffic control devices. Additional recommended topics and research strategies include —

- Evaluating vehicle design options relative to different user populations (e.g., by age and gender) and impairments (e.g., known medical conditions).
- Evaluating roadway guidance and warning systems relative to drivers' responses (e.g., signing, delineation, work zones, railroad crossings).
- Evaluating different methods of making motorcyclists and pedestrians (including workers in highway work zones) more visible to drivers.
- Developing research capabilities within the U.S. Department of Transportation (DOT) — in terms of both staff and equipment — to conduct research on driver-vehicle-roadway interaction.

Heavy Vehicle Safety Research

Improvements in truck design and performance are needed to ensure safe environments for both trucks and smaller vehicles. Heavy vehicle safety research is currently focused on the following areas:

- Developing advanced technology truck braking systems.
- Identifying ways to improve heavy truck stability.
- Identifying practical means of designing truck front- and rear-end structures to reduce the effects of truck impacts on smaller vehicles.
- Developing test procedures and ways to enhance truck occupants' crash protection.

Suggested areas of additional research include the following:

- Evaluating the use of special lanes on highways to isolate heavy vehicles from lighter passenger vehicles.
- Assessing the effectiveness of lowering urban speed limits for heavy vehicles.

Additional research is warranted on other issues affecting driver performance such as fatigue, sleep disorders, inattention, impaired driving, the use of special lanes on highways to isolate heavy vehicles from passenger vehicles, and the effectiveness of lowering urban speed limits for heavy vehicles.

Crash Injury and Survival Research

Crashworthiness Research

Crashworthiness research is focused on the major crash modes affecting occupants of passenger cars, trucks, and vans: frontal, side impact, rollover, and rear impact crashes. Research strategies for reducing the effects of these types of crashes include —

- Increasing occupant protection by improving door designs (hinges, latches, locks, and glazing) to prevent the occupant from being ejected through openings during a crash.
- Making the roofs of vehicles more crush-resistant.
- Making interior surfaces (including steering wheels and instrument panels) more energy absorbent, thereby reducing head injuries to occupants.
- Improving seats and restraint systems to provide better occupant containment and protection against injuries from interior impacts in crashes.
- Improving vehicle structures to preserve the integrity of the occupant compartment and prevent harmful intrusion.

Crashworthiness research also addresses protection for the approximately 7,500 pedestrians and pedalcyclists killed in motor vehicle crashes each year. For example, vehicle designs that incorporate softer hood and fender designs have demonstrated potential for reducing the severity of head injuries among pedestrians struck by motor vehicles (76). Test procedures and vehicle designs that reduce leg and thorax injuries — such as lower front bumpers — are other current research projects that seek to protect pedestrians in crashes.

Biomechanics Research

Fundamental to the practice of medicine and public health is the study of disease and injury causation. Crash injury is caused by application of mechanical forces to the body, and the amount of energy delivered and the area of contact are important determinants of the outcome. Biomechanics uses engineering principles to explore the physical and physiologic responses to mechanical forces (77). Fruits of biomechanical research include safety belts, airbags, antilacerative windshields, head restraints, child safety seats, padded dashboards, stronger side-door structures, and collapsible steering columns (77). Biomechanics research

contributes to the development of products designed to be safe **before** the public uses them, thus preventing injuries.

Impact severity can be reduced by energy-absorbing structures and padding material that limit deformations of the body to levels insufficient to cause injury. It is difficult to define the appropriate interface, recognizing the range in impact severities, tolerances of people likely to be exposed to impact risks, and the range in possible outcomes. Optimizing product designs is the critical issue requiring a scientific approach; this approach must be based on the goal of overall societal benefit and must emphasize safety for occupants of all ages and tolerances in a wide range of crashes (78, 79).

One research goal is to develop a test tool, such as an anthropomorphic testing device ("dummy"), or a test method, such as a crash test, in which products can be evaluated for safety performance. These tests determine the built-in safety of the product in a crash or impact. Crash tests provide only the most basic information on system performance, and the anthropomorphic test devices are only crude representations of people, yet biomechanicists and engineers rely on these procedures and devices to improve product safety.

The consequences of inadequate biomechanics research are enormous. If test devices to measure crash injury protection are unavailable, introduction of safety features can be delayed unnecessarily. The use of flawed test procedures can increase the cost of motor vehicles without providing commensurate safety benefits. Recommended areas of research on the biomechanics of injury control include the following:

- Developing centers of excellence in which research, education, and training are pursued in the basic biomechanics of injury and medical sciences.
- Optimizing the design of safety systems for the protection of the full population (recognizing a 4:1 range in impact tolerance from young men to older women).
- Establishing a method for assessing the societal benefit of products, considering differences in exposure severity, injury responses, risks, and tolerances.
- Improving the understanding of the biomechanics of brain and spinal cord injury.
- Developing the core needs for an improved science of injury biomechanics.
- Developing more realistic injury models in order to improve treatment protocols and develop innovative rehabilitation procedures.
- Improving the realism and accuracy of the evaluation of human safety with anthropomorphic testing devices and impact tests, emphasizing crash situations that cause serious injury and disability, and using a range of anthropomorphic testing devices, including newborns, children, small women, and other adults.
- Developing improved safety equipment, including motorcycle and bicycle helmets and protective clothing.
- Devising and implementing evaluations of crash safety restraints and energy-absorbing interiors.

- Identifying opportunities for improving pedestrian and cyclist protection through vehicle design.

Behavioral Research

Technological advances have helped reduce the severity of motor vehicle crashes. Yet technology alone cannot prevent or reduce the severity of crashes resulting from lack of knowledge and skills, poor judgment, and reckless driving. More importantly, technology cannot change the attitudes and motivations that predispose drivers to increased crash risks by excess speeding, aggressive driving, and substance abuse. Understanding how these aspects of human behavior affect the driving task requires research to develop new interventions, as well as rigorous evaluation of existing programs. Currently, there is no adequately funded program devoted primarily to peer-reviewed, investigator-initiated research on the role of behaviors (both motivation and performance) in traffic safety.

Behavioral scientists can help design interventions that work by changing the behaviors or social norms of individuals and groups. As with other public health issues, more data are needed on traffic safety to understand how people behave, why people behave the way they do, what the outcomes of various behaviors are, how deleterious behaviors can be changed, and how effective efforts to modify those behaviors are. As a model for approaching public health problems, this conceptual framework has recently received considerable attention as a means for limiting the spread of infection with the human immunodeficiency virus (80).

Similarly, applications of health promotion strategies in traffic safety could be useful (81-84). As James Mason, Assistant Secretary for Health, has noted, "Persons can hardly be expected to avoid the health risks imposed by personal choices about lifestyle when they do not know or understand these risks, when they lack the knowledge or skills needed to choose a healthier lifestyle or, worst of all, when they seek guidance or support from their community and it is unavailable to them" (85).

Driver Performance

An expanded program of human factors research could improve understanding of driver performance limits and capabilities, especially with respect to attention, vision, perceptual judgments, information processing, information overload, and motor control. Such research may be useful in redesigning driver licensing and education programs, and in making vehicle modifications and improving roadway design. This line of research should investigate the role of driver capabilities and should address not only the performance of well-motivated, safety-conscious drivers but also that of young and aggressive drivers.

Impaired Driving

Alcohol- and drug-impaired driving continues to be a major highway problem. Examples of promising areas of research include the following:

- Changing attitudes toward drinking and driving (86, 87).
- Evaluating further alternative methods to increase deterrence (39).
- Changing social norms and server and host policies (87, 88).
- Assessing the effects of alcohol intoxication on injury level and survivability (89).
- Evaluating alternative approaches to repeat offenders.
- Evaluating the relative effectiveness of various penalties and laws for deterring impaired driving.
- Developing and evaluating health promotion approaches (90).
- Identifying users of programs such as Techniques for Effective Alcohol Management (TEAM), responsible alcohol service, designated drivers, their characteristics, and the effects of these programs in reducing drinking and driving (DUI).
- Investigating the failure to cite underage drinkers or arrest underage drinking-drivers.
- Determining the extent of use of false identification and how technology can be used to minimize the manufacture and sale of false identification.
- Identifying treatment and rehabilitation programs for persons arrested for DUI.
- Researching new technology that would help law enforcement officers do their jobs.

Little research has been done on the use of drugs other than alcohol. Potential research topics include the incidence of driving under the influence of both illicit and prescription drugs; the effects of different types of drugs on driver behavior; the development of cost-effective, reliable screening methods to detect drug-impairment levels among drivers; and the assessment and ranking of cost-effective ways to decrease the incidence of impaired driving.

Traffic Laws and Their Enforcement

The highway system operates under a variety of laws. Expanded research and evaluation are needed to assess the relative effectiveness of traffic laws, the efficiency of various law enforcement techniques, and ways to apply advanced technology to law enforcement. Evaluations of traditional and innovative sanctions for traffic law violations are needed to determine which are most effective. Specific research questions include the following:

- What factors aid or abet traffic law enforcement? Which laws are vigorously enforced and which are overlooked? Why?
- How do community standards, customs, rules, and practices influence the enforcement of traffic safety laws?
- Given diminishing resources, how can communities support traffic law enforcement? What are some innovative approaches that communities can use to support traffic law enforcement, even with diminishing resources?

- How can private citizens contribute to traffic law enforcement? Some communities have used citizen patrols for speed watches. What are the constraints to mobilizing local citizens (as a neighborhood watch) for traffic law enforcement?

Driver Education and Training

Considerable expense and effort have been devoted to driver education and training, with little evidence of effectiveness with respect to safety. Further research and evaluation are needed to determine the most effective timing, content, and techniques for improving the driving skills of both the general driving public and of special populations (e.g., commercial vehicle operators and elderly drivers).

Pedestrians and Bicyclists

As noted earlier, approximately 7,500 pedestrians and pedalcyclists die each year in motor vehicle crashes (37, 91). Although the types of crashes have been described, effective countermeasures (such as improved crosswalk delineation and signing) must be developed, tested, and implemented, and more widespread use of bicycle helmets needs to be encouraged. Methods for improved visual detection of pedestrians and pedalcyclists must be researched, along with the development of multifaceted programs (92).

Motorcyclists

Many avenues of research hold promise for reducing the incidence and severity of motorcycle crashes. These include research on and evaluation of operator education, licensing, and training; risk taking; conspicuity; and roadway design. Methods to increase the use of motorcycle helmets should also be topics of evaluation research.

Youth

Young drivers are disproportionately involved in traffic crashes. More than 43% of all deaths among 16- to 20-year-olds result from motor vehicle crashes (93). Young drivers are also significantly overrepresented in alcohol- and other drug-related crashes, often drive at excessive speeds, and often do not wear safety belts. Research is needed on the reasons underlying unsafe driving practices by youths, on methods of changing attitudes to induce safer driving behavior, and on methods for deterring unsafe practices. Improvements to traditional licensing practices, such as graduated licensing programs, appear promising.

Elderly

By the year 2020, 22 million people will be 75 years of age or older **and** eligible for a driver's license. Of these, 7 million will be 85 or older (28). Driver performance research topics of particular relevance to the elderly include developing tests or measures of visual performance, glare sensitivity, contrast sensitivity, and cognitive performance such as attentiveness, information processing, and problem solving (94). Many of these lines of research have implications for highway signs, illumination, timing of pedestrian signals, and

roadway design. The development of optimal licensing programs for protecting elderly drivers should be based on research and effective pilot programs that screen, identify, and monitor drivers with impairments — such as loss of visual performance and increased reaction time — that affect their driving. In addition, the feasibility of identifying impaired elderly drivers through their physicians needs to be explored.

Diversity

By the year 2000, the demographics of the U.S. population will have shifted considerably. The effects of the population's diversity on traffic safety should be assessed, and appropriate countermeasures should be developed to meet the needs of different segments of the population. Topics to be addressed include the effects of age, sex, race or ethnicity, and language barriers on all aspects of traffic safety.

Data Needs

Valid data, in accessible and understandable form, will be the foundation of any effective program to control motor vehicle injury. Standardized data are essential for identifying problems, factors associated with these problems, and emerging issues, as well as for evaluating the effectiveness of interventions and making informed judgments about where to invest limited resources.

No single data source contains all the information necessary for the study and prevention of motor-vehicle injuries. Currently the Fatal Accident Reporting System (FARS) maintained by the National Highway Traffic Safety Administration (NHTSA) collects limited data on occupant, vehicle, and crash characteristics for fatal traffic crashes. FARS has proven invaluable in supplying detailed representative data on fatal traffic crashes and has been used effectively to identify traffic safety problems, develop and implement better ways to deal with these problems, and evaluate existing and proposed motor vehicle safety standards and traffic safety programs. Besides the benefits derived by NHTSA from FARS data, researchers in other government agencies and academia also use these data extensively.

Data Linkage Needs

Unfortunately, the full impact of injuries on individuals, families, and society as a whole remains difficult to quantify. Because of improvements in safety and medical technology, many people are surviving relatively severe injuries. However, there is no data system parallel to FARS for the far more frequent nonfatal traffic crashes. Statistical samples of motor vehicle crashes maintained by NHTSA are not of sufficient size to permit statistical analysis of detailed crash injury characteristics. Linking existing data bases to build statewide motor vehicle-related injury data bases would be the most cost effective solution. Linked data could provide a relatively low-cost surveillance system for the most common and costly injuries. For example, most states have computerized files of police accident reports (PARs) available. Although these files contain information on the vehicle, the crash,

and the use of safety equipment and alcohol, they contain little information on injuries and underestimate the numbers of injuries that occur. More accurate and complete information on injuries exist in statewide injury data systems such as prehospital (EMS), hospital, injury registry data, and hospital discharge data. Only by merging the information obtainable from PARs with EMS reports and hospital discharge data could a data base of sufficient size and detail be created. Linking PARs to the other injury information available at the state level would provide valuable data about —

- The relationship between vehicle design characteristics and their propensity to cause injuries in crashes,
- Outcomes such as frequency of occurrence, severity, and disability resulting from motor-vehicle related injury,
- Effects of legislation such as legislation related to alcohol-impaired driving and to safety belt use, child-restraint use, and other interventions.

Effective data linkage would facilitate the use of existing data to support the implementation and evaluation of drinking and driving laws and laws requiring safety belt use, child restraints, or motorcycle helmets. It would allow for better estimates of public costs associated with nonuse of safety devices and use of alcohol, and it would raise consciousness among policy makers and the public about the benefits of motor-vehicle injury prevention measures. Effective data linkage would improve accessibility of extant data and help identify data needs. It would help eliminate existing organizational and jurisdictional boundaries and help build upon successful models to reduce the frequency and severity of motor vehicle-related injuries. Effective data linkage in the field of motor-vehicle crash-related injury would also serve as a model for other causes of injury. The methods developed for linking records should be adapted to many types of epidemiologic studies that use administrative and hospital records.

Progress in and Impediments to Data Linkages

As noted above, motor-vehicle injury data bases can greatly increase in usefulness when they can be linked to other data systems. Over the past decades, progress has been made in linking crash files to highway files in order to identify highway problems. Linkages to driver history files and vehicle registration files have also been facilitated, so that drivers involved in crashes may be readily studied in relation to their previous driving records. As data bases are linked, the relative usefulness of each data file is enhanced.

Linking traffic records to detailed injury data in EMS records, trauma registries, and hospital records has not proceeded so rapidly. Some of the difficulty has been associated with the need for identifying information in order to make linkages. In most states, crash records and driver history files are public, but hospital records are confidential. One suggested approach to facilitate such linkages is to include police crash report numbers on hospital emergency room and admission records. However, researchers attempting to make such linkages should adhere to appropriate confidentiality guidelines with respect to the individual records.

Surveillance

Surveillance data for motor vehicle injury are better than data for other types of injury. As noted above, police, EMS, and hospitals report a variety of data on motor vehicle crashes. However, accurate data on safety belt use and work-relatedness in crashes are lacking, and many motor vehicle injuries do not result in hospitalization or an investigation and crash report by a law enforcement officer. Injuries to young children (e.g., from hitting the dashboard or windshield in a sudden stop, from falling out of the cargo area in a pick-up truck, or from falling out of a vehicle door) often go unreported in official police files (95), as do many motor vehicle injuries brought to medical attention in emergency rooms or physicians' offices. It is for this reason that injury surveillance systems that include information on the cause of injury (e.g., through use of external-cause-of-injury codes (E-codes)) are needed to determine the magnitude of the injury problem (58, 96).

Data are also needed on the long-term use of services, the effects of injuries on families, and the impact of impairments. These data will be used to assess the need for prevention and will help health officials and others set priorities for injury reduction at all levels of severity. Existing sources of data can be tapped. However, new sources of data will be needed to measure accurately these long-term effects.

Measures of Exposure

Exposure to risk is a standard measure used in public health to determine morbidity and mortality rates. For most diseases, population-based rates are routinely used. For motor vehicle injury, it has been customary to measure changes over time using mortality rates based on vehicle miles traveled (VMT). The rationale has been that the highway transportation system has been created to facilitate mobility and that mobility is of value. As noted earlier, using VMT as the denominator, the motor vehicle death rate in the United States has steadily declined since the mid-1930s.

Other widely used measures of exposure include number of motor vehicles registered, number of licensed drivers, and measures of induced exposure. Induced exposure reflects risk of being in a crash (97). One common measure of induced exposure is the "innocent" party or parties involved in two-vehicle crashes. Because induced exposure can be determined from existing crash data, and because it provides additional information such as time of day, day of week, and roadway type, it makes it possible to estimate risk in relation to more specific crash-related variables.

Some public health professionals prefer to use population figures. With respect to crash-related fatalities, the United States has one of the best records on a VMT basis, but does not fare so well on a population basis. Population-based rates for motor vehicle injury and death are higher in the United States than in many other industrialized nations. The measure of exposure used in calculating the rate greatly affects one's perceptions. For example, on the basis of number of licensed drivers, older drivers as a group do not appear to pose any special problem. However, on the basis of VMT, their risk of crash is second

only to that of teenagers (93) (Figure 2). Such discrepancies indicate the need to know the purposes to which the measures of exposure will be put.

E-Codes

E-codes have been referred to as "the missing link in injury prevention" (96). These are part of the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) that is used to code morbidity data in the United States and elsewhere. In this system, N-codes are used to describe the nature of the injury or the injury diagnosis, for example, "closed fracture of base of skull." E-codes are used to describe the external cause leading to the diagnosis of injury or poisoning. Thus, in the case of the skull fracture, the E-code would indicate whether it resulted from a fall, an assault, or a motor vehicle crash. While N-codes are important for treatment purposes, countermeasures to prevent injuries require information provided by E-codes. Hospital discharge data routinely include N-codes, primarily because this information is required for reimbursement. However, only a handful of states have mandated that E-codes also be included (98, 99).

The panel recognizes a need for E-codes in hospital discharge data and emergency room data for several purposes:

- To quantify severe injury morbidity according to cause.
- To help define the health and societal costs of vehicular injury by cause.
- To measure the magnitude of nonfatal occupational injuries by cause.
- To expand the usefulness of police accident reports and existing national data systems used to establish public health priorities.
- To identify the effectiveness of specific interventions (such as airbags or safety belts).

Driver Behavior and Characteristics Data Base

In 1987, NHTSA published its Driver Performance Data Book (100). Its intent was to provide a compendium of research data to assist researchers in setting up designs and paradigms and to aid administrators in making decisions regarding human performance research. It contains normative data on reaction time, visual performance, auditory performance, information processing, anthropometrics, and precrash behaviors. This data book should be updated with particular references to current highway safety trends and issues, such as IVHS and older and medically impaired drivers.

In addition, the data book could become a centralized source of information, for both researchers and practitioners, on safety belt use (nationally, by state, and by various demographic groups), incidence of alcohol-impaired driving, and information pertinent to motorcycle, bicycle, and pedestrian safety.

Programmatic Directions

The highway death rate per VMT reported by the DOT is now at an all-time low, as shown in Figure 1. However, much more remains to be done in applying known interventions in vehicle, roadway, and traffic safety programs more broadly.

Vehicle Safety

Crash avoidance and survival programs are complementary approaches to reducing both the incidence and severity of motor vehicle crashes. Improvements in vehicle design can yield reductions in the number of persons killed and injured in motor vehicle crashes each year. These improvements are areas of ongoing research not only in the federal government, but also in academic institutions and in the private sector. Examples of current crash avoidance research and programs include the application of safety technologies in four major areas:

- Use of antilock brakes.
- Ways to reduce the number of rollover crashes.
- IVHS — the development of electronic systems that should reduce the risk and severity of crashes.
- Human factors — driver performance and workload; vision and visibility; warning signals and warning systems; lighting and signaling; controls and displays; the aging driver; and crash causation analysis.

To reduce the effects of frontal crashes, NHTSA now requires light trucks and vans to meet the automatic crash protection standards currently required of passenger cars by Federal Motor Vehicle Safety Standard 208. These could save an estimated 2,000 lives per year if fully implemented. However, benefits due to regulatory interventions take many years to achieve because of the slow pace of fleet turnover.

To improve side impact protection, NHTSA is considering requiring that light trucks and vans meet dynamic side impact standards similar in concept to those that currently apply to passenger cars. In current studies, investigators are assessing the benefits and costs of this proposed regulatory requirement.

A variety of regulatory options are being considered to reduce both the propensity of vehicles to roll over and the severity of injuries that occur once vehicles are involved in this type of crash. Improved vehicle handling and stability can help drivers avoid a crash; in addition, several crashworthiness improvements are promising. These include —

- Door retention improvements such as stronger hinges, latches, and locks (to prevent an occupant from being ejected during a crash).
- Interior head impact protection, such as padded dashboards and safer steering wheel designs to lessen head and facial injuries.

- Improved roof crush resistance.

Roadway Safety

The following actions should be implemented by appropriate agencies with responsibility for the design, operation, and maintenance of highways to reduce the frequency of traffic crashes and their severity:

- *Improve roadway delineation through increased use of effective reflective pavement markings and signs* (Appendix A, Objective 9.20). Positive guidance through roadway delineation systems may be effective for crash avoidance, particularly in single vehicle accidents (71). Uniform and widespread application of pavement edge lines, advance warning signs for curves, and postmounted delineation facilitate the driving task, especially at night. Unfortunately, many of the devices, although easily visible during the daytime, have reduced visibility in the dark because they have lost reflectivity. Minimum performance levels for reflectivity, both at time of installation and subsequently, could alleviate this problem.
- *Provide physical separation from other vehicular traffic for nonmotor vehicle occupants.* Over 7,000 pedestrians and pedalcyclists die in traffic crashes annually. Because of the high severity of these crashes, more attention needs to be focused on crash avoidance measures. It has been argued that physical separation through the use of sidewalks, bikeways, grade separations, or even a well-marked reserved area along roadways are effective in reducing this type of crash (71).
- *Provide a "forgiving" roadside for errant vehicles on high speed roads.* Almost a third of all fatalities occur when a vehicle leaves the roadway and strikes a fixed object, rolls over, or both (71). Effective methods of reducing the incidence and severity of these types of crashes are to provide a forgiving recovery area and gentle sideslopes and to eliminate unyielding obstructions for a distance outside the edge of the roadway. Studies at the General Motors Research Laboratories indicated about 85% of run-off-road impacts occur within 30 feet of the edge of the roadway on high speed roads (101). Subsequent studies and experience on lower-speed high-volume highways (such as urban arterials) indicate a 10- to 15-foot clear distance can provide similar benefits. The practice of offsetting unyielding poles, signs, trees, and similar objects as far as possible within rights-of-way on all roads is beneficial.

Where obstacles cannot be eliminated practically, they should either be made to break away or be shielded with traffic barriers or crash cushions. Such devices should be performance tested for their ability to yield to or redirect a striking vehicle while minimizing the potential for injury to the occupant and bystander. However, attention should also be given to the compatibility of different safety systems.

- *Establish a management plan in every major metropolitan community to minimize losses due to disruptive traffic crashes.* This plan should address EMS. Losses due to injuries and congestion have been reduced through systematic planning for major incidents, often involving traffic crashes in heavily travelled urban corridors.

An effective incident management plan can reduce the risk of turning a relatively minor incident into a catastrophic occurrence; responsive EMS can minimize trauma losses.

- *Evaluate the safety of highway work zones* (including those on the interstate highway system), using surveillance of fatal and nonfatal injuries in such zones.

Traffic Safety Programs

The following actions should be implemented by appropriate agencies with responsibility for traffic safety efforts designed to reduce injuries and fatalities. For each intervention, researchers and policymakers should develop a better understanding of the factors that facilitate or impede safe driving behaviors among various population subgroups, and they should use these data to target prevention efforts.

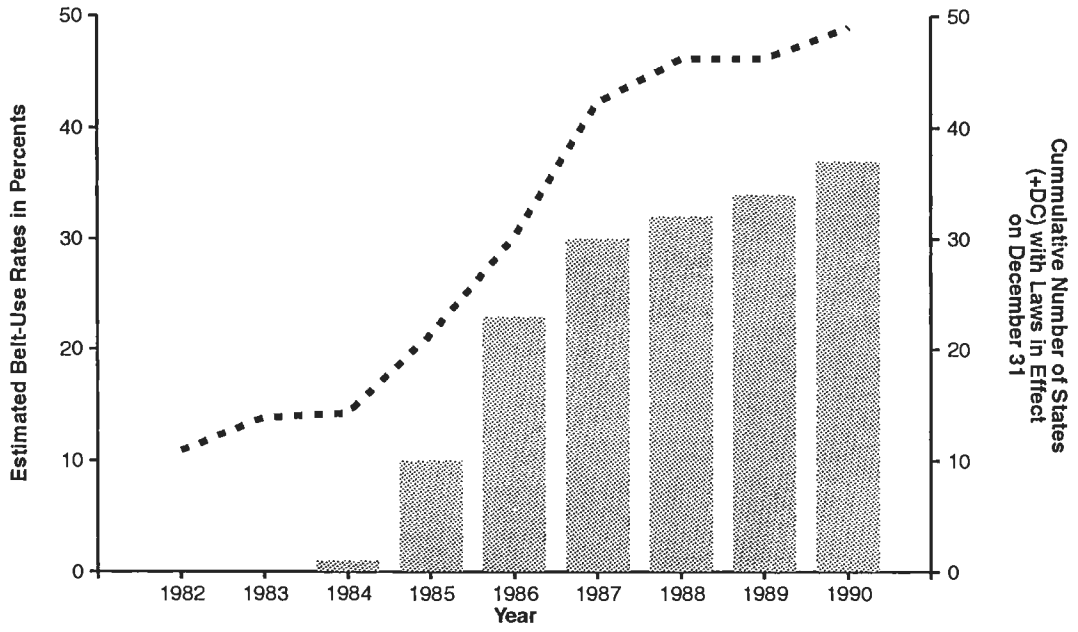
- *Provide a comprehensive program to combat impaired driving.* To be effective in reducing drunk and drugged driving, programs should incorporate prevention approaches (including programs for public information and education, schools, employers, alcohol servers, and transportation alternatives); deterrence approaches (including laws, public information and education, enforcement, prosecution, and adjudication); treatment and rehabilitation approaches; and coordinated program management with appropriate agencies. As part of this comprehensive program, alcohol and drug treatment programs should be accessible to impaired drivers, and the DUI event should be viewed as an opportunity to identify persons needing treatment, to initiate treatment and rehabilitation, and to prevent future impaired driving episodes.

Evaluations of community-based interventions such as "designated driver" programs need to be launched. Campaigns against underage and binge drinking on college campuses should also use motor vehicle-related injury as one of the outcome measures for evaluation.

- *Enhance comprehensive occupant protection programs that educate and motivate citizens to use available motor vehicle occupant protection systems, including safety belts, child safety seats, and automatic crash protection (such as airbags)* (Figure 4 and Appendix A, Objectives 9.12 and 9.13). A combination of use requirements, enforcement, public information, education, and incentives are necessary to achieve significant, lasting increases in safety belt and child safety seat usage.
- *Establish a comprehensive program to promote motorcycle safety.* To be effective in reducing the number of motorcycle crash deaths and injuries, programs and laws must address issues of the use of helmets and other protective gear (Appendix A, Objective 9.14), proper licensing, impaired riding, motorcycle conspicuity, and motorist awareness.

Figure 4

Number of States with Safety Belt-Use Laws and Estimated Safety Belt Use Rates, United States, 1982-1990



Sources: Rates: 19-City Survey, National Highway Traffic Safety Administration

Laws: Traffic Safety Programs, National Highway Traffic Safety Administration

- Emphasize dangers of excessive speed as part of a comprehensive traffic safety program. A national campaign must be conducted to educate the public about the dangers of excessive speeding and aggressive driving behavior. This campaign should be on the same scale as those aimed at curbing impaired driving and increasing the use of occupant protection devices. The campaign should include efforts to encourage legislation to ban the use of radar detectors in all vehicles.
- *Establish and implement a complete traffic records program.* A complete traffic records program is necessary for planning (problem identification), operational management or control, and the evaluation of state highway safety activities. The traffic records program should have a data base consisting of crash, driver, vehicle, roadway, citation or conviction, EMS, health care, and insurance files, and the program should provide for file linkage. (Data linkage issues are discussed in greater detail on pages 104-106.)
- *Develop comprehensive community-based traffic safety programs, including pedestrian and bicycle safety programs that target defined problems and high-risk populations, including highway workers.* Effective pedestrian and bicycle safety programs are implemented at the local level, and include education, enforcement, and engineering components (91, 102).
- *Provide for an efficient and effective police traffic services program to enforce traffic laws, prevent crashes, assist the injured, document specific details of individual crashes, supervise crash clean-up, and restore safe and orderly movement of traffic.* Traffic law enforcement plays an important role in deterring drunk and drugged driving, achieving safety belt use, encouraging compliance with speed laws, and reducing other unsafe driving actions. Experience has shown that a combination of highly visible enforcement, public information, education, and training is necessary to achieve a significant and lasting impact in reducing crashes, injuries, and fatalities.
- *Ensure that persons incurring traffic injuries receive prompt and appropriate emergency medical care.* An effective urban and rural system of emergency medical and trauma care includes comprehensive enabling legislation, regulations, and operational policies and procedures; a lead agency with resource management responsibility; recruitment of trained personnel; reliable, safe, ambulance transportation; appropriate medical facilities for seriously injured patients; an effective communications systems including universal system access numbers such as 911; trauma systems; public information and education; medical direction; and evaluation. (The Position Paper on Acute Care Trauma Systems also addresses this topic.)
- *Establish a comprehensive program to promote traffic safety in highway work zones.* To be effective in reducing the number of motor vehicle deaths occurring among highway workers in highway work zones, programs must address the issues of training all traffic control personnel (flaggers), improving the conspicuity of highway workers, evaluating state highway safety activities as they pertain to highway work zones, and improving the collection of injury data on highway workers in local, state, and national data bases.

How We Get There

A Strategy for Success

The Year 2000 Health Objectives for the Nation call for a decrease in the annual motor vehicle-related injury death rate from a 1987 figure of 2.4 per 100 million vehicle-miles traveled (VMT) to no more than 1.9 (Appendix A, Objective 9.3). Even if this objective is met, however, the number of lives that will be lost as a result of these injuries is still not likely to fall below 40,000 per year. Constant or slightly decreasing death rates are an improvement over previous trends, but the toll in lives and disabilities is still too high.

How can these levels of morbidity and mortality be reduced significantly? In this paper, four elements of a comprehensive strategy have been discussed. Although no single element can adequately reduce the impact of motor vehicle injuries, together these four elements constitute a strategy. The four elements are as follows:

- **Leadership, collaboration, and coordination** — in the traffic safety, injury control and public health fields, among different levels of government, and between private and public organizations.
- **Public recognition and support** — of motor vehicle injury as an unacceptable, preventable cause of morbidity and mortality, of the need for increased research funding and programs, and of tough, effective laws enforcing proven interventions.
- **Implementation of proven interventions** — such as comprehensive occupant protection and other traffic safety programs, including laws, enforcement, education, and engineering interventions; and vehicle safety devices such as airbags and antilock brakes.
- **Expansion of the scientific base** — to develop and test other effective interventions.

In this section, each of these elements is briefly summarized. In the next section, we discuss specific recommendations for elected officials, state and local governments, the U.S. Department of Transportation (DOT), the U.S. Department of Health and Human Services (DHHS), corporate America, private and public employers, the health care community, academia, and citizen advocacy groups.

Leadership, Collaboration, and Coordination

Many strategies have been at least partially successful in the prevention of motor vehicle injuries. Passage of safety-related laws, changes in societal norms, enforcement of the laws, road design, automobile design, and trauma systems all play significant and complementary roles in preventing motor vehicle injuries and deaths. While the spectrum of solutions is encouraging, it demands a multifaceted and coordinated approach in order to use resources as effectively as possible.

The list of organizations and agencies either directly or indirectly dedicated to the prevention of motor vehicle injuries is extensive. For example, consumer groups are concerned about auto safety and the high cost of car insurance; insurance companies are concerned about escalating medical costs; advocacy groups against impaired driving and head injury associations are concerned about those involved in motor vehicle crashes; government agencies, such as health, highway safety, and law enforcement, are all interested in protecting the public; auto manufacturers are concerned with the production of safe products at reasonable prices; hospitals are concerned with providing care but minimizing the financial impact of uncompensated care; labor organizations — especially those with highway maintenance and construction workers — are concerned with preventing work-related injuries; and medical care professionals are interested not only in caring for injured persons but also in preventing injuries. (An overview of federal agencies involved in motor vehicle research or regulation is provided in Table 5.)

Each group or agency has unique reasons for being concerned about motor vehicle injuries and has unique resources to offer. In combination, these organizations possess financial resources, scientific expertise, community organization skills, political influence, regulatory and enforcement authority, and data systems for program planning and evaluation. No single group or agency can tackle motor vehicle injury prevention alone. To continue the progress that has already been made in this field, there must be more coordination and collaboration among all interested parties.

Some interventions are clearly the responsibility of a particular organization or level of government. For example, developing minimum safety requirements for the design of automobiles is a federal responsibility, while enacting safety belt laws is a state responsibility. Enforcement of safety belt laws is carried out by state and local law enforcement agencies. At the local level, communities should address local traffic safety problems through the implementation of community traffic safety programs that combine education, engineering, and enforcement interventions.

The fact that organizations' interests, jurisdictions, and resources differ should not lead to conflict and competition for funds within the overall effort. Coalitions can be an effective way to influence legislators and the public, establish common goals, focus attention on underfunded areas, and help deliver effective interventions where they are needed most.

Motor vehicle injuries may be one of the few societal problems for which an array of known solutions, concerned organizations, and resources is available. When communities initiate broad, multifaceted interventions that bring together the forces of technology, the media, law enforcement, and product design, success can be achieved. Highway safety is the responsibility of a broad spectrum of government agencies and private industries (Table 6). A significant part of the answer to the prevention of motor vehicle injuries lies in coordinating these organizations and agencies and applying what is already available and known to work, while supporting and encouraging research in promising new areas.

Table 5

Federal Agencies Involved in Motor Vehicle Injury Research or Regulation

Department of Transportation (DOT) National Highway Traffic Safety Administration (NHTSA) Federal Highway Administration (FHWA)
Department of Health and Human Services (DHHS) Public Health Service (PHS) Centers for Disease Control (CDC) National Center for Environmental Health and Injury Control (NCEHIC) Division of Injury Control (DIC) National Institute for Occupational Safety and Health (NIOSH) Division of Safety Research (DSR) National Center for Health Statistics (NCHS) Health Resources and Services Administration (HRSA) National Institutes of Health (NIH) National Institute on Aging (NIA) National Institute of Child Health and Human Development (NICHD) National Institute of Neurological Disorders and Stroke (NINDS) Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA) National Institute on Drug Abuse (NIDA) National Institute on Alcohol Abuse and Alcoholism (NIAAA) Indian Health Service (IHS)
Department of Commerce (DOC) *(Regulates imported cars)*
Department of Defense (DOD)
Department of Education (ED) National Institute on Disability and Rehabilitation Research (NIDRR)
Department of Labor (DOL) Occupational Safety and Health Administration (OSHA) Bureau of Labor Statistics (BLS)
Consumer Product Safety Commission (CPSC) *(Bicycles, bicycle helmets, all-terrain vehicles)*
Interstate Commerce Commission (ICC) *(Interstate trucking)*
National Transportation Safety Board (NTSB)

Table 6

Major Sponsors of Highway Safety Research

Organization	Primary Areas of Emphasis			
	Human	Vehicle	Highway	Other
Federal Government				
National Highway Traffic Safety Administration	X	X		X[a]
Federal Highway Administration	X	X	X	X[b]
Centers for Disease Control	X	X		X[c]
States			X[d]	
Private Industry				
Automobile manufacturers		Xe		
Automobile suppliers		X		
Insurance industry	X	X		X[f]
Highway industry			X	

[a] **Crash data collection, maintenance, and analysis.**

[b] **Special regulatory analysis and motor carrier information systems.**

[c] **Research on trauma and injury mechanisms.**

[d] **The majority of state sponsored safety research is highway-related but a modest amount of human- and vehicle-related safety research is also conducted.**

[e] **The majority of the research sponsored by the automobile manufacturers is vehicle-related. However, evaluations of crashes are also undertaken and some research is conducted on driver-related issues, such as alcohol-impaired driving.**

[f] **Crash analysis.**

Source: Adapted from (103) which presents a detailed discussion of the complementing organizational responsibilities of government agencies in motor-vehicle injury prevention research.

Regulations in the areas of occupant protection, motor vehicle design standards, and motor vehicle maintenance standards can have a significant impact on the incidence of injury. They should be developed on the basis of the best scientific information available and tested in a scientific manner whenever possible. This will be accomplished only if there is communication between researchers and regulators.

DOT-Sponsored Highway Safety Research

Recently, the Federal Highway Administration (FWHA) and the National Highway Traffic Safety Administration (NHTSA) jointly funded a Strategic Transportation Research Study for Highway Safety to assess the adequacy of current research programs to take the lead in improving the Nation's safety record (103). A special committee of the Transportation Research Board, which carried out the study, reviewed the scope, direction, and funding of highway safety research programs. The panel heartily supports the committee's recommendations with respect to ways that the process of conducting research could be improved to encourage innovation and quality of scholarship. These recommendations include the following:

- The rebuilding and sustaining of programs of long-term research in the mission agencies.
- Additional annual federal funding of $30 to $40 million (in 1990 dollars), growing annually at 5% to 7% in real terms over the next 5 to 10 years, to support long-term research programs and build the necessary research infrastructure (this recommended funding level would be higher but for the lack of available qualified scientists to conduct the research).
- Use of the recommended additional resources to support a program that emphasizes peer-reviewed, investigator-initiated research; multiyear funding of research programs; more flexible funding arrangements; and the education and training of new researchers.
- Enhanced funding of biomechanics research by DOT to provide the knowledge base for further advances in injury reduction.
- Support for three to five university centers specializing in human factors and other highway safety research disciplines to advance the knowledge of effective crash avoidance strategies.
- A new cooperative program for state-sponsored highway safety research to stimulate more joint state research on driver- and vehicle-related issues.

DHHS-Sponsored Injury Control Research

To address motor vehicle and other types of injuries as a public health problem, the panel recommends full implementation of the organizational structure recommendations in *Injury in America* (104). These include establishing of a National Center for Injury Control (NCIC) within the federal government. The Centers for Disease Control (CDC) is recommended as an appropriate location for such a center.

A solid scientific base formed by research would allow DHHS to develop injury control interventions; to work with epidemiologists and other public health professionals in evaluating those interventions; to serve as an interdisciplinary model and national resource in injury control for academic institutions, state and local health departments, and others; to provide standards or serve as a reference laboratory; to increase the visibility of injury control as a science; and to develop internal expertise in the area of injury to help facilitate extramural research activities and coordinate national efforts in injury control. Center activities should include research in epidemiology, biomechanics, behavior, and the clinical and rehabilitative sciences. The continuing contribution of researchers in traffic safety, which cuts across several of these disciplines, should be ensured.

The NCIC would have the following functions:

- To coordinate prevention research within and outside the federal government.
- To fund research outside the federal government.
- To fund training for researchers in various aspects of injury control.
- To develop intramural research.

To support the functions of the NCIC, the panel recommends the following:

- Allocation of sufficient resources to serve these functions.
- Allocation of positions and funding for research by DHHS for motor vehicle injury research and prevention (in collaboration with DOT), commensurate with its size and importance as a public health problem.
- Establishment of an injury control laboratory, but only after sufficient expansion of the CDC injury control program (see Recommendations to Implementers: Department of Health and Human Services, page 126.)

The proposed center should collaborate with federal agencies involved in research in motor vehicle-related injuries, as well as agencies that have regulatory functions over motor vehicle travel. (These agencies are listed in Table 5, page 115.) The NCIC should also collaborate with the Division of Safety Research at the National Institute for Occupational Safety and Health (NIOSH) to ensure coverage of issues related to work-related motor vehicle injuries.

Public Recognition and Support

Recognition of motor vehicle injuries as a public health problem can lead to increased support for research funding, for acceptance of laws and enforcement, and for existing programs and technology. In addition, consumer demands for motor vehicle safety features can continue to expedite safety innovations in vehicle design.

Efforts by advocacy organizations, law enforcement, public health, and safety officials — primarily at the state level — have produced new-found public support for public education and for enforcement of state laws requiring responsible behavior by motor vehicle

operators. Impaired driving laws and laws requiring safety belt, motorcycle helmet, and child safety seat use are examples of state legislative actions that have saved lives. When these laws are combined with sustained education and enforcement efforts, roads can be made even safer.

The lesson of these efforts is clear: strong public policy, law enforcement, and widespread, yet focused, public education are required to change public attitudes and behavior. In contrast with earlier highway safety campaigns that emphasized media campaigns alone, successes during the last decade have been based on comprehensive, multifaceted programs. Building on this foundation, education can reach more of the public and have a more lasting impact.

Implementation of Proven Interventions

The effectiveness of various vehicle and highway safety features is well documented and was discussed earlier. Programs designed to educate the public and enforce traffic safety laws can reduce the rate of motor vehicle injuries. Finally, passage and enforcement of strict impaired-driving laws can deter impaired driving and its consequences. Each of these types of interventions offers unrealized potential to save more lives, if the interventions were systematically implemented.

Expansion of the Scientific Base

Although proven interventions must be more fully implemented, new research offers the potential for further interventions, as well as technical support for specific interventions and public policies. Research in the areas of biomechanics, Intelligent Vehicle Highway Systems (IVHS), crash avoidance technologies, occupant protection technologies, driver performance, trauma care, behavior, appropriate treatment, and highway design must be funded and sustained to understand the causes of motor vehicle injuries and to design interventions that prevent them.

Recommendations to Implementers

In this section, recommendations to "implementers" are discussed, with special attention to the previous four elements: leadership, collaboration, and coordination; public recognition and support; implementation of proven interventions; and expansion of the scientific base.

Elected Officials

Motor vehicle injuries, unlike many other public health problems, offer many opportunities for near-term cost-effective interventions. By supporting comprehensive programs, legislative initiatives, and funding of basic scientific research, members of Congress and other elected officials have a rare opportunity to support programs that represent some of

the most cost-effective ways to save lives as well as future dollars. This is clearly demonstrated in the President's budget discussion on managing risk sensibly (9).

Implementation of Proven Interventions

Motor vehicle safety is a national issue and deserves national attention. Elected officials should champion motor vehicle safety because of the compelling evidence that proven interventions save lives and money and because the overwhelming cost-effectiveness of these interventions is well documented.

The combined federal commitment to motor vehicle safety research is $41 **million** a year, but the federal government spends between $12 and $15 **billion** annually in direct subsidies to people injured in motor vehicle crashes. Legislators should recognize and emphasize that far greater amounts can be saved by implementing proven, effective interventions.

Many effective interventions, such as enforcement of laws and ordinances, education, and trauma systems, can be shown to prevent injuries — especially costly head and spinal cord injuries — and to save thousands of lives (105). These types of interventions — and results — are within the legislative realm, and should be promoted by elected officials.

Expansion of the Scientific Base

Beyond drawing national attention to these issues and advocating the implementation of proven interventions, Congressional leaders and other elected officials can ensure continued success by maintaining and expanding the field's scientific base. This means that funding levels for existing intervention research and surveillance programs within DOT and DHHS should be expanded. Congressional leaders should also encourage leaders in the private sector to initiate, sustain, and expand their safety research programs.

State and Local Government

Although some measures to reduce motor vehicle injury must occur at the federal level (e.g., motor vehicle safety standards), state and local traffic safety efforts play a critical role in preventing motor vehicle injuries. State and local governments can play a significant role in promoting traffic safety by providing leadership, collaborating and coordinating with other agencies and levels of government, building public recognition and support, supporting data and research systems, and identifying local needs.

Leadership, Collaboration, and Coordination

To achieve maximum effectiveness, a state program should be closely coordinated with all appropriate state and local agencies. Ideally, a state should create a statewide mechanism for designing an overall injury control plan, with input from the local governments so as to assure the acceptability and feasibility of the proposed programs. Because injury control requires the commitment of so many different state agencies, it is difficult for any one agency

to plan and implement a comprehensive program. A mechanism that has proven successful in several states is a Governor's Task Force on Injury Control, either exclusively or partially dedicated to motor vehicle injury. Such a mechanism draws together interagency resources, skills, and knowledge and provides endorsement of the program from the highest level.

A successful Governor's Task Force must have knowledgeable technical support to ensure that programs are based on the results of sound scientific research or effective programs. However, the membership of the task force itself should include persons with influence in the political and private sector communities, such as representatives of law enforcement agencies, intergovernmental and health care provider associations, insurance companies, consumer groups, labor organizations, voluntary organizations, state and local elected officials, educational institutions, and local health departments. Injury control professionals seldom wield such influence, but they can provide those who do with the data necessary to persuade decision makers to support injury control programs.

A primary focus and one of the first missions of a Governor's Task Force should be to compile statewide data on the extent and type of motor vehicle injury experienced in that state. In addition, the estimated costs of the injury should be calculated, including both total societal costs and direct costs to the state — that is, the amount paid for by public funds. Such information should enable the task force to make informed judgments and recommendations about where to expend resources and estimate the kinds of savings that may be anticipated from implementing countermeasures.

Some effort should be devoted to cataloging current state programs in injury control. It is likely that such programs are fragmented and not coordinated with other programs sharing similar interests. The task force can be instrumental in identifying gaps in coverage and facilitating better coordination and collaboration among programs. The task force can also bring strong leadership to the implementation of programs that have proven to be effective in reducing motor vehicle injury, such as effective laws and enforcement strategies. Collaboration with the State Highway Safety Agency (SHSA), which includes the Governor's Highway Safety Program, is essential from the outset. The SHSA provides leadership, state-of-the-art technical information and assistance, data, grants to local communities, and coordination with other public safety agencies, such as law enforcement and emergency medical services (EMS).

Another agency that must be heavily involved in any statewide motor vehicle injury control program is the state health department. One important goal of any state program should be to institutionalize injury control within existing programs. Although a few state health departments have developed injury control programs, this has been largely accomplished with federal funds and institutionalization will require some state core funding for such programs. In the area of motor vehicle injuries, much can be accomplished if the SHSA and state health department join forces and increase their collaborative efforts.

Although federal monies may appropriately be used to initiate programs, ultimately state and local programs should be self sufficient. Because responsibility for the reduction of motor vehicle injury requires the involvement of so many different interests and entities, it becomes difficult to calculate how costs and benefits affect each agency's budget. It may be that if more funding were provided to highway engineering, enforcement, and education, health care costs would be reduced. However, because the specific budgets are quite independent, it is difficult to arrive at a decision based on the more global view. It is unlikely that one state agency will agree to spend more of its budget on a particular program to enable another state agency to save money. It is this kind of problem that requires high-level leadership to solve.

Public Recognition and Support

State-level task forces have played an important role in focusing attention on motor vehicle injury. Over the past 10 years, many state task forces have been established in the area of impaired driving or occupant protection. These task forces have been instrumental in initiating legislative and program action. For example, in 1989, the North Carolina Governor's Highway Safety Program initiated a statewide task force, appointed by Governor James Martin, to collect and review injury morbidity and mortality data, develop a plan for increasing public awareness on injury, and convene the first statewide symposium on injury. During this same period, the Wisconsin Highway Safety Office and Wisconsin Department of Health initiated a statewide task force, appointed by Lieutenant Governor Scott McCallum, to address childhood injury. Both task forces were successful in drawing both public and political attention to injury prevention and control and have established ongoing collaborative statewide programs.

Implementation of Proven Interventions

Within each state, the support of the Governor and the legislature is also critical to the establishment of a statewide motor vehicle injury prevention and control program that is adequately funded. Their political clout and effort will be needed to enact significant life-saving legislation and establish self-sufficient programs (106). Local government also plays a critical role in enacting local ordinances where state laws do not exist and in supporting law enforcement, EMS, and the establishment of community traffic safety programs. For example, in Lexington-Fayette County, Kentucky, driver restraint use increased from 36% before adoption and implementation of a local safety belt ordinance to 76% after enforcement began (107). Recently, the first bicycle helmet ordinance in the United States was enacted in Howard County, Maryland.

Expansion of the Scientific Base

Much of the information needed to quantify the scope of the motor vehicle injury problem and to evaluate programs is not readily available. Data concerning motor vehicle injury are far more complete than they are for other major injury types, but even here there is room for improvement. Leadership at the state level could facilitate the coordination of data

systems — for example, routine linkage of motor vehicle crash data with medical examiner files and hospital discharge data.

Leadership at the state level could also encourage the increased use of technology for purposes of data collection and linkage. For example, the use of bar coding for driver licenses and vehicle registration could facilitate the recording of this information and reduce the time required for data collection. Laptop computers could be used in the field for crash data entry, thus bypassing the time-consuming and expensive process of editing and coding crash reports as currently practiced in most states.

State-level task forces will become increasingly aware of important questions that remain unanswered. Especially in times of limited resources, reliable research, evaluation, and other data are essential for decisions regarding the allocation of resources. The task force can play a significant role in steering research resources into those areas that will most benefit the statewide programs.

Department of Transportation

By statute, the U.S. Department of Transportation (DOT) is the federal agency charged with responsibility for motor vehicle and highway safety. Under the National Motor Vehicle and Traffic Safety Act of 1966, DOT is responsible for establishing necessary motor vehicle safety standards, conducting motor vehicle safety research, and requiring manufacturers to recall defective vehicles.

Under the Highway Safety Act of 1966, DOT is required to collaborate with state and local governments to develop and implement comprehensive highway and traffic safety programs. Under the various motor carrier safety statutes enacted during the 1980s, DOT is responsible for removing unsafe drivers and vehicles from the road and establishing operating requirements for all commercial operators of motor vehicles involved in interstate commerce. DOT, which includes NHTSA and FHWA, has produced a number of policy statements that establish safety as one of the Department's highest priorities. DOT's efforts include funding programs, data systems, research and demonstrations, state-of-the-art technology transfer, state legislative advocacy, new motor vehicle safety regulations, vehicles-in-use regulations, training, and evaluation.

The Department has adequate statutory authority to continue to make important contributions to the reduction of motor vehicle crash-related morbidity and mortality. DOT has been and will continue to be an important agent for change in each of the following areas:

Leadership, Collaboration, and Coordination

DOT is uniquely positioned to work with virtually every sector of our society to promote the effective prevention and control of transportation injuries. DOT is a source of objective

data in the field and can provide evaluations of the widest variety of transportation safety interventions.

While DOT has worked closely with state and local governments and has recognized the importance of working with citizen activists in the field of safety, it also can seek more effective collaboration with the private sector, the scientific community, and the field of public health. Transportation safety has been viewed as a mobility constraint and not a societal health problem of enormous magnitude. To remedy this, DOT should consider collaborative research with the transportation industry, where appropriate, particularly with motor vehicle manufacturers and with agencies within DHHS. However, as noted in the section on corporate America, there are legal constraints that currently proscribe such collaborative research. DOT should also continue to make its databases widely available to the scientific community to encourage its involvement in transportation safety issues.

With respect to coordination, DOT should serve as a national source of objective data as well as a national clearinghouse for research in the field. Currently, there is no available means to inventory adequately the body of work in the field of transportation safety.

NHTSA has successfully participated in an ongoing Interagency Agreement with CDC since March 1986. Through this agreement, these agencies have been able to combine forces in supporting cross-cutting programs such as biomechanics, trauma research, data collection, and acute care. Continuing and fostering such agreements between DOT and DHHS agencies should be encouraged in the interest of developing procedures to jointly fund competitive grants for biomechanics research centers, to enhance and develop trauma registry database linkages with crash databases, and to work with the public health community in addressing issues of behavior modification.

Public Recognition and Support

If we are to reduce the incidence and severity of motor vehicle crashes, we must have the public's support. The Department's role in this area is best fulfilled by making information available to the entire safety community. DOT must also continue to focus attention on both the size of the injury problem and the long history of successful intervention. The message that DOT must promote is that there are effective solutions to the motor vehicle safety problem.

Implementation of Proven Interventions

In the areas of motor vehicle crash avoidance and crashworthiness, DOT's authority to issue Federal Motor Vehicle Safety Standards assures that vehicle safety performance can be required in the new car fleet as soon as countermeasures are determined to be feasible and meet the need for motor vehicle safety.

In the traffic safety areas, DOT has the authority to implement state and community grant programs that address the issues of impaired driving, occupant protection, EMS, police traffic services, motorcycle safety, and traffic records, among others. Through its Section 402 State and Community Highway Safety Grant Program, DOT helps to assure that financial support can be provided to begin implementing countermeasures at the state and local levels, once they have been determined to be effective. In addition, these grants support the development of effective local traffic safety programs that can be targeted to community needs.

NHTSA has published a priority plan for the implementation of proven interventions (108). This plan is a schedule of actions that address motor vehicle safety, impaired drivers, occupant protection, technology innovation, and other safety initiatives.

Similarly, FHWA has recently published a list of 11 complementary priority short-term countermeasures that are considered to offer a high payoff within the next 2 years. FHWA will emphasize national implementation of these countermeasures (109).

Expansion of the Scientific Base

DOT should consider establishing two parallel research programs: extramural and intramural. DOT's current mode for conducting research is a hybrid of both, with outside contractors responding to DOT's internally defined needs and approaches via Requests for Proposals (RFPs). This approach should be continued and expanded. With additional funds, an extramural grant program could be established. Such a program would nurture long-term academic interest, scientific credibility, and activity in the area as well as provide DOT with an additional source of creative inputs. DOT should also enhance its internal capabilities by hiring scientists to conduct selected studies and not only monitor them. Finally, innovative collaborations with other agencies or the private sector should be pursued as a means of expanding support for the safety research community.

In addition, NHTSA has developed a detailed research and development program plan for 1992-1996 that addresses the following topics:

- Crashworthiness research.
- Crash avoidance research.
- Highway safety research.
- Crash data collection and analysis.
- Technology transfer.
- Program delivery.
- Resource needs (110).

FHWA's 1992-96 research and technology program emphasizes the following highway safety areas:

- Highway safety information management.
- Human factors research for highway safety.
- Pedestrian and bicycle safety.
- Highway safety design practices and criteria.
- New traffic control methods and devices.
- Motor carrier safety research (109).

Attention should be given to these plans as a framework for priority research in these areas.

Department of Health and Human Services

Although Congressional mandate has given NHTSA primary responsibility for reducing the burden of traffic injury, leadership is needed at the highest levels of the Department of Health and Human Services (DHHS) to focus national attention on the extent of this injury problem. Throughout DHHS and the federal government, several agencies are charged with various aspects of injury control programs. In 1984, the Committee on Trauma Research recommended that the federal government create an organizational setting and structure to coordinate the study of injury and that this unit be placed within DHHS, initially at CDC (104). Such a single coordinated focus of activity would give visibility to injury as an "important public health issue and permit an organized program of effective action to address the problems." In addition, the Committee emphasized that "vast sums could be saved by a relatively small investment in this field." Accordingly, our panel finds historical precedent in the spirit of its recommendations to DHHS. These include the full implementations of the organizational structure recommendations in *Injury in America,* including the establishment of a Center for Injury Control as previously described. Other panel recommendations to DHHS are as follows:

Leadership, Collaboration, and Coordination

To address motor vehicle injury more comprehensively, collaboration and coordination of program research and prevention activities must be conducted within DHHS. Over the past 10 years, motor vehicle injury research and prevention activities have been conducted through the Indian Health Service, Bureau of Maternal and Child Health, National Institutes of Health, the Alcohol, Drug Abuse, and Mental Health Administration, CDC's National Institute for Occupational Safety and Health, National Center for Health Promotion and Education, National Center for Environmental Health and Injury Control, and several other organizations. The coordination of programs, strategic goals, research, and data systems within DHHS is instrumental in effective collaboration with other federal agencies and state health departments.

In accord with the recommendations of the Committee on Trauma Research in *Injury in America,* the panel recommends that DHHS coordinate the Nation's injury prevention efforts in a spirit of collaboration with DOT, the Consumer Product Safety Commission, the Department of Defense, the Department of Labor, and other federal agencies. Because of DOT's regulatory responsibilities and transportation-related focus, DHHS has been perceived as a better locus for these coordinating efforts. However, active participation of DOT and other federal agencies will help in setting the agenda and overseeing DHHS' injury control activities.

The panel recommends that state health departments be actively encouraged to collaborate in injury research and prevention projects with State Highway Safety Agencies (SHSA). As noted earlier, such an agency provides leadership in the state for highway safety programs. In addition to program action, there are a number of data sources that collect various aspects of the motor vehicle injury problem. Although there is no comprehensive national surveillance system for nonfatal crash-associated injury and disability, "police accident reports," trauma registries, and EMS "run sheets" all provide a collective view of the problem. Linkage of these systems with hospital records would —

- Provide valuable data on the impact of nonuse of safety belts and child safety seats, pedestrian and bicyclist injuries, and impaired driving.
- Provide data to decision makers regarding resource allocation or legislative action.
- Increase interest in using data that are already available for analyzing injury issues.

The panel believes that the motor vehicle aspects of the injury control program, as well as the other aspects, would benefit from a specific responsibility for injury control in the Office of the Assistant Secretary for Health. This office would help ensure an orderly growth and development of the program and would act as a leader in coordinating the various satellite activities within DHHS. This responsibility is also critical because coordination with DOT and other cabinet-level departments will be vital for a cohesive national program. Since injury is underfunded in comparison to other health and societal problems, a responsible contact within the DHHS leadership will help develop an appropriate allocation of a funded and broad-based focus for injury control.

The principal current DHHS injury control program at CDC must balance its support of motor vehicle research in the broader field of injury control (111). This will help attract talent to address all aspects of injury control while rebuilding the cadre of professionals active in the field. To assure proper balance in the CDC program, the panel recommends that the DHHS Advisory Committee on Injury Control maintain adequate representation from the transportation safety research and program field and that grant review panels dealing with transportation-related proposals have adequate representation of traffic injury control researchers and program managers. This should include traffic injury control researchers as reviewers on biomechanics and traffic injury prevention grant reviews and CDC's reliance on professionals active in traffic safety as the field grows. This approach should lead to the orderly development of a research base in motor vehicle safety.

Expansion of the Scientific Base

The federal government needs a laboratory to conduct research on the basic sciences of injury control, including traffic-related issues. This will provide not only a visible focus for broad-based studies and national attention, but also the opportunity to involve leading scientists and professionals outside the DOT and DHHS as partners in the injury control program. In addition, an injury control laboratory can help ensure the real-world effectiveness of various countermeasures. The proposed laboratory is envisioned as an essential component of a future National Center for Injury Control, and would complement DOT research as well as that of the university-based "centers of excellence" and industrial research regarding motor vehicle injury prevention. The laboratory should have close connections to CDC and NHTSA and to universities involved in engineering, human sciences, and medicine, thus enabling the field of injury control to attract professionals in biomechanics, acute care, and rehabilitation.

Although a laboratory is an important way in which federal programs can effectively develop capabilities, such a laboratory should be funded by new monies and not drain funds from CDC's extramural research program or from NHTSA's research budget. These needs speak to a requirement for growth in the overall budget of federal injury control programs. By playing a key role in developing an applied injury research laboratory, CDC's mission will be broadened. This laboratory should also collaborate with NIOSH's Division of Safety Research to facilitate research in work-related motor vehicle injury issues.

DOT does not solicit investigator-initiated studies, but rather conducts studies on areas it establishes. This has led to a fragmented development of academic expertise and little or no development of training and education for traffic safety researchers. Consequently, the panel recommends that DHHS resources be allocated for training programs for researchers and practitioners in all aspects of the motor vehicle injury field, both inside and outside government agencies. Attention should be given to the judicious allocation of funds for creating and managing sorely needed research training programs in epidemiologic, behavioral, biomechanical, clinical, and rehabilitative medical sciences related to motor vehicle injury. Adequate attention must be provided to state and local practitioners in the field who assume program responsibilities for injury control program activities.

The panel recommends that the National Committee on Vital Health Statistics consider making the following recommendation to the Secretary of DHHS: Whenever an injury is the principal diagnosis or directly related to the principal diagnosis for a hospitalized patient, an external cause of injury should be recorded in the medical record. When an external cause is recorded, applicable E-codes should be reported in the hospital discharge data set.

The panel also recommends that E-codes be required for all hospitalized patients, in all DHHS programs that deliver care, regardless of the payment source. The panel also recommends that the revised Uniform Bill (UB-82) for hospitals accommodate the collection of E-codes. The panel also strongly encourages all other jurisdictions and programs

collecting Uniform Hospital Discharge Data Set (UHDDS) data to include E-coding as a requirement for injury hospitalizations. The panel is concerned that, without strong financial incentives or sanctions, the mandate to report E-codes may not succeed nationally.

Corporate America

As part of the Nation's program to reduce motor vehicle crash injuries, the corporations of America can play a role. Some businesses, including motor vehicle manufacturers and automobile insurers, have unique opportunities to contribute to reducing injuries, because their products are directly involved with the problem. Other corporations can also play a role in reducing crash injuries.

Motor Vehicle Manufacturers

Manufacturers of motor vehicles and components sold in the United States are asked to undertake several key initiatives:

- *Develop a cooperative research program with DOT and DHHS.* Considering the range of research needed and the limited resources in both the public and private sectors, the panel believes that CDC, NHTSA, and motor vehicle manufacturers should be specifically permitted to conduct a collaborative research program that gives adequate protection to the public's interest and adequate protection to the manufacturers' proprietary concerns. Currently, without specific authorization, NHTSA and the manufacturers are precluded from developing such a program.
- *Expand safety marketing and provide consumer information.* It is recommended that manufacturers emphasize safety in their advertising and refrain from advertising unsafe practices such as speeding. For example, they should cancel advertisements that require disclaimers such as the following: "This maneuver should not be attempted by ordinary drivers." Manufacturers can also emphasize safety by encouraging auto and motorcycle dealers to provide point-of-sale education on safety features.
- *Accelerate the pace of safety-related design changes.* Manufacturers should hasten the development and introduction of design improvements that will lead to crash avoidance and reduced injuries.
- *Curtail the production of high-speed vehicles.* Many vehicles capable of speeds well in excess of 100 mph are produced every year, even though the maximum speed limit is 65 mph. The production and promotion of such cars and motorcycles should be curtailed.
- *Assist state and local authorities in promoting safety laws.* Manufacturers should continue to promote safety belt use laws and require their own employees to use belts. In communities where manufacturers have facilities, they can contribute directly to community efforts by becoming actively involved in traffic safety programs.

Car Rental Companies

Car rental companies can contribute to motor vehicle safety by purchasing fleet vehicles equipped with antilock braking systems and driver and passenger airbags, by reminding customers to use safety belts and child safety seats, and by providing child safety seats to customers free of charge.

Insurance Industry (Auto and Health)

The Nation's property and casualty insurers have a vested interest in reducing the incidence of motor vehicle crashes and crash injuries. Other segments of the insurance industry, including life and health carriers, also have a strong interest in this reduction because crashes are a leading cause of death and serious injuries.

Insurers should undertake several crash prevention and crash injury reducing initiatives, including the following:

- *Provide premium discounts.* Auto insurers should promote the use of safer cars and driving practices, such as safety belt use, by providing appropriate premium discounts for cars with safety features such as airbags and antilock brakes.
- *Supply consumer information.* Auto insurers should routinely supply policyholders with information about motor vehicle safety, including information about the actual insurance losses associated with specific car makes and models. In addition, the insurance industry should provide consumers with comprehensive information on the relative safety of new cars. To encourage safe driving behaviors, auto and health insurers should provide risk prevention information to policyholders.
- *Assist state and local authorities in promoting safety laws.* Like motor vehicle manufacturers, insurers should actively assist state and local authorities in enacting and promoting safety laws. In states and communities where insurers are located, they could participate in existing community traffic safety programs and other educational campaigns and contribute directly to enforcing local safety laws by providing equipment to improve the enforcement of such laws.

These and other initiatives can contribute to increased public awareness of traffic safety issues, as well as to an improved public understanding of the insurance industry's commitment to controlling costs.

Alcohol Beverage Industry

A high proportion of fatal motor vehicle crashes involve drivers who are impaired by alcohol. For this reason, the alcohol beverage industry has a special responsibility to contribute to motor vehicle crash injury reduction efforts. However, it is unlikely that the industry will change its successful and profitable marketing of alcohol significantly. If the alcohol beverage industry were to alter its promotion practices, the panel recommends the following

as two areas in which it could make the most significant contribution to reducing the toll of impaired driving on our society.

- *Discourage drinking and driving.* The alcohol beverage industry should not promote its products in a way that encourages the use of alcohol in connection with motor vehicle use. The industry should emphasize responsible use of alcohol, including abstinence by drivers, and the problems that result from irresponsible use. Companies that make alcoholic beverages should not sponsor motor sports activities.
- *Discourage drinking among young people.* The problem of impaired driving is acute among young people who are learning to drive at the same time that they are beginning to consume alcohol. The alcohol beverage industry should not promote its products in ways that encourage underage drinking; rather, the industry should encourage compliance with the minimum drinking age of 21. For example, the industry should reassess the common practices of sponsoring collegiate, athletic, and cultural events geared to young audiences and advertising alcoholic beverages in ways that glamorize dangerous driving or other risky behaviors.

News and Entertainment Industries

The magnitude of the motor vehicle injury problem is such that it warrants wide attention — wider, perhaps, than it now receives in the print and electronic media. Such attention should be increased in both the news and entertainment segments of television and newspapers. For example, the news and entertainment industries should do the following:

- *Encourage more — and more accurate — news coverage.* A straightforward way in which media coverage can contribute to injury reduction involves reporting when safety belts are (or are not) used in crashes, when airbag deployments are involved in crashes, what the alcohol levels of drivers were, and similar information. But news reporters are not public health experts. Therefore, highway safety and health professionals must work with reporters on a long-term and continuing basis to ensure that what they report is accurate and that it helps reduce motor vehicle injuries.
- *Encourage injury reduction themes in television programming.* The public gets a message about injury-related behavior every time an actor on film wears or does not wear a motorcycle helmet or safety belt, and every time film and television stars unrealistically survive drinking and driving or dangerous driving maneuvers in chase scenes. Programming executives should ensure that entertainment themes serve the public health purposes of reducing injuries.

All Segments of Corporate America

As employers, all of the Nation's businesses are in a position to implement work-related travel measures that affect motor vehicle injury rates. Corporations are urged to implement the motor vehicle safety measures recommended below, in the section titled "Employers, Contractors, and Labor Organizations."

Employers, Contractors, and Labor Organizations

Employers, contractors, and labor organizations are in a unique position to implement work-related travel measures that affect motor vehicle injury rates. These may include measures not yet legislated in the state or Nation, as well as reinforcement of existing legislation.

Collaboration, Leadership, and Coordination

Management and labor should be encouraged to be partners in this effort. The industries most affected by motor vehicle fatalities — transportation, communications, and public utilities — have generally been quite supportive of programs such as those outlined above. Now, however, these industries account for less than a third of the occupational motor vehicle injury problem. Therefore, it is important that efforts be generalized to other industries, especially those in which motor vehicle injury fatalities account for a significant number of occupational injury fatalities. For example, research is needed in the construction industry to assess the effect of fatalities as a result of vehicle-associated injuries occurring in highway work zones.

Labor unions and employers can also promote motor vehicle safety programs through their associations or by participating directly in state and local injury prevention and control coalitions. Likewise, employers, business associations, and labor unions employing health and safety professionals and joint labor-management education, training, and health and safety funds can be effective independent forces in the state and local legislative arena to advocate for maintaining and expanding effective injury prevention legislation and regulation. Examples include occupant protection and impaired-driving legislation. These groups can also contribute to surveillance efforts by collecting accurate data on incidence and costs of motor vehicle crashes and injuries in the workplace. Finally, employers and associations can provide employee education programs in injury prevention as part of an overall health promotion and disease prevention program. These educational efforts are important beyond the immediate work environment; employer policies and programs in the workplace may "spill-over" to off-the-job driving practices.

Implementation of Proven Interventions

Examples include the following:

- Purchasing fleet vehicles that are equipped with safety features such as antilock brakes and driver and passenger airbags.
- Prohibiting alcohol use before or during driving on the job.
- Mandating the use of safety belts (regulation recently proposed by the Occupational Safety and Health Administration (OSHA)).
- Providing transportation to and from all corporate events at which alcohol is served.

- Imposing company penalties for on-the-job traffic violations.
- Regulating maximum permissible continuous driving hours.

Health Care Community

Hospitals, physicians, nurses, and other health care providers have many opportunities to help prevent motor vehicle injuries by participating in data collection systems, training staff, and acting as a point of contact with patients. Several specific recommendations follow.

Leadership, Collaboration, and Coordination

- Physicians, trauma nurse coordinators, and other hospital personnel should join and actively participate in state and local coalitions, which will set policy and programmatic initiatives for injury prevention.
- Physicians, emergency personnel, and other hospital personnel should serve as agents to identify and refer persons with identified substance abuse problems or other conditions that put them at risk for injury.
- Hospitals should actively work with EMS personnel, state and local health departments, highway safety agencies, and other governmental and nongovernmental agencies in developing and promoting injury prevention programs.
- State medical societies and public health, nursing, and hospital associations should have a motor vehicle injury prevention committee and actively support motor vehicle safety legislation.

Public Recognition and Support

- Physicians and other health care providers should make questions and counseling about the use of safety belts, child safety seats, and helmets a routine part of patient consultations (112, 113).
- Hospitals with obstetric and pediatric units should participate in programs to promote use of safety belts and child safety seats.
- Whenever feasible, all primary health care providers should be furnished with clear, brief, authoritative handouts on proper safety belt use, child safety seat selection and use, and motorcycle and bicycle helmet selection and use, for distribution to their patients.
- Hospitals should have safety belt education and child safety seat use discharge policies for all inpatients and outpatients.

Expansion of the Scientific Base

- Physicians and emergency department personnel should provide sufficient information in medical records so that hospital personnel can record E-codes in hospital discharge data systems, and they should obtain and record a blood alcohol concentration (BAC) level for all patients treated for acute traumatic injury.

- Hospital administrators should recognize the community need for E-coded data and should provide sufficient resources to train and provide personnel to use E-codes.
- Hospitals should receive sufficient resources to provide high-quality information to state trauma, head injury, and spinal cord injury registries.
- Hospitals should provide sufficient patient identifiable information through discharge data and registries to allow linkage with other data sets. Confidentiality guarantees should be in place to restrict the use of such information to research purposes only.

Training and Educational Institutions

The panel recommends that resources be allocated for training programs for researchers and practitioners in all aspects of motor vehicle injury, both inside and outside of government agencies. Attention should be given to the judicious allocation of funds for creating and managing sorely needed research and training programs in the epidemiologic, behavioral, biomechanical, clinical, and rehabilitative medical sciences related to motor vehicle injury. Attention should also be given to state and local practitioners in the field who assume program responsibilities for the delivery of injury control program activities.

Recent efforts are drawing more attention to the health aspects of injury, but the health establishment itself remains remarkably indifferent. A major target in overcoming such indifference is the preparatory training and continuing education of health professionals. In the past, the treatment of injury has received attention but the prevention of injury has been virtually neglected. From 1965 to 1975 DHHS funded only one training program for public health professionals in injury prevention, and there is no systematic federal funding of such programs today.

In the absence of DHHS training, NHTSA developed a motor vehicle injury prevention course for highway safety and health professionals. Medical and nursing specialties in injury control, such as emergency medicine, have been stepchildren in the medical arena and are only beginning to gain academic credibility. The panel recommends that training in all aspects of motor vehicle injury be included in the curricula of all health professionals and that their knowledge in this area be evaluated in professional board examinations.

Leadership, Collaboration, and Coordination

Training health professionals in motor vehicle injury prevention can be facilitated through collaboration with state and local agencies. Some health care delivery training programs work closely with state and local agencies involved in injury prevention, but they are the exception, in part because so few training programs address injury control at all. Fewer institutions formally address motor vehicle injury control in their training programs. However, collaboration with state and local programs provides mutual benefits. The programs benefit from having access to the latest information and the energy and enthusiasm of students and faculty, while the students and faculty learn more about the real world

constraints in implementing programs and conducting research or evaluation. In addition, such collaboration builds bridges that facilitate access to databases and the collection of better data.

Expansion of the Scientific Base

Although increased university funding to support injury control teaching and research is a worthy goal, there is a need to include motor vehicle injury control. Unfortunately, even the enormous magnitude of the problem and the associated societal costs may not be sufficient to overcome institutional inertia. Universities are struggling with budgetary limitations, but university administrators need to understand the worthiness of this program and adopt it as a growth area. State and national leadership, including funding, will be essential to the successful incorporation of injury control into academia.

Although prevention is the key to injury control, few schools of public health address injury. The prevention of injury involves disciplines beyond those in public health and indeed beyond the health professions entirely. Schools of engineering have been the first to move toward requiring attention to injury control as a condition of accreditation. Requirements to teach courses on injury control should certainly be placed on training programs in public health and safety, as well as in medicine, nursing, law, and public policy. Efforts should be made to incorporate injury control into the standard curricula of such training programs. Traffic injury control must bridge the gaps among medicine, engineering, public health, law, and the behavioral sciences.

University-based "centers of excellence" may provide an example of a multidisciplinary approach to injury control that advances the field's scientific base, trains researchers, and leads to innovative, effective countermeasures. The academic setting lends itself to collaborative research involving a variety of disciplines that together can consider aspects of injury control that cannot be studied in isolation. Such approaches should be encouraged through funding mechanisms, university programs, and peer-reviewed publications.

Another aspect of the academic setting is the geographic concentration of youth whose subsequent lifetime driving and social behaviors can be influenced by university policies. These policies can include alcohol regulations, safety belt requirements while on campus or in university vehicles, use of helmets while riding bicycles and motorcycles on campus, and enforcement of pedestrian right-of-way at crosswalks. Many of these policies — especially those concerned with bicycle and pedestrian safety — also apply to younger, school-aged children.

Citizen Advocacy Groups

A critical element in the continued success of the injury control movement in the United States is the legislative support and national awareness efforts of advocacy groups. These groups represent health, professional, disability, industry, and public interests and provide

leadership in building a constituency and coalition for injury control. Advocacy groups have been needed because of the lack of money and attention devoted to injury in America. This general lack will probably persist for some time, making stronger ties between different advocacy groups even more important.

Leadership, Collaboration, and Coordination

Many advocacy groups in the injury field share common goals. For example, the objectives of organizations concerned with impaired driving are largely shared by many concerned groups, such as the numerous groups within the National Coalition to Prevent Impaired Driving, and by professional groups. The programs of these groups, and those of federal and state agencies, must have more funds if they are to address prevention and intervention.

A national council of advocacy groups should convene and consider common goals and areas of cooperation. This event would add to the cooperation that is emerging in the field. The council could identify areas in which groups may not have common objectives but may not have opposing positions either. The council also could identify the areas in which competing agendas are being pursued. With this approach, common objectives can be pursued more broadly and effectively.

Advocacy groups should continue to foster closer coordination and cooperation on the important areas of injury prevention. These areas should include attention and the granting of priority status to the following:

- Preventing impaired driving.
- Increasing the use of safety belts, child safety seats, and bicycle and motorcycle helmets.
- Abiding by posted speeds and signs.
- Eliminating unsafe use of vehicles in advertising, commercials, television programs, and movies.
- Assuring proper belt and helmet use in advertising, commercials, television programs, and movies.
- Encouraging safety in vehicle purchase decisions.
- Encouraging safe bicycling and appropriate pedestrian behavior.
- Passing effective state laws.
- Supporting enforcement of laws.
- Developing and implementing effective public education programs.
- Increasing media attention and making news of crashes and injuries more accurate.
- Registering disabling injuries.

Public Recognition and Support

Injury control is a prominent area of public health and a priority area for the Nation. If we are going to reduce the economic, social, and family devastation injury produces, advocacy groups can and should play a role in the national program to garner money and attention to the problem and to develop broad-based education and prevention efforts.

New advocacy initiatives are needed to develop the voice and power of youth, older adults, and the lower socioeconomic segments of society. These groups are disproportionately affected by injuries and would benefit from grass roots advocacy directed at community awareness, injury prevention, and local, state, and federal government initiatives.

We have a great deal to gain from leaders in minority communities addressing injury control through family units, churches, and schools. In many instances, advocacy initiatives can be adapted for use in communities made up of minorities or of people with a specific culture and language.

Expansion of the Scientific Base

In many cases, advocacy groups can be effective by challenging conventional assumptions, even though their approaches may seem unscientific or unorthodox. However, it is increasingly important that injury control advocacy be based on sound research findings and the proper interpretation of data. Each advocacy group should regularly assess its programs to ensure that its recommendations are based on sound scientific research. In areas in which additional scientific findings would strengthen advocacy efforts, coordination with health professionals is recommended. This not only offers the benefit of developing links among groups, but also ensures that the most appropriate research findings are used in legislative activities and in defining goals. In addition, this approach can help identify research and data needs that deserve national attention.

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Appendix A:
Healthy People 2000:
Health Objectives for the Nation
Excerpt: Objectives Concerning Motor Vehicle Injuries

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9.3	Reduce deaths caused by motor vehicle crashes to no more than 1.9 per 100 million vehicle miles traveled and 16.8 per 100,000 people. (Baseline: 2.4 per 100 million vehicle miles traveled (VMT) and 18.8 per 100,000 people (age adjusted) in 1987)
9.9	Reduce nonfatal head injuries so that hospitalizations for this condition are no more than 106 per 100,000 people. (Baseline: 125 per 100,000 in 1988)
9.10	Reduce nonfatal spinal cord injuries so that hospitalizations for this condition are no more than 5 per 100,000 people. (Baseline: 5.9 per 100,000 in 1988)
9.11	Reduce the incidence of secondary disabilities associated with injuries of the head and spinal cord to no more than 16 and 2.6 per 100,000 people, respectively. (Baseline: 20 per 100,000 for serious head injuries and 3.2 per 100,000 for spinal cord injuries in 1986)
9.12	Increase use of occupant protection systems, such as safety belts, inflatable safety restraints, and child safety seats, to at least 85 percent of motor vehicle occupants. (Baseline: 42 percent in 1988)
9.13	Increase use of helmets to at least 80 percent of motorcyclists and at least 50 percent of bicyclists. (Baseline: 60 percent of motorcyclists in 1988 and an estimated 8 percent of bicyclists in 1984)
9.14	Extend to 50 states laws requiring safety belt and motorcycle helmet use for all ages. (Baseline: 33 States and the District of Columbia in 1989 for automobiles; 22 States, the District of Columbia, and Puerto Rico for motorcycles)
9.20	Increase to at least 30 the number of states that have design standards for signs, signals, markings, lighting, and other characteristics of the roadway environment to improve the visual stimuli and protect the safety of older drivers and pedestrians. (Baseline data available in 1992)
4.1	Reduce deaths caused by alcohol-related motor vehicle crashes to no more than 8.5 per 100,000 people. (Age-adjusted baseline: 9.8 per 100,000 in 1987)
4.8	Reduce alcohol consumption by people aged 14 and older to an annual average of no more than 2 gallons of ethanol per person. (Baseline: 2.54 gallons of ethanol in 1987)

4.15	Extend to 50 states administrative driver's license suspension/revocation laws or programs of equal effectiveness for people determined to have been driving under the influence of intoxicants. (Baseline: 28 states and the District of Columbia in 1990)
4.16	Increase to 50 the number of states that have enacted and enforce policies, beyond those in existence in 1989, to reduce access to alcoholic beverages by minors.
4.17	Increase to at least 20 the number of states that have enacted statutes to restrict promotion of alcoholic beverages that is focused principally on young audiences. (Baseline data available in 1992)
4.18	Extend to 50 states legal blood alcohol concentration tolerance levels of .04 percent for motor vehicle drivers aged 21 and older and .00 percent for those younger than age 21. (Baseline: 0 states in 1990)

Appendix B:
List of Documents with Recommendations Relevant to Motor Vehicle Injury Prevention

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American Association of State Highway and Transportation Officials (AASHTO), Standing Committee on Highway Traffic Safety. Highway Safety Strategic Plan, 1991-2000. McLean VA: AASHTO, 1990.

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