the highway
loss reduction

STATUS REPORT

INSURANCE INSTITUTE
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Motor Vehicle Related

'The Costs Of Spinal Cord Injuries'

The Insurance Institute for Highway Safety today released, in book form, a ground-breaking study that identifies and describes the huge, measurable direct and indirect losses – both to society as a whole and to the individual people damaged – of the thousands of spinal cord injuries produced annually in motor vehicle crashes. Such injuries often result in lifelong paraplegia or quadriplegia.

The study, ***The Costs of Motor Vehicle Related Spinal Cord Injuries****, was prepared by Charles N. Smart and Claudia R. Sanders of Policy Analysis, Inc., Boston, an organization that specializes in health economics. The study was sponsored by IIHS.*

"Recognition of the sizes of these costs should be an important consideration in reaching the decisions that would help reduce the severity and frequency of such injuries and, thereby, the human and economic waste they generate," William Haddon, Jr., M.D., president of the Institute, said in announcing the book's release.

Following are the foreword to the book and its summary of the study's comprehensive findings, together with explanatory charts.

Foreword

Our brains maintain most of their communications with the rest of our bodies through the thousands of tiny circuits contained in our spinal cords. Many of these circuits carry incoming sensory information that lets us know how our bodies feel, what postures they are in, and whether they are operating properly: Many other circuits carry outgoing, "motor" information by which we signal our bodies what to do, such as which muscles to relax, and which to contract. It is small wonder that injuries to this remarkable communications pathway are among the most devastating that we can sustain, especially since most are permanent, being repairable neither by our bodies themselves, nor by the most advanced medical science of our day.

(Cont'd page 2)

Five-Year Study Of Spinal Cord Injuries—Page 7

Physicians and others who care for persons with paraplegias and similar results of damage to the spinal cord have known for decades that large proportions of such injuries are produced in motor vehicle crashes, a fact which has not, however, been widely appreciated outside the medical community. Moreover, although improving greatly in recent decades, statistical information concerning many aspects of this field has remained inadequate, especially from the standpoint of its suitability for use as the basis of governmental and private decisions related both to the allocation of relevant resources and to the actions, such as requiring better vehicle "crashworthiness," which would decrease the number of new cases.

Since we in the Insurance Institute for Highway Safety work to identify the kinds of losses that burden the public as a result of motor vehicle use, and the steps that can be taken to reduce their frequency, severity and cost, it was logical for us to address the spinal cord injury problem, and in ways that would build on and augment the extensive work already done in the United States and other countries. Consequently, in 1971, we first arranged with the Departments of Community Health and Orthopaedic Surgery, School of Medicine, University of California, Davis, to marshal all practical resources to determine the incidence, sources, and many other characteristics of new spinal cord cases in 18 contiguous but highly diverse northern California counties with a combined population of nearly six million people.

This has resulted in an increasing number of important additions to knowledge in this field, the reports of which are identified in the Selected Bibliography of this volume. Especially noteworthy are rates

Single copies of the book are available by writing for "Spinal Cord Injuries," Insurance Institute for Highway Safety, Watergate Six Hundred, Washington, D.C. 20037.

of occurrence of spinal cord injuries per capita by age and sex, counting both those who reach hospital care alive *and* the many who die before such care is reached. The California work also confirmed that the spinal cord injuries produced in motor vehicle crashes do indeed far outnumber those produced in any other way, a pattern that holds among both males and females of all ages.

Among the many additional results of this work to date are detailed data on survival. These confirm that spinal cord injury patients who survive the early post-injury period may be expected, typically, to survive for many years. As is well known to specialists, this reflects the great advances made in recent decades in the care of persons with such injuries, and especially in the prevention and treatment of infection.

When the results of the work in California were sufficiently available, we next contracted with Policy Analysis, Incorporated, an organization specializing in health economics, to estimate the losses our society sustains each year from the spinal cord injuries produced in motor vehicle crashes, both in relation to individual cases and in relation to all cases combined. The resultant estimates have used both conservatively modified data from the California work and the best information that could be obtained from the many other specialized sources.

The conclusions are staggering.

Each year the spinal cords of some five thousand three hundred Americans are severed, crushed, or otherwise seriously injured in motor vehicle crashes. Of these damaged people, two-thirds are less than thirty-six years of age, and more than two-thirds are male. (See figure, page 6.) A large majority, more than six out of ten, do not die, but only a small minority of these ever functionally recover. Most, some *two thousand six hundred each year,* further increase the already huge number of other Americans with similar injuries. The process continues year after year.

Yet from an economic standpoint, it is noteworthy that the costs of this damage to people remain largely external to the balance sheets of many whose actions, of both commission and omission, substantially influence the numbers of Americans whose spinal cords will be injured in some of the millions of motor vehicle crashes that occur, for all sorts of reasons, in the United States each year. Such costs cannot, therefore, be expected to directly produce, through the medium of balance sheets, much corrective, dampening influence on the occurrence of such injuries.

In illustration, when an intersection or curve is designed and built in such a way that serious crashes are produced, those responsible only rarely suffer an economic penalty. The situation is the same in the case of organizations and individuals that line roads with utility poles (which would be recognized instantly as likely to produce very serious injuries if placed closely along runways for aircraft) that each year convert thousands of off-the-road mishaps from minor events into disasters. Similarly, manufacturers of motor vehicles suffer no substantial penalty from an economic standpoint when they do not provide the greatly improved levels of automatic crash injury protection that have long been practical. Analogous points can be made concerning many others whose actions either needlessly augment, or fail to help reduce, such injuries among vehicle occupants, pedestrians, cyclists and other travelers.

Among its many analyses and conclusions, this work very strongly supports the longstanding emphasis of specialists on bringing persons with spinal cord injuries very early into thoroughly modern centers specializing in the expert care and rehabilitation of such cases. It is well known that patients in these centers do far better, and are more likely to receive and profit from suitable rehabilitative therapy. Moreover, since the authors believe that such care is probably less costly in the long run, and find that a substantial fraction of the societal cost is in foregone productivity, such handling has very strong economic as well as humanitarian justification.

The authors of this report have made a major contribution to knowledge of the human tragedy of spinal cord injuries. Let us hope that it will aid in bringing the forces to bear that will both greatly reduce the incidence of such injuries and improve the care and rehabilitation of those that still cannot be prevented.

William Haddon, Jr., M.D.
President
Insurance Institute for Highway Safety
Washington, D.C.

Summary

Spinal cord injury (SCI) provides a graphic example of a low incidence catastrophic disease resulting in extreme physical and emotional deprivation to the afflicted individual. From an economic perspective it also accounts for unusually large direct and indirect costs that must be borne both by the individual and by society in general. Typical SCI patients may be expected to generate high initial hospitalization costs, often followed by substantial annual maintenance charges that continue over their remaining lifetimes. While forced to cope with new physical limitations, the spinal cord injured may also have to accept social and vocational constraints that will radically change and, perhaps, seriously limit their former contribution to society as homemakers, students, or productive members of the labor force.

MOTOR VEHICLE INJURIES

Approximately *50 percent of the spinal cord injuries suffered annually in the United States occur in motor vehicle crashes,* making this by far the principal source of such injuries. The purpose of the analysis

described in this report was to estimate the annual incidence of SCI occurring as a result of motor vehicle crashes for a recent year (1974) and to project both the total direct and indirect costs associated with those injuries. The findings of the analysis provide valuable insights into the dimensions of this aspect of motor vehicle crashes.

In 1974, an estimated *5,315 spinal cord injuries occurred in motor vehicle crashes in the United States;* this corresponds to an average annual incidence rate of 25.1 per million population. Of the 5,315 SCI cases, 1,938 were classified as dead either at the crash scene or upon arrival at an emergency medical facility (DOA), while the remaining 3,377 survived to hospital admission.

HOSPITAL ADMISSIONS

The 3,377 hospital admissions were subclassified into the following impairment categories: 1,091 quadriplegics with permanent impairment, including both complete and incomplete lesions; 1,501 paraplegics with permanent impairment, including both complete and incomplete lesions; 447 in-hospital fatalities; and 338 patients who were functionally recovered at discharge.

TABLE 27
Summary of Total Expected Societal Costs of Motor Vehicle Related SCI: United States, 1974

Cost Category	Present Value of Societal Costs* Discounted at 6 Percent	Discounted at 10 Percent
Direct Costs:		
Initial Hospitalization	$ 69,578,460	$ 69,578,460
Institutional and Attendant Care	66,761,170	47,144,840
Rehospitalization	45,543,930	31,648,020
Drugs and Medical Supplies	26,352,440	18,065,240
Miscellaneous Services	15,759,010	10,760,180
Home Modifications	9,892,260	9,892,260
Medical Equipment and Appliances	8,950,410	6,158,100
Vocational Rehabilitation	3,703,870	3,569,200
Emergency Assistance	2,087,240	2,087,240
Subtotal	$248,628,790	$198,903,540
Indirect Costs:		
Foregone Productivity	$558,399,440	$340,366,370
Legal and Court Services	15,581,220	15,581,220
Insurance Administration	4,848,270	3,878,640
Subtotal	$578,828,930	$359,826,230
Total Societal Costs	$827,457,720	$558,729,770
Number of Patients	5,315	5,315
Average Cost Per Patient	$155,680	$105,120

*Costs are in 1974 dollars.

SOCIETAL COSTS

Table 27 provides a summary overview of the total societal costs resulting from the 5,315 SCI cases. The present value of *total expected societal costs was approximately $828 million at a 6 percent discount rate and $559 million at a 10 percent rate.* Table 28 summarizes the average societal costs per case, both for the 5,315 SCI cases and for the 2,592 permanently impaired survivors. The relatively high value obtained for overall societal costs compared to the relatively low number of patients in the incidence sample generating these costs emphasizes the enormity of the expected costs associated with an individual occurrence of spinal cord injury – approximately $156,000 at 6 percent and $105,000 at 10 percent.

DIRECT COSTS

The direct costs of SCI include a variety of treatment expenditures paid for by the patient, the patient's family, and in many cases by third party reimbursement agencies. Direct costs analyzed in this report include the costs of emergency assistance following the crash, initial hospitalization, home modifications, vocational rehabilitation, institutional and attendant care, medical equipment and appliances, special drugs and medical supplies, rehospitalization care, and miscellaneous services and supplies. For 1974, the estimated present value of these direct costs measured over lifetimes of all patients was approximately $249 million, based on a 6 percent discount rate and $199 million at a 10 percent rate. This translates into an average cost per patient of $47,000 at 6 percent and $37,000 at 10 percent.

INDIRECT COSTS

The indirect costs of SCI are not directly tied to the treatment of the injury but are related nevertheless to its occurrence. As a proportion of total societal costs, indirect costs dramatically outrank

TABLE 28
Summary of Average Societal Costs Per Patient of Motor Vehicle Related SCI: United States, 1974

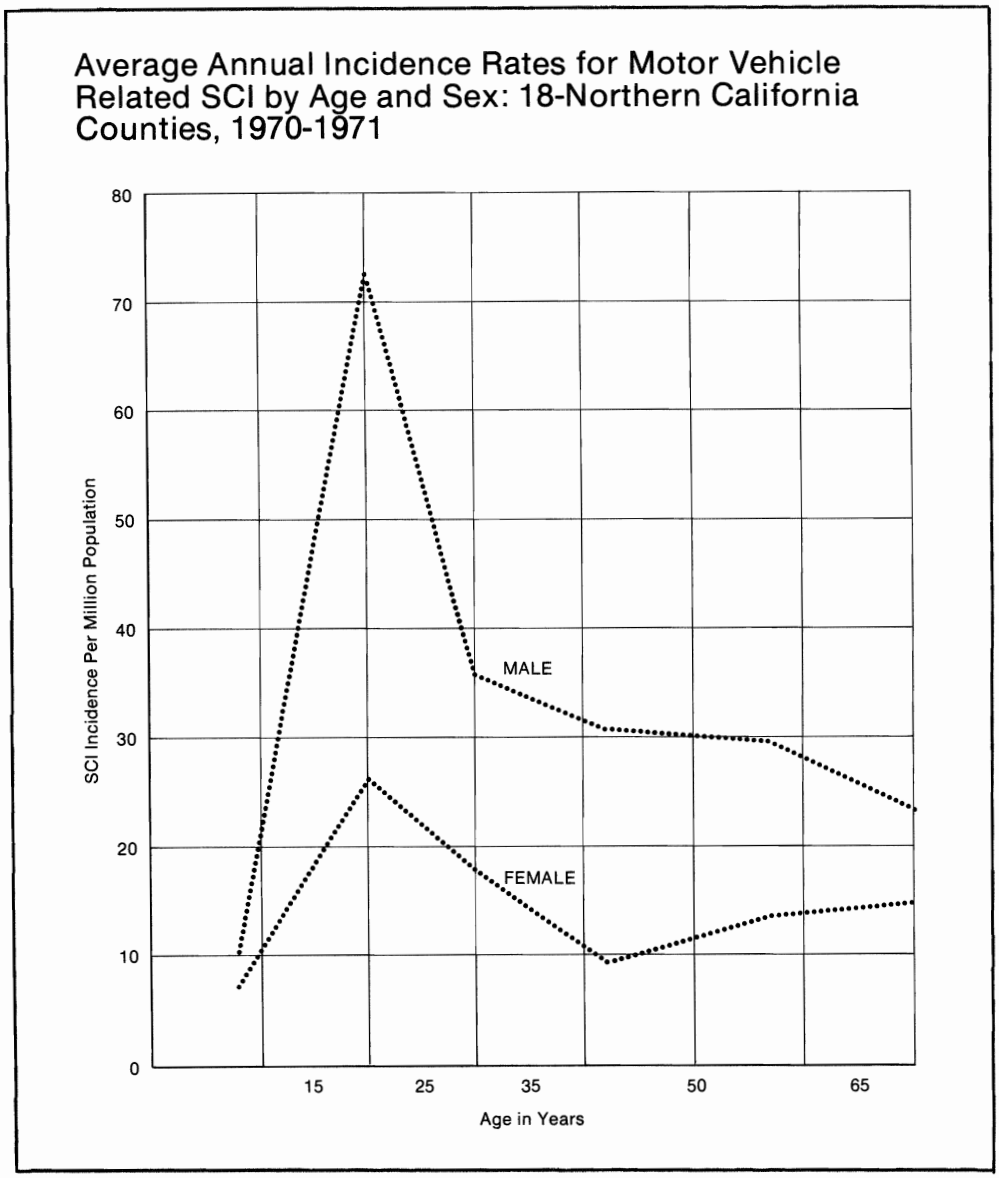
Cost Category	Present Value of Societal Costs*	
	Discounted at 6 Percent	Discounted at 10 Percent
Number of Patients	5,315	5,315
Average Direct Costs Per Patient	$ 46,780	$ 37,420
Average Indirect Costs Per Patient	$108,900	$ 67,700
Average Total Societal Costs Per Patient	$155,680	$105,120
Number of Permanently Impaired Patients	2,592	2,592
Average Direct Costs Per Permanently Impaired Patient	$ 92,410	$ 73,230
Average Indirect Costs Per Permanently Impaired Patient	$ 88,910	$ 57,710
Average Total Societal Costs Per Permanently Impaired Patient	$181,320	$130,940

*Costs are in 1974 dollars.

direct costs. Furthermore, the overwhelming majority of indirect costs consists of losses attributable to the net foregone productivity of SCI patients. For 1974, the estimated present value of these indirect costs was approximately $579 million when discounted at 6 percent and $360 million at 10 percent. This corresponds to an average loss of about $109,000 per patient at 6 percent and $68,000 at 10 percent.

DEMOGRAPHIC TRENDS

Several demographic trends common to SCI populations were reflected in the 1974 motor vehicle crash group. *Males predominated over females in the ratio of 2.2 to 1.* Approximately 55 percent of the injured were between the ages of 16 and 35 while this age group comprises only 32 percent of the general population. This emphasizes the *disproportionately high SCI incidence rates among young people.* The economic ramifications of high incidence rates among young people in general, and males in particular, are significant. (See figure below.) Since the expected lifetime costs of SCI are strongly influenced by both the direct and indirect costs accruing to the patient during the years following onset of injury, younger patients with relatively longer life expectancies may be expected to generate larger societal costs. In addition, for the indirect costs due to a patient's foregone productivity, the average male currently accounts for a far greater loss than the corresponding female.



PATIENT MORTALITY

In general, patients with spinal cord injuries have higher mortality rates and, hence, lower average life expectancies than individuals of similar age and sex in the general population. The reasons for the patients' increased mortality lies primarily in their greater susceptibility to complications such as urinary tract infections and decubitus ulcers that can lead to more serious complications and death. Not surprisingly, patients with more severe impairments such as complete quadriplegia are found to have average life expectancies that are noticeably lower than those of members of the general population of equivalent age and sex. Even in the case of paraplegics, a less severely injured group, the life expectancies remain lower than those of the general population.

The reduction in value of life expectancies has both human and economic consequences. From a human perspective, the increased likelihood of premature death and the unpleasant medical complications leading to death constitute a tremendous physical and emotional burden for the patient and his family. From an economic standpoint, the decrease in life expectancy reduces the span of time over which many injury related costs may accrue and certain costs, such as those associated with expected foregone productivity, may be recouped.

THE PERMANENTLY IMPAIRED

In the assessment of total direct costs, the contribution made by permanently impaired quadriplegics and paraplegics assumes great significance since these patients generated close to 95 percent of all such costs. When the approximately 5 percent of overall direct costs generated by DOAs, in-hospital fatalities, and the functionally recovered is excluded, permanently impaired SCI patients average about $92,400 per patient in direct costs discounted at 6 percent, compared to $47,000 for the complete sample.

It is important to recognize that some indirect costs of spinal injury that are conceptually important, such as those associated with the pain and emotional suffering experienced by the patient and the patient's family, are not measured in the analysis. Furthermore, the information base used to estimate both direct and indirect costs included in the analysis was limited and tended to yield conservative approximations of these costs. Hence, from a cost-benefit perspective, the cost estimates presented in this study, although very large, should be considered as only first order approximations of the total economic benefits that could be obtained by reducing the magnitude, severity and consequences of motor vehicle related spinal cord injuries.

Spinal Cord Study

Survival Rates For Injured Determined

"Almost half of the persons experiencing traumatic spinal cord injury were alive 4-5 years later," according to a five-year California study.

And, it said, of those who survived at least 24 hours, 84 percent survived 4-5 years. "Survival following an acute spinal cord injury depends on many factors including patient age, extent and location of spinal-cord lesion(s), extent and severity of other injuries, availability and adequacy of emergency and primary treatment, and the nature of medical complications," according to the study.

The work was conducted by community health researchers and physicians at the University of California at Davis. It is the continuation of research begun in 1970-71 on the incidence of spinal cord

injuries. (See *Status Report,* Vol. 9, No. 19, Oct. 29, 1974.) Both the original work and the follow-up were supported by the Insurance Institute for Highway Safety.

The researchers followed the medical and death records of 619 persons suffering spinal cord injuries in 18 northern California counties in 1970 and 1971.

"Slightly more than 27 percent died within the first hour. Within the first 24 hours 39.8 percent died from their injuries, and at four years after the time of the injury 50.2 percent had died," the researchers reported.

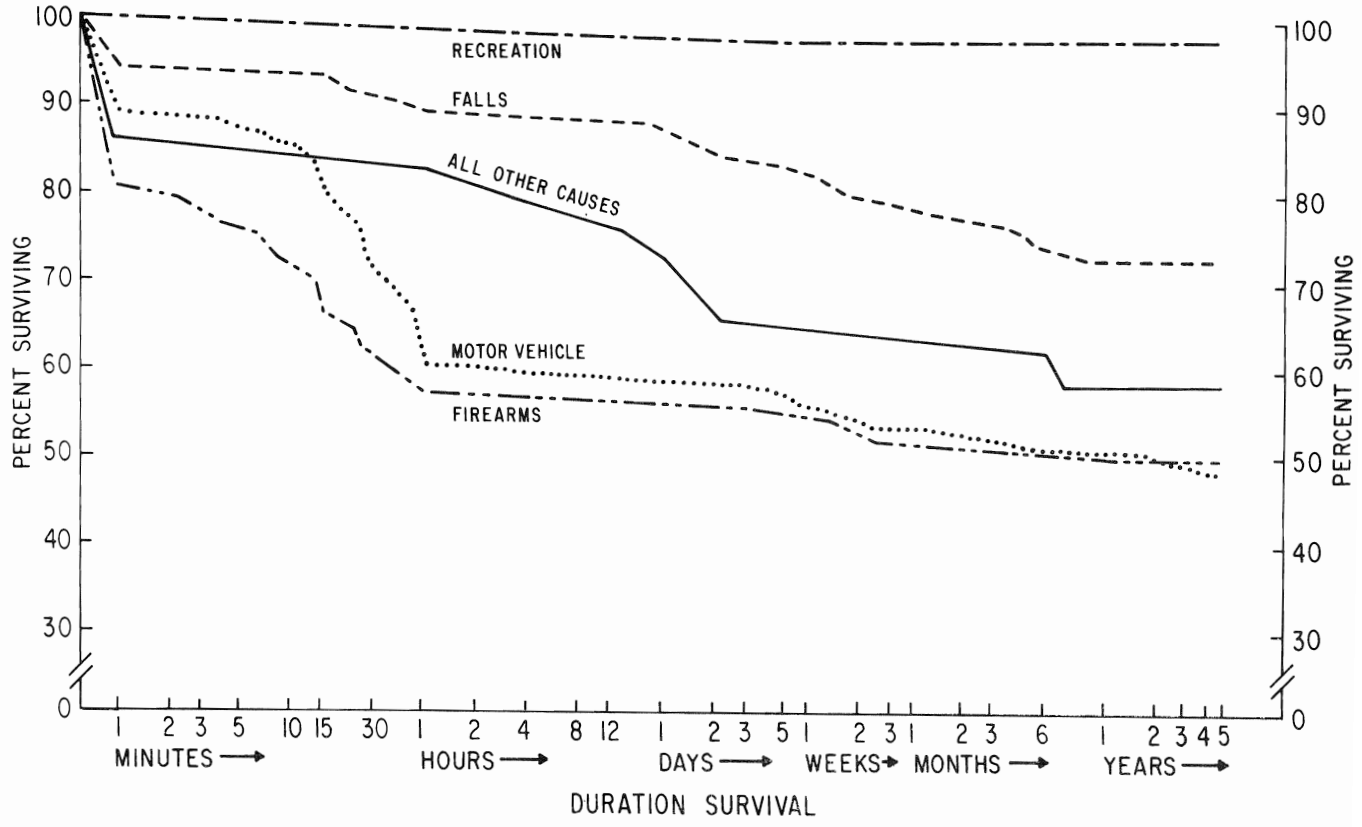
Persons suffering spinal cord lesions had differing survival rates depending on the cause of the injury. The first figure shows that individuals injured in motor vehicle crashes or by gunshot wounds had poorer chances of survival than those injured in falls or in recreational incidents (primarily diving).

Figure 2 shows the survival rates of individuals who suffered "massive multiple trauma" in addition to their spinal cord injuries. The authors of the study defined massive multiple trauma as "extensive serious damage to multiple body parts, as in crushing injuries."

In discussing motor vehicle related injuries, the researchers said that the relatively poor survival rates of these individuals "suggest that they may have sustained more severe injuries from a greater amount of

Figure 1

PERCENTAGE SURVIVAL FOR PERSONS WITH AN ACUTE SPINAL CORD LESION ACCORDING TO EXTERNAL CAUSE OF INJURY



energy delivered in more concentrated fashion. The range of forces generated in motor vehicle impacts is considerable for various kinds of motor vehicle collisions. For example, impact by an automobile to a pedestrian can deliver extensive damaging forces to a whole body area as well as the damage from secondary impacts with the ground. On the other hand, occupants in a motor vehicle may sustain fewer and/or less extensive injuries because of the lesser energy exchange resulting from the 'packinging' of occupants within the vehicle."

Survival rates for individuals in motor vehicle crashes were also compared by the type of crash. (Figure 3 indicates the poor survival rates for pedestrians.)

The researchers also found that the survival rates differed according to age. (Figure 4 shows this comparison.) The authors state that, with the exception of those less than 15 years of age, the younger the person, the greater were the chances of surviving more than four years.

Authors of the study, *Survival Among Persons Sustaining Acute Spinal Cord Injury*, are Jess Kraus, Charles Franti, Richard Riggins and Nemat Borhani. The paper was presented at a recent meeting of the American Public Health Association. Single copies can be obtained by writing "Survival Rates For SCI," Insurance Institute for Highway Safety, Watergate Six Hundred, Washington, D.C. 20037.

Figure 2

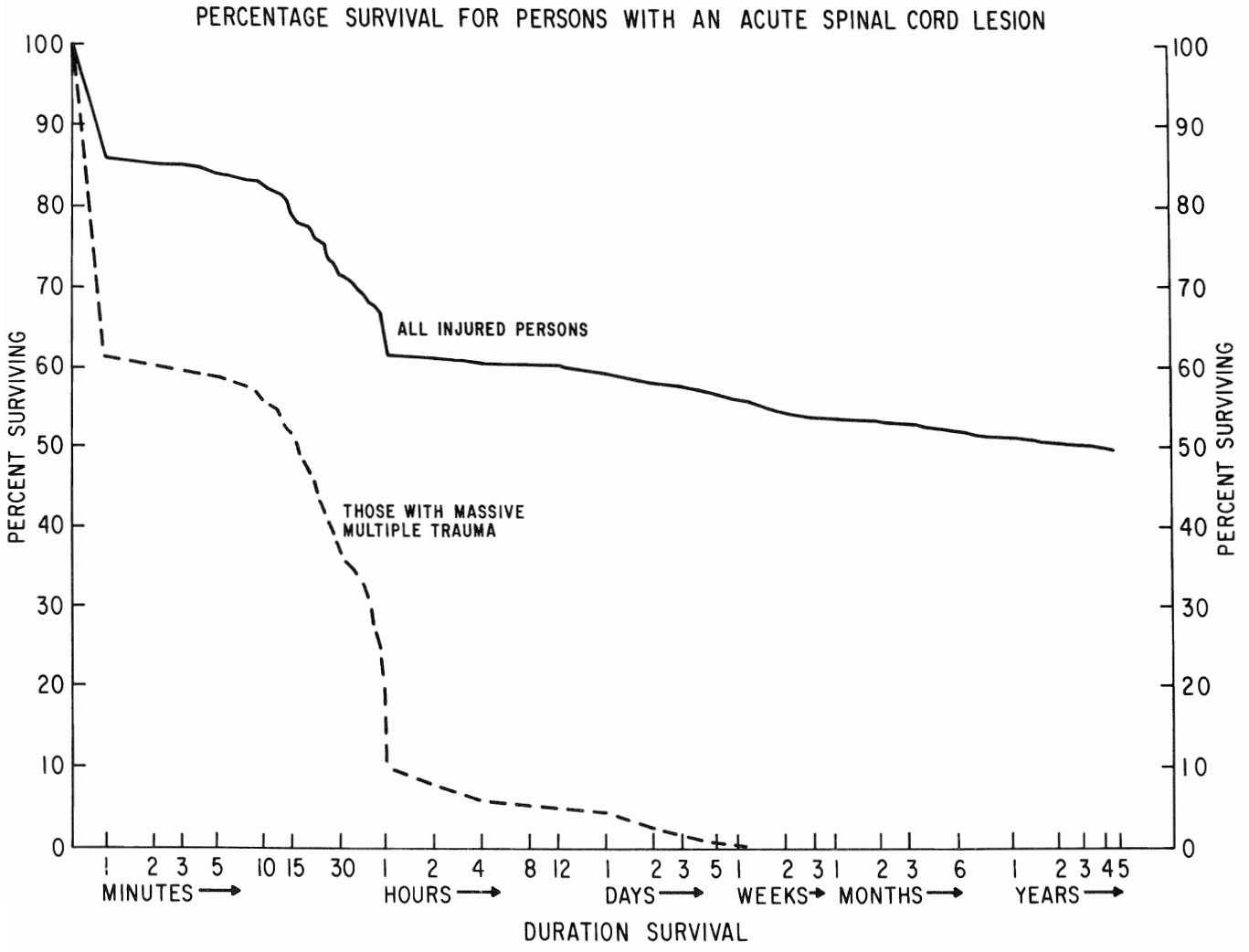


Figure 3

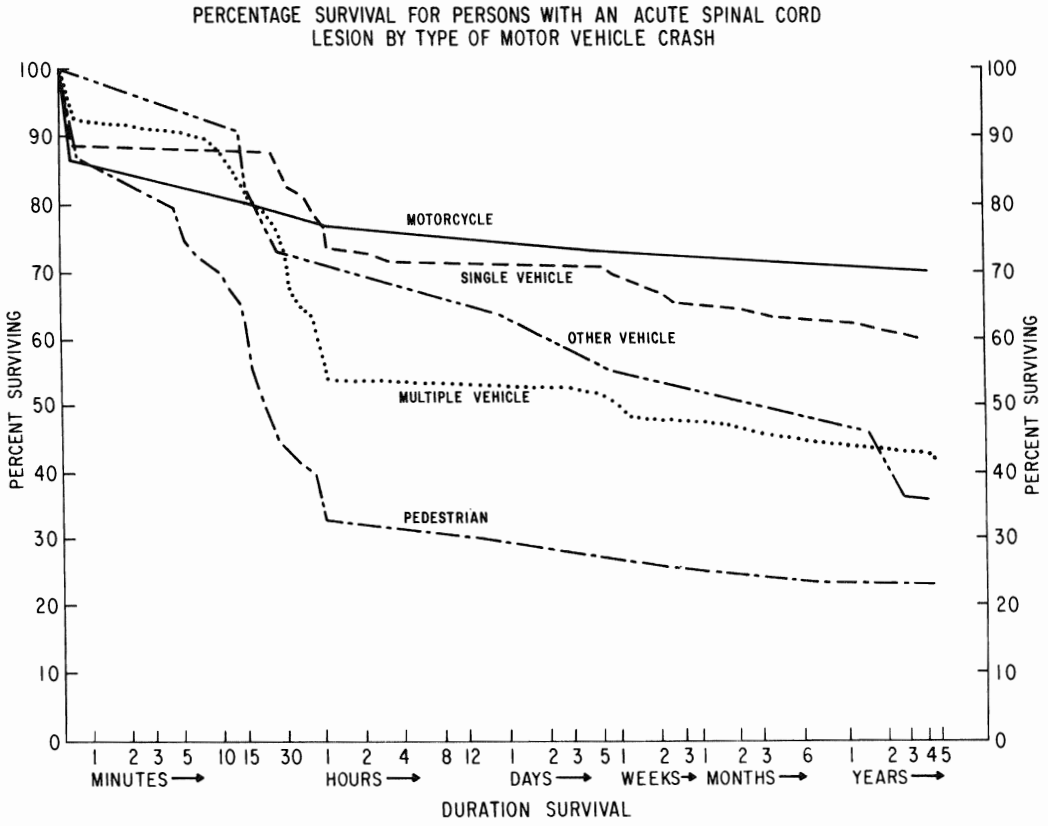
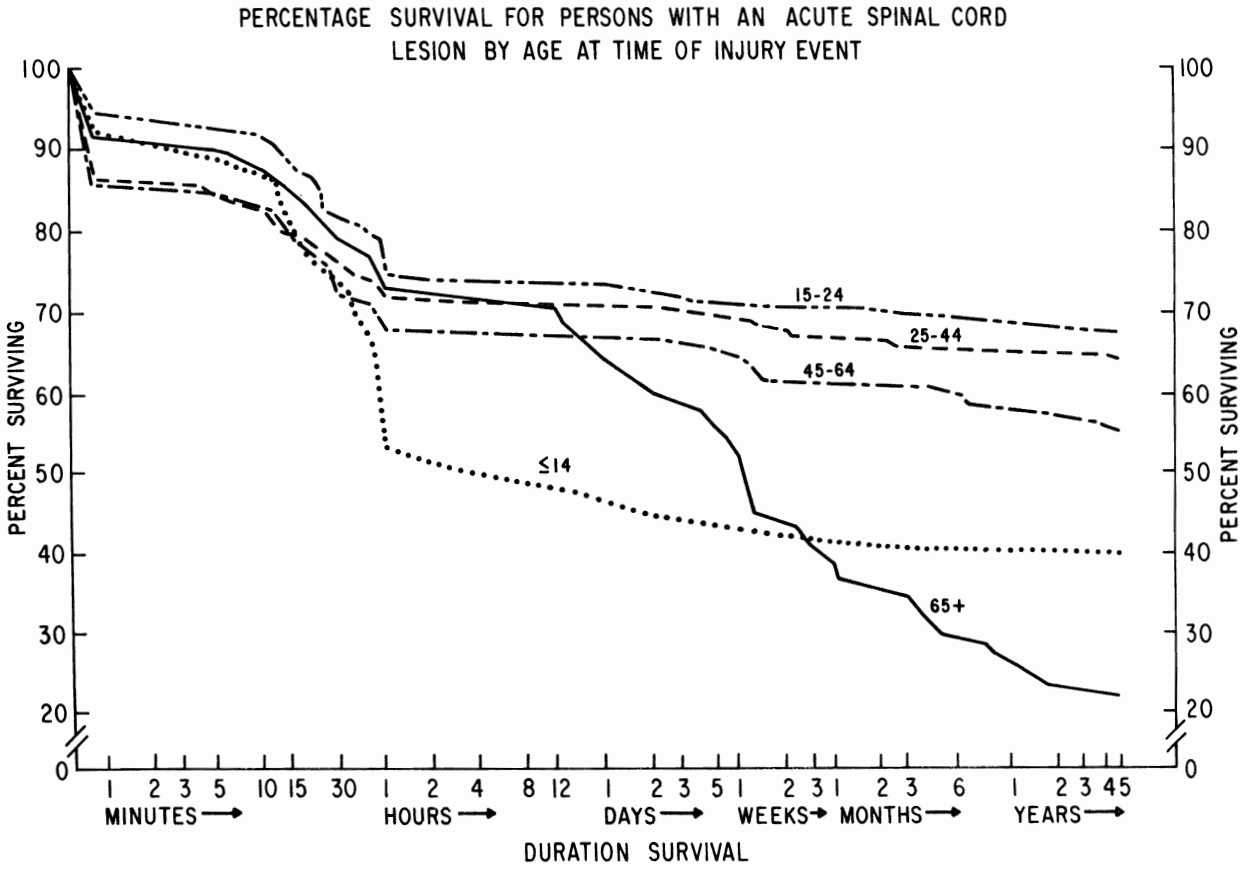


Figure 4



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Investigating Free-Fall Impacts

In 1598 five Spanish soldiers in Acoma, New Mexico, were trapped atop a 400-foot cliff by some 1,000 Indians. The soldiers leaped from the cliff into sand dunes, and four of the five survived the fall.

That free-fall incident, possibly the first recorded in American history, is mentioned by Gaspar Perez de Villagra in his *History of New Mexico* (1933).

The moral of the story depends upon one's point of view. Don't stir up the natives? Make sure your cliffs have adjoining sand dunes? Don't believe everything you read in history books?

Anyway, if Dr. Richard G. Snyder and David R. Foust of HSRI had been conducting their study of free-fall impacts in 1598, they would have heard about the case. One of them would have gone to New Mexico to question the survivors and witnesses, obtain detailed information on the impact injuries, inspect and measure the site, and collect all data useful for reconstructing the falls and impacts, so that they could later be modeled mathematically at the HSRI labs in Ann Arbor.

Dr. Snyder, U-M Professor of Anthropology and Head of the Biomedical Department of HSRI, has been conducting such a study of human impact tolerances since the fall of 1975, under sponsorship of the Insurance Institute for Highway Safety. The objective of the project is to collect precise and reliable data on human tolerances to severe impacts, with emphasis on cases involving infants, small children, females, and elderly persons. Virtually no data on impact tolerances of these segments of the population have been available, and such information is urgently needed by researchers concerned with developing better means of protecting occupants in crashes of automobiles, buses, subway and railroad cars, aircraft, and other transportation vehicles.

Every day in the U.S., dozens of people fall from various heights and hit various surfaces — concrete, asphalt, soil, water, snow, car roofs, etc. The HSRI research team learns of these cases through newspaper clippings and a network of private sources. Potential cases for investigatior are selected according to whether they can contribute significantly to the data base. Then Professor Snyder or David Foust, a bioengineer, go to the site to establish if the fall was a free-fall, the impact surface is definable, and important details of the case can be determined. If so, the case is investigated in depth.

While the investigative area is concentrated within a 600-mile radius of Ann Arbor, the team has investigated cases in 22 states, including Florida, Georgia, Iowa, Colorado, Arizona, and California, as well as in the Provinces of Ontario, British Columbia, and Quebec. In related work, the team has been conducting drop tests in the HSRI laboratories, using the HSRI anthropormorphic dummy equipped with triaxial accelerometers in its head, torso, and pelvis, and load cells in each femur.

Several of the free-fall case investigations have shown, not surprisingly, that car roofs cushion impacts. In one case a 30-year-old male survived a fall of 166 feet from a window of a tall building to the vinyl-clad roof of an automobile. His impact velocity was calculated to be 95 ft/sec. His injuries were serious but non-critical. In another case, a window washer fell 144 feet to the roof of a car (illegally parked) and suffered only minor injuries.

It is a long and complex route from investigation and collection of free-fall impact data to lab simulations, improvement of anthropomorphic dummies, experimental impact tests with dummies and cadavers, development of new protective materials and devices, and their incorporation in transportation vehicles. Yet the end results of the process depend on the quality of data obtained concerning the types and durations of impact forces the human body can tolerate. This is the kind of unique information the HSRI team is obtaining in its free-fall study. Survivors of a 1984 monorail accident in Los Angeles or an automobile crash in Kansas City will most likely not be aware that their survival will have been partly the result of the work Professor Snyder and his team were doing in the 1970's. But their survival, not their awareness, is what is important.

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