LEON S. ROBERTSON

INJURIES

Causes, Control Strategies, and Public Policy

An Insurance Institute for Highway Safety Book

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Injuries

Causes, Control Strategies, and Public Policy

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To the memory of
Louis E. Dotson,
mentor and friend

Preface

Writing a book is easy at the start, painful by the middle, and exhilarating after the finish. In this case, the euphoria is tempered by the realization that we have a long way to go to reach our goal of controlling injuries. This book is an attempt to lay out possible paths to that goal within the limits of our present knowledge. The road to that end result can be boring in spots, challenging in others, or can lead to dead ends for those who have failed to prepare themselves. Although it is possible for persons who have no scientific training to make a major contribution to injury control, efforts based on mythology, good intentions, or traditional approaches that have repeatedly failed or led in wrong directions only hinder achievement.

The knowledge needed to solve the many aspects of the problem is drawn from various scientific disciplines. Persons knowledgeable in one or another discipline jump in occasionally, some to make a contribution and others to create difficulties. One of the problems in the field is that some applications commonly thought evident turn out to be useless. Many such pitfalls and failures are discussed throughout the text.

The nonscientist should not be intimidated by unfamiliar words such as epidemiology, or by concern that the technical points are incomprehensible without a scientific background. A little more concentration is required than that usually devoted to bedtime reading, but esoteric points have been kept to a minimum, and the few simple equations in chapter 2 are explained in English.

At the beginning, in chapter 1, the issues are presented in bits and pieces. For some severe injuries, such as those related to motor vehicles, we can clearly delineate the various factors involved and when and where they occur. Those injuries that occur in the home and other settings in relation to many consumer products are becoming better known through emergency-room surveillance. The data on injuries in the work place are being collected, but in insufficient detail and seldom with proper analysis. A discussion of the use and abuse of data, one of our most important tools, is an important early task.

Chapters 2 and 3 discuss essential evidence from the physical and behavioral sciences, respectively. Chapter 4 provides a variety of methods to achieve injury control through the use of logical and systematic analysis. Some possible shortcuts to our goal are outlined; through them we can achieve far greater benefits than we might have imagined.

Chapter 5 tracks a course through behavioral theories of injury control. A number of these have resulted in an increase rather than a reduction in killing and disabling. Others pertain only under special conditions. A separate tack is reviewed in chapter 6, which defines how and what we can achieve in injury control through rules and sanctions for changing individual behavior. This method has been more successful than strictly persuasive efforts, but rules have different effects on specified groups of people and in various environments. Chapter 7 notes some of the advantages for injury control of built-in and controlled elements in the environment; these have become increasingly important as our understanding of individual human limits has increased.

The estimation of costs of injury control and the problems of balancing costs against risks are the subject of chapter 8. The illusion that cost/benefit analysis supplies an objective formula for such decisions is explained.

The old American problem of the extent to which government can set rules for individual behavior and protective facilities, and how many of the latter will be well-constructed with such rules, is the subject of the final chapter. It is not clear whether attempts to reverse governmental regulations will be supported by the courts or changes in the body politic. It is clear that premature death from injury cannot be reduced at a scientifically feasible and practical pace without government intervention. Opposition to use of state-of-the-art technology in certain industries has placed them in economic jeopardy because of the threat of strict liability suits.

Preparation for this writing effort and help along the way was provided by many mentors, colleagues, family members, and friends who gave unselfishly and will understand if they are not individually mentioned here. Special thanks go to Elaine Zajkowski, who typed several drafts, to Margery Mills for finishing touches, and to colleagues for their insights. Julie Greenberg, William Haddon, Jr., Ben Kelley, Nancy Robertson, Sylvia Tesh, and Phil Shepherd each offered useful suggestions. None of these people agrees with everything that is written here and are, therefore, not to be held responsible for the views expressed.

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1 The Scope of Injuries as Public-Health and Research Problems

The narrow epidemiological view of a public-health problem such as injuries focuses on incidence (how many injuries occur), their severity (death or length and type of disability) and factors that place one at greater or lesser risk of these outcomes. In this book that narrow view is confined mainly to the first three chapters. The basic theme of the book is that, technically, we know enough about injuries to prevent many and reduce the severity of the vast majority of them. There remains some basic epidemiological and other research work to be done and the problems associated with it will be addressed. But the major focus is on the conceptual, behavioral, social, economic, and legal barriers to injury control.

The term *injury* is used interchangeably with trauma throughout to refer to damage to the body caused by exchanges with environmental energy that are beyond the body's resilience.[1] Mechanical-energy exchanges in motor vehicle crashes, shootings, and falls are the most common causes of severe and fatal trauma. The result of acute exposure to large concentrations of energy is usually called injury, while the result of long-term, less concentrated exposures, such as to low-level ionizing radiation, is usually classified as disease.

The definition of injury in terms of its necessary and specific cause, energy exchange, avoids the issue of fault that has so pervaded scientific investigation as well as injury-control efforts. The attribution of fault or human error is of prime concern to many persons in cases where the injury was unintended, while the intent of the injured is usually the major focus of attention in the case of suspected suicide or that of the one or more assailants in the case of homicide. This obsession with blame is at least partly the result of a legal system that focuses on allocation of compensation and punishment according to the intent or fault of the persons immediately involved.

Prior intent in the attribution of fault is not measured directly nor often scientifically inferred; it is concluded from statements of the persons involved and any physical evidence of the injury having been planned. While the assessment of intent may be relevant to compensation of the injured party or punishment of the party blamed for the injury, there is substantial doubt that this process has much effect on the prevention of injuries. In contrast, the application of public-health principles has shown great promise in the limited instances in which they have been used. This book discusses those principles and their applicability to specific energy sources and the injuries they cause.

It is interesting that notions of fault and negligence of individuals immediately involved in damaging transfers of mechanical, thermal, chemical, and radiation energy have seldom been applied to interpersonal transfers of harmful biologic organisms. In medieval times, persons thought to be carriers of the plague, but who actually were not, were persecuted and in some instances murdered.[2] But in modern times people seldom if ever think of suing someone who conveys bacteria or viruses that result in disease. Surely the person who knowingly has a disease that is transmitted by sneezing in crowds, kissing, sexual intercourse, or whatever and who then infects others by engaging in those activities is no less negligent than the alcoholic who drives while intoxicated and injures someone. Why do we believe that the latter is somehow more subject to control by legalistic faultfinding and punishment than the former? Infectious-disease epidemiologists seldom if ever concern themselves with blame assignment, although carriers of the more serious diseases may be pursued by public-health physicians for the purpose of treating the disease and stopping the chain of transmission. Yet the primary purpose of police and often of expert investigation of car crashes is to assign fault in reports or to testify in lawsuits for damages.

Traditionally, and in much current popular parlance, people refer to "accidents" when they mean unintentional injuries. The emphasis on intent reinforces the blaming approach, and the broader rubric, accident, includes a large set of phenomena in which no damage occurs. Most people daily experience unintended events that are called accidents (a tie in one's soup, mistakes in typing, locking keys in one's car) but that are not physically injurious. It is only those events that result in human damage that concern us here. If for no other reason than the magnitude of the problem, it makes more sense to think about injury control than accident prevention.

The significance in terms of public health of an injury is not whether it was intended but the extent and ultimate outcome of the damage. Concepts of blame, including blame attributed to chance, acts of God, and the like in the unintentional case, are barriers to injury control. The fact that injuries are not often considered as a public-health problem is one of the reasons that they are a public-health problem.

Incidence and Severity

Because many injuries are minor cuts and bruises that are not medically treated and are soon forgotten, estimates of the total incidence of injuries are questionable. The National Health Survey reports that in 1979 about 74 million injuries occurred to 69 million persons—more than a third of the U.S. population. This estimate is based on recall in interviews of a random sample of the population.[3] Obviously, only a percentage of the minor cuts and bruises were probably included.

Injuries in the survey report are classified by where they happened, age and sex of the injured, and numbers of days in bed as well as days of restricted activities associated with the injuries. Per population in each group, injuries were reported more frequently among males (38.6 percent) than females (25.9 percent) and more often among children and adults up to age forty-four (35 to 39 percent) than among adults aged forty-five to sixty-four (23.3 percent) and older (18.2 percent). The responses indicate that 12.5 percent of the population was injured in the home in 1979, compared to 8.9 percent at work and 2.7 percent by motor vehicles. An additional 14 percent were in the "other" category.

The cliche that "accidents occur most often in the home" may be true, but such statements are misleading with respect to severity. If the reported bed disability days are divided by the numbers of persons injured, a quite different perspective emerges. The bed disabilty days per person injured is highest among those injured in or by motor vehicles, more than twice that in either the work place or home (table 1-1). This statement is qualified somewhat by the fact that for some people the motor vehicle is the work place. Also, injuries are much more likely to result in bed disability the older the person injured, particularly so among the elderly.

At least three factors could account for these patterns. First, persons being interviewed in their homes may selectively recall injuries that happened there more often and/or selectively remember those that happened to the children or other members in the household. Second, the level of violence in motor vehicle crashes is more often severe compared to that in home and work incidents. And, third, resilience declines with age.

Assessment of injury severity based on clinical evidence is usually more accurate than recall of incidents such as bed disability. Substantial progress has been made toward objectively classifying injury severity and relating it to predictability of outcome. For research purposes, though seldom used clinically, the Abbreviated Injury Scale (AIS) is used to rank injuries in five categories, exclusive of death: (1) minor (for example, ache or stiffness); (2) moderate (such as simple rib fracture); (3) severe, not life-threatening (such as multiple rib fracture affecting respiration); (4) severe, life-threatening, survival probable (for example, flail chest); and (5) critical, survival uncertain (such as aortic laceration).[4] In multiple injury cases, each injury is scored but the most severe (MAIS) is often the only one reported.

Follow-up study of 2,128 persons who suffered motor vehicle injuries and who were hospitalized or who died during a two-year period in Baltimore led to an important refinement of the AIS. The researchers noted that survival declined exponentially as the MAIS increased. Also, people who had two injuries scored as 3 and 4 respectively had about the same survival rate as those with one injury scored 5. Further work with the data led to the Injury Severity Score (ISS), "the sum of the squares of the highest AIS grade

Table 1-1
Injuries Reported Per 100 People and Average Days of Bed Disability Per Person Injured

Age in Years	*Total*		*Motor Vehicle*		*Work*		*Home*		*Other*	
	IR	*BD*	*IR*	*BD*	*IR*	*BD*	*IR*	*BD*	*IR*	*BD*
All ages	32.0	2.9	2.3	7.0	5.6	3.4	11.5	2.5	14.0	2.5
Under 6	38.1	0.5	0.8	*	*	*	22.4	0.3	15.2	0.8
6-16	34.9	0.8	2.1	4.5	*	*	12.8	0.4	20.5	0.7
17-44	37.3	2.4	3.4	5.2	10.4	2.4	10.2	1.8	15.3	2.2
45-64	23.3	4.8	1.8	13.9	5.4	6.5	9.4	3.7	7.9	4.2
65 and over	18.2	12.5	0.6	27.8	0.8	12.8	9.1	12.0	7.9	11.6

Source: National Center for Health Statistics, *Current Estimates from the National Health Survey: United States, 1979* (Hyattsville, MD: U.S. Department of Health and Human Services, 1981).

Note: IR = injuries reported per 100 people; BD = average days of bed disability per person injured.

*Insufficient data or not applicable.

in each of the three most severely injured areas."[5] The proportion of persons who died was a linear function of injury severity scores above 25. Also, an elderly person with the same ISS as a younger person was more likely to die.

The injury-severity-scoring procedure has been simplified into a standardized instrument that can be used in case abstraction from medical records and subsequently translated into AIS, MAIS, or ISS from a computerized dictionary.[6] The researchers who developed this procedure are applying it to all injuries seen in acute care facilities in five northeast Ohio counties—up to now a unique opportunity to compare injuries from a variety of sources on the same severity scales.

Most studies of injury incidence and severity are limited to a specific source of injury, site of injury, or disability outcome. The AIS was originally developed to score motor-vehicle injuries and it has been most widely used in classifying such injuries. Although a nationally representative sample of all injuries of any kind has never been scored by the AIS or other clinical criteria, national estimates of motor vehicle injury distributions have been derived from samples of crashes in which a vehicle was towed away in a wide variety of areas around the country. The total incidence is estimated to be about 2 percent of the population per year. This means that about 1 in 50 Americans (some 4.2 million) is injured annually in motor vehicles; and more injuries of a similar or greater severity may occur to pedestrians in situations where the vehicle is not sufficiently damaged to be towed.

Since the case findings for these estimates are from official police reports, the actual incidence is probably higher. The Northeastern Ohio Trauma Study of emergency-room trauma cases found almost 46,000 cases related to motor vehicles compared to 32,000 in police records for 1977. The discrepancy for aggravated assault and rape was even larger, the rate in emergency-room cases being four times that in official police statistics.[7] Higher injury rates based on hospital data compared to official police records also have been reported in Britain[8] and California.[9]

The distribution of the nonfatal injuries in the vehicle towaway study by MAIS, age, sex, and age-sex specific population rates is presented in table 1-2. Although most of the injuries are in the less severe categories, more than 1 per 500 population is categorized as severe (MAIS 3) or worse and more than 1 per 2,000 population is classified as life-treatening (MAIS 4 and 5). The rates are much higher in the teenage and young-adult groups, particularly among males. About 1 of every 21 males aged 15 to 24 in the population is injured annually in or by motor vehicles in a towaway crash and 1 of every 565 males of that age sustains a life-threatening motor vehicle injury annually, excluding those who die.

Studies of potentially life-threatening and permanently disabling injuries such as spinal cord and head trauma find similar distributions. Almost 56

Table 1-2
Annual Incidence of Motor Vehicle Road Nonfatalities, by Maximum Abbreviated Injury Scale (MAIS) Level, Age, and Sex, United States, 1975

	MAIS 1		*MAIS 2*		*MAIS 3*		*MAIS 4*		*MAIS 5*		*Total Nonfatalities*	
Sex/Age	*Incidence*	*Rate*[a]	*Incidence*	*Rate*[a]	*Incidence*	*Rate*[a]	*Incidence*	*Rate*[a]	*Incidence*	*Rate*[a]	*Incidence*	*Rate*[a]
Males												
0-14	213,442	78.0	33,670	12.3	20,338	7.4	2,590	0.9	2,590	0.9	272,630	99.6
15-24	695,244	341.5	171,422	84.2	82,460	40.5	25,812	12.7	10,246	5.0	985,184	484.0
25-34	348,562	227.0	80,789	52.6	40,054	26.1	15,039	9.8	2,190	1.4	486,634	316.9
35-44	158,365	142.0	34,435	30.9	25,107	22.5	6,067	5.4	2,422	2.2	226,397	203.0
45-54	126,081	109.7	32,758	28.5	18,390	16.0	4,223	3.7	1,334	1.2	182,786	159.1
55-64	84,237	90.1	22,024	23.6	14,503	15.5	3,121	3.3	1,467	1.6	125,352	134.1
65-74	46,104	76.5	14,915	24.7	8,259	13.7	1,601	2.7	615	1.0	71,494	118.6
75 +	21,055	66.9	6,811	21.7	3,771	12.0	731	2.3	281	0.9	32,649	103.8
Subtotal	1,693,091	162.4	396,824	38.1	212,882	20.4	59,184	5.7	21,145	2.0	2,383,126	228.6
Females												
0-14	187,003	71.1	27,148	10.3	8,212	3.1	3,190	1.2	679	0.3	226,231	86.1
15-24	488,508	245.3	114,832	57.7	39,520	19.8	8,440	4.2	3,076	1.5	654,376	328.6
25-34	262,234	168.3	51,321	32.9	20,801	13.4	5,217	3.3	1,432	0.9	341,005	218.9
35-44	139,748	119.7	33,147	28.4	18,242	15.6	2,848	2.4	1,112	1.0	195,097	167.2
45-54	123,585	100.6	35,238	28.7	15,354	12.5	3,620	2.9	535	0.4	178,332	145.2
55-64	89,664	85.9	21,922	21.0	16,939	16.2	1,818	1.7	458	0.4	130,801	125.3
65-74	44,784	57.1	14,555	18.6	13,991	17.8	1,906	2.4	113	0.1	75,349	96.0
75 +	24,418	45.4	7,936	14.7	7,628	14.2	1,039	1.9	62	0.1	41,083	76.3
Subtotal	1,359,944	124.3	306,099	28.0	140,687	12.9	28,078	2.6	7,466	1.0	1,842,274	168.4
Total	3,053,035	142.9	702,923	32.9	353,569	16.6	87,262	4.1	28,611	1.3	4,225,400	197.8

Source: Reprinted by permission of the publisher, from *The Incidence and Economic Costs of Major Health Impairments* by Nelson S. Hartunian, Charles N. Smart, and Mark J. Thompson (Lexington, Mass.: Lexington Books, D.C. Heath and Company). Copyright 1981, D.C. Heath and Company.

[a]Incidence rate per 10,000.

percent of traumatic spinal cord injuries and consequent deaths or paraplegia and quadraplegia occur in or by motor vehicles. These, along with those associated with firearms (12 percent), diving (5 percent), and other recreation peak in teenaged and young adult males.[10] The exception is spinal trauma associated with falls (19 percent), which is higher in the elderly population. Approximately 2,500 to 3,000 new cases of permanent disability from spinal cord injury are added annually.[11]

In addition to paralysis, trauma to the head can result in seizures, amnesia, personality changes, psychiatric disorders,[12] and disfigurement[13] if the person survives. Using minimum criteria of loss of consciousness, posttraumatic amnesia, or skull fracture for case finding, one study found an annual incidence of 270 per 100,000 population in males and 116 per 100,000 population in females.[14] Forty-six percent of these injuries were associated with motor vehicles or bicycles, the latter often to people struck by motor vehicles. Falls accounted for 29 percent, and recreational incidents (led by falls from horses and football injuries) contributed to 9 percent, of the head trauma. As in the case of spinal-cord injury, head-injury rates peaked among males in their mid- to late teens and early twenties in the motor-vehicle and recreational cases. Falling from horses was the only case of higher rates for women among the various activities of the young. Head injuries from nonrecreational falls were highest among the elderly. These data come from a northern state where the severity of the winters reduces the extent of activities that contribute to head injuries, such as driving, motorcycling, diving, and horseback riding. In areas where these activities are more frequent, the incidence of injuries is probably worse.

Persons with severe head trauma (brain contusion, intracerebral or intracranial hematoma, or twenty-four hours of unconsciousness or amnesia) suffered subsequent epilepsy many times more frequently than the general population. Epilepsy occurs in less than 0.1 percent of the population; but, excluding those with pretrauma seizures, 7.1 percent of persons who survived severe head trauma had seizures within one year and 11.5 percent had them within five years.[15]

Persons with less severe head trauma nevertheless have substantial problems, including headache and memory problems three months after the injury in the vast majority of moderate injury cases.[16] Among those classified as suffering minor head injury (loss of consciousness for twenty minutes or less), 34 percent who had been employed before the injury had not returned to work, 79 percent had frequent headaches, and 59 percent were experiencing memory losses at a three-month postinjury examination.[17]

The author is unaware of research that systematically separates out by cause the loss of sight, hearing, and various lengths of limbs and other appendages from injuries. Surveys of disability suggest substantial increases in the number of these conditions from 1966 to 1976 in persons less than forty-