Chapter 23

The Pre-Crash, Crash, and Post-Crash Parts of the Highway Safety Problem

WILLIAM HADDON, JR.

H IGHWAY CASUALTIES IN THE United States alone are now running at an average daily rate of more than ten thousand injured. Weekly, we average more than one thousand killed. Monthly, identifiable economic losses total about one billion dollars, and the actual figure may be considerably higher. Yearly, the casualties who survive require over eight million days of hospitalization, not to mention the scarce medical resources and care also required.

There are many other measures of the seriousness of this continuing national disaster, a situation that President Johnson, in signing the two Safety Acts in 1966, described as "a raging epidemic."

For decades the scarring of the brain, so frequently caused by impacts of the head with hard structures both in and out of the car, has been a prominent cause of epilepsy in the United States. Extreme facial disfigurement is commonplace. Paraplegia and quadraplegia, as a result of spinal cord damage in crashes, are commonplace. Losses of unborn children, as the result of crashes involving their mothers, and the deaths of infants, children, adults and the elderly accumulate to our total weekly casualties of nearly eighty thousand injured. The more than four million Americans injured each year would easily reach head to toe from the Atlantic to the Pacific.

As the scientific evidence accumulating at an accelerating rate for a quarter century becomes increasingly available, it is clear that these losses have long been, largely unnecessary. That they have continued to occur is the result of our past unwillingness as a society to regard this as a modern problem susceptible of solution rather than as a medieval plague beyond our power of influence. The tables, however, have been shifting at an accelerating rate for more than a quarter of a century.

In 1942, in a discontinued publication called "War Medicine," De Haven published a scientific analysis of a series of cases of workmen and others who had survived falls of up to 150 feet.* He had been curious as to why he, as an Allied pilot during World War I, had survived a serious crash whereas others had been killed in impacts of much less severity. The prob

---

*De Haven, H.: *War medicine,* 2:586-596, 1942 (reprinted with discussion in *Accident Research, Methods and Approaches* by Haddon, W., Jr., Suchman, E.A., and Klein, D.; Harper and Row, New York, 1964).

lem haunted him until, finally, with the beginning of World War II, he set out to learn the answer.

He could not accept, in the face of the discrepancy represented by his own experience, the notion held by everyone else at that time and largely since, that the issue was merely one of preventing crashes or other high-speed decelerations commonly resulting in injury and death. He was starting the ball rolling on a very different view of the entire field; a view that suggested that even in situations where it might not be feasible to prevent a crash it might still be feasible to prevent, completely or largely, the resultant deaths a and injuries.

Many of you know the history of the subsequent work. Small groups of resarchers, working chiefly at the Holloman Air Force Base at Alamogordo, at U.C.L.A., and at Cornell, confirmed and extended De Haven's basic findings and conclusion that the body could survive major impacts, in fact, the overwhelming majority of these now fatal on our highways, if properly packaged.

This was an emphasis on the amelioration or preventing of an end rather than merely concentrating exclusively on the first step which leads to that end result.

It was not a denial of the importance of collision, that is, crash prevention, but rather a long overdue recognition that crash prevention per se was far too narrow an approach to this serious problem to yield the payoffs in prevention of injuries and death and that the end results could be achieved through recognition of the nature of the entire process and of every step that contributes to the damage to be prevented.

This newer approach leads to a broader and systematic emphasis on all of the pieces of the highway safety problem, each of which must be dealt with intensively. It avoids approaches that focus narrowly or in isolation on only single parts of the overall problem and identifies the many different aspects of the situation which offer major opportunities to reduce the casualties we continue to sustain.

Viewed differently, we refuse to place our resources in only one place, since there are many payoffs that can only be recognized and achieved by broader and more balanced emphasis.

How then does one sort out and categorize the pieces of such a complex field?

Briefly, there are three principal parts of the problem: the first, or Precrash Phase, the second, or Crash Phase, and the third, or Post-crash Phase of highway safety.

In the first, or Pre-crash Phase, are active all of the factors, such as drunk-

en driving, blowouts, and the shortcomings of highways that increase the likelihood of crash.

In the second, or Crash Phase, are all of the circumstances, such as spilling out on the road of human cargo, that determine, once a crash has been initiated, whether injuries will be sustained and if so, their nature and severity.

In the third, or Post-crash Phase, are the circumstances, such as improper emergency medical care, that determine the likelihood of the continuing urvival of the survivors.

Corresponding to each contributing cause in each phase are the specific countermeasures that together can reduce the end results of injury and death, our primary objective.

More specifically, and as far as the Pre-crash Phase is concerned, we are dealing in the case of serious collisions with factors such as heavy drinking, alcoholism, and problems in the medical area, many of which, like alcoholism, are of broader base, spilling over to crash initiation. Senility is one of many examples.

The road also contributes to crash initiation, especially through deficiencies in design, maintenance and signing.

Nor is the vehicle absent in contributing to crashes. The evidence is strong that death rates from motor vehicle crashes decrease in association with the institution of vehicle inspection programs. The effect is most pronounced when inspection is introduced, for example, on an annual basis, and increases, though to a lesser extent, when more frequent checks are instituted. With vehicle inspection, crash deaths among those in the lower socioeconomic group decrease the most markedly, as one would predict from their poorer equipment, and deficiencies in maintenance. The usual statistics based on accident investigations, in which no adequate scrutiny of the vehicles involved has been undertaken and which rarely list vehicle factors as contributors, fail to identify these factors to any substantial extent. Stated differently, reductions in death rates associated with vehicle inspection suggest that vehicle factors in crash initiation are more common than many have assumed.

With respect to the second, or Crash Phase, an initial question is how often do vehicles get into trouble sufficient for someone to be injured or killed. As information on the contributions of deficiencies in the vehicle package increasingly came to light during the past decade and a half, some contended that crashes were so rare that it made no sense to anticipate them.

Although precise figures as to the extent to which individual vehicles get into crashes during the period of their use, between their manufacture and junking, are not yet available, information has been available since about

1961 on which to base estimates that are close to the mark. In a paper that Dr. James L. Goddard and I wrote in 1961,* we provided estimates very similar to those now based on much more recent information.

Each year in the United States, about a third of a million Americans are hit by the front ends of passenger cars and other vehicles sufficiently hard so that they are injured or killed. Next time you pass a car, note whether even casual inspection suggests that these impacts have been sufficiently anticipated by the designers by reducing sharp ridges and protrusions. Stated differently, if you knew you were to be struck, what kind of contour would you choose?

Nor are these impacts of such violence that nothing could be done. Since a large fraction occur at low speeds, shifting design can contribute to lessening of human damage. More important, about one vehicle in thirty at sometime during its lifetime hits a pedestrian hard enough to produce injury or death.

With respect to the frequency with which injuries to drivers and passengers occur per vehicle manufactured, the percentages are higher. On the basis of excellent scientific data from the National Health Survey, more than four million men, women and children are injured in motor vehicle crashes of all types each year, the overwhelming majority of whom are drivers and their passengers. Making reasonable assumptions of the type detailed in the 1962 publication by Goddard and myself, at least one in five cars at sometime during its lifetime is involved in a crash in which someone is injured by violent impact with its interior. At present rates, about one vehicle in thirty at some time has pedestrian blood on it, and at least one vehicle in five has the blood of a driver or passenger on it at some time before its junking.

Such routine experience of our tens of millions of present vehicles must be regarded as bankrupting the still heard argument that cars and drivers should not crash, whether through their own shortcomings or as innocent parties, and that, therefore, proper crash design is neither needed nor obligatory.

The inescapable conclusion is that injuries and deaths that occur in crashes can be largely eliminated by proper attention to the crash design of the vehicle and the better packaging of its cargo.

Our society's response to this problem has been very different from its earlier handling of other environmental hazards involving considerably lower risks. As stated in 1962, medical research had shown conclusively that

---

*Goddard, James L., and Haddon, William, Jr.: An introduction to the discussion of the vehicle in relation to highway safety, 1-6. Passenger Car Design and Highway Safety. The Proceedings of a Conference on Research, May 1961, sponsored and published by the Association for the Aid of Crippled Children and Consumers Union of U.S., 1962.

among those ingesting raw polio virus in the days before vaccines, considerably less than one in a thousand developed clinical polio. Similarly, in the days of typhoid and other infectious disease epidemics whose organisms were carried by water, milk, and food, public hazards were considerably less than those posed by the structures of the vehicles on which our society is now based.

Unwillingness as a society to identify and clean up the hazards presented unnecessarily by our vehicles has been inconsistent with our approach to earlier environmental hazards, long since largely eliminated.

In the Crash Phase we are concerned with guaranteeing the integrity of the passenger compartment. The doors should not open with any crash at any speed for which that vehicle is designed, a goal still by no means accomplished. The practice of the last seventy years of designing steering shafts like a spear aimed at the driver's chest is discontinued in favor not only of hardware that does not so behave but, more importantly, with the substitution of energy-absorbing steering assemblies that act like fire nets for deceleration of the driver, rather than the reverse.

The side structures of the passenger compartment must be designed so that on lateral impacts the impinging vehicles do not substantially penetrate the passenger space, a routine occurrence especially in intersection crashes.

Proper crash design also means the construction of the vehicle interior so that to the maximum feasible extent, it cushions the impact of those hitting it.

It means that restraint devices, whether safety belts, or newer innovations, are provided so that the drivers and passengers decelerate with the vehicle and not merely by smashing into its interior.

Beginning development of hardware to support such objectives is now more than a decade in the past. Some results have already reached production vehicles, especially in the 1968 models. In illustration of what can be accomplished through better approaches to occupant packaging, consider three requirements for all vehicles as of January 1st, 1968. First, the energy-absorbing steering assemblies introduced in the passenger cars of three of the four major American companies (fall 1966) are, on the basis of preliminary research by a university medical and engineering group, estimated to be reducing injuries and deaths to drivers by 70 to 80 per cent. Second, the newer laminated windshields introduced on American cars in the fall of 1965, after prolonged research and development work, are similarly estimated to be reducing injuries to a comparable extent among those impacting them. Third, recent Swedish research demonstrates clearly that reductions as high as 80 per cent in deaths of drivers and passengers can be achieved through safety belts which in addition to restraining the pelvis and preventing ejection, also prevent the upper torso from smashing forward,

like an upside down pendulum into the structures in front of the face and head. Such belts are mandatory in all vehicles manufactured for the United States market after December 31, 1967.

Crash design of the vehicle is not the only Crash Phase consideration. It is essential that far more attention be paid to crash design of our highways. Thousands are killed each year because of deficiencies in highway crash design, especially on high-volume, high-speed roads.

Here, as the recent hearings of the Special Subcommittee of the House Committee on Public Works, under chairmanship of Congressman Blatnik, documented, the issue is whether provision has been made systematically for the crashes which will continue to occur on such roads.

One can calculate for specific locations, the probability that a given pole, bridge pillar, concrete structure, or ditch will be similarly involved. Unless structures along such roads are either removed, surrounded by appropriate guard rails (not guard rails with spear-like ends which effectively skewer so many cars) or provided with support poles to break away gently rather than to kill, many unnecessary injuries and deaths will continue to occur for these reasons. To list another example, unless we recognize that narrow grass strips have insufficient influence on vehicles crashing across them at high speeds, many unnecessary deaths in head-on collisions that could be prevented by appropriate guard-rail placement and design will also add to the millions of casualties. Here, too, developments over several years have resulted in substantial improvements. Present work of state highway officials, in cooperation with the Federal Highway Administration and other groups, is evolving highway crash design that will greatly reduce these problems.

In the third, or Post-crash Phase, we are concerned with saving those who need not die, and reducing hospitalization, permanent disability and unnecessary death. We do not know how many die needlessly because of deficiencies in emergency systems, but they undoubtedly number tens of thousands a year in the United States. In most parts of the country there has been no adequate advance planning of emergency communications and transportation.

Ambulance attendants and drivers commonly are not required to know first aid. Requirements for equipment are frequently nonexistent. Generally there are no regulations of areas, rapidity of response, or routing to give certain injuries to hospitals specialized in their handling.

The situation has been well summarized by two recent reports, the first by Colonel Louis C. Kossuth, USAF, as recently published in the Traffic Safety Research Review.*

---

*Kossuth, Louis C., Colonel, USAF: A survey of emergency ambulance service. Traffic Safety Research Review, 67 (9) 73-74, September 1967.

The abstract reads

"A survey of 133 cities and towns revealed that no agency controlled the establishment of ambulance services in 38 percent; less than 60 percent of the towns specified first aid equipment for ambulances; requirements for ambulance attendant training are questionably adequate; and that periodic inspection adequacy of ambulance services is not required in the majority of towns. Seventysix percent of the replies indicated that they knew of no specific training for the removal of injured personnel from wrecked vehicles."

The second report (1966) from the National Academy of Sciences, National Research Council, reads in part:

"The general public is insensitive to the magnitude of the problem of accidental death and injury.

Millions lack instruction in basic first aid.

Few are adequately trained in the advanced techniques of cardiopulmonary rescuscitation, child birth, or other life saving measures, yet every ambulance and rescue squad attendant, policeman, fire fighter, paramedical worker and worker in high-risk industry should be trained.

Local political authorities have neglected their responsibility to provide optimal emergency medical services.

Data are lacking on which to determine the number of individuals whose lives are lost or injuries are compounded by misguided attempts at rescue or first aid, absence of physician at scene of injury, unsuitable ambulances with inadequate equipment and untrained attendants, lack of traffic control, or the lack of voice communication facilities.

Helicopter ambulances have not been adapted to civilian peacetime needs.

Emergency departments of hospitals are overcrowded, some are archaic and there are no systematic surveys on which to base requirements for space, equipment or staffing for present, let alone future, needs.

Fundamental research in shock and trauma is inadequately supported.

Medical and health-related organizations have failed to join forces to apply knowledge already available to advance the treatment of trauma, or to educate the public and inform the Congress."

The situation is particularly tragic since we have demonstrated far more modern techniques under military conditions with greater saving of the seriously injured. With the more stable logistical requirements of the civilian scene we should be able to do as well. Yet how many viewing the television pictures of superbly trained medical corpsmen and helicopter evacuation of the injured stop to think about the presence and potential of such approaches in response to our highway injured here at home?

This has been a brief introduction to many points of attack in the three

---

*Committee on Trauma and Committee on Shock, Division of Medical Sciences, National Academy of Sciences, National Research Council, Accidental Death and Disability: The Neglected Disease of Modern Society. Washington, D.C., 1966, 38 pp.

phases of the sequences of events that lead up to our more than ten thousand highway casualties per day.

Since the first activity called for by the two Safety Acts passed in 1966, which began to be implemented with their first funding in November 1966, many programs have been undertaken in virtually all aspects of this problem. These activities include the continuing process of Federal rule-making steps leading to standards for motor vehicles and motor vehicle equipment, and the setting of standards for state programs, the first group of which were promulgated by Secretary Boyd, June 1967. Within our limited resources, we have had under way since spring 1967 a large-scale research program where much better scientific information is needed.

Examples in the Pre-crash Phase are standards, issued months ago, dealing with truck lighting, standards with respect to implied consent legislation, and the collection of far better data on the role of alcohol in highway crashes. Additional examples are concerned with periodic examination of drivers, tighter licensing requirements, and vehicle braking systems.

In the second, or Crash Phase, are standards for energy-absorbing steering assemblies, safety belts, windshields, crash design of the highway, strength of door locks, and latches, and helmets for motorcyclists.

In the Post-crash Phase, standards include upgrading of state and community emergency systems, requirements for the qualifications of attendants and other personnel, and fuel tank specifications to remove the likelihood of fuel spillage and fire after crashes.

General standards, previously issued, deal with aspects such as record systems and related issues to provide necessary support for the quantitative rather than speculative identification of problems, and program management.

The initially slow, but increasingly accelerated, scientific, governmental and private attention to problems of highway safety that began in the 1940's is progressing now at a more rapid rate and we are pushing this process. We have made a great deal of progress during past months and our programs are moving well, especially considering our limited resources.

The states have joined enthusiastically in pushing their own parts of the overall approach and more than twenty-five have passed enabling legislation, not to mention scores of other relevant legislations, during the sessions just ended. This initiative on the parts of so many states is particularly impressive in light of the Highway Safety Act of 1966, which grants over a year before requiring "implementing of programs in accordance with Federal standards."

Vehicle design is also evolving more rapidly, and the developments in the pipeline for 1969 and 1970 models will result in substantial, further advances.

Highway crash design is also evolving. The death rates have broken their years long rise in recent months. Everyone, however, still has a great deal to do to build for the immediate and long-term safety of the American public. This is a job for all levels of government, private organizations, and universities. It is not a job which will be accomplished overnight or cheaply. But, we are under way, and the results, though early, are already beginning to show.