CHAPTER 1

Car

INTRODUCTION

Motor vehicle fatalities are the leading cause of injury death in every developed nation. In 2005 in the United States 120 people died per day in traffic crashes, and traffic crashes were the leading cause of death for every age from 2 through 34. Motor vehicle crashes also cause nonfatal serious injury, such as traumatic brain injury and spinal cord injury. On an average day in 2005, over 9,000 Americans were injured seriously enough in traffic crashes to seek medical attention in hospital emergency departments.

Fortunately many policies can help reduce traffic injuries. Using a matrix (Table 1) developed by Bill Haddon, we can first divide policies into three categories: those focused on (1) the human (e.g., the driver), (2) the vehicle, and (3) the road. We can also divide policies into three categories: those focused on (a) the pre-event (preventing the collision), (b) the event (reducing the immediate harm caused by the collision), and (c) the postevent (ameliorating the injury and preventing further injury).

The first seven success stories in this section focus on the human, and the first three deal with policies that attempt to reduce alcohol-related injuries. Alcohol consumption is a risk factor for serious automotive injury; indeed, it is a risk factor for virtually every type of injury. Policies that raise the minimum legal drinking age, increase the likelihood of being caught drunk driving, and raise the penalties for being caught are designed primarily to reduce the chances of a crash by changing driver

TABLE 1
Haddon matrix

	Human	*Vehicle (agent of injury)*	*Environment*
Pre-event	1	4	7
Event	2	5	8
Postevent	3	6	9

behavior (Cell 1 in Table 1). The focus is on the pre-event. In addition, alcohol in the body tends to increase the seriousness of injury once a collision has occurred. It is a myth that a drunk person is less likely to be injured during a crash or fall because relaxed. The evidence shows conclusively that in the same collision a drunk individual is far more likely to be injured severely than others who have not been drinking (Evans 2004). The fourth success story (graduated driving licenses) deals with policies that focus on the pre-event and are designed to reduce injuries to the young, inexperienced driver.

In the next three success stories, the focus is on changing human behavior to reduce the seriousness of injury once the collision has occurred (Cell 2). The goal is to reduce the injuries caused by the "second collision," when the human body decelerates into the interior of the vehicle or some other object. Seat belts, helmets, and child safety seats do little to reduce the likelihood of collisions but protect the human during the event (crash) phase of the incident. However, the occupant must take appropriate action for the devices to have a beneficial effect: the motorist has to "buckle up," to wear the motorcycle helmet, or to strap a child into the child safety seat.

Some of the most important changes in motor vehicle safety in the past half-century have been safety improvements to the vehicle itself. These improvements include better headlights and brakes, energy-absorbing steering columns and laminated front windshields, head rests (reducing whiplash injuries), seat belts with shoulder straps, and air bags. Some of these changes reduce the likelihood of collision (e.g., headlights, brakes; Cell 4); some primarily reduce the likelihood of immediate injury once the collision occurs (e.g., air bags, steering column and windshield improvements; Cell 5); and some reduce the likelihood of subsequent injury (e.g., improvements in gas tanks that lessen the likelihood of fire after the collision; Cell 6). Many of these changes are "passive" safety measures; that is, they do not require the motorist to do anything to be protected.

In the United States in the late 1960s and early 1970s the forerunner of the National Highway Safety Administration mandated many safety standards for new motor vehicles. It is estimated that by 1980 these standards had reduced occupant deaths by some 40 percent (Crandall et al. 1986). Virtually all developed countries now have similar safety standards for automobiles.

Three success stories in this section deal with changes in the motor vehicle. The third brake light reduces the likelihood of collision (Cell 4), and energy-absorbing steering columns and air bags reduce the likelihood that the second collision will cause serious injury (Cell 5). An additional success story deals with the gasoline that is used to power the vehicle; getting the lead out of gasoline reduces the likelihood of lead poisoning to people in the community.

Roads are much better than they were a half-century ago, reducing the likelihood of collision (e.g., better lighting; Cell 7) and the seriousness of a collision (e.g., deformable lampposts; Cell 8). Sometimes road improvements do both; for example, improved guardrails keep an out-of-control motorist from crashing into other cars or unmovable objects and make it less likely that the motorist will suffer serious injury from colliding with the guardrail itself (Cell 8).

Speed bumps cause motorists to slow down and thus protect pedestrians and other vehicles (Cell 7). Indeed, there a score of other "traffic calming" road measures, including chicanes (road narrowings that alternate from one side of the street to the other, forming S-shaped curves) and neckdowns (sidewalk extensions at intersections that reduce roadway width from curb to curb), which help keep pedestrians safe (Elvik 2001). At the extreme, one way to protect pedestrians is to ban motor vehicles entirely from an area, as by the creation of pedestrian streets.

The final three success stories in this chapter deal with measures that change the roadway. Roundabouts and guardrails reduce both the likelihood and the seriousness of injury (Cells 7 and 8). Crash cushions largely reduce the severity of injury once the collision has occurred (Cell 8). These are three of the many types of road improvements that have made driving so much safer (but still not safe enough).

The Centers for Disease Control and Prevention (CDC) calls the improvements in traffic safety in the United States a "twentieth century public health achievement" (CDC 1999). The creation of an excellent data system by the National Highway Traffic Safety Administration enabled scientists to determine the main factors affecting road safety and which public policies were and were not effective (Waller 2002). Yet many areas for improvement still exist, particularly concerning teens and elderly drivers.

CAR SUCCESS STORIES

1.1. Minimum Legal Drinking Age

Injuries are the leading cause of death for youths ages 18–20, and alcohol is a risk factor for sustaining a fatal injury. Historically, the minimum legal drinking age in the United States has ranged from 18 to 21. In the 1970s and 1980s numerous state legislatures enacted changes to the drinking age. In 1970, thirty-three states had a drinking age of 21; between 1970 and 1975, twenty-five state legislatures lowered their drinking age to 18. Starting in 1977 many states began raising the legal drinking age, until by 1988 the minimum legal drinking was 21 in all states.

This natural experiment is the most well-studied alcohol control policy in U.S. history. At least forty-six high-quality studies find an inverse relationship between the drinking age and traffic crashes among youths 18 to 20 years old: when the drinking age goes down, traffic injuries and fatalities among youth go up, and vice versa. The relationship holds even when there has not been strong enforcement of the law and youth still have some access to alcohol. The National Highway Traffic Safety Administration estimates that traffic fatalities have fallen by over 800 deaths per year due to the higher drinking age. Raising the legal drinking age to 21 probably also reduced other injuries; one study found an 8 percent reduction in youth suicides when the drinking age rose from 18 to 21.

LESSON: Laws can have a beneficial effect, even when there is little enforcement and some people flout the law.

1.2. Random Breath Testing

Alcohol consumption substantially increases the risk of a motor vehicle crash. In 1982 in New South Wales, Australia, police introduced highly visible checkpoints on main thoroughfares, and passing drivers were chosen arbitrarily and directed to stop for an alcohol breath test. Implementation of the program was intensive. Two hundred new highway patrolmen were recruited to help administer the tests. By the end of the fifth year of operation, over 50 percent of the motorists in Sydney had been tested at least once, and 80 percent reported seeing the program in operation. The campaign received extensive publicity and included a catchy jingle: "How will you go when you sit for the test, will you be under .05 or under arrest?"

The intervention led to a sustained decrease in motor vehicle fatalities of some 15 to 20 percent due to a reduction in alcohol-related crashes. "This is one of the clearest and largest changes in traffic safety associated with a specific intervention" (Evans 2004, 254). The effects were credited more to deterrence than to catching motorists driving drunk. Four elements of the campaign helped ensure its success: publicity, visibility, enforcement, and sustainability. Random breath testing has been widely adopted in other Australian states, with comparable results.

LESSON: Enforcement of the law is one way (but not the only way) of reducing dangerous behavior.

1.3. Increased Penalties for Drunk Driving

Alcohol-impaired driving is a leading cause of traffic fatalities in developed and developing countries. In 2002 Japan enacted a law designed to reduce alcohol-impaired driving. The law reduced the allowable blood alcohol concentration from .05 percent to .03 percent. More important, it substantially increased the penalties. Fines for drunk driving were raised from $425 to $4,250, a tenfold increase. In addition, the law made bartenders and passengers culpable along with the arrested drivers.

The new law was widely publicized. The official advertisement for the campaign was memorable. In it, a drunken man intends to go home in his car, and the bartender requests that he pay $4,250 for the last drink, equal to the drunk-driving penalty and more than the average monthly salary in Japan.

The law appears to have been quite successful. Comparing the period before and after the law, alcohol-impaired traffic fatalities fell 38 percent (all traffic fatalities fell 14 percent), and alcohol-impaired serious traffic injury fell 37 percent (all severe traffic injury fell 4 percent). These large reductions occurred even though the definition of alcohol-impaired driving was expanded in the postlaw period, including drivers with .03 percent and .04 percent blood alcohol concentrations.

LESSON: Substantially increased penalties for dangerous behavior can sometimes help prevent injury.

1.4. Graduated Driver's Licenses

Sixteen-year-olds have almost ten times the crash risk of drivers ages 30–59 and close to three times the risk of older teenagers. A contributor to the elevated risk is lack of driving experience, but the best way to get experience is by driving. What is needed is a way to gain experience while minimizing risk. This is the goal of graduated licensing.

Graduated licensing is designed to phase in on-road driving, permitting novices to gain experience under safer conditions. The first few months of driving have the highest crash rates. Early research also identified the overrepresentation of young drivers in crashes at night and when another young person was the right front passenger.

A graduated license system typically entails a six-month supervised learner's permit (e.g., with a minimum of fifty hours certified driving), followed by an intermediate phase that permits unsupervised driving only in less risky situations (e.g., during the day and with no other adolescents in the car, unless accompanied by an adult). Full licensure follows if all the conditions of the first two stages have been met.

In 1984 New Zealand became the first country to adopt a graduated licensing system. Michigan became the first U.S. state, in 1997. By 2006 some elements of graduated licensing had been adopted in all fifty states. The reductions in crash and injury rates among 16- and 17-year-olds have been impressive. For example, crash risk among 16-year-old Michigan drivers fell 29 percent between 1996 and 2001. A review article of the more than two dozen evaluations of graduated licensing systems for the United States and Canada concluded, "The results [of all the studies] are surprisingly consistent. Overall, graduated driver licensing programs have reduced the youngest drivers' crash risk by roughly 20 to 40%" (Shope 2007, 165).

LESSON: Research can help identify risk factors for injury and help inform sensible policy.

1.5. Seat Belt Use

The efficacy of seat belts in reducing mortality and morbidity in traffic crashes has been well established. A problem has been getting motorists to buckle up. In 1980, for example, only 11 percent of the U.S. motoring population wore seat belts. By 1999 that percentage had increased to 71, a clear injury prevention success story. The National Highway Traffic Safety Administration estimates that seat belts probably saved more than 11,000 lives in 1999 alone.

The big jump in U.S. seat belt use came between 1984 and 1992, when usage rates went from 14 to 62 percent. In 1984 the U.S. secretary of transportation ruled that passive restraints (e.g., air bags) would not be required in motor vehicles if more than two-thirds of the nation's population resided in states with mandatory seat belt laws meeting five specific criteria. The auto industry, which had long fought passive restraint requirements for their vehicles, immediately began a massive lobbying campaign to enact state seat belt laws, forming a new organization, Traffic Safety Now, to spearhead the effort. No state had a seat belt law in 1983; by the time Traffic Safety Now closed its doors in 1992, forty-two states had enacted seat belt laws. In an ironic twist for the auto companies, but of great benefit for safety, it was ruled that many of the state laws did not satisfy the criteria in the regulation, and the United States ended up with both state seat belt laws and automobile air bags.

LESSON: Given the right incentive, industry can often push successfully for laws promoting consumer safety.

1.6. Helmet Laws

Taiwan has one of the highest motorcycle use rates in the world; over two-thirds of their motor vehicles are motorcycles. In mid-1997 Taiwan followed most other Asian countries by enacting a mandatory helmet use law for cyclists. Mandatory helmet laws are easily enforced because noncompliance is readily observed. Helmet use rose immediately, from about 20 percent to over 95 percent; the number of licensed cyclists remained the same. In the first six months following the law, fatalities due to motorcycle head injuries fell 22 percent (all motorcycle-related deaths fell 14 percent) and nonfatal head injuries fell 44 percent. Although the vast majority of cyclists wore helmets, over half of all motorcycle-related head injuries were to individuals who were not wearing a helmet.

One of the beneficial side effects of motorcycle helmet laws is that they reduce motorcycle theft. For example, following the mandatory helmet law in West Germany in 1980, while thefts of cars and bicycles remained largely unchanged, motorcycle thefts fell from 153,000 in 1980 to 54,000 in 1986. Why the reduction? It turned out that many thefts were opportunistic rather than carefully planned. Any would-be thief who had not brought along a helmet would be quickly noticed by the police and pulled over for violating the helmet law. Similarly, in London, motorcycle thefts fell 24 percent after Great Britain enacted a helmet law in 1973, and the Netherlands saw a 36 percent drop in thefts in 1975 when its law was enacted.

LESSON: Regulations of observable conduct typically have a larger effect than regulations of unobservable conduct.

1.7. Child Safety Seats

In the 1960s it was common for parents to hold their infant in their lap while traveling in a motor vehicle. During a crash, the physical forces would make it impossible to keep hold of the child, who would fly through the air, crashing into the inside of the car or through the windshield. Often the child would serve as an "air bag" for the parent who was supposedly protecting her.

In the 1970s the major policy initiatives in child passenger safety were educational. When it became clear that education alone was not sufficiently changing parental behavior, a small group of pediatricians in Tennessee lobbied that parents be required by law to restrain small children in their cars. The lobbying was effective: some legislators were approached by the very pediatrician who cared for his or her children. In 1978 Tennessee became the first state to mandate child safety seat use. Between 1978 and 1983 in Tennessee, occupant deaths to children under age 4 declined by more than 50 percent. Children not in a restraint device were eleven times more likely to die in a crash than those who were restrained.

By 1985 every state had passed child seat restraint legislation. Safety seat use in cities rose from 23 percent in 1982 to 82 percent in 1987.

LESSON: A few determined people can save many lives.

1.8. Third Brake Light

Rear-impact collisions account for more than 20 percent of all motor vehicle crashes. In 2005, for example, it was estimated that there were more than 1.2 million rear-impact crashes involving passenger cars, with 400,000 injured occupants. Countermeasures intended to reduce the problem have included head restraints, crash-resistant gasoline tanks, stronger bumpers—and improved brake lights. Between 1977 and 1980 fleets of taxicabs and telephone company passenger cars were randomly provided with center, high-mounted brake lights. The cars so fitted were rear-ended 44 to 54 percent fewer times while braking than those cars without this third brake light.

Based on these randomized studies the National Highway Traffic Safety Administration required that all passenger cars manufactured after August 1985 be equipped with a center high-mounted stop lamp. Studies find that these lights have reduced rear-end collisions, but only by 4 to 5 percent. Part of the reason for the lower levels of effectiveness is that drivers may have become acclimated to the new lights, and the novelty effect has worn off. Still, even a 4 percent reduction in rear-end collisions may represent some 25,000 injuries prevented each year.

LESSON: Safety devices work, but sometimes have less of a real-world impact than predicted.

1.9. Energy-Absorbing Steering Columns

The steering assembly is the most common source of serious injury for drivers in frontal crashes. In most passenger cars before the 1967 model year the steering column was a rigid pole ending in a narrow hub. It was like a spear pointed at the chest of the driver. In frontal crashes, the driver would hit the rigid column with the force concentrated on the narrow hub. Even worse, the steering column would often be propelled rearward, toward the driver, at a high rate of speed. Not surprisingly, the driver's lungs and other internal organs would be punctured, and the driver would often die.

In the 1960s the General Services Administration began requiring improved steering assemblies in government-purchased vehicles. In 1967 the new National Highway Traffic Safety Administration extended this requirement to all new passenger cars sold in the United States. A comprehensive analysis of the safety benefits estimated that these safer steering assemblies reduced the risk of driver fatality in a frontal crash by 12 percent and the risk of serious injury to the driver by over 17 percent. For 1978 alone, that meant 1,300 fewer driver deaths and 24,200 fewer serious injuries. The average cost to the consumer for this safety feature was only $10.50 per car. Most motorists were unaware of this important safety improvement.

LESSON: Many important public health policies can benefit consumers without their awareness.

1.10. Government Purchase of Air Bags

Government-mandated motor vehicle air bags are currently saving the lives of thousands of motorists each year. The struggle to ensure that motor vehicles were equipped with such passive restraint systems was a long and tortuous one. One step along the way was the purchase by the General Services Administration (GSA) in 1985 of 5,000 vehicles equipped with air bags.

Ralph Nader and a group of insurance companies helped convince the GSA chief to purchase vehicles equipped with air bags for the federal government's automotive fleet. With some government subsidies, Ford finally agreed to provide Tempos equipped with air bags. The exemplary safety performance of these air bags provided real-world evidence for the value of government mandating this safety device.

Gerald Carmen, a Republican businessman and the head of GSA at the time, calls the air bag purchase "an exciting adventure, initiated by Nader, supported by the insurance companies, and a real success story for GSA" (quoted in Hemenway 1989, 124).

LESSON: Government procurement can be used to promote safety and reduce injury.

1.11. Unleaded Gasoline

Lead is a major environmental health hazard to adults, but is even more dangerous to young children. High blood lead levels can result in lowered intelligence (e.g., IQ), learning disabilities, impaired hearing, reduced attention span, hyperactivity, and antisocial behavior. Until the late 1970s, ambient concentrations of lead (from lead that was added to gasoline) were a major contributor to childhood lead poisoning.

In 1972 the Environmental Protection Agency launched an initiative to phase out leaded gasoline; by 1986 the primary phase-out was complete. Average blood levels in children under 6 fell 78 percent between the late 1970s and the early 1990s. The decline was largely due to the phasing out of lead in gasoline; some of the decline was due to legislation banning lead from paint and plumbing supplies. Unfortunately, as of 2004, many developing nations still allowed lead to be added to gasoline.

Getting the lead out of gasoline not only reduced the unintentional injury of childhood lead poisoning, but may also have reduced subsequent intentional violent injuries perpetrated by these children. It is well known that childhood lead exposure can lead to psychological traits that are strongly associated with aggressive and criminal behavior. One controversial study finds that the reduction in lead from gasoline in the late 1970s and early 1980s was responsible for substantial declines in violent crime in the 1990s (Reyes 2007).

Sometimes public health success stories are due to previous public health failures. In 1922 General Motors discovered that adding tetraethyl lead to gasoline raised engine performance by eliminating the "knock." This enhanced the development of the modern automobile. Even then, there was enough awareness of the public health dangers posed that leaded gasoline was banned in New York City for over three years; in 1925 the production of leaded gasoline in the United States was halted for over nine months.

A surgeon general's conference in 1925 brought together the major interested parties in the controversy. As one participant noted, the conference gathered together in one room "two diametrically opposed conceptions. The men engaged in industry—chemists and engineers—take it as a matter of course that a little thing like industrial poisoning should not be allowed to stand in the way of a great industrial advance. On the other hand, the sanitary experts take it as a matter of course that the first consideration is the health of the people" (Rosner & Markowitz 1985, 347).

While Ethyl Corporation claimed that tetraethyl was a "gift of God," the Yale physiologist Yandell Henderson expressed horror that hundreds of thousands of pounds of this slow, cumulative poison would be dispersed in every major city. He accurately foresaw that "conditions would grow worse so gradually and the development of lead poisoning will come on so insidiously . . . that leaded gasoline will be nearly universal . . . before the public and the government will awaken to the situation" (Rosner & Markowitz 1985, 349).

The authorities took the position that they should not act until there was overwhelming evidence that leaded gasoline was actually harming many people. That took another fifty years.

LESSON: Public health may not be the first concern of industry.

1.12. Roundabouts

It is estimated that some 40 percent of all traffic injury collisions in developed countries occur at intersections. Converting intersections from traffic signals to roundabouts, and especially from yield signs to roundabouts, can dramatically reduce injury while increasing traffic flow. Roundabouts have become common at many intersections in the United Kingdom and other European nations.

Roundabouts improve safety in a variety of ways. They reduce the number of conflict points at crossroads from thirty-two to twenty. All traffic comes from one direction in roundabouts, and there are no left turns. Motorists cannot drive a straight path, and thus reduce speed. Finally, motorists entering a roundabout are required to yield to those already in the roundabout and are forced to observe traffic more closely.

At least thirty-three studies have evaluated the effects of roundabouts on traffic safety (Elvik & Vaa 2004). The evidence indicates that changing from yield signs to a roundabout at crossroads reduces injury crashes by about 40 percent; changing from traffic signals to a roundabout reduces injury crashes by approximately 17 percent. Because of the reduction in the speed of the crashing vehicles, the reduction in *serious* injury or fatal crashes may be as high as 70 to 90 percent (Persaud et al. 2001).

In spite of the fact that roundabouts reduce speed, they actually increase mobility, or traffic flow, by eliminating many turning maneuvers and reducing the need to stop. For example, a study from Sweden found that converting an intersection with 23,500 incoming vehicles per day from a traffic light to a roundabout saved motorists an average of 10.1 seconds per car (Varhelyi 1993).

By lowering speed and increasing traffic flow roundabouts also reduce automotive air pollution. For example, a Danish study found that emission of hydrocarbons, carbon monoxide, and nitrogen oxide were about 10 percent lower at roundabouts compared with traffic signals (Bendtsen 1992). A Swedish study found a 29 percent reduction in carbon monoxide emission and a 21 percent reduction in nitrogen oxide emissions after a signalized intersection was converted to a roundabout (Varhelyi 1993).

The conversion of many intersections to roundabouts in Europe has helped reduce traffic injuries while lowering pollution and speeding motorists on their way.

LESSON: A focus on safety can sometimes lead to improvements in other goals, in this case mobility and clean air.

1.13. Guardrails

Between 1979 and 1985 twenty-seven fatalities occurred when motorists lost control of their vehicles along the winding roads and plunged over the steep embankments along a hundred-mile stretch of Routes 96, 169, and 299 near the Hoopa, Yurok, and Karok Indian reservations in the vicinity of Willow Creek, California.

In 1985 the California Highway Department installed strong guardrails at fifty sites where the embankments were particularly steep and where fourteen fatalities had occurred in the previous seven years.

In the following ten years, no fatalities were reported at these sites. By contrast, on the rest of this dangerous stretch, the fatality rate did not change; thirteen motorists had died in the previous seven years from going over the embankment, and sixteen died in the subsequent ten years. It is estimated that the guardrails saved two motorists a year from plunging over the embankments and dying.

LESSON: Roads can be made more or less safe.

1.14. Crash Cushions

The vast majority of improvements in roadside safety have occurred since 1960. Prior to that time little attention was given to the roadside; run-off-the-road crashes were attributed to the "nut behind the wheel." This philosophy resulted in untreated guardrail terminals, unyielding signs, and nontraversable ditches. In recent years the general acceptance of the "forgiving roadside" philosophy has helped reduce motor vehicle serious injuries and deaths (Wendling 1996).

Ideally, in a forgiving roadside all roadside hazards would be eliminated and there would be a clear zone so that a vehicle leaving the road would not contact anything. As far as we know, no one has ever died when they lost control of their car and it ran off the road into an open field. While it is often infeasible to eliminate all roadside hazards, the remaining hazards can be made less injurious (e.g., by making lighting columns collapsible). If it is not possible to move the object or make it breakable, the highway authority should provide protection with a safety fence, guard, or barrier.

Crash cushions are energy-absorbing structures installed in front of bridge pillars, tunnel portals, or road dividers at exit ramps. They are designed to safely stop a vehicle within a relatively short distance. Crash cushions do not prevent collisions, but reduce the extent of damage and injury when a collision occurs. Studies from the United States, Great Britain, and the Netherlands indicate that new crash cushions reduce injuries and fatalities in crashes into permanent obstacles by approximately 70 percent (Elvik & Vaa 2004).

Since the early 1960s the use of crash cushions to help protect vehicles from crashes with fixed objects at highway gore areas (e.g., between the exit ramp and the highway) has become a widespread practice in the United States.

LESSON: The built environment can be constructed to reduce the seriousness of injury.

HEROES

1.A. Hugh DeHaven (1895–1980)

In World War I, Hugh DeHaven served as a young American volunteer cadet with the Canadian Flying Corps. During combat practice his plane collided with another plane, and both crashed. DeHaven suffered two broken legs and a ruptured liver, pancreas, and gallbladder. The other pilot walked away from his crashed plane.

During his six months of convalescence DeHaven began to consider the features of the aircraft that led to his injuries. He concluded that his own internal injuries were due to the stiff and pointed buckle on his lap belt, which he had jackknifed over at impact, and that solid structures in front of the pilot's head often caused serious injury. When he began to discuss his ideas and findings with his superiors, he encountered resistance and inertia. His commanding officer preferred to attribute escapes from injury to the "Jesus factor" and death to the "luck of the game."

Eighteen years later, a minor automobile crash led DeHaven to recall his earlier ideas about vehicle structure and unintentional injury. He presented his ideas to a special committee for aviation medicine and other groups. He again found little or no interest in improving survivability; the argument was that money would be better used if spent to prevent the accident from occurring in the first place (the pre-event).

Between 1938 and 1941 DeHaven personally investigated aircraft crashes and falls from heights. In 1942 he published his seminal paper on surviving falls, and he was appointed director of a project called Crash Injury Research at Cornell University Medical College.

DeHaven's 1942 article presents case studies of eight falls from heights, falls that could well have led to death but in which the people not only survived, but had little serious injury. For example, in Case 1 a 42-year-old woman jumped from the sixth floor and fell onto fairly well-packed earth in a garden plot, landing on her left side and back. The superintendent of the building reached the victim immediately after she struck the ground. She raised herself on her left elbow and remarked, "Six stories and not hurt." Later in life DeHaven said that these eight cases "did more to support [his] theories about crash injuries and crash survival than all the words in the dictionary," and that at the time the article was written, "people knew more about protecting eggs in transit than they did about protecting human heads."

DeHaven's work provided strong evidence that the human body was less fragile than had generally been assumed, that the structural environment was the dominant cause of injury, and that the environment could be modified to reduce the likelihood of injury. He argued that the basic laws of physics operated for human injuries, and the distribution of force largely determines the damage inflicted. His analyses formed the basis for many of the most effective injury prevention measures used today, including soft playground surfaces, air bags, and helmets.

DeHaven is considered a genuine pioneer. Although hundreds of combat pilots had died as a result of injuries sustained in crashing, DeHaven seems to have been the first to seriously give consideration to the actual cause of death. The same held true for car crash victims. Automobile manufacturers did not have the type of safety departments they have today, and there was little basic scientific research. Much of the early fundamental work in crash protection was due to the efforts of DeHaven, who for years financed his own research in this new area.

DeHaven's work at Cornell was aimed at reducing the direct cause of airplane and motor vehicle injuries: the secondary impact between the occupant and the interior of the vehicle. For example, by the early 1950s DeHaven and his associates had conceived, designed, and tested almost all of the features that would later be incorporated into automobile safety belts. His work demonstrated that human bodies could withstand forces of severe car crashes without death or serious injury if they were properly "packaged." DeHaven is sometimes called the father of crashworthiness research.

Later in life, DeHaven received numerous awards, and his status in the injury field is now high. However, virtually no one outside the automotive and aviation safety field knows his name. As of August 2008 his name did not appear in Wikipedia.

1.B. John Paul Stapp (1910–1999)

John Paul Stapp, a physician, PhD, and Air Force colonel, became famous as "the fastest man on earth," traveling faster than a speeding bullet. He also was the fastest man to stop (decelerate). His scientific work helped reduce the risk for aviators, and his advocacy helped save the lives of many motorists.

In the early 1940s Stapp began studying the effects of high-altitude flights on pilots, particularly how they could prevent dehydration, freezing, and the bends (the deadly formation of bubbles in the blood). The final problem was the most difficult, but after many flights in subzero temperatures, Stapp discovered the answer: if a pilot breathed pure oxygen for thirty minutes prior to takeoff, symptoms could be avoided.

After this success Stapp was assigned the problem of human deceleration, the body's ability to withstand G forces (a G is defined as the force of gravity acting on a human on Earth at sea level). At the time, 18Gs was considered the most a human could expect to survive; as a result, military cockpits were built to withstand only an 18G impact.

Stapp not only supervised experiments on the rocket sled track, but he was his own test subject. He suffered concussions, lost dental fillings, and found that for G forces, the most vulnerable part of the human anatomy was the eye. He also showed the inadequacy of certain Air Force restraint systems and that rearward-facing occupants could survive higher G loads than forward-facing ones. Most important, he debunked the 18G limit. If humans could tolerate 30G decelerations, seat belts and cockpits needed to be built so that pilots could survive such a deceleration.

With aircraft beginning to travel at supersonic speed, the next issue was whether pilots could survive ejection at such speeds. On December 10, 1954, on a test track in New Mexico, Stapp strapped himself in for his twenty-ninth (and final) sled ride. In five seconds he was accelerated to 632 mph, then brought to a complete halt—in 1.4 seconds.

For more than a second, Stapp endured 25Gs, the equivalent of a Mach 1.6 ejection at 40,000 feet (a force about the same as crashing into a wall at 120 mph). He suffered complete red out, as nearly every capillary in his eyeballs burst. Fortunately, by the next day, his eyesight had returned.

Stapp became an instant celebrity. He was labeled not only the fastest man on earth but also "the bravest man in the Air Force." He was featured on the covers of *Life* and *Collier's* magazines, and became the subject of a Hollywood movie. He used his fame to promote the cause of automotive safety.

Stapp persuaded the Air Force to build an automotive testing facility, and he conducted the first-ever crash tests with dummies. He also convinced the Air Force to take up the automotive safety cause by providing statistics showing that more Air Force pilots were killed in traffic accidents than in plane crashes.

At every opportunity Stapp lobbied for the installation of seat belts (not even an option on most 1954 cars), soft dashboards, collapsible steering columns, and shock-absorbing bumpers. "I'm leading a crusade for the prevention of needless deaths," he told *Time* magazine, making its cover in 1955.

In 1966, when President Lyndon Johnson signed a law requiring seat belts in all new cars, Stapp was by his side. “The fastest man on earth” received numerous awards before his death, including the Presidential Medal of Technology and the Legion of Merit.

1.C. William Haddon Jr. (1926–1985)

Bill Haddon is probably the best known of all injury control professionals. The Haddon matrix is one of the first concepts taught in every injury prevention course. A tool to help systematically identify all options available to reduce injuries, the Haddon matrix divides possible interventions into three phases (pre-event, event, postevent) and three factors (human, agent, environment).

During the first sixty years of motor vehicle use, research and prevention efforts were focused almost exclusively at the pre-event, human factor: the bad driver. It was claimed that over 90 percent of crashes were due to driver error, so naturally the goal became to improve the driver. Yet education and enforcement efforts were not always successful at changing driver behavior or reducing injuries. Haddon helped change this exclusive focus on the driver to one that included the vehicle and the road.

“It is hard to overemphasize the importance . . . of the conceptual shift from this single-cause, behavioral explanations of injury to multiple-cause, environmental explanations” (Christoffel & Gallagher 1999, 32). With many possible countermeasures, the choice became picking the most cost-effective ones. These were often changes to the agent (e.g., the motor vehicle) or the environment (e.g., the highway), rather than attempts to change human nature. And the most successful interventions were often “passive” measures (a word coined by Haddon), measures that protected the individual automatically, without any action on his or her part (e.g., collapsible steering columns, air bags).

Most traffic safety interventions in the 1950s were based on “expert opinion”; there was little good scientific information to back them up. High school driver education classes, for example, have long been popular, though we know today that they do not reduce crashes or save lives. However, many states allow teenagers who take these classes to drive at a younger age, when they are at high risk for injury (Robertson 1998). Haddon insisted that the injury field be based less on opinion and more on science. At traffic safety meetings, when supposed experts made assertions, Haddon was known to ask, “Where are the studies?”

Usually there were no scientific studies, and often the assertion was wrong.

Haddon himself undertook many of the early scientific studies in injury prevention. He and his colleagues, for example, were the first to document the large role played by alcohol in fatal highway crashes and pedestrian fatalities (ICADTS Reporter 1999). He also contributed substantially to the methodology of the injury field. For example, some motorists are likely to have more crashes simply because they drive more, on more dangerous streets, or at more dangerous times. Unfortunately there are rarely good data available on such measures of "exposure." Haddon and his colleagues developed a method to control for exposure when it was not possible to actually measure the amount of exposure. For injuries occurring in public settings, Haddon's method was to compare the motorist in a crash to a control population of uninjured persons at the site of the injury event at the same time of day and day of the week.

Haddon was versed in epidemiology, medicine, and engineering. He received his undergraduate degree from MIT and his medical and public health degrees from Harvard. But Haddon was more than a scientist. He also directed major institutions that made important changes. As Ralph Nader said of Haddon, "He connected knowledge to action in the great tradition of preventive medicine. His was a rare combination of being a thinker and a doer" (ICADTS Reporter 1999, 3). As the Johns Hopkins University injury expert Sue Baker (1997, 371) noted, "Haddon set a great example to all of us in passionately fighting to have public policy based on fact rather than myth and guesswork, and to have regulations shaped by public need rather than private profit."

In 1966 Haddon became the first administrator of the National Highway Safety Bureau (now the National Highway Traffic Safety Administration). During his tenure the agency issued the first safety requirements for new vehicles, including requirements for shoulder belts, laminated windshields, energy-absorbing steering columns, and side door beams. Later, almost identical vehicle standards were adopted in Canada, Australia, and a number of countries in Europe (O'Neill 2002). From 1969 to his death in 1985 he served as the president of the Insurance Institute for Highway Safety. With Haddon at the helm, this nonprofit institution, supported entirely by automobile insurance companies, became an internationally known research organization and joined the effort to transform the highway safety field. The institute continues to be a leader in providing unbiased information on motor vehicle safety. Other areas of injury prevention lack such a strong insurance voice. More than anyone else, Bill Haddon "produced or strongly influenced the thinking that is central to understanding of the field" of injury prevention (Robertson 1983, 71).

The contributions of DeHaven, Stapp, Haddon, and others were successful in shifting injury prevention "away from an early, naive preoccupation with distributing educational pamphlets and posters and toward modifying the environments in which injuries occur" (National Committee for Injury Prevention and Control 1989, 7).

1.D. Ralph Nader (1934–)

As a law student at Harvard, Ralph Nader published an article in *The Nation* in 1959 entitled "The Safe Car You Can't Buy." He elaborated on this theme in his 1965 book, *Unsafe at Any Speed: The Designed-in Dangers of the American Automobile*. Using the sporty Corvair as an illustration, the book documented how Detroit subordinated safety to styling.

Although sales of the book were initially modest, General Motors' concern about litigation regarding the Corvair's safety led it to hire private detectives to tail Nader to dig up information that might discredit him. The story broke in the *New Republic*, and Connecticut Senator Abraham Ribicoff's subcommittee (to which Nader had acted as an unpaid advisor) summoned the president of GM, who was forced to apologize publicly to Nader.

This remarkable incident catapulted automobile safety, and Nader, into the public spotlight and sent his book to the top of the best-seller list. Senate hearings in 1966 led to the creation of a new federal agency, the forerunner of the National Highway Traffic Safety Administration, with power to create safety performance standards, conduct investigations, and order recalls. In 1977 Henry Ford conceded on *Meet the Press,* "We wouldn't have the kinds of safety built into automobiles that we have had unless there had been a federal law."

The GM incident ratified a core Nader conviction: that a few people, acting with truth and persistence, could make a difference. Nader was not a one-issue wonder, but built his fame into the largest consumer and citizen movement in American history. Real patriotism, he claimed, was caring enough about your country to get involved and do something to make it more moral and caring. Instead of being an inconsequential private citizen, one should become an engaged "public citizen."

In the late 1960s Nader's advocacy in the injury area helped create federal standards for the safety of natural gas pipelines and radiation limits for microwave ovens, sun lamps, and televisions. Injury prevention, however, has been only one small part of Nader's work to improve society. He has "dedicated his life to good citizenship and showing others how to put democracy into action" (Marcello 2004, xi).

1.E. Seymour Charles (1921–2002) and Robert Sanders (1927–2006)

During one Thanksgiving weekend in the early 1960s a young patient of the pediatrician Seymour Charles was killed in an automobile crash. The child, who had not been restrained by any safety device, had flown through the car window and died instantly. That incident transformed Dr. Charles into a crusader for automobile safety.

After the death Charles attended an automobile safety conference held in Detroit. At the meeting he stood and asked why the engineers were not designing cars to protect the occupants. With the encouragement of Ralph Nader, Charles (with Annemarie Shelness) organized Physicians for Automotive Safety (PAS). In 1965 the group picketed outside the Coliseum in New York City, where automakers were holding their annual new car show. Charles remained the PAS president until it closed shop in 1989.

In the 1960s Charles testified before Congress about car safety and was invited to the White House Rose Garden when President Lyndon Johnson signed the legislation creating the Department of Transportation. Before he died in 2002 Charles received a citation from the American Academy of Pediatrics as the "leading national advocate for child auto safety."

In 1975 Charles's article in the journal *Pediatrics* on children in cars served as a wake-up call for pediatricians and advocates nationwide. That article, and the work of PAS, inspired a Tennessee pediatrician, Robert Sanders, and his wife, Pat, to press for the passage of a state mandatory child restraint law, which was enacted in 1978. By 1985 all fifty states had enacted similar laws.

Sanders headed a Tennessee county health department for over twenty years. A soft-spoken physician, he proved to be a tough, persuasive lobbyist. He believed that car seats were like vaccines in preventing death and injury in highway crashes. A tireless fighter for passenger safety generally, he became known as "Dr. Seatbelt."

In 2006 the Robert Sanders Award was created for Outstanding Public Policy Achievement in Child Passenger Safety. At the ceremony, the General Motors director of auto safety said, "Dr. Sanders was a true pioneer whose legacy is improved safety for generations of the nation's most precious cargo—our children."

1.F. Candy Lightner (1946–)

In 1980 a drunk hit-and-run driver killed Candy Lightner's 13-year-old daughter, Cari, while she was walking in a bicycle lane on her way to a church carnival in suburban Sacramento, California. The driver had four prior arrests for drunk driving; one had occurred two days before the tragedy. For killing Cari he served no jail time, only nine months at a work camp and halfway house. Outraged, Lightner and a group of friends decided to form an organization to lobby for stiffer penalties for drunk drivers. They called their organization Mothers Against Drunk Drivers, or MADD.

Lightner previously was "neither registered to vote, nor able to distinguish Democrat from Republican" (Frantzich 2005, 80), but she quickly became a political force. She sat through court hearings and watched the lenient way the judicial system typically handled drunk driving cases. "One judge said to me: 'If you don't like the law little lady, go and change it,' and I said: 'O.K., I will'" (Creamer 1984). She established a mailing list of parents who had also lost their children to drunk drivers and called for the creation of task forces at all levels of government—local, state, and federal—to investigate the problem.

Lightner asked President Ronald Reagan to create a commission on drunk driving and gathered a hundred people to picket the White House when he didn't respond. This event received such news coverage that California governor Jerry Brown, who had previously been unwilling to meet with her, not only met her but established a governor's task force on the issue. In 1982 President Reagan created a National Commission against Drunk Driving and appointed Lightner to serve on the board of directors.

Through lectures, speeches, published works, and personal appearances Lightner helped create a movement. Only two years after its creation, a national survey found that 84 percent of the U.S. population had heard about MADD. In 1983 NBC produced a television movie about Lightner, and the *Ladies' Home Journal* named her one of the top one hundred women in America.

In 1983 the government reported that 129 new anti–drunk driving laws had been passed that year, and in 1984 President Reagan signed a law raising the federal minimum drinking age to 21. When Lightner left MADD in 1985 it had over 350 local chapters and more than half a million members and donors.

MADD helped to create a sea change in American attitudes and policies concerning drunk driving. The organization works to pass strong anti–drunk driver laws; to ensure strong enforcement of these laws, its volunteers attend drunk driving court cases and report the outcome to the media. MADD deserves much of the credit for the reduction in alcohol-related traffic fatalities in the United States. Between 1982 and 2000 these declined 34 percent, and the percentage of the nation's traffic fatalities that were alcohol-related fell from 60 to 41 (National Highway Traffic Safety Administration 2002).