

SPECIAL SECTION: 1987 CONFERENCE ON INJURY IN AMERICA

EDITORIALS

Injury Prevention and Control Comes of Age

I have drunk from wells I did not dig, and I have warmed by fires I did not build.—Proverb

This is an extremely important time in injury control and public health. While we talk of new opportunities for solving old problems, we simply must pay tribute to those who have come before us. I think of the proverb cited. In injury control today, we are building on the methodologies—epidemiology, surveillance, evaluation—that have been honed through the decades.

Injury control interrelates with all of society: politics, law enforcement, mental health, pediatrics, business, mining, transportation. And it relates to all of history because the one consistent plague throughout history, year in and year out, from one culture to another, from one country to another, has been the plague of violence. Our work to control injury will affect the course of that plague for future history.

Many in public health talk about the world as becoming a global village where nations and continents are interdependent. They speak about this interdependence as if it were a new phenomenon. But Polybius, over 2,000 years ago, wrote, "Now, in earlier times, the world's history has consisted of a series of unrelated episodes, but from this point forward, history becomes an organic whole." So, by our efforts to curb intentional and unintentional injuries, we are sowing seeds of immortality in relation to future prevention, future treatment, future rehabilitation, and even in relation to war and its avoidance.

The recent history of injury control provides us with the names of some innovators to be thanked. To them, what is new is not the approach, but the recent and widespread interest in injury control.

We thank those in academic public health: Susan Baker, Leon Robertson, Julian Waller, and others. We thank those in public health practice, particularly Robert Saunders of Tennessee, who was instrumental in getting child restraint laws passed, and William Haddon and Brian O'Neill. We thank those in the Public Health Service, from Jim Goddard, who 30 years ago directed an injury control program that was ahead of its time, to the present Surgeon General, Dr. C. Everett Koop, who has been promoting violence control. We thank workers with the Department of Defense, the Department of Transportation, and the National Traffic Safety Administration—especially Michael Finkelstein for his work over the past years.

Yet, despite all of these people, the response has not been commensurate with the problem. Society has simply accepted injury as being inevitable—that, despite the lessons of history, this is a cause-and-effect world; despite the fact that we are a scientific culture, we have remained fatalistic when dealing with injuries. This belief is a throw-back to the Middle Ages.

The public health response is certainly not commensurate with the problem. How often have we heard that injury and violence are not public health problems? They are enforcement problems or transportation problems, but not public health problems.

Well, thankfully, old adages die when they lack substance. For example, in 1905 Grover Cleveland said that reasonable and sensible women did not want the vote; in 1899 Charles Duell, Director of the U.S. Patent Office, said that everything that could be invented had been invented; and Robert Milligan, 1923 Nobel Prize winner in physics, said that there was no likelihood that man could ever tap the power of the atom. So adages do die, and

now violence is recognized as a public health problem.

One person who deserves our gratitude and praise for this change in attitude is Congressman William Lehman. He arranged for the National Academy of Sciences to look at the problem of injury in America. But that in itself was not sufficient. Earlier, injury in America had been investigated by the National Research Council and the results published in 1966 in "Accidental Death and Disability: The Neglected Disease of Modern Society" (1). That report pointed out the need for preventive measures, but nothing happened. Two and a half million Americans were to die from injuries between the time of that report and the time of the 1985 study by the National Academy of Sciences (2).

The recent landmark publication, "Injury in America," was put together by an unusual committee that included not only public health people but surgeons (among them neurosurgeons) as well. Those surgeons were as vocal as anyone in saying that the answer to the problem of injury is prevention, that we must become involved with surveillance and epidemiology, and that we have to involve the public health community. The committee pointed out that injuries take more years away from Americans before they reach age 65 than cancer and heart disease put together, but only a fraction of research money is put into injury control.

Once this report was completed, Congressman Lehman arranged for money to be put into the Department of Transportation's budget for a National Center for Injury Control. Later, the American Public Health Association organized people at the State level when funding for that Center was threatened.

This we know about the injury problem: 10,000 deaths per month in this country are caused by injuries. The problem is worse internationally because intentional violence in many countries exceeds what we find in the United States, and unintentional violence is rapidly increasing along with the numbers of vehicles and machinery.

Violence is a major problem, but it is solvable. More than that, it is worth solving. It is worth the time of professionals; it is worth the resources.

Preventing violence will improve the quality of life in this country and the world.

Now that attention has been focused on injury control and the coalition is developing among the Department of Transportation, the Department of Defense, the Public Health Service, Congress, Federal and State governments, and the private sector, solutions will come faster and faster. But, safety will impinge on profits. Safety will impinge on freedom. It will often be resisted by an industry that can be powerful enough to have political influence. And, as in the case of handgun control, we who advocate prevention shall not be heard when we use the rational arguments that are accepted in the field of science or in most of society. However, it is important to remember that we shall be institutionalizing a process that will become increasingly rational.

The epidemiologic demonstrations of Semmelweis and John Snow gained new power when epidemiology was institutionalized as academic epidemiology by Wade Hampton Frost at Johns Hopkins. Public health epidemiology gained even more power when it was institutionalized by Alexander Langmuir in the Epidemic Intelligence Service. Injury control is now gaining power because it is being institutionalized. We public health workers are now the diggers of wells and the builders of fires for the generations to come.

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Adapted from Dr. Foege's presentation at the 1987 Conference on Injury in America, Atlanta, GA, February 17-19, 1987.

References

1. Accidental death and disability: the neglected disease of modern society. National Research Council, Washington, DC, 1966.
2. Committee on Trauma Research of the National Research Council: Injury in America: a continuing public health problem. National Academy Press, Washington, DC, 1985.

One Fine Solution to the Injury Problem

Injury makes the news every night. The national networks never fail to devote at least one story to injury, but the broadcast coverage comes into our homes on the local news day after day: fires, crashes, muggings, murders, suicides, and drownings. This is injury, termed by the National Academy of Sciences as the leading public health problem in the United States today. Yet, despite the devastatingly high toll it takes from our society, injury remains an area that is largely unappreciated by the health community and underfunded in terms of research and prevention. Why this disparity between the attention we give to injury as a news event and the lack of attention we give it as a public health problem?

The first explanation is a conceptual barrier: We tend to think of injuries as "accidents," random events that occur by chance, unrelated to anything we do, or could do. We are starting to learn otherwise. We are learning that we can save thousands of lives by building more crash-worthy cars, by wearing seatbelts, and by reducing drunk driving. But, we would be even further ahead if we stopped using the word "accident" and substituted injury. Let us not underestimate the power of a word. Look at the effect, for example, of the term "recreational drugs." Substance abuse kills thousands of people each year, many through fatal injuries related to motor vehicles or firearms. Is not the term "recreational drug" an oxymoron? Is not "accident"?

The second explanation for our lack of progress in injury control is that there has not been a coordinated effort to unite and lead the field toward a common goal. Disparate groups have

attacked different types of injuries at various times, but there has not been an identified field of injury control nor an identified discipline of injury control practitioners. This is going to change. The

Centers for Disease Control (CDC) has been designated as the lead agency for injury control, and the 1987 Conference on Injury in America was CDC's coming out party. In partnership with the National Highway Traffic Safety Administration, CDC plans to make this national injury conference an annual event where the formerly disparate groups and isolated individuals come together to share information and develop common strategies and approaches.

We have also adopted a fine approach to overcoming the conceptual barrier to injury control. Anyone caught using the term "accident" to refer to an injury will be fined 25 cents. The fine will be payable by the honor system, mailed to me at our newly renamed center at CDC. Even if only a few of us are honest and abide by our honor system, we will markedly improve the status of funding for injury research.

And what is the new name of our center at CDC? As of August, we became the Center for Environmental Health and Injury Control. And that, my friends, was no accident.

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1987 Conference on Injury in America: a Summary

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"Introduction" (p. 581). The 1987 Conference on Injury in America brought together a wide variety of disciplines and diverse groups to address injury control research, interventions, funding, and organizational cooperation. The participants considered five separate aspects of injury—epidemiology, prevention, biomechanics, acute care, and rehabilitation—in attempting to

- Establish visibility for injury control
- Create interdisciplinary information exchange
- Build a broad injury control constituency
- Clarify and strengthen relationships among diverse programmatic and research-oriented interest groups
- Suggest future directions

"The Injury Problem from Different Perspectives" (p. 583). Injury research and control programs are disproportionately underdeveloped compared with the economic costs of injury to our society. From an academic perspective, teaching and research in injury control are inadequate because the fundamental causes of injuries are not understood, funding is insufficient, and there are not enough scientists trained in injury control. From the perspective of State government, injury control advocates must sell their programs to legislators who know little about the causes of injury and face many competing demands for funding. In addition, injury control activities are frequently conducted by many different departments with no centralized coordination or leadership. From a research administrator's perspective, research in injury control has been hampered by an artificial and frequently adversarial distinction between what is most important in injury prevention—changes in environmental factors or changes in human behavior. In fact, progress in injury control is most likely when researchers can study actual injury events, focusing on how environmental factors and

human behavior interact. From a neurosurgeon's perspective, progress in injury control will occur when biomechanics—the base science that links injury events to injury outcomes—becomes incorporated into the medical school curriculum; and when we have long-term, longitudinal data on the consequences and social meaning of injury. Finally, from a trauma surgeon's perspective, we need to view trauma care as a system, paying close attention to all five important factors that determine the outcome of such care: the severity of the injury, age of the patient, pre-existing medical conditions of the patient, time from injury to definitive care, and quality of trauma care.

"Injury Research: States of the Art" (p. 590). Injury control research is examined in five separate areas. In *prevention*, the National Highway Traffic Safety Administration has invested hundreds of millions of dollars, and tens of thousands of vehicle injury deaths have been prevented through the design and use of occupant restraints and more crash-worthy vehicles. But research on other types of injuries has gone through fluctuating levels of support and has never even approached the levels of funding that were needed to develop the motor vehicle injury control data bases and interventions.

In *epidemiology*, we need to develop systems for classifying injuries, linking records, using registries, and evaluating interventions. In *biomechanics*, automotive research has led to energy-absorbing steering systems, penetration-resistant windshields, and effective occupant restraints. Further progress requires better ways to combine safety systems and the development of anthropomorphic dummies that can accommodate the different tolerances of women, children, and the elderly. Applied to *occupational injuries*, biomechanics can help prevent injuries from slips, falls, and repetitive overexertion. *Acute care* research addresses questions of basic science, such as metabolic disturbances caused by injury, clinical care, resuscitation, and systems of triage and medical care. *Rehabilitation* research addresses the prevention of secondary complications, enhancement of function, psychological and social adjustment, and vocational success.

"Interventions: Unintentional Injuries—A Behavioral Focus" (p. 605). Injury prevention strategies

that address behavior change include changes in knowledge and attitudes, increases in resources necessary to enable change, and reinforcement of behavioral changes through social and family support. For the workplace, we need to know more about the roles of environment, workplace design, job task design, and their effects on human performance and behavior. For preventing childhood injuries, however, the most effective methods require changes in public policy to bring about environmental changes, regulation of products, and changes in the behavior of caregivers because the behavioral characteristics and developmental sequence of the child cannot be changed.

"Interventions: Intentional Injuries—Groups at Greatest Risk" (p. 611.) Using public health practices to prevent violence can bring new resources into the picture, including public education through media campaigns, health education strategies (particularly those implemented in schools), and the resources provided through health care institutions (for example, the emergency room). Prevention strategies for youth suicide need to address personality and behavioral characteristics of young suicide attempters and other special risk features (family history, close friendship with another who committed suicide). Without improved evaluations of school and community-based prevention strategies, we do not know what is effective and what might actually facilitate suicidal behavior.

To develop better interventions to prevent homicide among minorities, we should study the decline in homicides among minorities since 1980 to identify social, economic, psychological, and cultural factors that may have led to this improvement.

"Interventions Targeted at Substance Abuse" (p. 617). The degree to which drinking and drugs actually cause injury is difficult to assess without knowing the effects of drinking and drugs on motor skills and inhibitions, without knowing whether a crash would have occurred if a driver had not been drinking, and without knowing more precisely how alcohol and drugs affect violent behaviors.

Although studies show a much higher rate of unintentional injury for people who take sedatives, little is known about the specific effect of prescription drugs on injury rates. Large numbers of prescriptions are written for sedatives, and many of them affect the central nervous system. There

are no good data on the number of people driving under the influence of drugs, in part because people often abuse drugs in combination with alcohol. Also, police officers are trained to spot symptoms of alcohol intoxication but not drug abuse.

Legislative attempts to deter automobile injuries related to alcohol have focused on deterring or punishing the offender, regulating servers, and holding the server liable. Deterrence has been hampered by a low risk of punishment, whereas the regulatory approach has seen some success in Federal encouragement of laws prohibiting sales of alcohol to persons under age 21, prohibiting sales of beer in convenience stores, and prohibiting happy hour sales. The impact of server liability is yet to be assessed.

Drugs and violence are related in several different ways. Acute or long-term use of drugs alters some people's behavior so that they act violently or are more likely to be victims of violence. Others turn to crime (that occasionally results in violence) to support their drug use. Some simply are caught up in the violence inherent in a system of drug use and distribution.

"Interventions: Other Approaches" (p. 629). Studies show that 20 to 30 percent of trauma deaths are preventable with regionalization of services, emergency care protocols for personnel, and trained emergency room physicians and nurses all contributing to the efficacy of emergency medical services.

In addition, many lives have been saved through the Federal testing and standards program which has given us collapsible steering columns, safety belts, and air bags. Federal standards also require dual braking systems, side door beams, roof crush strength, fuel tank integrity, and head restraints.

There is a great need to develop better ways and adequate resources to evaluate the effectiveness of interventions. One approach is to establish community-based, active, long-term surveillance for morbidity, mortality, and the effectiveness and cost of interventions.

In some cases, litigation may be an intervention that can help force an issue or strengthen the argument for change. Litigation has been advocated to promote the availability of air bags and to decrease the availability of handguns to criminals and terrorists. Because advocacy is important in the making of laws, schools of public health need to train people to promote injury control in the legislature.

"Costs of Injuries" (p. 634). In 1985, injuries cost our economy about \$107.3 billion. The National Safety Council estimated that unintentional injury alone cost \$31.2 billion in lost wages (for fatally injured persons only), \$17.8 billion in medical expenses, \$14.2 billion in insurance administration costs, and \$19.3 billion in property damage to vehicles. In addition, the National Fire Protection Association estimated \$7.3 billion in fire losses, and there were \$17.5 billion in indirect losses from occupational injuries.

These estimated costs do not include costs of "pain and suffering" and other unmeasured societal costs of injury. A "social consequences" model of loss is needed that would include economic and societal losses from injury.

The costs of violence and intentional injury extend well beyond the costs associated with unintentional injury. The costs of family violence, for example, include costs of psychiatric and psychological services; police, legal, and social services; imprisonment and institutionalization; and the costs of other violence and crime committed by those abused in childhood.

Workers' compensation for injury has become a major cost to States because of a growing number of cases in litigation, rising medical costs, and increased awards. Compensation needs to be found that provides for injured workers without creating disincentives for rehabilitation and returning to work.

We need much more research on the economic cost of injuries of farm workers, an occupation with the second highest rate of work-related mortality. The high level of agricultural injuries may reflect that 90 percent of U.S. farms are not covered by government regulations, and that very little Federal money has been allocated for agricultural safety programs.

The costs of alcohol abuse, one of the most expensive health problems in the United States, were estimated to be \$90 billion in 1980 and include significant injury-related costs: decreased productivity, motor vehicle crashes, and part of the costs of violent crime.

The high cost of trauma care has created problems for hospitals with heavier than normal caseloads of trauma patients when they depend on reimbursement from Medicare or other third party payers. We need to know whether patients treated in a trauma center system fare significantly better than those in nontrauma systems. We need to assess how much the improved outcomes are worth and to develop mechanisms to fund such systems.

"Sources of Funding" (p. 658). In 1986 and 1987, Congress appropriated \$10 million for a research grant program in injury prevention and control that would follow the suggestions of "Injury in America" and be administered through the Centers for Disease Control (CDC). The response by those interested in injury control was tremendous—420 applications were received (39 academic center proposals and 381 research and demonstration projects). Using a two-step peer review system, CDC awarded grants to 5 injury prevention research centers and to 31 research and demonstration projects. Reviewers highlighted aspects within the various injury areas that warranted further research:

- **Acute care:** Need to direct attention to all components of the acute care system including medical care technology, training, communications, triage, transportation, prehospital and hospital care, rehabilitation, and evaluation of the outcomes of acute care.
- **Biomechanics:** Need to develop a scoring system for describing injury in quantitative rather than in qualitative terms (minor, severe); need to apply principles of biomechanics to injuries at work and home; and need to convey the significance of biomechanics to the public and the injury prevention community.
- **Epidemiology:** Need to determine causative factors amenable to intervention and need to study the interaction between human and environmental factors.
- **Prevention:** Need to begin setting priorities with emphasis on injuries that have a high potential for prevention, and need to include complex problems of intentional violence and suicide.
- **Rehabilitation:** Need to design studies that focus on the rehabilitation process, emphasizing continuity of care from emergency care through physical and vocational rehabilitation, community services, and return to society.

Support for injury control at the State health department level grew in the 1980s with the recognition that injuries were preventable. But Federal cuts in nondefense spending are forcing health departments to explore alternative sources of funding for injury control programs, including cooperative ventures with other public and private organizations and programs supported by grants.

Many types of support for injury control are provided by the Federal agencies that are involved in injury control through their regulatory func-

tions, direct injury control programs, surveillance systems, or provision of technical assistance. These agencies include the lead Federal agency for injury control, CDC, as well as the National Institutes of Health; Health Resources and Services Administration; Alcohol, Drug Abuse, and Mental Health Administration; and the Office of the Assistant Secretary for Health, all in the Department of Health and Human Services. The National Highway Traffic Safety Administration (NHTSA) in the Department of Transportation focuses on transportation-related injuries. The Consumer Product Safety Commission protects the public from product-associated injuries. The Department of Justice works in the area of crime and intentional injury. The National Institute on Disability and Rehabilitation Research in the Department of Education seeks ways to minimize medical, social, economic, and family consequences of disabling injuries.

The lack of a clinically based patient classification system that appropriately identifies trauma patients has interfered with equitable reimbursement for trauma care and has inhibited the evaluation of the effectiveness of trauma centers in terms of patient outcomes and costs. The diagnosis-related groups (DRGs) used by most payment systems do not classify patients effectively, especially the severely injured who are likely to have multiple problems.

The insurance industry provides only a small amount of money to support research in injury control but contributes to injury control programs as the largest underwriter of workers' compensation.

"Advocacy Groups and Key Organizations in Injury Control" (p. 665). Consumer advocates have concentrated on preventing injuries and death by changing the design of consumer products to make them safer. This choice—to change product design rather than changing human behavior—is pragmatic; changing product design can often improve safety faster than changing human behavior. From an injury perspective, priority must go to the products that kill or injure the most people—alcohol and motor vehicles.

Advocates for injury victims have also worked actively for comprehensive care and rehabilitation of the patient, including the psychological care of the injured and his or her family.

Within the government, several agencies oversee the work of injury control from different perspectives. NHTSA has been instrumental in reducing

highway deaths by implementing the Federal Motor Vehicle Safety Standard, the passive restraint standard, and the National Minimum Drinking Age Law. CDC is committed to administering innovative public health programs at local, State, and Federal levels. The National Association of Governors' Highway Safety Representatives is responsible for conducting Statewide and community-based highway safety programs, in large part through the management of Federal grant money and coordination of highway safety activities. For the past 30 years, the Department of Defense research laboratories and their programs have been the focus of experimental work in biomechanics, particularly on injury mechanisms and biodynamic responses.

"Future Directions: Where Do We Go From Here" (p. 671). The future holds great promise for more technical improvements in vehicle design and in the creation and enforcement of laws that will help reduce crash-related injury. But improvements in these areas will require organizational cooperation. All groups working in specialized areas of injury control must adopt a broader view, share data and a common vocabulary, and create a diffusion of ideas throughout the scientific community to achieve the high level of success that is possible.

Although motor vehicle safety researchers continue to focus on driver behavior and automotive design, we must not forget that roadway modifications in the past 10 years have been very effective in reducing highway injuries: warnings at railroad crossings, left-hand turn lanes, no-pass stripes at high-collision areas, guard rails at high-risk areas, and four-way stops. A portion of funds designated for the new construction of roads must be allocated to implementing these measures of proven effectiveness as well as to developing new and safer roadway design features.

We can reduce occupational injuries by implementing the existing national strategies for reducing injuries in the workplace. These include improving surveillance, disseminating information obtained through investigations and research, and developing programs in education and training. Reducing occupational injuries will require the cooperation of regulators, labor, management, State and local health departments, lawyers, and citizens.

Continued improvements in other areas of unintentional injury will depend on continuously better data collection—we must continue to learn in

greater detail how injuries occur and why. We must have data to convince physicians and health care providers that we need their help. We need data to help unravel competing priorities and help researchers identify the relative contribution of each component of the host-agent-environment complex to the problem under study.

Preventing intentional injury will require convincing those making policy decisions to give this problem its share of attention. As unintentional

injury has been an underattended public health problem, so intentional injury has been a much neglected part of the injury problem. There is no reason why interpersonal violence and suicide should continue at their current unacceptably high levels. There must be an effective, planned interdisciplinary approach to the problem, and we must study further the agents and the psychological consequences of violence.

Introduction

Injury Prevention: CDC Will Coordinate the Approach

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ON FEBRUARY 17-19, 1987, the Centers for Disease Control (CDC), in conjunction with the National Highway Traffic Safety Administration, sponsored the 1987 Conference on Injury in America. This conference for the leaders in the injury control field was a major step toward implementing the recommendations outlined in "Injury in America. A Continuing Public Health Problem" (1) and could only have been possible with the support of the American Public Health Association and the Association of State and Territorial Health Officers.

"Injury in America" focused national attention on the need to provide increased resources for research in injury control. This landmark publication also set the stage for the national agenda for injury prevention, epidemiology, biomechanics, rehabilitation, and acute care by awakening us to the enormity of the injury problem in the United States.

Injury causes the loss of more years of life than cancer and heart disease combined and is the leading cause of death up to age 44. More than 80,000 persons each year receive permanently disabling brain and spinal cord injuries. Injuries are the leading reason for seeking physician care in the United States and are estimated to cost this economy more than \$100 billion annually. Moreover, many injuries are preventable.

This conference addressed five major areas of injury research: epidemiology, prevention, acute

care, rehabilitation, and biomechanics. For each area, conferees examined the current state of efforts, major issues that must be addressed to make progress, and future directions in injury control. The conferees also examined other significant issues in injury control, especially programmatic issues related to State and local health agencies, the academic community, practitioners, and others.

CDC proudly notes that it has taken very seriously the charge of the Committee on Trauma Research, author of "Injury in America," to establish itself as the focus and leader of a coordinated approach to the prevention of injury.

Reference

1. Committee on Trauma Research: Injury in America. A continuing public health problem. National Academy Press, Washington, DC, 1985.

Injury Control: Synergistic Efforts Will Help To Make It Work

Howard M. Smolkin, Managing Director, National Highway Traffic Safety Administration, 400 7th St., SW, Washington, DC 20590

INJURY CONTROL INITIATIVES have moved rapidly toward implementation since their inception in 1983, when the National Academy of Sciences' Committee on Trauma Research was set up to examine the need for a comprehensive Federal approach to combat the threat of trauma to the American people. But the movement has

not promoted cohesiveness among the many professionals working to control injuries.

The field of injury control comprises many disciplines. However, the professionals in each of these disciplines cluster. That is, engineers tend to talk to other engineers; epidemiologists to other epidemiologists. This behavior reinforces a professional's preexisting view of injury control rather than challenging him or her to consider different perspectives.

The 1987 Conference on Injury in America provided a rare opportunity for professionals to confront and consider the many different viewpoints that must be examined concerning the problem of injury. Grants have been awarded to encourage and facilitate work on various aspects of the injury problem (details about the grants are in the section "Injury Prevention Grants and Demonstration Projects"). The extent to which we benefit from the full synergistic impetus that these grants provide will be determined by the way we meet both formally and informally with our neighbors in the injury control field and the way we share ideas and approaches with those who look at the same problems from a slightly different perspective.

Members of Congress, especially House Appropriations Chairman William Lehman, have demonstrated a great deal of creativity and leadership in providing the original funding for the concept of the Center for Injury Control. The legislative and financial framework now exists. The Centers for Disease Control has provided leadership in the implementation of this concept. The climate is fertile for all of us to broaden our views, to meet our neighbors in the injury control area, and to make the potential benefits of these synergistic efforts a reality.

Preventing Injuries: HHS Cares

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IT IS UNFORTUNATE that so many people do not seem to care about the issue of injury in the United States. However, the Department of Health and Human Services (HHS)—and all who gathered for the 1987 Conference on Injury in America—

care that in the United States 140,000 deaths result from injuries, and 1 in 3 people suffers a nonfatal injury each year. And the Department cares that trauma is the number one killer in the age group 1 to 40 years. The Department's concern is exemplified by the following facts.

HHS estimates that in 1985 the National Institutes of Health, an agency of HHS, provided approximately \$78 million for research related to trauma. In 1986, that figure increased to about \$84 million. All but one institute, the National Institute for Environmental Health Services, provide support for research into virtually every aspect of this area. The response of HHS to the injury problem began in the early 1970s through the Centers for Disease Control (CDC). By fiscal year 1986, CDC was spending about \$1.8 million a year on that problem. The program was further expanded by congressional action that in fiscal years 1986 and 1987 gave CDC an additional \$10 million a year through the National Highway Traffic Safety Administration. The objective was to implement the recommendations of "Injury in America" (1).

The leadership role of HHS in injury control is encouraged and supported by a broad spectrum of endorsers, including the American Medical Association, American College of Surgeons, American Public Health Association, members of Congress, other Federal agencies, General Motors Corporation, and local and State agencies.

HHS believes that in addition to the current technical, medical, and related research and activities in injury control, more emphasis should be placed on the fundamental problems of human behavior and tougher enforcement. The automobile industry may build the safest car in the world, but it cannot alter the behavior of a driver under the influence of alcohol or drugs whose driving creates a life-threatening situation. In addition to persons who drive while under the influence, there is the speeder. The speeder is found not only on the open highway, but in the business and residential areas of our cities as well. There is no greater threat to life than that posed by drivers who speed and who otherwise drive discourteously and inconsiderately. It seems clear that more should be done to educate or reeducate drivers. Finally, HHS encourages those concerned with injury control to work for adoption of the Uniform Vehicle Code by all States.

In short, for all the advances in the treatment of trauma, there can be no substitute for prevention. Consequently, HHS is taking a much longer,

harder look at injury-producing behaviors. The result is that many questions are being raised. For example, why are some people willing to wear seatbelts and others are not, even when required by law? Why do so many people persist in alcohol and drug abuse, knowing it is dangerous to their health? What is the root of behavior that leads to suicide, homicide, or murder? What can or should we do to prevent or modify such behavior?

Admittedly, the answers might seem to be self-evident. As the HHS Assistant Secretary for

Health puts it, the answer is AIR—an acronym for assumption of individual responsibility. People must assume individual responsibility, even as HHS applauds the motivation of this important conference.

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The Injury Problem from Different Perspectives

Perspectives in Injury Prevention and Control: What Is the Problem?

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THIS SECTION covers the topic "Perspectives in Injury Prevention and Control: What Is the Problem?" By presenting unique perspectives on injury control, the contributors seek to foster a broader view of the problems that must be addressed to reduce injuries. This section sets the stage for the topics that are developed in later sections.

The publication "Injury in America" (1) focused our attention on providing resources for injury control and also set the national agenda for injury control in terms of prevention, epidemiology, biomechanics, rehabilitation, and acute care. By focusing our attention in these areas, we can develop a positive attitude concerning injury control. Something can be done; injuries are not accidents. The obstacles are not insurmountable.

Panelists for this conference mentioned the following perceived barriers to injury control: (a) the lack of appreciation of the sheer numbers of injuries as a public health problem and ignorance as to their preventability, (b) the lack of sustained resources devoted to injury research and programs, (c) the lack of a uniform surveillance system for injuries, (d) the lack of acknowledgment of injury control as a specific discipline, (e) the lack of biomechanics training for researchers and practitioners, and (f) the continued use of the word

"accident," which is misleading because it implies that these events are random and not preventable and that injury victims are somehow blameworthy.

By examining these "barriers," we can appreciate the diversity of viewpoints and the complexity of problems that must be solved. The result will be a broader and more sophisticated view of injury control.

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An Academic Perspective

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IN GRADUATE SCHOOLS, the dearth of teaching and research concerning injuries is a problem that must be solved if we are to continue to make headway in injury control. It is a deficiency that reflects a lack of understanding about the injury problem, a lack of funding, and a lack of appropriately trained scientists.

Lack of Understanding

Last week, a friend noted the slow progress that has been made in controlling injuries: "I guess it's

'Funding for injury research has a long way to go to reach the level of funding for heart disease and cancer.'

because injuries happen when people are lazy and careless, while diseases aren't anyone's fault." She was expressing a misconception that is far too common, a misconception that has prevented many people from taking a scientific approach to injury prevention.

The notion of fault is associated with a view of interventions based solely on changing personal behavior. The result has been ineffective preventive measures and an approach that is not appealing to graduate students. A textbook on occupational health conveys the message that occupational diseases have specific causes and can be prevented by such measures as "substitution, enclosure, removal at the source, segregation, and what may broadly be called good housekeeping" (1). About injuries, the same book reports that the most important means for preventing occupational "accidents" is to inculcate an attitude among persons at risk that makes them aware of the necessity to comply with safety measures.

If graduate students perceive such statements to be true, is it any wonder that they choose to study disease prevention rather than ways to convince people to change behavior to avoid injury? The approach to injury control must be effective and realistic. Thus, it must entail more than the encouraging of safe behavior.

Lack of Funding

The \$10 million appropriated this year by the Centers for Disease Control and the Department of Transportation for Centers of Excellence and for injury research and demonstration projects has stimulated tremendous interest and activity in the academic and research community. Funding for injury research has a long way to go to reach the level of funding for heart disease or cancer. This difference is even more dramatic when we take into account that injuries affect younger age groups than do heart disease and cancer. Therefore, injuries cause the loss of many more years of productive life than either heart disease or cancer. If the number of lost years of productive life is

used to assess the relative magnitude of the injury problem, the \$10 million funded this year is less than 1 percent of the money required to fund injury research at a level comparable to funding for heart disease or cancer.

Everyone concerned with the problem of trauma must continue to work to increase funding for research, teaching, information distribution, prevention programs, and program evaluation. We must not let anyone think that five Centers of Excellence are enough, or that 25-30 research and demonstration projects can solve a problem that is centuries old and of devastating dimensions. The 39 applications for Centers of Excellence and the 381 research proposals demonstrate forcefully that there is much good work waiting to be done and that many good proposals are going unfunded.

Lack of Trained Scientists

Today there is new interest in injury research and prevention programs. For the first time, there is hope that we have reached a turning point in the funding crisis. Yet we still see a critical shortage of relevant teaching at schools of public health, medicine, nursing, law, engineering, and architecture—schools whose graduates must have a better understanding of injury control. Remedying this shortage by training faculty from a variety of graduate schools and by developing educational curricula that can readily be used elsewhere is one of the major objectives at Johns Hopkins University.

As injury control as a discipline enlarges its scope and attraction, the need will increase for a mechanism that recognizes the attainment of certain standards of performance and mastery of specific subjects. People will need to be able to assess their own competence in areas of injury control, to attain recognition for their command of material, and to enjoy the benefits of professional associations and services available through an agency established to serve these goals of professional excellence.

Conversations at a conference in the spring of 1986 among injury control leaders, who represented six States and as many disciplines, indicated a strong consensus for an American College of Injury Prevention. Precedents for this concept may be seen in the American College of Epidemiology and the Society for Critical Care Medicine. Both of these organizations provide professional certification and development as well as a forum for discussion of major issues.

Establishing such an organization, which would emerge from a process of consensus development and be devoted to developing and recognizing professional excellence in injury prevention, would be a significant step toward acknowledging injury control as a major scientific discipline.

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A State Health Officer's Perspective

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STATES HAVE BEEN interested in injury prevention for the last several years. The past few years have witnessed an increase in public concern about the costs of injuries and public pressure to implement injury prevention programs. Now, there is leadership at the national level as the Centers for Disease Control (CDC) moves to form the new Center for Injury Control.

The problems associated with injury prevention programs include organization, coordination, education, and funding. These problems indicate the need to change attitudes toward injury or trauma as a disease.

Far too many State legislators maintain that injury is a normal, unpredictable, random event to which we are all subject. Other legislators see injury initiatives as a problem of competing public needs. How does one weigh an injury prevention initiative against a new State park, especially if that park is in one's district? Still others do not view prevention as important, but see the solution to the problem of injury as improving access to health insurance, so that care is insured after the event.

Many States that have patterned their organizational structure after the Federal Government now must assume leadership in injury prevention, especially in the areas of coordination and evaluation. This need becomes apparent when one considers how many State agencies normally have an injury control function. Numerous legitimate roles are

played by State traffic safety committees, police departments, emergency medical services commissions, and occupational health and safety administrations. To be effective, strategy must be coordinated, and the logical place for coordination to occur is the State health department because it is best able to understand the health status implications of each intervention.

The most important problem to solve at both the State and Federal levels is that of evaluation. Before we can evaluate, we must measure. What data should be collected? Who should collect the data? What sources should be used? Who should have access to the data and at what level of detail? Perhaps the toughest question of all is, who should pay?

States need an acceptable, nationally standardized system for injury surveillance. As soon as feasible, CDC should describe a core data set that each State could and should use in injury surveillance activities.

States would also benefit by CDC's descriptions of cost-effective methodologies with proven worth. For any health department to compete effectively for scarce State dollars, it must be demonstrated how proposed interventions will reduce State and Federal expenditures and improve the lives of its citizens. Injury prevention and control initiatives must be tied to State expenditures in other areas such as Medicaid and State employee benefits and disability. It is no longer sufficient to believe that our interventions are effective or to show that the interventions result in longer, healthier lives. In addition, we must show that each dollar spent in preventing an injury represents a savings to the State and Federal Government when compared with the dollars that would have been spent had that injury occurred.

A Research Administrator's Perspective

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WHEN DEVELOPING AND SUSTAINING an injury control program, a research administrator confronts problems from two perspectives: technical and institutional. In the institutional context, I will review principal sources of financial

support for research in highway safety in the past two decades and discuss the implications of this record with respect to the nature of the research. But first, I should like to discuss the technical aspect—particularly a specific matter that warrants research.

The factors that influence the process that gives rise to crash injuries can be grouped according to three categories (a) human or driver factors, (b) product or vehicle factors, and (c) environmental (primarily highway design-related) factors. A large body of empirical data exists that demonstrates that, among these categories, driver factors play the dominant causative role in motor vehicle crashes. From a prevention perspective, however, many analysts have argued that there is a greater potential benefit in concentrating on changes to vehicle or highway design factors because human behavior is so complex and, even when understood, difficult to influence. But substantial understanding of the driving process (that is, understanding to be derived from researching the human factors) is an absolute prerequisite to the development of effective measures directed toward preventing crashes through changes in vehicle or highway design.

In reviewing research relating to crash prevention, it is useful to draw a distinction between two categories of research activities: observational and phenomenological. Historically, observational research on crash prevention has yielded relatively little concerning effective intervention strategies. Parenthetically, this outcome is in marked contrast to the record on the crash event, whereby knowledge gained through epidemiologic studies has led to very successful interventions, including improved door locks and windshield glass, universal installation of three-point safety belts, removal of roadside obstacles, and development of breakaway signs and lampposts.

The only noteworthy exceptions to this negative characterization of the historical payoff of observational studies vis-à-vis crash prevention are (a) studies sponsored by the National Highway Traffic Safety Administration (NHTSA) that led to the introduction of high-mounted stoplights, and (b) the many studies documenting the enormous role that alcohol has in causing serious motor vehicle crashes. Those studies have paved the way for recent changes in attitudes and, in turn, laws concerning driver-drinking behavior.

There is much less of a record to review in the area of phenomenological research that relates to crash avoidance. The principal reason for the

relative dearth of such work has been its inherently fundamental nature and the attendant difficulty of making a case to potential sponsors that such research will lead to successful interventions in the short term. Indeed, most previous research on the driving process has tended to focus on those aspects that are most easily studied (namely, the psychomotor aspects) rather than on the more complex, subtle aspects of information acquisition and processing that are far more important to understanding why crashes occur and what can be done to prevent them.

Until the mid-1960s, financial support for independent researchers in the highway safety field was mostly limited to modest funding by individual motor vehicle manufacturers and a rare contract or grant from the Public Health Service or some other government agency. In enacting the Motor Vehicle Safety Act of 1966, Congress recognized the need for enhanced support for highway safety research by explicitly charging the Department of Transportation (DOT) with a mandate to develop and sustain an appropriate program of research, development, and demonstrations. DOT duly responded (through NHTSA), and in the late 1960s a major increase occurred in the funding of related programs at universities and elsewhere.

With time, however, the Motor Vehicle Safety Program at NHTSA increasingly focused on the development of regulations. Consequently, the justification of the agency's research budget before the Office of Management and Budget and Congress depended upon demonstrating the direct relevance of all project activities to short-term regulatory milestones.

By the mid-1970s, virtually all NHTSA's research and development was procured through highly specific requests for proposals to perform very precisely defined analytical or experimental tasks to meet an agency-specified regulatory development agenda. There was no mechanism available to fund unsolicited proposals or to sustain a continuing long-term program that addressed fundamental problems. Moreover, other sources of funding for such activities also dried up, as other Federal agencies such as the Public Health Service and the National Science Foundation withdrew completely from the field of injury control.

In 1977, NHTSA convened an ad hoc advisory panel to review the management of its research and development program. The panel's recommendations included extending the planning horizon of the agency's research development and allowing for more researcher input to its directions and

priorities. As the Deputy Administrator of the agency at that time, I sought to implement those recommendations and failed; I was unable to overcome the pressures on the agency to justify its actions in terms of short-term results.

The only hope for serious, sustaining support for fundamental research on the prevention of motor vehicle injuries is to have a Federal agency with a long-standing charter and tradition of basic research support take command of the issue. The emergence of the Centers for Disease Control's new program, therefore, seems to be a uniquely favorable development. It is also good to see that NHTSA management has supported that program as positively as it has rather than having mounted a bureaucratic turf battle. I applaud the NHTSA policy makers who had the statesmanship and wisdom to follow this policy.

A Neurosurgeon's Perspective

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INJURIES ARE, by any logical definition, a class of disease; yet some scientists, science writers, and many persons in the public still view injuries as accidents, that is, chance happenings. This attitude will prevail until we find ways to make people pay attention to the evidence that supports the classification of injury as a disease.

But changing public perceptions is no easy task. Cognition has been described as being hot or cold (1). Cold cognition is the logical process—the kind used in scientific work. Hot cognition is the affect or emotional process that brings about a person's readiness to accept a message. In other words, the quality of our cognition is dependent on the quality of our affective attitudes. A remark like "Injuries are contagious" could capture interest among people in the health care field and would also get the attention of the general public. We need to discover how to develop hot cognition regarding injury control to make the public aware of the problem and ready to do something about it.

Although my remarks in this paper are directed primarily to neural injuries, they are applicable to other injuries as well. Head and spinal cord injuries are a class of conditions in which the

cause is some type of mechanical loading. This definition also reveals an important clue to the problem of why injuries, despite their public health importance, have been relatively neglected in the biomedical sciences and treated somewhat as a poor cousin compared with the attention given to such diseases as cancer and infectious diseases. Unlike those diseases for which the basic sciences of molecular biology, virology, and bacteriology are well represented within the educational and administrative structure of the medical establishment, the basic science for injuries is physics and, in particular, its subdisciplines of biomechanics and engineering science. Medical school curricula, graduate training programs, and Federal medical research organizations (for example, the National Institutes of Health) do not fully understand and integrate these disciplines. Our medical establishment needs to realize that biomechanics is as fundamental to the major public health problem of our day, injury, as microbiology was to the major public health problem of 75 years ago, infectious disease.

Four additional premises are essential to the improvement of our understanding and control of injuries, particularly as they apply to the head.

- *Linking injury input to the outcome by way of the mechanisms.* Existing problems in defining the severity of head injuries are due in part to artificial limitations of the research domain. The boundaries of research must be expanded to include the means to study cause and effect of injury in its most comprehensive form. There must be a strong link between the bioengineering and physiological aspects of research on injury mechanisms, on the one hand, and the biomedical and psychosocial research on the biological responses, treatment effects, and social factors determining the long-term outcome, on the other hand. Lack of such linkage is clearly reflected in the evolution of fragmented strategies for injury research dependent on the research concerns of different disciplines.

Thus, automotive safety research has, until recently, been mainly concerned with relating injury causation biomechanics to passenger and pedestrian survivability rather than outcome and has used the AIS (abbreviated injury scale). On the other hand, the biomedical research community has focused on how outcomes have been affected by treatments without significant attention to the causative factors and have used such tools as the Glasgow Coma and Outcome Scales (2). Obvi-

ously, this disparate approach must be reconciled, not simply to allow burgeoning data bases to be correlated, but more importantly, to enhance the scientific precision of such data bases.

- *Long-term longitudinal observation.* The effect of injury must be measured longitudinally to times well beyond the initial post-injury period. New categories of economic cost must be applied to the problems that go beyond medical dollar costs and lost work time. Problems of measurement must not restrict the definition of the cost of injury. Research on head injury is just beginning to show that injuries have significant costs 5-10 years after the injury in realms of life that heretofore have not been studied.

- *Determining the social meaning of head injury.* Each major injury has attributes that require observations of different aspects of recovery and reintegration into social life. Disability is a different experience for someone who has suffered spinal cord and head injuries from that of someone who has broken a leg. Research categories must reflect this difference.

- *The problem of consciousness.* Head injury must be viewed not only as causing abnormalities in neural and bodily functions but also as a disturbance of consciousness, which is the unique function of the brain (with all the complex subjective and objective changes that this implies). This is why neurological and behavioral observations of outcome alone are insufficient. The existence of consciousness implies a dynamic interactive response to the injury as well as to environmental influences, resulting in changes in the way the brain adapts to the trauma. A head injury is different from a broken leg. The suffering caused by head injury is greater because the recovery of the brain is a much more interactive process than recovery from a broken femur. These interactions are often neglected in current research (3).

It is only by improving our research strategies through the inclusion of such factors as those just described that we may hope to improve our injury control strategies as classically defined by Haddon. Applied to head injuries, these factors then might be able to help resolve many problems, of which the following two are illustrative:

- Head injury mortality appears clearly to depend on the severity of injury, but morbidity is not so obviously correlated, particularly for minor and moderate head injuries.

- Individual outcomes for head injury patients who do not die or do not fall into the obvious extremes of injury severity (for example, patients in a coma for many weeks or the briefly dazed or transiently amnesic) are currently quite unpredictable.

Finally, there is a need to develop mechanisms for sustained support of comprehensive injury control centers in which both the physics and bioengineering as well as the public health, biomedical, and behavioral sciences are well represented and integrated. Without long-term support of such interdisciplinary integration, injury control cannot prosper.

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The Trauma Surgeon's Perspective

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TRAUMA IS the most important, the most expensive, and the most tragic of the health problems facing the United States today. According to the American Trauma Society, the cost of trauma exceeded \$96 billion in 1984. In terms of years of life lost, trauma surpasses cancer and heart disease combined (1). Lest we lose sight of the true meaning of the millions injured each year and the dead and disabled that result from trauma, the words of Sir John Wilson should be remembered: "It is only in statistics that people are disabled by the millions—each person is disabled individually and in his own predicament."

Trauma follows a trimodal distribution (1). Approximately half of all trauma deaths occur

within minutes of the injury, 30 percent occur within 1 to 2 hours, and the remaining 20 percent of trauma-related deaths occur days or weeks later from sepsis, multiple organ failure, or both. Based on this reproducible pattern of trauma deaths, the five principal determinants of trauma outcome become more meaningful in directing an effective attack on the trauma problem:

- *Severity of injury.* Because severity of injury is an untreatable component, the only effective way to address the issue of injury severity is through trauma prevention programs. Restraint systems and well-designed vehicles and highways have the potential for reducing the severity of injury in automobile crashes. However, the major factor in the occurrence of virtually all forms of trauma is alcohol (2). Therefore, even small gains in controlling alcohol abuse can result in vast improvements in the problem.
- *Age of the patient.* It is well known that the elderly do not tolerate injury as well as younger trauma victims.
- *Preexisting medical conditions of the patient.* Mortality and morbidity will be greater in the patient with preexisting medical conditions.
- *Time from injury to definitive care.* This is a major predictor of trauma outcome in the injured patient who sustains a life-threatening injury that is not immediately fatal. Definitive care of the injured means operative care in an operating room staffed by qualified personnel and backed up by support services that can sustain the multisystem-injured patient through the direst of circumstances. This capability is not immediately available at most hospitals in the United States today; thus, getting the patient to the right hospital at the right time is one of the remaining challenges for improving the care of the injured patient.
- *Quality of trauma care.* The quality of care issue begins in the pretreatment phase by having knowledgeable dispatch personnel present and continues at the scene during the preliminary care phase with good communication, complying ambulances (air or ground), and fully trained prehospital providers. Trauma is a surgical disease, and the earlier the surgeon is involved in the care of the patient, the better the outcome. Likewise, highly trained emergency medicine physicians provide a vital link between the prehospital phase and the in-hospital phase of trauma care. In general, highly qualified personnel demand high-quality facilities and support for the care of their patients.

The issue of time from injury to definitive care and quality of trauma care are best addressed together by the implementation of a trauma care system. A trauma care system may be defined as an organized approach to the acutely injured patient that provides personnel, facilities, and equipment for effective and coordinated trauma care in an appropriate geographic area under emergency conditions. It is now conceded even by those opposed to trauma center designation that trauma care systems are effective in improving outcome. Numerous researchers have investigated the impact of trauma care systems on preventable death among trauma patients (3-8).

Meaningful trauma-related research can have a direct impact on reducing trauma-related morbidity and mortality. So can rehabilitation; it has been overlooked too long. Major improvements in trauma outcome await only the implementation of well designed and controlled trauma care systems. Research and rehabilitation hold promise for even further progress.

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Injury Research: The States of the Art

An Overview of Where We Are and Where We Need To Be

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IN 1960, THE STATE OF KNOWLEDGE and action in injury research could be described as follows. Several health departments were involved for at least a few years in injury control activities. The Public Health Service (PHS) was establishing an accident prevention branch. The American Public Health Association was showing interest. The National Safety Council had been involved to some extent since 1904. The American Medical Association (AMA) had an active committee in highway safety. The American Association for Automotive Medicine (AAAM) was 3 years old. The National Highway Traffic Safety Administration (NHTSA) and the Consumer Product Safety Commission (CPSC) were not to appear until about a decade later.

A small amount of research money was available in 1960 through the grant mechanism of the PHS. However, most research was aimed at identifying what was wrong with people who got into crashes and at motivating them to do better, preferably before the event.

Interesting changes occurred in the next several years. The most important was the conceptual shift that began in the field. Based on Gibson's observation in 1961 that the agents in all injury events are the five forms of physical energy, Dr. William Haddon developed the concept of preinjury, injury, and postinjury phases of injury events, the matrix of human and environmental factors that needs to be examined across all three phases, and an integrated model for intervention programs based on the control of physical energy as the injury agent.

Current research and intervention activities increasingly are built on this foundation. There is lessening animosity for the approach that considers injury control largely—but not entirely—as an area of environmental health, rather than almost entirely one of behavioral modification.

During the next several years the AMA moved almost completely out of the field, as did PHS.

The National Safety Council modestly expanded its interests in research, AAAM became a strong proponent of the multidisciplinary approach to research, and NHTSA and CPSC were born. NHTSA has contributed to highway injury research through contracts, but rarely has tested new ideas that did not originate with NHTSA. For various reasons, CPSC has not done much nonhighway injury research. Until about a year ago, nonhighway injury research was moribund.

Building on the 1985 report of the National Research Council's Committee on Injury Research, and the interest of Centers for Disease Control (CDC), responsibility for developing a center for injury control was delegated to CDC. The specific goals were to strengthen the injury research community, injury research, and those injury programs that are based on sound scientific and administrative principles and which show close interaction between researchers and administrators. That approach is beginning to pay off: health departments are back in the game, and medical schools and schools of public health are beginning to teach related courses.

The first five injury research centers have been chosen from among 39 applicant institutions. There were 381 grant proposals submitted in competition for \$5 million in research grant funds designated to support 31 projects. This is barely enough, however, even to start to study injury, which is the major cause of lost person-years of productive life in the United States.

The agenda for research lists these key issues:

- The body of grant money remains far too small and too evanescent to attract and maintain a critical mass of competent researchers and research concerning injury.
- Publishing injury research findings is difficult because of the lack of appropriate journals that are also recognized as acceptable by one's academic peers. As a result competent researchers sometimes have problems getting tenure or promotions and are lost from the field because their work and publication routes are poorly understood by colleagues in their primary disciplines.
- Although some good human-factors research is being carried out by psychologists, epidemiologists have largely ignored the area. Consider, for example, that most studies of highway crash causation start with the antiepidemiologic assumption that vehicles and roadways are ignored as contributors to crashes unless they clearly acted in a manner contrary to the way they were built. That some-

thing could be built so that its planned function would increase crash likelihood is considered irrelevant.

- There continues to be relatively little research into the long-term effects, costs, and cost distribution of injuries.
- Although the number and diversity of injury control programs may be increasing, well-designed and properly implemented evaluations remain a scarce entity.
- Studies of socio-political and economic factors that affect the adoption and maintenance of injury control efforts are almost nonexistent. The research agenda of the future must include attention to such political and administrative research.
- In October 1986, a congressional committee report, "OMB Review of CDC Research," documented how the Office of Management and Budget was making its own decisions on research to be carried out by CDC. The letter of transmittal states "the report found that OMB officials were seven times more likely to reject CDC's environmental and occupational research projects than research relating to infectious or other disease processes" (1). One of the projects scuttled was an epidemiologic study of injuries in falls from ladders.

The changes in these seven areas will indicate whether injury control progresses or merely continues alternating periods of ups and downs.

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Epidemiology: an Academic Perspective

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ONE OF THE MOST IMPORTANT contributions of academia to injury research is the variety of disciplines and expertises that can be applied to

the study of a problem. Only recently have the social and behavioral sciences researchers taken a serious view of developing and testing theories to explain injury phenomena. In these disciplines, initiatives in injury research will come with the availability of research funding. These scientists need to develop fundamental understanding of injuries as a social problem. Without well-planned and implemented training programs, injury research will remain an academically uninteresting and unrewarding career goal.

Evaluation is a legitimate role of academia. For decades, numerous countermeasures and strategies for prevention or control have been implemented as environmental controls, legal or social sanctions, or attempts at behavioral change through education. The evidence to support the effectiveness of most of these strategies or countermeasures is weak or nonexistent.

Currently, the greatest single resource for funds for injury research in the United States is the National Highway Traffic Safety Administration. However, equal efforts should be given to solutions involving injury causes that are not related to motor vehicles. The most rational approach is to expand the funding base for all injury research under one agency equal to the level of that currently provided for motor vehicles.

There are several crucial technical needs that can, or should, be addressed from an academic setting. Classification is one of those needs. The forthcoming 10th Revision of the International Classification of Diseases will demonstrate a dramatic departure and improvement in the system of classification of injuries by external cause. Yet, with these changes, problems remain of discordant methods of classification for fatal injuries, as opposed to nonfatal injuries. In addition, a fair amount of the classification system is not exposure-based, but appears to be injury-mechanics-based. An attempt to recognize the role of exposures, either quantified or qualified, is an important step forward in understanding the etiology of injuries.

Nationwide injury surveillance never can be accomplished with the injury resources available now or in the foreseeable future. Since one-quarter to one-third of the entire U.S. population sustains a medically attended injury per year, it is easy to imagine the effort needed to construct, implement, and evaluate a truly useful nonfatal-injury surveillance system. The most logical approach, therefore, is to encourage local surveillance efforts. A study is needed on how to do injury surveillance

rather than simply instituting surveillance programs based on untried methods and incomplete information or understanding of the myriad data-recording systems now in place. Perhaps the first priority should be to focus on surveillance of fatal injuries and those injuries that have the most devastating social, family, and personal impacts, including a high probability of future medical or psychological disability. At a minimum, surveillance of brain and spinal cord injuries, burn injuries, and nonfatal immersion injury should be included.

A related surveillance question is record linkage. Injuries and the facts surrounding them are recorded in a variety of places and ways. Yet attempts to connect these injury-data sources have been thwarted because of genuine concerns over confidentiality, access to information, and the citizen's right to privacy. There must be further focused research into efforts on how record linkage can be accomplished, keeping the safeguards of the citizen in mind.

One approach to wider availability of injury information is data pooling. Efforts from within academia to study how these pooling projects might be formulated and how inconsistencies in definitions and recording might be overcome would be a productive approach to using to the fullest what is already available.

Injury surveillance cannot be discussed without addressing the prospect of, and problems associated with, injury registries. The validity of registries is well established; however, within the context of injuries, there is a need to identify which classes of injuries would benefit most from a registry and why the registry is essential. To justify a registry of injuries requires that many unresolved, crucial questions be answered. Important questions remain for injuries to the central nervous system, burns, and immersion injuries. These injuries are catastrophic, having the most severe social, medical, and economic impacts. Yet the amount of data that is epidemiologically useful is quite limited; further, what information is available often is not consistently collected, recorded, coded, or analyzed. From the academic perspective, efforts to establish baseline criteria and data needs for injury registries are worthwhile.

There is a need to continue national or international conferences on selected methodological issues or substantive problems. In addition, although the amount of information now being gathered is impressive, and a quantum improvement from several decades ago, technical studies are needed to explain major variations in rates and

causes of injury. More classic epidemiologic approaches are required, such as case-control studies, prevalence studies, or studies within existing cohorts to address relevant gaps in data.

Further, it is not certain that the available information has been used effectively. A more aggressive approach is needed in implementing known solutions. Perhaps the academic community is the place for "think tank" attempts to understand why these solutions have not been effectively implemented.

Finally, there are a few efforts in the United States to distribute basic information from the meager injury resources available. However, a national, or even international, information network—possibly within a Federal agency with input from State and local governments, academic institutions, voluntary agencies, and the World Health Organization—might be a worthwhile mechanism for disseminating information. Information would be available not only for existing, new, or emerging injury problems, but for successful and unsuccessful solutions as well.

Research Trends in Injury Prevention

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FROM 1965 TO 1985, mileage exposure for the United States population increased from about 90 billion miles per year to 1,700 billion miles per year, an increase of 93 percent. However, highway deaths decreased 7 percent. Within that decrease, the pedestrian death subset decreased 6 percent—very close to the overall decrease. Motorcycle deaths increased 300 percent, however, reflecting the great increase in the use of those vehicles. Truck deaths increased 55 percent, a disproportionate increase relative to truck registration.

The number of passenger car deaths decreased 27 percent during this period. Progress has been made in making vehicles more crash-worthy, and in reducing and preventing injury and death. This is the result of several factors, in part linked to the development of better information on human tolerance to impact, and of data bases used to identify injury sources and evaluate injury prevention countermeasures. Note that this considerable

accomplishment in reducing motor vehicle death and injury was achieved without substantial progress on the issue of occupant restraint.

Where do we want to be 20 years from now? The driving and riding population will be using physical restraint devices, whereas as recently as 2 years ago it was essentially unrestrained. If vehicle designers could assume that occupants would be restrained, it might be easier to increase the burden of crash energy management on the vehicle structure itself.

A restrained occupant population might permit other improvements. With unrestrained occupants, it is inadvisable to have a stiff underride structure on the rear of a truck. If designers could assume that occupants were restrained, then a stiff under-ride structure on trucks could become a net benefit. If that sort of tradeoff is true for trucks, it might be true for bridge rails and median dividers, for which little lateral excursion can be tolerated. With restrained occupants, higher overall levels of protection might become reasonable.

There have been decades of progress in developing motor vehicle official data bases that are useful for some levels of research, monitoring trends, and evaluation. Police accident reports offer a potential ready-made data collection capability because an officer is present at the scene with responsibility for managing the crash scene and collecting certain information. Some States have a mechanism for compiling and transferring individual crash reports to a centralized data base, enabling researchers to analyze data, test for shortcomings, ascertain benefits, and use the results to improve the data.

One goal that might be set for injury prevention in nonmotor vehicle areas, such as home fires and gunshot wounds, is to build more official data bases that are of interest to the injury prevention research community and useful for research. The requirement for officials to be present at the scene opens the possibility of gathering data in a way similar to the reporting of motor vehicle crashes.

In the future, hopes will be realized for better quality research in the injury prevention area. The multiple factors that mediate injury, complex relationships among factors related to injury, and the low probability of the event make good study design a challenge and a necessity.

A corollary of this point is the need to focus on the dual roles of injury prevention advocates and injury prevention researchers. Because there is an ever-present potential for conflict between the requirements for objective research, such as the

need to proceed slowly and deliberately, and the need for advocacy to produce action, those who frequently serve in both roles must remember these different requirements.

Research Trends in Acute Care of Injury

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ACUTE CARE RESEARCH comprises basic research, which examines the physiological and pathophysiological responses at the cellular level; clinical research, which applies changes to the clinical management of traumatic injury in the hope of improved survival; and systems research, which analyzes the contributions of individual components of a trauma system to overall patient care. By necessity, systems research includes fiscal analysis to determine the true cost of an increment in medical care in terms of improved survival, and to examine where these resources need to be placed.

Basic Research

Acute injury causes a vast array of metabolic disturbances that are as yet poorly understood. Although acute restoration of blood volume will prevent many late sequelae, much needs to be done to determine what changes occur because of acute injury. Can manipulation of the various vasopressors and kinins that are released improve survival in animal models? One still needs to be able to control spinal cord and central nervous system swelling and potentially improve the survival of patients with combinations of injuries. Research is continuing on the defense mechanisms (both humoral and cellular) in order to be able to manipulate these systems and prevent the septic complications of injury. Particular attention needs to be paid to research on head and spinal cord injuries because this is an area with high benefit potential.

Clinical Research

Clinical research on injury deals primarily with the resuscitative, operative and acute care phases

of acute care. The clinical management of pulmonary and cardiac complications is well understood, and there are techniques to manage acute renal failure. Research trials in several new antibiotics are ongoing, and research into the manipulation of the neuroendocrine response is being performed. As funding for clinical research on injury diminishes, consideration should be given to centers that have demonstrated excellence in academic and clinical research. Appropriate trauma populations of sufficient size can provide statistically meaningful answers to many current questions.

Systems Research

Trauma systems research is still in its infancy. Trauma systems work, and do reduce mortality, but more research is needed in:

System components. What components of the system are essential for success; what are their relative weights?

Triage research. Although it is known which physiological values are of use in triage, more information is needed on the mechanisms of injury, which patients can benefit from the system, and how to identify those patients.

Morbidity data. Although morbidity data are available, they need to be organized and developed.

Data application. The data for acute care systems evaluation should not only be linked to data on rehabilitation and outcome, but should be used to identify populations at risk.

Trauma registries. The use of trauma registries should be encouraged; several States are developing trauma registries similar to cancer registries to follow systems development and evaluation.

Research Trends in Rehabilitation of Injury

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TRAUMA CARE IMPLIES advanced life support, the essence of the life-saving process itself. A question that comes to mind is: life-saving for what? Trauma usually is not limited to impairment

of a single bodily system. In many cases, numerous impairments or potential impairments are present. These require much work on the part of the total treatment team, the patient, and the patient's family.

Rehabilitation is the comprehensive, multidisciplinary delivery of services for long-term, chronic or catastrophic problems. The goal is to achieve optimal return of function or maintenance of function. Functions are physical, psychological, social, and vocational.

Among the problems presently of interest in the rehabilitation community is the pathophysiology of trauma or the disease process. Research in the clinical course is also important; it focuses on identifying rehabilitation problems that accrue. Of particular interest is the enhancement of function, the maintenance of function in a progressive disorder, and all aspects of psychological and social adjustment, vocational success, and community reintegration. The prevention and treatment of secondary medical complications deserve mention.

In 1968, the Rehabilitation Services Administration (DHEW) began to explore what could be done for one of the catastrophic injuries, spinal cord injury. After a few years of development, a "model system of care" was conceptualized. The important phases of the model system included emergency and acute care, acute physical restoration and rehabilitation, psychosocial adjustment services, vocational preparation, life-time followup care, and prevention. As early as 1970, DHEW was beginning to conceptualize primary prevention as an important component of this model system program.

The program began with one system in 1970 and has 13 projects today. The National SCI Statistical Center at the University of Alabama in Birmingham is the coordination point for an established nationwide standardized data base that has been developed by this research program.

This data base is crucial because of the protocols designed to pool and do statistical analysis of the data from the numerous sites in a standardized way. The National Institute of Disability and Rehabilitation Research (NIDRR) is building a data base for physicians and rehabilitation teams. As of 1985, this data base included 9,647 patients as research subjects and 28,951 patients whose progress had been followed for up to 12 years. Data are available on each patient as a research subject from point of injury through long-term followup. NIDRR also has a designated pediatric trauma research and training center with more

than 3,000 patients representing 34 different participating trauma centers.

Where are we going in the field of trauma rehabilitation? Progress has been made in brain injury, thanks to the National Head Injury Foundation, concerned physicians, and allied health professionals. Progress has been made with burn rehabilitation, which requires more resources, information, and coordinated efforts.

Progress has been made in orthopedic trauma and musculoskeletal disability, with such specific problems as the knee and shoulder injuries, and in terms of the needs of the whole patient, particularly children.

Improved service delivery models—a part of the continuum of care described for spinal injury—can and should be applied to brain injury, severe thermal injury, major orthopedic trauma, and maxillofacial rehabilitation. We need development, testing, and evaluation of new modalities for functional restoration and the enhancement of function, and existing methods and techniques should be evaluated. Although much is being done in rehabilitation, it is not known if some new techniques work. We need to develop improved measures of functional appraisal of clinical outcomes. Every institution working in rehabilitation is collecting data, which should be shared with clinicians and scientists. We need as well increased emphasis on psychosocial outcomes and community adjustment.

Finally, new approaches are needed to involve families early in acute care and in acute rehabilitation settings. Policy research can help to eliminate disincentives to work, encourage community reintegration and independent living, stimulate major research efforts for the prevention and treatment of secondary medical complications, and further the development and testing of innovative public education programs for the primary prevention of disability.

The Role of Biomechanics In Vehicle Design for Control of Injury

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THE DESIGN OF AUTOMOTIVE occupant protection systems is a process based on an

understanding of the mechanisms of injury and human impact tolerance. Injury mechanisms are the physical processes that result in tissue damage and functional impairment. Human impact tolerance refers to the levels of stress or load that the human system can withstand with little or no injury. This field of research is called injury biomechanics (1). It focuses on the nonpenetrating types of injuries that can occur among restrained and unrestrained occupants of highway vehicles involved in crashes.

Given sufficient information about injury mechanisms and tolerances, engineers can develop systems that will provide maximum occupant protection across the full range of crash configurations. Effective systems are achieved through developing realistic anthropomorphic test devices, or dummies, that respond with biomechanical fidelity to impact. Their characteristics provide criteria for evaluating engineering measurements in relation to human injury risk. In turn, the dummy and criteria are used to assess the effectiveness of protective systems in the development stage as well as in actual crashes.

Crash Injuries

There are two basic mechanisms involved in blunt, nonpenetrating impact injury to persons: localized loading of the human body and acceleration in the direction of loading. In the automotive environment, the primary collision of the vehicle with whatever it strikes is followed by an impact of the occupant with the inside of the vehicle. Local loading of a part of the human body against the instrument panel, or a seat belt, is referred to as the "second collision." There is a "third collision" between soft tissue and skeletal structures that takes place inside the body as it is stopped by the vehicle's interior or restraint system. The contribution of the two types of impacts to the injury process differs, depending on the body region and the severity of impact. The basic function of an occupant protection system is to reduce the severity of these impacts and thus their potential for causing injury. Several examples of occupant protection systems currently in passenger cars will demonstrate the role of biomechanics in vehicle design for injury control.

Early Years in Automotive Safety

The earliest automotive safety technology emphasized structural integrity of the passenger com-

... Data derived from head, chest, and knee contacts ... provided the first information on human tolerance to impact forces.'

partment to provide containment of the occupant in frontal and roll-over crashes. In the 1960s, the concept of energy management through crushable front-end structures was added. This combined approach attempted to preserve the occupants' space, while the vehicle's crushing structures absorbed crash energy, lengthened the stopping time and distance of the passenger compartment, and thus reduced impact decelerations acting on the occupant. Further improvements were achieved by isolating the front-end structures from the passenger compartment to minimize intrusion or deformation around the occupant. This method of controlling the vehicle's impact is an important part of the total occupant protection system in current automobiles.

For an unrestrained occupant, the controlled deceleration of the vehicle in a frontal crash is followed by the impact of the occupant against the vehicle interior. During this "second impact," the unbelted occupant continues to travel forward at the vehicle's precrash velocity and strikes the interior, which has come to rest in front of the occupant. The protection of the occupant in this situation depends upon energy-absorbing interior structures and load-distributing surfaces that reduce the occupant's deceleration while spreading the impact forces over a broad portion of the body's strongest parts.

Interior Safety Engineering

The concept of impact energy absorption has two aspects. First, the deceleration of the occupant should be extended as long as possible. This can be done by having the occupant interact with something that deforms in a controlled manner, thus increasing the body's stopping distance. Second, it is important that the yielding structure does not spring back at the occupant, but deforms permanently or recovers very slowly. Otherwise, the impact energy is returned to the occupant and not absorbed by the deformed structure.

Although one method to achieve energy absorption and load distribution is with thick, slow-recovery foam padding, there are practical limitations on its effectiveness in severe crashes. As

a result, more complex systems have been developed to improve occupant protection. This has been achieved for the driver by the development of an energy-absorbing (EA) steering system, which uses a force-limiting column to safely decelerate the driver's chest, and a high-penetration-resistant (HPR) windshield, which uses a stretchable plastic layer between two sheets of glass for head impact protection.

Energy-Absorbing Steering System

In the early 1960s, automotive safety engineers were seeking information on the force tolerance of the chest. This information was needed for the development of an EA steering system to safely decelerate an unrestrained body contacting the steering wheel. The basic concept was to design a steering column to crush at a prescribed load, one not great enough to cause significant rib fracture. This device would increase the driver's stopping distance, decrease thoracic deceleration, and absorb impact energy.

However, the design effort stalled because the available human tolerance data did not provide specific information on the appropriate yield force for the system. In addition, the calculated tolerable force using the accepted 60-g whole-body deceleration tolerance, and an approximately 30-kg chest mass, indicated a 17.6 kilo-Newton (3,960-lb.) tolerance that seemed unrealistically high for system design. The basic safety objective was to design the yield force as high as practicable consistent with human tolerance; to maximize the energy-absorbing capacity; and to extend the range of safety function of the system.

Faced with uncertain information on the force tolerance of the chest, researchers developed a crash simulation facility and conducted experiments on human tolerance in automotive crash situations. The first experiments (2) involved sled tests with embalmed cadavers in order to simulate the response of an unrestrained occupant interacting with loadmeasuring surfaces. Data derived from head, chest, and knee contacts against padded load-cells provided the first information on human tolerance to impact forces. The resulting data on force tolerance of the rib cage provided the necessary biomechanical information to permit design of the energy-absorbing element in the steering system. Subsequent experiments (3) with prototype EA steering system confirmed that 3.29-kN (740-lb.) maximum hub force on the sternum and an 8.00-kN (1,800-lb.) maximum lo

on the shoulders and chest allowed column compression with only minor risk of rib fracture for a well-centered impact. These tests demonstrated the benefit of load sharing between the chest and shoulders, which was accomplished through load distribution over the rim, spoke, and hub surfaces of the steering wheel.

The EA steering system was introduced in 1967-model vehicles. The final system included a compressible ball-sleeve column, a steering wheel with improved load distribution and stiffness, and an anti-intrusion mounting bracket to reduce rearward motion of the steering system resulting from crush of the engine compartment. When the load of the driver on the steering wheel exceeds the compressive force of the energy-absorbing element, the column slips out of the shear capsule, compresses, and absorbs energy. This system has proved effective in saving lives and reducing injuries.

An evaluation by the National Highway Traffic Safety Administration (NHTSA) (4) found the overall risk of driver fatality in a frontal crash reduced by 12 percent since the introduction of the EA steering system. The risk of serious injury (including fatality) specifically from contact with the steering assembly was reduced by 38 percent. More recent safety developments of the steering system have focused on the steering wheel to improve protection of the face of the lap-shoulder-belted driver, and the abdomen of the unrestrained driver, and on better methods of assessing crash protection.

High-Penetration-Resistant Windshield

Injury research during the early 1960s indicated that the windshield glass in use was a possible source of deep facial laceration. These windshields were constructed of two glass layers with a thin (0.38-mm or 0.15-in) layer of plastic tightly bonded between them. The laminated glass was thus fairly brittle and would break and be penetrated by the head in severe crashes. This often resulted in the face being raked against the jagged edge of the hole made by the head. A proposal was made that better occupant protection could be achieved if the head could be kept from passing through the glass during impact, while ensuring that the head would be safely decelerated to protect against concussion injury.

Extensive collaboration between engineering and medical experts was required to determine an injury assessment procedure for the evaluation of

prototype head protection systems. Evaluation of head protection systems was needed to develop a laminated glass that would yield under impact to increase the head's stopping distance, yet still resist head penetration at higher impact speeds. The collaboration resulted in a series of head impact experiments (5) and led to a weighted impulse criterion based on average head acceleration raised to the 2.5 power ($A^{2.5}$; $GSI = A^{2.5}T$) and impact duration to assess concussion injury risk. This so-called Gadd Severity Index (GSI) became a widely accepted method of head injury assessment in anthropomorphic dummy tests and was the forerunner for the current Head Injury Criterion (HIC).

Other research (6) led to the development of a chamois covering for the dummy head, which provided an objective indication of laceration protection of prototype windshields. Eventually, cadaver impact experiments were conducted using various prototype windshields in simulated vehicle crashes. These tests showed that a thicker (0.76-mm or 0.30-in) plastic interlayer bonded more loosely to the two outer sheets of glass could provide a stretchable structure with greater energy-absorbing capability, while still safely keeping the head from penetrating the windshield at high-impact speeds.

The optimum characteristics for occupant protection were worked out in a joint effort between the auto industry and the glass manufacturer, so that it was possible to introduce the new windshields in 1967-model vehicles. Since then, the HPR windshield has proved remarkably effective in reducing injuries to the face while not increasing the risk of brain concussion. A recent evaluation by NHTSA (7) found a 70-percent reduction in nonminor facial lacerations and fractures through the use of HPR windshields. More recent safety developments of windshield glass have focused on (a) antilaceration inner shields, whereby a layer of plastic lines the inner surface of the windshield to further prevent laceration of the face and scalp, and on (b) a better method of assessing head dynamics and facial contact force during glass impact.

The Need for Occupant Restraint

Although interior safety in the form of energy-absorbing structures and load-distributing surfaces has achieved tremendous gains in occupant crash protection, the crush distance available is only a fraction of that which is needed to achieve safe

'A lap-shoulder belt restraint system adds significantly to the effectiveness of the total occupant protection system. When used, seat belts reduce the risk of fatality by 43 percent and serious injury by 40 to 70 percent . . .'

occupant decelerations in high-speed vehicle crashes. Further enhancements of occupant protection can only be achieved with restraint systems, which allow the occupant to take better advantage of the vehicle's crash-worthy structure.

A snug-fitting lap-shoulder belt ties the occupant directly to the passenger compartment and allows that occupant to "ride-down" the crash as the vehicle's front-end crushes. This coupling and ride-down decelerates the occupant more gradually and over a longer distance than is possible with energy-absorbing interior structures, while minimizing the more severe occupant-to-interior impacts. Belts are designed to distribute restraining loads over strong skeletal structures, including the shoulder, rib cage, and pelvis, while minimizing the level of whole-body deceleration in recognition of human tolerance. Finally, belts provide significant control over the occupant's motion, particularly in roll-over crashes, and virtually eliminate the risk of ejection. A lap-shoulder belt restraint system adds significantly to the effectiveness of the total occupant protection system. When used, seat belts reduce the risk of fatality by 43 percent (8) and serious injury by 40 to 70 percent (9) in motor vehicle crashes.

Air-bag restraints were developed to overcome the primary weakness of belt systems: to be effective, belts must be fastened in advance, usually by the occupant. Using a pyrotechnic device to generate nitrogen gas, a bag can be rapidly inflated during the early phase of vehicle frontal crash without action by the occupant. The bag then fills some of the space between the occupant and the interior, which couples the occupant to the passenger compartment and achieves some of the safety benefits of ride-down and load distribution. This coupling is only temporary, however, because the bag must be vented and deflated, so that it will not act as a spring. However, injury biomechanics research (10) has found that the rapid development speed of an air bag can present a risk to those who may be close

to the bag during inflation. Thus, air bag design requires a tradeoff between a long inflation time, to reduce the risk of inflation injury, and a rapid inflation, to quickly fill the space between the occupant and the interior. Because air bags neither remain inflated nor provide lateral restraint, seat belts are needed to adequately control occupant kinematics over the range of crash types.

Occupant Crash Protection

The current safety thinking is focusing on combinations of safety systems to further improve occupant protection in a crash. In this context, inflatable restraints are viewed as a supplement to seat belts. The lap-shoulder belts would provide the primary coupling to the vehicle and control of kinematics, whereas the air bag would provide the additional protection of load distribution and crash energy absorption in the more severe frontal crashes.

This effort is part of the car industry's goal that new car development continue to seek improvements for the protection of the unrestrained as well as the restrained passenger. Although challenging, strategies may exist for improving protection for both by vehicle design. But as there is an effort to introduce more sophistication in safety systems, there is a greater need for sensitive measures of occupant protection to objectively determine the most effective combination of systems (11). The resulting combination of safety technologies can work with crash-worthy vehicles and safe interiors to further enhance occupant protection.

As our understanding of injury mechanisms and biomechanical responses expands, we are developing more refined injury criteria and better anthropomorphic test dummies. The Hybrid III dummy measures more than 50 different responses to assess occupant protection systems. It is currently the most sophisticated dummy available for frontal crash testing. Efforts are underway to expand its capability to assess head and facial injury (12) and chest and abdominal injury (13). We are also moving rapidly to interpret injury risk as a continuous function of dummy responses rather than as a strict tolerance threshold. This approach recognizes the distribution in tolerance of the population at risk and the range of crash severity resulting in injury, and is leading to a scientific basis for safety engineering (14).

Biomechanics programs are establishing the different tolerance levels and injury patterns

expectant mothers, children, and the elderly, as well as the type of crashes resulting in their injury. In addition, we are identifying factors (15) such as intoxication and osteoporosis that influence impact tolerance. Finally, injury biomechanics research is addressing the issue of brain and spinal cord injury impairment and seeks to define the mechanism of injury and tolerance of neural tissues. This eventually will lead to better interpretations of the risk of injury disability from laboratory tests with dummies. The goal is to provide the means to effectively evaluate safety systems and optimize their benefits for the protection of the driving public.

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The Role of Biomechanics in Preventing Occupational Injury

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AS IN VEHICLE ACCIDENTS, when a worker slips and falls or is struck by moving equipment in industry, the force of the impact, often over a short period and applied to a localized tissue, causes serious injury and even death. Workers' compensation data indicate that these "impact trauma" events account for about 37 percent of all injury and illness claims (1). Further, when a worker is required to perform a manual exertion, occasionally or very repetitively, the physical stress of the exertion(s) causes a large variety of serious, disabling injuries (figure 1). Worker's compensation data indicate that such "overexertion trauma" accounts for more than 31 percent of serious injury and illness claims (1). In both impact- and exertion-related trauma, biomechanics knowledge is essential to understand the mechanism of injury and to devise scientifically valid strategies for control of the risk factors so identified.

Biomechanics trauma research in industry. Epidemiologic studies by Kelsey and White (2), Pope and coworkers (3), Snook and Jensen (4),

Figure 1. Two different types of biomechanical injury mechanisms common in industry

Event	Type of trauma	Typical medical outcomes
Sudden force	Impact	Contusions Lacerations Fractures Amputations Joint subluxations Concussion
Volitional activity	Overexertion	Tendonitis Tenosynovitis Myofascial disorders Nerve entrapment disorders (CTS) Low back pain

and others show that overexertion injuries are prevalent and costly to industry. They produce 31 percent of all Workers Compensation claims; comprise 60 percent of lower back pain in reported injuries; permanently disable about 60,000 workers a year and temporarily disable about 4.2 million workers a year; and cost the economy an estimated \$15 to \$20 billion a year, the equivalent of about \$400 per worker.

Most often, lifting, pushing, or pulling objects is associated with the incidence of overexertion-related back problems (5). Recently it has been shown that maintenance of awkward postures for sustained periods and highly repetitive hand or arm exertions are major risk factors in different types of overexertion-related trauma (4, 6). Frequently, there is not simply one risk factor causing injury, but several combining in the workplace to raise the probability of harm. As an example, a 1978 review of the literature sponsored by the National Institute for Occupational Safety and Health (NIOSH) on the cause of occupational low back pain listed 17 potential risk factors (both personal and workplace-related). An expert panel assembled by NIOSH 2 years later listed five workplace risk factors as the major cause of occupational low back pain but included five others as major contributing factors (5).

A suggested plan for occupational biomechanics research on musculoskeletal injuries. Research is needed to help measure the types of forces to which workers are subjected in different job situations, and to provide postural and motion description data in jobs suspected of causing excessive numbers of injuries. Fortunately, recent advances in video and force measurement systems

make it possible to acquire such data and classify the kinesiological aspects of manual labor in many industries (7).

Data on human size, shape, flexibility, and strength are not being acquired with the detail necessary to represent the large variations that exist in different ethnic, gender, and age groups. Despite the limitations of the existing population and job descriptive data, some human kinetic models have been devised to predict the forces and moments within various joints while performing common industrial tasks (7).

One of the biggest limitations of the existing models in predicting the stresses on various tissues is the lack of knowledge on the neurological motor control strategies used to activate various muscles during a given situation. However, with the advent of multiple electrode electromyography systems and computerized data acquisition and processing systems, such muscle activation rules are slowly being revealed (8). Until computerized tomography and magnetic resonance imaging are more widely used, the precise shape and relative positions of distinct musculoskeletal components will not be known. Tissue stress models have been devised to help define potential injury mechanisms, but with limited validation to date. One reason for the lack of tested validity is that the parameters of stress leading to failure of various relevant musculoskeletal tissues are only now being estimated in laboratory studies. True models to predict tissue injury will result as tissue failure data are acquired. These models will then need to be validated by epidemiological studies.

By using simplifying assumptions, it has been possible to learn how different risk factors in the workplace combine to cause overexertion-related low back pain and sciatica, carpal tunnel syndrome, and finger flexor tendonitis and tenosynovitis (9-11). Recent studies (12) have disclosed how fibers are destroyed by certain types of stretching and repetitive exertions. Brinckmann and Johansson (13) have disclosed that the spinal discs fail at relatively low loads when repeatedly stressed. Human gait analysis studies have documented how important appropriate shoes are in preventing certain types of lower extremity injuries (14). Studies of industrial activities have shown how important it is to maintain high levels of foot traction in certain tasks (15) and that many industrial floors do not provide such traction (16). Slipping and falling often result from a lack of certain types of muscle coordination, which varies among people and with age (17).

Figure 2. Opportunities for biomechanics research to contribute needed science for prevention strategies: Stages of overexertion trauma, prevention levels, and appropriate strategies

Stage of overexertion trauma	Stage of prevention	Prevention strategies
Stage 0: Population performing manual exertions	Primary	Ergonomic design of jobs for all workers
Stage 1: Mild symptoms but still able to work normally with some personal days lost	Secondary	Screening Training Job rotation Job modifications
Stage 2: Severe symptoms; substantial impairment of work with temporary disability	Tertiary	Aggressive medical follow-up and rehabilitation, with job special accommodations
Stage 3: Recurrence of symptoms after treatment or development of muscle weakness and loss of motion	Permanent disability	

Biomechanics and prevention of overexertion and impact trauma in the workplace. Biomechanics research has and should continue to contribute to understanding of the following areas to prevent overexertion- and impact-related injuries in industry: (a) the effects of various types of floors and shoes in different tasks known to cause slips, falls, and lower extremity impact trauma; (b) the kinetic effects and resulting neuromuscular reactions during a slip or trip; and (c) personal protective clothing.

Overexertion trauma in workers may be described in symptom stages corresponding with suggested prevention strategies which depend upon biomechanical studies to obtain the required scientific understanding. Primary prevention strategies for the total worker population performing manual exertions entail ergonomic design of jobs for all workers. Secondary prevention strategies consist of screening, training, job rotation, and job modification. These are directed toward such problems typically resulting in mild symptoms, but with the worker still able to work normally, but with some personal days lost. The third prevention strategy level calls for aggressive medical followup and rehabilitation with special accommodations on the job. Symptoms at this level are severe, with substantial impairment of work with temporary disability. At the next level, recurrence of symptoms after treatment, or development of muscle weakness and loss of motion, leads to permanent disability (figure 2).

In primary prevention, biomechanics knowledge is critical in defining the job and personal risk factors and the engineering guidelines necessary to redesign jobs. In this context, biomechanics becomes the foundation discipline for ergonomic job improvements. In secondary prevention, biome-

chanics knowledge can provide the means to evaluate those who perform certain types of hazardous manual work, such as by providing muscle-strength testing parameters (18). Biomechanics becomes important when prescribing certain types of manual training, such as lifting methods (19), and under what conditions job rotation should be considered. Tertiary prevention strategies, if a person is impaired, require more precise knowledge of the person's performance capability within the context of the manual jobs for which the person could qualify. Knowing the biomechanical requirements of various jobs and the capabilities of impaired individuals can greatly expedite the disability evaluation process, and thus reduce lost time and rehabilitation costs.

Summary. Overexertion and impact trauma are the major cause of occupational injuries and deaths. These types of injuries result from a lack of biomechanics knowledge, combined with ineffective dissemination and use of existing biomechanics knowledge. The cause of these type of injuries is not single factored, and hence both the research and prevention strategies must be comprehensive and multidisciplinary. Understanding the cause of these injuries in industry will also have direct relevance to many sport activities that cause similar injuries, but may be less easily controlled and prevented, owing to the competitive nature of most sports.

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Interventions: Measuring the Progress of Injury Control Objectives

Objectives for Injury Control Intervention—The Department of Health and Human Services Model

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IN THE 1980 PUBLICATION "Promoting Health/Preventing Disease: Objectives for the Nation" (1), the Department of Health and Human Services (HHS) described objectives to be achieved by 1990 for injury prevention and control. These objectives were designed to meet some of the goals set forth in "Healthy People: The Surgeon General's Report on Health Promotion and Disease Prevention" (2). These objectives targeted several broad areas of injury for reduction, specifically motor vehicle injuries, falls, drownings, burns, gunshot wounds, and poisonings. This paper reviews these objectives, describes currently available and other potential intervention strategies for achieving these objectives, and briefly reports on the status of meeting these objectives.

Motor Vehicle Injuries

The 1990 objectives include a 25-percent reduction in the motor vehicle fatality rate from 1984 levels (to 18 per 100,000 people), a 40-percent reduction in this rate for children under age 15 (to 5.5 per 100,000 people), and a 75-fold increase in the proportion of motor vehicles with automatic restraint protection (to 75 percent from a 1984 level of 1 percent). Potential interventions suggested by HHS can be grouped into education and information strategies, product design or technological improvement strategies, legislative and regulatory strategies, and economic strategies. Data from 1984 reveal that deaths from motor vehicle injuries for all ages dropped to 19.6 deaths per 100,000 people, and for children aged 0-14 years to 5.9 deaths per 100,000. These statistics indicate that two of the 1990 objectives are within reach.

Using data from the 1985 National Health Interview Survey (NHIS) to indirectly assess the nation's progress toward the 1990 objectives, Hoffman reports that 36 percent of households report use of safety belts all or most of the time, 68 percent have heard of child restraint seats, and 45 percent were instructed in the use of child

Selection of interventions to reduce injuries from motor vehicle accidents

Criteria	Interventions			
	Education and information	Technological	Legislative and regulatory	Economic
Demonstrated efficacy	1	2	1	2
Demonstrated effectiveness	1	3	3	0
Public acceptability	3	2	2	3
Implementation ease	2	2	2	2
Low personal commitment	1	3	2	1
Cost effectiveness	1	2	2	0
Total	9	14	12	8

straints by a health professional (3). These statistics are far short of the 1990 objectives on education and seat belt use.

The 36 percent of households reporting seat belt use is higher than the approximately 10 percent reported by various insurance studies. This effect, if real, indicates some successful interventions, probably the result of media campaigns, education, and mandatory seatbelt laws. However, there is no indication that continued or intensified education efforts will significantly increase this proportion; the most promising method for improvement in this area seems to be mandatory use legislation. Where studied (Michigan and New York), such laws have increased rates of observed use and were associated with decreased fatalities. The major historical barrier to such legislation was one of individual freedom; this barrier is succumbing to pressures from automobile manufacture lobbies who will support nationwide seatbelt laws to avoid legislation mandating air-bag installation. Thus, legislation is more likely to be targeted toward mandatory restraints than product design improvement.

Falls

The 1990 objectives include a 68-percent reduction in the mortality rate from falls (to 1 per 100,000 people) and an 18-percent reduction in the home injury fatality rate for children under 15 (to 5 per 100,000 people). The overall mortality rate for falls has remained fairly stable over the last few years at 5 incidents per 100,000 people. The home injury rate for children dropped to 5 injuries per 100,000 children in 1983 but rose again in 1984 to 5.2 incidents per 100,000 children.

Potential interventions include educating the elderly in how to reduce risk of falls, and educating parents and child caretakers about supervisory and safety measures to prevent falls.

Other possible interventions are improving the design of products to reduce the potential for injuries from falls, as well as legislation to provide standards for structural improvements. No reliable data exist on progress toward these objectives. The intervention that appears most likely to help reduce this problem is education to improve the awareness and therefore change the behavior of the populations at most risk from falls: children and elderly. Because both populations have a high rate of exposure to health care providers, this provides an obvious arena to introduce educational interventions.

Drownings

The 1990 objectives involve a modest reduction (6.2 percent) in the mortality rate from drowning (to 3 per 100,000 people). This goal was reached in 1981; a new goal of 1.5 drownings per 100,000 people was set for 1990. Data from 1984 revealed that this rate had fallen to 2.1, similar to the 1982 and 1983 levels.

Recommended interventions include water safety and swimming programs, improved design of swimming pools and pool areas, safety standards for public pools and flotation devices, as well as alcohol-use laws for boaters, and reduced insurance rates for swimming pool owners who have used effective safety measures. Although there is no good data source for judging progress in reducing drownings, the literature suggests that improving pool environs might be the most effective means of intervention (4).

Burns

The objectives, calculated using 1978 data, include a 50-percent reduction in tap water scalds requiring hospital care (to 2,000 people per year);

a 16.7-percent reduction in deaths in residential fires (to 4,500 victims per year); and a 2.7-fold increase (over 1970 data) in the number of functional smoke alarms installed (to 110 million systems, or 75 percent of households). The goal for deaths in residential fires has been reached with the 1984 level of 4,466 deaths (1.9 deaths per 100,000 people). The new 1990 goal has been set at 1.5 deaths per 100,000 people.

Interventions include educating children about fire and burn prevention; educating building professionals and health care providers on fire safety; product design improvement, with increased use of fire-retardant materials and self-extinguishing matches and cigarettes; legislative measures mandating smoke-detector installation and hot-water heater settings; and economic incentives involving reduced insurance rates for homes with fire-protection devices.

Hoffman's study of the 1985 NHIS data reveals that 63.2 percent of households have at least one functioning smoke detector, which is a significant improvement from 1979 conditions but still short of the 1990 objectives (3). Also, 36 percent of respondents indicated they at least knew the temperature of their hot water, and 20 percent knew the safest temperature to avoid scalds.

Legislation mandating smoke detector use is in place for rental dwellings, which likely is in part responsible for success toward the detector goal. Although legislation for private homes might improve use in this setting, it would be difficult to enforce. Further gains might be made by community-sponsored campaigns and education by health care providers. Decreases in tap water scalds may require the availability of large-capacity, low-temperature water heaters, especially for large families.

Gunshot Wounds

The 1990 objective is a 5.6-percent reduction in nonintentional fatalities from firearms (to 1,700 victims per year). This target was reached, with 1,688 such deaths reported in 1984; a new goal has been set at 1,600 gun deaths (0.68 deaths per 100,000 people). This target, seemingly small, reflects the United States' adamant stand against gun control. A legislative change in this area would also likely have an effect on homicides and suicides.

Without such a philosophical change, remaining potential interventions include development and use of nonfatal projectiles such as wax bullets,

improved trigger-safety mechanisms, and improved public education on the safe handling of firearms. There are no data to suggest that any improvements have occurred in this area; improvement may require interventions aimed at changing social consciousness.

Poisonings

The main objective is an 18-percent reduction in household injury fatalities (most victims are children). The other major objective involves increasing awareness of poisoning as a safety hazard and of poison control centers. Hoffman reports that 70 percent of households with children under 10 years of age had the telephone number of a poison control center and 25.4 percent had Ipecac in the house (3). These figures indicate the success of educational intervention by community campaigns and health care providers and suggest that efforts to provide optimal poisoning control were badly needed.

Other objectives involve improvements in awareness of safety measures for parents, in health care providers' injury control advice to patients, in trauma center access and emergency transportation, and in injury surveillance.

Selecting an Intervention Strategy

The critical decision for policy makers and program personnel is the selection of intervention strategies for each injury control area to serve as the basis for developing program activities. In selecting an intervention strategy, at least six factors should be considered, as follows:

- demonstrated efficacy of the intervention in reducing injuries
- demonstrated effectiveness of the intervention when implemented at a community or State level
- public acceptance
- ease of implementation considering political, economic, and logistic barriers
- level of personal commitment (for example, how much of the success of the intervention is not dependent on individuals making frequent decisions to adhere to the intervention?)
- cost-effectiveness

Unfortunately, the policy maker or program planner usually has few data available in these areas; those available are limited in scope, depth, and

accuracy. To help prioritize interventions, each intervention can be rated against the six criteria on a scale of 0 to 3, with 3 representing the highest (preferable) score. A rating of 0 implies that there is no basis for a judgment. Accuracy *versus* precision is the goal of such an exercise; thus, the relative ranking of the various interventions is more important than the accuracy of the total score. The purpose of the exercise is not to eliminate potential interventions, but to determine which interventions should be emphasized in a total program to reduce injuries.

The table displays the results of applying such a scheme to motor vehicle injuries and suggests that the greatest contribution to injury reduction in this area is likely to come from emphasizing technological and legislative interventions. Applying similar

methods to other injury areas could be helpful in optimizing efforts to reach the 1990 objectives.

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Interventions: Unintentional Injuries— A Behavioral Focus

Behavioral Aspects of Injury

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FOUR MAIN ISSUES WILL BE EXAMINED in this section. These are the influence of behavior on injuries, the influence of other factors on behavior (such as social, environmental, and occupational factors), the influence of interventions on behaviors, and the possible transferability of interventions used in one area to other areas of injury control.

There are two broad areas we need to understand to make progress in injury prevention. One is to recognize the multiplicity of factors involved and the complex interactions that exist between behaviors and other factors. The second is the role of behavioral and educational interventions—a role that includes direct and indirect influences. We have learned many things about the direct effects of educational interventions. Now, we need to apply this knowledge in more sophisticated ways in the future. We must recognize the indirect influences of public education.

Most societal health measures, such as mandatory seatbelt use, depend on an informed public,

knowledgeable about health risks and consequently willing to accept reductions of personal freedoms to accomplish an overall reduction of risk (1). Public opinion data suggest that public education has convinced people of the value of seatbelt use in a car crash. This does not mean they practice seatbelt use. It means they understand and accept that mandatory seatbelt use legislation will save lives.

In 1979, the publication "Healthy People" (2) highlighted the large proportion of premature death, preventable morbidity and disability, and reduced quality of life that is related to the health practices of the American public. A followup document, "Health Promotion/Disease Prevention: Objectives for the Nation" (3), established objectives regarding many health issues, three of which have an injury focus: control of stress and violent behavior, accident prevention and injury control, and occupational safety and health.

Another document, "The Model Standards: A Guide for Community Preventive Health Services" (4) specifies a series of outcome objectives, very similar to the objectives set forth in "Health Promotion/Disease Prevention." "The Model Standards" also document process objectives that recognize the role that behavioral interventions play. For example, one objective recommends that the community be served by comprehensive pro-

'Most societal health measures, such as mandatory seatbelt use, depend on an informed public, knowledgeable about health risks and consequently willing to accept reductions of personal freedoms to accomplish an overall reduction of risk.'

grams intended to prevent vehicular injuries and fatalities, focusing at the minimum on drinking and driving, seatbelt use, and infant and child restraints.

The objectives of "The Model Standards" reinforce the conviction of many that a community focus is a key element of a comprehensive injury prevention strategy. This focus requires community organization and development, an area that those in the behavioral and educational field recognize and support.

One of the most important process objectives in "The Model Standards" states that the community will be served by an injury surveillance system. By implication, epidemiologic surveillance ought to focus on behavioral and environmental risk factors, as well as on the injuries themselves. If those in this field are serious about incorporating behavioral strategies in a comprehensive injury prevention program at the community level, then community surveillance to establish baselines and monitor trends would seem to be an essential element of the strategy.

The Centers for Disease Control has begun such surveillance at the State level in the Behavioral Risk Factor Surveillance System. Thirty-six States are participating in this system, which covers about 78 percent of the U.S. population for such variables as smoking, control status for high blood pressure, weight and overweight, exercise patterns, chronic drinking, acute alcohol use or binge drinking, self-reported drinking and driving, and self-reported seatbelt use. These data provide States and communities with the information needed to reinforce community programs in a wide variety of health promotion, disease control, and injury control areas.

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Health Education Approaches to Motor Vehicle Injury Prevention

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ASK ANY EPIDEMIOLOGIST what to do to improve the chances of living beyond age 65 and the answer probably would be "avoid heart disease, cancer, and stroke." Ask how to improve the chances of reaching your 30th birthday, however, and the answer probably would be "avoid injury," and especially motor vehicle injury. Because of the magnitude of the motor vehicle injury problem, and its close association with behavioral and lifestyle factors, a combined strategy of behavior change and environmental modification will be necessary to reduce the unacceptable motor vehicle injury toll.

"Healthy People" (1), the Surgeon General's report on disease prevention and health promotion, outlined three parallel strategies to reduce the problem of injury, including motor vehicle injury: *health services* directed at improving health care and its delivery, such as the organization of regional trauma centers, and improvements in emergency care; *health promotion* directed at behavioral change, such as programs to encourage people to use safety belts; and *health protection* directed at environmental change, such as strengthening occupant protection laws and motor vehicle safety regulations.

Each of these strategies relies on slightly different methods to accomplish its goal of injury reduction. Using the strategy of health services requires improvements in the organization and delivery of injury care. Using health promotion

requires the modification of predisposing, enabling, and reinforcing factors that influence preventive behavior. Using health protection requires changes in the environment to make motor vehicles and highways safer.

Each strategy builds on the other. Effective health promotion efforts also will reinforce changes in health protection and improvements in health service, and *vice versa*. This paper considers the use of health promotion techniques to affect change in occupant protection behavior.

There is a strong relationship between health promotion and behavioral change. Green's definition of health promotion underscores this. Health promotion "... is any combination of health education and related organizational, economic, and environmental activities designed to support behavior conducive to health (2)." Green's PRECEDE framework has been used to structure interventions that have successfully modified many health-related behaviors. Use of this framework to develop health promotion interventions for motor vehicle injury control requires that three categories of variables be addressed.

Predisposing factors. These include knowledge, attitudes, values, and perceptions about occupant protection. These factors might best be influenced by direct communication, individual counseling, formal and informal instruction, or through the media. Examples of predisposing factors include knowledge about injury dynamics in a crash, the perception of personal vulnerability to being involved in a crash during a lifetime of driving, valuing life, and an attitude of confidence that occupant protection devices are effective in preventing injuries in a crash (3).

Enabling factors. These include availability and accessibility of occupant protection devices, skill in their proper use, an organized referral system for products and services, and an occupant protection networking system. Examples of enabling factors that influence occupant protection behavior are availability and affordability of passive restraints and back-seat lap and shoulder belts, skill in properly using safety belts and child safety seats with comfort and convenience, the presence of child safety seat loaner programs, and an active occupant protection coalition. Community organization is necessary to ensure such factors are present (4).

Reinforcing factors. These include incentives, behavioral modeling, rewards, and the development of social norms favoring increased levels of occupant protection. These factors are influenced

through the use of social engineering and social marketing approaches. Examples of reinforcing factors include incentives such as insurance discounts to those who wear safety belts or purchase passive restraint-equipped vehicles; role models such as parents, peers, teachers, and health professionals using safety belts; tangible rewards, such as gifts and additional compensation for wearing safety belts and using child safety seats, and intangible rewards like social recognition or special privileges (5-6); and portrayal of safety belt and child safety seat use as normative behavior in television shows and in print and advertising media (7).

In sum, health education approaches to motor vehicle injury prevention are most effective when they are planned to impact predisposing, enabling, and reinforcing factors that influence personal protective behavior (8-9). This approach requires working in partnership with the community to foster individual and social responsibility for injury control (10). Mason and Tolsma have reminded us that "Persons can hardly be expected to avoid the health risks imposed by personal choices about lifestyle when they do not know or understand these risks, when they lack the knowledge or skills needed to choose a healthier lifestyle, or worst of all, when they seek guidance or support from their community and it is unavailable to them" (11:772). Health education approaches can help assure that these deficiencies are properly addressed.

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Ergonomics: The Basis for Interventions to Avoid Accidents and Reduce Injuries

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DESPITE THE LACK of developed theories to explain accident causation, several theories exist that attempt to categorize reasons, or causal event chains, leading to accidents. Although these theories address the concept of "unsafe act," each de-emphasizes that and concentrates on other, usually management-dependent, aspects in pursuing interventions.

This approach may arise for two reasons. First, it reflects an understandable revulsion at the historical tendency of employers to blame the injured person (itself a contribution to the passage of Workers' Compensation legislation). The second reason, more pertinent to reducing future injuries in the United States, is the lack of understanding of human behavior that leads to such "unsafe acts." This lack of understanding also prevents the selection of appropriate interventions in situations where accidents and injuries do occur, but which could not be appropriately described as "unsafe acts."

The complexity of both the human organism and contemporary social and industrial environ-

ments demands a multidisciplinary approach to injury prevention. Since its inception in the late 1940s, the objective of ergonomics has been to satisfy the need for a problem-oriented, multidisciplinary approach to human performance. Ergonomics is defined as the application of anatomical, psychological, and physiological knowledge to the problems of the human within the environment (social or occupational).

The role of ergonomics is well illustrated in the following situations, which are known to produce chronic and acute injuries. Although it is clear that there have been successes, it is equally clear that there is often a lack of basic understanding and a compelling need for multidisciplinary research.

- Manual materials handling. Ergonomics criteria for safe handling have been developed (1), but descriptive studies necessary to determine common lifting postures are available and the effect of repetitive motions at a very submaximal level is not understood.
- Workplace design. Criteria are available but are not commonly applied by designers.
- Environmental stresses. As an example, for 50 years thermal stress has been claimed to affect accident rates, but why and how are still unknown.
- Complex systems. Ergonomics has improved the reliability and speed of human responses to system components such as dials and warning signals, but understanding of significant areas of concern is rudimentary.
- Repetitive motion injuries. In regard to hand operations, the relationship(s) between deviation, forces, rate of application, and total numbers of applications is clearly vital and yet is totally unknown.
- Falls. The etiology of falling and slipping behavior is unknown, despite the huge economic and personal costs of injuries resulting from this behavior. The need for a multidisciplinary investigation of falling behavior is apparent, including coupling between footwear and surface, gait and anthropometry, load-carrying, environmental factors, speed versus safety, task characteristics, inclination of surface, perceptual loads, and attention and individual capacities.

Ergonomics has concerned itself with human performance, which encompasses accidents; industrial output; industrial quality; error rates; speed and accuracy; changes with shifts or time of day; limitations to speed, capacities, and endurance;

and motivational aspects, including job satisfaction. In doing so, it has, by design, interfaced with many disciplines. The potential of ergonomics in injury prevention will not be achieved by discussing such boundaries, but by encouraging scientists to develop an interdisciplinary approach and by concentrating on the development of integrative theories of human behavior. Without such changes, little progress may be expected.

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Injuries to Children: The Relationship of Child Development to Prevention Strategies

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LEADERS IN THE FIELD of injury control need to understand how behaviors during specific phases of the human life cycle interact with environmental hazards. With such understanding, it is possible in most cases to modify the environment in ways that reduce the risks of certain types of trauma and injury. In other cases, modification of individual behavior, such as adult supervision, are needed to produce effective results.

Developmental Susceptibilities

Epidemiologic studies have demonstrated that the most frequent causes of childhood injuries vary by age. For example, the number of deaths from pedestrian injuries is highest among elementary school-age children (1-5). These children have limited cognitive ability to assess distance and speed and localize sound; they have limited ability to perceive and react to impending danger and a tendency toward impulsive behavior. Prevention strategies that modify the environment, such as overpasses separating the child from vehicular traffic, fenced play areas, sidewalk barriers, speed bumps in certain areas, and alterations in the

external design of the vehicle would seem to offer a greater potential for success than would individual behavior modification (6-8).

Death and severe neurologic impairment secondary to water submersion is a major problem among those less than 5 years of age, and in particular, the 2-year-olds. It appears that barriers to access may be effective (9). However, based on case reviews at the University of California, Irvine, existing barriers are not always childproof; hence, there is a need for (1) more effective barriers and (2) behavioral modification of the caretaker in this case. The barrier concept does not eliminate the need for constant supervision.

Trauma to child passengers in motor vehicles has, in part, been addressed by considering the physical characteristics of the infant and toddler, thus warranting the design of a specialized restraint system that would provide adequate protection in a crash. The availability of the child safety seat and educational campaigns designed to promote use have had only a limited impact. An additional strategy was necessary—mandated restraint use, which has markedly decreased occupant injuries among children less than 4 years old (10-15). To further decrease motor vehicle occupant mortality, automatic protection in combination with seat belt-use laws will be necessary (16).

Injuries to children from firearms is largely a problem of the proliferation of handguns and the acceptance of handgun violence in our culture. The young child is introduced to the handgun as a toy; violence with handguns is a mainstay of television drama. Moreover, there are an estimated 50 million guns in America, including tens of millions kept in households in which there are children. The young child does not understand the danger of the real object or the difference between it and a toy gun. While "playing" with the family gun, one child somehow kills another child. As for the adolescent who has grown up in our "gun culture," the handgun is all too often seen as the quick solution to conflict, and there has been increased incidence of handgun suicide and homicide among adolescents, ages 15-24 (17-20).

Prevention and Intervention

These examples illustrate critical features regarding injury control among children that must be built into intervention and prevention strategies. First, the innate behavioral characteristics and sequence of development of the child cannot be changed. Therefore, at this stage injury prevention

should be directed at modifying the behavior of the caretaker and at modifying the environment. Second, although educational programs are an essential part of an intervention strategy, they generally have limited effectiveness and must be carefully targeted (21-25). Third, it is important to promote better documentation of injuries in the medical records of our pediatric patients, so that specific injuries at specific ages and their attendant circumstances may be identified for further study.

Finally, environmental modifications ultimately will be most effective; in most cases they will require public policy changes and regulation of behavior and products. However, critically important public policy changes do not come easily.

If everyone were to devote 5 percent of his or her time to changing the behavior of U.S. society, especially its laws (such as handgun restrictions, disincentives for purchase and consumption of alcohol, incorporation of passive restraints in motor vehicles, and compelling modification of vehicle design), a substantial number of traumatic deaths in this country would be eliminated.

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Interventions: Intentional Injuries— Groups at Greatest Risk

Strategies for Prevention of Youth Suicide

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THE ANNUAL INCIDENCE OF SUICIDE among teenagers is 12 per 100,000, and there are significant differences in incidence between the sexes and ethnic groups. During the 1980s, approximately 2,000 adolescents committed suicide each year. Very few children under the age of 12 commit suicide, but the rate increases with age until it reaches a peak at age 24.

In the United States, boys commit suicide 4 to 5 times more often than do girls. In general, the suicide rate is higher among whites than blacks. The suicide rates in the Hispanic and oriental communities are similar to those of whites. Generally, North American Natives have very high suicide rates, which vary in different tribal subgroups.

A threefold increase has occurred during the past 25 years in the rate of suicide among white males ages 15–24, with an increase noted nearly every year. The increase for black males during this period has not been so great; the increase for girls has been very small across all ethnic groups.

Suicide attempts are more difficult to monitor than are suicide deaths, but there is evidence that attempted suicides have also increased during this period in both sexes (1,2). The reason that suicide deaths have increased only among males while attempts have increased in both sexes may be attributed to choice of method. Deliberate drug overdose is often the female's preferred method; treatments for drug overdose have improved, and rapidly lethal drugs such as barbiturates are less easily available. On the other hand, mortality may have increased among males because they favor methods for which treatment has not improved.

Both boys and girls are most likely to commit suicide with a firearm. The next most common method for boys is hanging; for girls, it is jumping from a height. Drug overdose, by far the most

common method in suicide attempts, is an unusual method for completed suicide.

Many teenagers commit suicide very shortly (often within hours) after finding out that they are in trouble, when they are afraid and uncertain about the consequences. Other less common precipitants include rejection and humiliations (for example, a dispute with a girlfriend, being teased, failing at school, and failure to get work). There appear to be relatively few cases of suicide where no immediate precipitating stress can be identified but where there is evidence of longstanding planning.

Most youth suicides are preceded by one of the common stresses of adolescence experienced every day by countless teenagers who do not respond with suicidal behavior. To explain suicide, we have to look beyond the stressor to some feature of personality or to a coexisting mental illness.

Characteristics of Suicidal Adolescents

The information on the suicide-prone teenager, which is summarized subsequently, was obtained from the New York State Psychiatric Institute Project. Because this project has not been completed, these statements should be regarded as provisional.

- About one-third of teenage suicide victims are known to have made a previous suicide attempt; also, one-third abuse drugs and alcohol.
- Approximately half of suicide-prone adolescents experience intense labile mood changes and aggressive outbursts. These problems may coexist with periods of depression.
- Uncomplicated depression, without any associated behavior problems, is uncommon.
- There is a subgroup of teen suicide victims who have not previously appeared to be troubled. However, such teenagers worry a great deal about getting things "just right." They become excessively and unnecessarily anxious before tests, not because of parental pressure but because of their own anxiety about performing well. They are unreasonably distressed at times of change and dislocations, such as moving to a new home or changing to a new school.
- Only a small proportion of all teen suicides occurs among teenagers with manic depressive or

schizophrenic psychosis because these conditions are relatively rare. However, among teen patients suffering from psychosis, the rate of suicide is extremely high.

- Biochemical abnormalities consisting of low levels of the breakdown products of the neurotransmitter serotonin (3) have been consistently identified among suicidal persons. This abnormality has also been found in persons with aggressive or impulsive tendencies.
- Suicide is familial—a high proportion of youths who commit suicide have had a close family member or friend who attempted suicide. It is not yet known if this is because of the example that has been set or because of some genetic factor.

Evidence is accumulating to show that imitation may be an important facilitator of suicidal behavior among young people. Examples of the evidence follow.

- Prominent coverage in newspapers of a suicide leads to an increase in suicidal deaths—mainly among young people—for a 1- to 2-week period after the news (4).
- Research shows that suicide completion and attempt rates increased during the 2 weeks following fictional television shows dealing with adolescent suicide (5).
- Young attempters had many more close contacts with others who had made a suicide attempt than did nonsuicidal psychiatric controls (6).
- Documented examples exist of “copycat” suicides taking place within a few hours after a vulnerable teenager has seen a film or a news story, or read a book, featuring suicide (7).
- The occurrence of suicide clusters is thought to depend on imitation. It appears that teenagers who die in a cluster outbreak will not usually know one another personally but will have read about the other teenagers’ deaths during the extensive and intensive local newspaper coverage of each case.

These findings are clearly relevant to suicide prevention activities that often involve presenting the facts about suicide to children and teenagers. A major challenge is how to present such findings without encouraging imitation.

Suicide Prevention Strategies

The most common prevention strategies developed for teenagers and young people are school-based casefinding and educational programs. These

incorporate a mixture of primary and secondary goals. There has as yet been no research on their efficacy; however, because they will be new to many, I will describe such programs briefly.

Secondary prevention that focuses on the treatment of high-risk groups (mainly suicide attempters) is generally untested. The impact of self-referral services such as hotlines has been reviewed elsewhere (8) and will not be dealt with in detail here. The impact on youth suicide rates of controlling access to firearms has not been assessed, but evidence from other countries suggests that this method is probably the most efficacious. Given the evidence of media facilitation, one other unevaluated approach to suicide prevention is the prohibition of potentially suicidogenic programming.

School-based prevention methods. The goals of most educational, school-based suicide prevention programs are these:

- casefinding—identifying potentially suicidal students by teaching “warning signs” to peers and staff in the expectation that the potential suicide victim is more likely to confide intentions to such persons than to a mental health professional or to a parent,
- informing young people and teachers about therapeutic resources in the school and surrounding community,
- developing some behavioral skills among teachers and peers in handling confidences concerning suicide and presenting communication models that usually promote trust and disclosure from a potentially suicidal student,
- providing education about stress management, coping strategies, and mental health symptoms.

These programs may or may not include specific mention of suicide. They are typically given in health class and may also be aimed at identifying and supporting students with drug or alcohol problems, failing grades, parent problems, and so forth.

Evaluation. There is a complete absence of any systematic evaluation of inschool programs. It is possible, however, to comment on such programs. It is likely to be helpful for students and staff to receive information on local resources and how mental health professionals work and can help. It may also be helpful for staff to receive guidance on how to handle a referral to an outside service

through defined procedures to be followed when severe emotional disturbance is brought to the attention of staff.

In general, however, the explanations and descriptions of suicide produced by many programs play down the importance of prior personality or behavior difficulties, overemphasize the role of stress as a "cause" for suicide (rather than as a trigger in an otherwise vulnerable teenager), and lay too little emphasis on special suicide risk features (for example, family history or close friendships with a person who committed suicide).

Sufficient evidence exists that young people imitate actual and fantasized suicide to warrant concern about discussing the topic in the classroom. Such discussions are intended to reduce the taboos around suicide and thus facilitate the disclosure of preexisting preoccupations among suicidal pupils, reducing the student's urge to commit suicide and enabling others to point to alternatives to the problems that preoccupy the youngster.

Given the general rarity of suicidal behavior, one must assume that only a small minority of youngsters will feel stimulated toward suicide after a classroom discussion. The remainder would emerge better informed and better able to help their vulnerable classmates. Ideally, therefore, the pupils would be prescreened to identify those who are suicide prone. For them, another kind of intervention would be devised.

However, this solution requires careful research, which quite simply has not been done. In the absence of data, a rational cost-benefit calculation cannot be done. Given this situation of uncertainty, one can only counsel extreme caution in proceeding with direct classroom discussion about suicide until reasonable research has been undertaken. A cautious approach would be to offer one-to-one followup interviews with trained personnel to any pupil who admits to feeling more preoccupied with the idea of suicide after such a presentation.

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Homicide and Minorities

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BLACK AMERICANS continue to be the highest at-risk population for homicide, a position that the group has maintained since statistics based on race of victims were first compiled in 1914 (1). The explanations attributed to this group-specific form of lethal injury are highly varied, encompassing individual and group behavioral orientations, with emphasis varying from one period to another. Current high-risk levels, however, are frequently attributed to the behavioral styles of young adult males, poverty, and membership in the subculture of violence (2). Yet, there are researchers who find problems with some or all of these explanations (3-5). But explanations are not temporally stable, and the underlying causal factors during one period later give way to others. Correspondingly, intervention efforts should reflect an awareness of the changing nature of interpersonal relationships that lead to homicide.

Homicide Risk for Black Americans

One objective of this paper is to determine the direction in which the aggregate risk of homicide for blacks has been moving during the 1980s. Because blacks are highly concentrated in the nation's largest cities, where risk is known to be appreciably higher, it is particularly germane to attempt to detect if place of residence is tied to trends in risk behavior. To do this, homicide

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trends in a small sample of cities (which were scrutinized at the neighborhood level during the late 1970s) will be reviewed.

The target cities include Detroit, St. Louis, Los Angeles, Atlanta, and Houston—all cities with large black populations that have formed expansive ethnic territorial communities. It can be assumed that the prevailing homicide risk within these ethnic communities is either an indicator of the operation of a subcultural pattern that favors risk or the impact of economic forces that promote maladaptive behavior. Probably some combination of these factors underlies the observed risk pattern.

Character and Composition of Risk

The Federal Bureau of Investigation's Annual Crime Reports demonstrate a decline in the aggregate number of homicides for each year since 1980 and a corresponding decline in the magnitude of black victimizations. This observation raises several questions, the chief among them being: Does this reflect an improvement in group socioeconomic status, a weakening of subcultural traits that promote interpersonal violence, or simply a population-aging effect?

It was recently noted that a decline in the commission of criminal acts can be anticipated as 1990 draws near and that a sizeable share of that reduction can be attributed to a population-aging effect (6). However, the observed decline in the 1980s in black victimization and its associated risk varied substantially from one place to another, a situation that led to the conclusion that population aging in the sample communities, at least by mid-decade, had not been a major contributor to a decline in risk in large urban centers.

This conclusion leads one to embrace an explanation that is principally associated with economic and cultural factors. Although it is difficult to disentangle these interdependent factors, I will

estimate in this paper not only changes in aggregate risk in the sample locations, but I will focus on trends in the structure of victimization as well.

Variations in risk among sample communities. Among the sample communities, risk patterns demonstrate varying degrees of disparity. Not only are there notable differences in recent levels of estimated risk, but also individual places have been characterized by different risk trajectories since the peak risk level was reached in the United States in 1980. The magnitude of differential risk characterizing these individual places suggests that there are forces at work that tend to highlight their differences. Whatever these factors, they tend to manifest themselves not only in levels of risk, but in the structure of victimization as well.

Attenuated risk as a function of gender. The probability that any single confrontation will end in death is extremely difficult to determine but is clearly influenced by the motivating circumstances, the setting, the number of onlookers, the age and sex of the combatants, and the lethality of the weapons employed. Confrontations leading to death, however, far more often involve black males, so that extreme elevations in risk tend to be more common among this population. Thus, any serious effort to reduce the aggregate risk for blacks would of necessity lead to singular scrutiny of this population, in terms of psychosocial and sociocultural development and impact of macroeconomic changes on adaptive lifestyles.

Differences in the structure and pressures on the local economy seem to clearly affect black male lifestyles. These differences subsequently appear to affect the motivation and circumstances surrounding each confrontation, leading to the probability of differential risk. Note, however, that although black females are not immune to elevated risk, they seldom constitute more than 25 percent of all black victims. Current trends show that the ratio of black female to male victims is declining further; in most of the sample locations, it had dropped to a level of less than 20 percent.

Cities in the sample that continue to maintain extremely high-risk levels are those in which efforts to suppress felony-motivated behavior (for example, robbery, drug trafficking) have been unsuccessful. (Cities with declining risk have witnessed a relative decline in conflict-motivated or expressive killings since the mid-1970s.) Although the risk for blacks, generally, and for black males, particularly, is still unacceptably high, it is even higher in

cities where economic motives mobilize individual or group confrontations. This pattern is manifested in a higher failure to clear cases by arrest and an increased likelihood that the most victim-prone group is likely to be represented by young adult males. But this, like other conditions, may prove to be ephemeral as aging cohorts tend to cling to earlier established lifestyles. Moreover, it appears that youthful black males are moving toward adopting similar lifestyles in most of the nation's largest black communities, but at a different pace. This situation could lead to increased risk in locations with previously declining risk levels.

Community status and risk. What is unclear, at least ecologically, is how important poverty and inequality are in intensifying risk across places. Several researchers have recently concluded that poverty appears more often to undergird expressive risk, for example, family homicide (7), whereas inequality is more likely to stimulate heightened levels of instrumental risk, for example, robbery homicide (8). Thus, as ghetto communities continue to display signs of relative deprivation in a metropolitan context of economic growth (9), traditional patterns of risk are likely to give way to nontraditional ones, which may be less sensitive to the aging effect that was attributed to lower risk. Nevertheless, many analysts still attribute the outcome of lethal injury to a set of unchanging relations among antagonists, whereas others view the phenomenon in individualistic terms. Note, however, that researchers are unlikely to be able to predict risk effectively until it is better understood how individuals are apt to behave in specific settings.

The point to be emphasized is that although aggregate black risk is subsiding nationally, the national trend could obscure the growing seriousness of the problem in selected locations and of our inability to reduce the risk to males who are just reaching young adulthood.

A critical element involves how those approaching or entering young adulthood are prepared to successfully earn an honest living. This endeavor has become increasingly difficult in the face of changing labor requirements, inducements offered by the irregular economy, altered family structure, and the subsequent entrapment in poverty of a large share of the population (10,11). Nevertheless, renewed efforts are needed to promote positive socialization strategies and the adoption of lifestyles associated with lower risk.

Until researchers look more closely at the circumstances surrounding homicide and how it varies from place to place, they will be less likely to be able to lower risk. What will be required is a careful assessment of the more pertinent contributors to risk, in terms of individual and aggregate characteristics, if black males entering young adulthood are not to face the same or higher risk levels than their slightly older peers.

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Violence Prevention

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INTENTIONAL AND UNINTENTIONAL injuries are different and require different prevention strategies. Environmental manipulations may lessen the impact of intentional injuries but can be predicted to be less effective than they have been with unintentional injuries. Why should we apply

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the public health model or public health strategies to intentional injuries if they are so different?

Let us begin by examining the characteristics of the problem. Over half of homicide victims know their assailant, and most homicides begin with an argument—not with the commission of another crime. Furthermore, alcohol and handguns frequently play a role in homicides. In terms of a preventive approach, law enforcement strategies have little or no control over such intentional injuries.

With its emphasis on education and prevention, the public health model offers an opportunity to change attitudes and behavior, as demonstrated in efforts to reduce smoking, heart disease, and drunk driving.

One of the major benefits of viewing interpersonal violence as a public health problem relates to the new resources and strategies that can be applied to this problem. The traditional law enforcement approach sorely lacks the prevention strategies that are present in the public health model. It is at best secondary prevention focusing on the identification of the perpetrator and the description of the victim in traditional terms.

What resources can the public health model bring to this problem? First, there is the education-public awareness campaign, which is a large part of the public health model. Media campaigns often provide a successful conduit for such efforts. Community agencies (for example, churches, tenants' organizations, police organizations) provide successful vehicles for launching public education campaigns.

School-based efforts (that is, health education) are a second resource for conducting education campaigns. Perhaps every elementary school ought to have a curriculum on handling anger and how to avoid fights.

Health institutions are a third resource available through the public health model. Four times as many cases of nonfatal assault are seen in the emergency room as are reported to the police. Given these figures, the emergency room cannot be

ignored as a source for prevention and intervention strategies. As a medical student in one of Boston's emergency rooms, I treated a man with a laceration above his eyebrow, which had resulted from a fight. After treatment, he was released; but before leaving the hospital, he advised us that he intended to find the man who injured him and send him to the emergency room, in turn. We did not take him seriously, and he left. However, if he had attempted suicide and indicated the intention to try again, the response of the health care team would have been different.

Hospitalized patients represent an additional opportunity for intervention and secondary prevention. For instance, an initiative in Boston identifies adolescents admitted to the hospital as victims of interpersonal violence and offers limited specialized counseling. It is hoped that eventually this initiative will be expanded to offer such teenagers not only traditional medical care, but expanded psychological and social interventions as well. A Boston pediatrician, Dr. Peter Stringham, has developed a series of protocols for screening infants, toddlers, young children, early adolescents, and their families for their exposure to and use of violence.

Clearly, there are many resources that can be applied to this new concept of interpersonal violence as a public health problem. Environmental manipulations are perhaps going to be less effective in reducing interpersonal violence; rather, the focus should be on changing human behavior.

The success of any intervention strategy in this area necessitates a multidisciplinary approach. Although the public health model is accustomed to the involvement of epidemiologists, emergency room personnel, health educators, and community outreach people, it has not often embraced the criminal justice or the mental health communities as part of that model. However, these two communities must be incorporated into this multidisciplinary model to effectively address intentional injury.

Targeting Interventions at Substance Abuse Problems

Relating Drinking and Drugs to Injury Control: Perspectives and Prospects

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THE LITERATURE RELEVANT to alcohol, drugs, and injuries appears in such diverse forms that it is not easy to attain a global overview of the field. However, it appears that the existing epidemiologic literature is seriously imbalanced.

By far the largest body of literature on drugs and casualties is devoted to alcohol in traffic injuries, although there have been some recent well-designed studies of alcohol's role in nontraffic injuries and crimes (1-4). In recent years there has been an increase in the literature on illicit and prescription drugs and traffic injuries (5-8), but the data remain scarce, particularly when compared with the voluminous data available for alcohol (9). Most of the literature on illicit and prescription drug injuries is concerned with overdoses (that is, drug poisoning).

There is very little literature on tobacco and injuries. In the exhaustive review on smoking and health that formed the Surgeon General's report for 1979 (10), the relative risk of injury for heavier smokers was reported in a table to be as high as or higher than the relative risk for infective and acute upper respiratory conditions. Although this finding is likely to reflect an association between heavy smoking and heavy drinking and other factors, there may still be a direct connection to be followed up. In a review of the interaction between smoking and occupational exposures, smokers had twice the total rate of job accidents of nonsmokers, suggesting links through "loss of attention, preoccupation of the hand for smoking, irritation of the eyes, and cough" (10).

From the perspective of injury control, more may be gained from research in less-studied areas than from further research in well-studied areas. The literature's relative focus on particular areas,

reflecting funding resources, goes well beyond the relative magnitude of the problems. Thus, the literature on alcohol in nontraffic injuries and violent crimes is far less developed than that on alcohol in traffic casualties, and there has been less attention on alcohol overdoses than illicit drug overdoses (11,12).

Alcohol, Drugs, and Aftermath of Injury

The existing literature on alcohol, drugs, and injury concentrates on the roles of drinking and drug use as risk factors for the occurrence of injury events, but neglects how drinking or drug use may affect what happens after the event. Trauma physicians have long suspected that intoxication and a history of heavy drinking or drug use are also causally implicated in a poorer response to treatment and rehabilitation.

Although the authors of "Injury in America" note a few references in the recent medical literature on drinking and severity of injury (13), a contrary finding has been reported (14). Do drinking and drug use have negative impacts on the aftermath of the injury? In addition to possible physiological mechanisms, attention must be given to potential discriminatory reactions of health agencies and workers to intoxicated patients (15,16).

Alcohol and Drugs in Reporting Systems

Reporting-system coverage of alcohol and drug involvement in injuries suffers from the general deficits of injury reporting in the United States. In addition, special problems affect the reporting of alcohol and drug involvement. Reflecting general tendencies in the field, injury reporting systems often focus on the environmental or engineering aspects of injuries, sweeping such factors as drinking or drug use into residual codes. Until 1986, there was no provision at all for specifying alcohol involvement in casualties in the Consumer Product Safety Commission's surveillance system (17).

Reorienting injury reporting systems to handle alcohol and drug involvement more adequately may involve a substantial rethinking of their conceptual basis and dimensional emphasis. This is implied, for instance, by the current discussions of ways of providing for the recording of alcohol or

drug involvement in injury coding in the revision of the International Classification of Diseases (ICD). Under current ICD-9 rules, alcohol or drug involvement can be recorded only in the case of poisonings (18). An adequate provision for recording alcohol or drug involvement would require not only appropriate three-character ICD codes, but also instructions encouraging the use of multiple codes for injuries and a reorientation for injuries of the general ICD understandings and conventions on "cause" (19,20).

Improving the handling of alcohol and drug involvement in injury recording and reporting systems serves an important public health policy purpose: it will create the popular and political will for effective prevention measures. We have already seen an example of this. Blood-alcohol testing technology, which established that alcohol's potential role in the traffic injury rate had been seriously underestimated, motivated a public health response to reduce it.

Issues of Causation and Attribution

The involvement of alcohol and other drugs in injuries highlights the difficulties our language and thought patterns—and often our research designs—have with conditional causation. As Gusfield (21) and others have noted, the causal involvement of alcohol or other drugs in an injury is usually conditional: the casualty would not have occurred without both the impairment due to drinking and environmental and other factors. But everyday language tends to deal in single causes: we say an injury is "due to" some particular factor.

At the level of the individual casualty event, the causal role of drinking or drug use is often indeterminable. It is only at aggregate levels that the issue of causation can be assessed. To assume that drinking or drug use play a causal role whenever they are involved in a casualty will result in a substantial overestimate of their causal effect. Reed, for instance, estimated that about half of the "drinking-related" traffic fatalities in the United States would have occurred even if there had been no drinking (22).

There are many potential mechanisms by which alcohol or other drugs may be causally involved in an injury. Some mechanisms are specific to particular injuries; special pathways of involvement are suspected, for instance, in the role of alcohol in drownings. At a more general level, alcohol is known to have a direct physiological effect on motor skills. In U.S. culture, alcohol is also seen

as a "disinhibitor"; that is, it is seen as having the power to compel people to act in ways they normally would not. Although this link is commonly assumed to be pharmacological, the link between drinking and disinhibition is seen in the current research literature as a matter of cultural belief rather than of pharmacological action. Drinking indeed makes one feel different, but the meaning and import of that feeling are culturally determined (23).

Reflecting general thought patterns of U.S. society, the literature on injuries divides serious injuries into two classes, intended or unintended. Generally, accidents, which are presumed to be unintended, are distinguished from crimes or suicides. Whether intention is assumed to be involved in the event deeply influences our methods of research. For events assumed to be unintentional, the preferred study model is the case-control method. But where intention is assumed to be involved, the case-control method is usually seen as inappropriate.

The conventional contrast between intentional and unintentional events is shaky at best. Many crimes, for instance, are crimes of opportunity, whereas many accidents involve purposeful elements. The contrast becomes even murkier when alcohol or drug use is involved, because potentially they may alter intentions. The conventional case-control study of accidents, controlling for time and circumstances, is thus somewhat problematic as a means of estimating the effects of alcohol or drug involvement, because the drinking or drug use may have affected the time and circumstances of the event.

New Directions in the Prevention of Injury

In the last 10 years, there has been a revolution in our understanding of the changeability of drinking patterns and of the potential effect on rates of alcohol-related casualties and other problems. Perhaps the most dramatic evidence of the potential effect on casualty rates has come from the "strike studies," the before-and-after studies of the effects of large-scale but usually temporary changes in the availability of alcohol (24). These studies have shown that even a relatively small restriction of supply can have quite strong effects, which tend to be concentrated in types of problems related to poor, habitual heavy drinkers. Although these studies show that casualty rates can be surprisingly responsive to changes in alcohol availability, the temporary nature of the changes

studied renders them of limited policy significance.

However, other studies of changes in alcohol availability or consumption levels have shown that longer-lasting effects on casualty rates are quite possible. Many studies of the effects of changes in the minimum drinking age have shown significant effects on traffic crashes across all levels of crash severity; even a change as small as 1 year in the legal drinking age has had an impact (25). Recently, an effect on nontraffic injuries has also been reported (26). A study of State liquor tax raises in the United States has shown that automobile accident fatality rates tend to fall in their wake (27). Studies in Scandinavia (28) and Australia (29,30) have shown that adding or subtracting a weekend alcohol sales day often affects both casualty and violent crime rates. Making spirits available by the drink in North Carolina counties has been shown to increase alcohol-related traffic crashes (31). Alcohol consumption levels have been shown to affect, among other indicators, violent crime rates—at least in some cultures and perhaps particularly when alcohol purchases are rationed (32–36).

Cumulatively, these studies show that, given appropriate circumstances and the political will, changes in the availability of alcohol (and presumably of other psychoactive drugs) can significantly affect injury rates. Ten years ago, the response to this would have been that the necessary political will for such changes was lacking in U.S. society. However, there have since been substantial shifts in the cultural climate concerning acceptance of all psychoactive drugs, notably alcohol. In this new era of “neotemperance” sentiment, strengthened popular support may give new effectiveness to old strategies. This, as much as the content of the laws, may explain the effect of some recent changes in drinking-driving laws (37). The shift in the cultural position of alcohol and other drugs also opens the way for new strategies of prevention, such as “server intervention” on military bases and elsewhere (38).

In the current political climate, changes in the level or circumstances of psychoactive drug consumption may be no harder to achieve than changes in crash-worthiness or other environmental protections from harm. Of course, where causes are multiple and conditional, pressing one strategy does not substitute for following another. Safer vehicles, consumer products, and environments remain important public health goals regardless of changes in psychoactive drug use. Because drunkenness and drug intoxication may diminish but will

‘The shift in the cultural position of alcohol . . . also opens the way for new strategies of prevention. . . .’

not disappear, making the world safe for (and from) those persons who are intoxicated remains an important prevention strategy (39). Nevertheless, the recent literature on the impact of alcohol controls has opened up new vistas on the prevention of casualties related to alcohol and other drugs.

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Accidents and Therapeutic Prescription Drugs

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THE USE OR ABUSE of therapeutic prescription drugs may be an important factor contributing to avoidable injuries in many settings. Despite increasing interest in studying the adverse effects of therapeutic drugs, little is known about the association between commonly used drugs and accidents. The magnitude of the public health risk that may unintentionally be imposed by such adverse medication effects is potentially enormous. About 75 percent of all visits to primary physicians result in a drug prescription (1); about 12 percent of all general physician office visits made by middle-aged persons result in prescriptions for psychotropic medications, the category of drugs that has been shown most clearly to pose the risk of impaired psychomotor performance (2).

Drugs and the Spectrum of Accidents

Injuries caused in part by drug-related impairment can occur in many settings. Impaired driving ability is a major cause of concern and an area

needing more intensive investigation. A large number of published scientific studies have dealt with pilots in flight simulation. The workplace is another important site where impaired function may lead to injury. Both the operating of machinery and the making of quick, complex judgments require alertness and optimal psychomotor function. The frail elderly are at particular risk of injuries resulting from falls that may be related to adverse drug effects. The morbidity and mortality from falls are substantial among this group; 20 percent of all patients with hip fractures die within several months of their fracture.

How Drugs May Contribute to Accidents

One major area of concern is the effect of drugs on the central nervous system. Many drugs, psychoactive and nonpsychoactive, may cause sedation and slow down certain cognitive processes. A task such as driving requires several complex psychomotor skills that may be affected by drugs acting on the central nervous system, including attention and vigilance, judgment, reaction time, spatial perception and orientation, and motor coordination. A medication that increases choice reaction time by 20 percent, from 0.5 seconds to 0.6 seconds, will cause a car driven at 55 miles per hour to travel an additional 8 feet. Drugs may affect the nervous system in other ways. Some may reduce motor abilities by affecting peripheral nerves and their capacity for sensation or for muscular control; others may cause tremors or muscle stiffening and the slowing of movements. Visual and auditory acuity may also be impaired by drugs. Here, too, the elderly are at risk of falls that may be partly attributed to these sensory impairments and excessive lowering of blood pressure by drugs with cardiovascular effects.

Drugs That May Contribute to Accidents

Of those drugs suspected of impairing psychomotor function, the psychotropic drugs, which are prescribed specifically to affect brain function, have received the greatest scrutiny. This group includes antianxiety, antidepressant, and antipsychotic drugs. The antianxiety drug diazepam (Valium) consistently ranks in the top 12 drugs prescribed in outpatient practice (3). Antihistamines, another drug group in widespread use in over-the-counter hypnotic and decongestant preparations, may cause severe sedation. Drugs with anticholinergic properties that affect the central

and the involuntary nervous system may impair concentration and are in wide use. Narcotics can sedate and impair performance, and psychomotor impairment may also result from the use of anticonvulsants.

Perhaps the most poorly studied categories of drugs with regard to potential psychomotor impairment are the antihypertensives and other cardiovascular drugs. Nearly 50 percent of those persons older than age 65 may have hypertension that should be treated (4). One drug often used to treat hypertension, propranolol, was recently shown to be the single drug most frequently prescribed in ambulatory office practice (3). This and other cardiovascular drugs have been shown to cause fatigue, poor concentration, and depression in some people (5,6). However, detailed studies of the effect of these drugs on psychomotor performance are almost nonexistent.

Existing Information on Drugs and Accidents

Research on the contribution of drugs to accidents has taken a variety of approaches. A population-based epidemiologic approach taken in a British study linked the prescriptions of 43,117 patients with hospital admissions for injuries from traffic accidents. Researchers found that patients using sedatives were five times more likely to have serious accidents than patients not taking psychoactive drugs (7). Other studies have examined blood or urine levels of drugs in victims of accidents and compared these with samples from control drivers. A study in Finland evaluated blood samples from 201 drivers taken to emergency rooms after road accidents (8). Psychotropic drugs were found in twice as many injured drivers as in control drivers who had not been in an accident.

Sophisticated driving simulators have also been used, especially in Scandinavian countries, as have test cars with special instruments. A group studying driving performance in Holland found that the ability to drive a car in a straight line was impaired the morning after a popular hypnotic, flurazepam (Dalmane), was taken (9). In U.S. studies, components of psychomotor skills (such as reaction time) have most commonly been studied in controlled laboratory settings. Studies of falls and injuries in elderly persons have most commonly used retrospective case review approaches. One investigation found an increase in night-time falls and hip fractures in patients taking barbiturate sedatives (10).

Methodological Pitfalls

Many objective tests of performance are removed from real-life tasks; there is no consensus on how to measure functional impairment. Additionally, individuals vary enormously in how they are affected by given levels of drugs in their blood. The use of certain types of drugs may be highly associated with the simultaneous use of alcohol or illicit drugs. Furthermore, the indication for medication, such as anxiety or depression, may confound an apparent drug-related impairment; it is possible that an antidepressant may impair psychomotor function, but it may also be true that a withdrawn, depressed patient may function better while taking medication than when not. Similar questions arise concerning antianxiety and antipsychotic medications.

Future Directions

Better consensus must be developed on the appropriate laboratory tests for objectively studying psychomotor function. The use of large data bases to link drug use with accident records holds great promise for a powerful epidemiologic approach to studying these relationships (11). Work must be done to evaluate the additive contributions of multiple drugs and of drugs and alcohol taken concurrently. Tests of drug effects on psychomotor function and cognition, especially in the elderly, should be carried out before many compounds are approved for marketing and after they are in widespread use.

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Workplace Employee Assistance Programs and Injuries

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DURING THE PAST YEAR, the media have highlighted costly workplace accidents in the transportation industry, particularly the recent railway accident in Maryland in which drugs and alcohol have been implicated. Nevertheless, despite the impression that there are many casualties in the workplace that are linked to alcohol and drugs, this remains a poorly researched area.

Although many companies have voluntarily started employee assistance programs as the primary response of the workplace to the problems of alcohol and drugs, these programs do not focus on injury prevention. This is primarily because these programs are by design reactive and, second, because they address issues of work performance and of behavior disorder. Their focus contrasts with a proactive strategy that might identify accident-prone substance abusers. Furthermore, the employee assistance approach focuses on the individual rather than on the possible sources of injury that may be found in the workplace.

These programs should not be labeled irrelevant in terms of their potential for preventing injuries. Rather, their strategies must be examined and expanded to include preventive approaches. Employee assistance must also be studied to reveal what can be learned about program adoption and implementation.

There are at least three different ways that attention can be drawn to alcohol and drug problems as they relate to the issue of injury in the workplace. One way is drug-screening programs, but drug screening faces technical difficulties because of the problem of false positives on test results. There is also considerable employee resistance to drug screening. Finally, drug testing has not often been applied to the prevention of injury in the presence of alcohol use or abuse in the workplace; it may reduce these problems by eliminating drug abusers in pre-employment screening.

The second way to direct attention in the workplace is through wellness and health promotion programs that may hold the greatest long-term promise for reducing workplace injury. The goal of many of these programs is to change lifestyles so that one would not be likely to be at work when impaired due to alcohol or inappropriate use of other drugs. However, the implementation of such programs is uneven, as is the extent to which they address alcohol and drug problems, with the possible exception of their involvement in smoking cessation.

The third method is employee assistance programs. These programs operate through two basic mechanisms. The primary mechanism involves managerial referral on the basis of an employee's poor performance. Data indicate that about half of these cases are the result of alcohol abuse and only about 5 percent the result primarily of abusing other drugs. (Many people whose primary drug of choice is alcohol also use other drugs.) The second mechanism driving employee assistance programs involves the tremendously high proportion of self-referrals. Although some degree of injury prevention may be built into both of these strategies—in the sense that intervention based on the detection of poor performance or self-diagnosed personal problems will head off eventual injuries—it is extremely difficult without well-designed long-term studies to establish this empirically. It is also possible for injuries themselves to be the basis for referral to an employee assistance program, although this represents a relatively small number of referrals.

It is significant to note that employee assistance

programs have been integrated into organizations relatively independent of the safety function within the companies. Safety directors and officers have been affiliated with drug-screening efforts to a much greater degree. In examining the integration of employee assistance programs into the workplace, these programs have more frequently reflected the medical- and human-resource-reactive approach than the prevention and safety approach.

Although employers will provide substantial resources to programs seen as benefiting long-term goals of productivity and maintaining a stable workforce, employee assistance programs represent the prevailing attitude in today's workplace. The time may come when the employer feels an intense responsibility for ensuring primary prevention of both accidental injuries and substance abuse, but that will be far in the future. U.S. society remains very prone to blaming the victim rather than looking beyond the individual to the environment.

Employee assistance programs can, however, provide considerable information on how and why employers will take the initiative to deal constructively with employees' behavioral health problems. Research on these patterns of program adoption and implementation can provide strategies for enhancing constructive and preventive approaches to accidents and injuries.

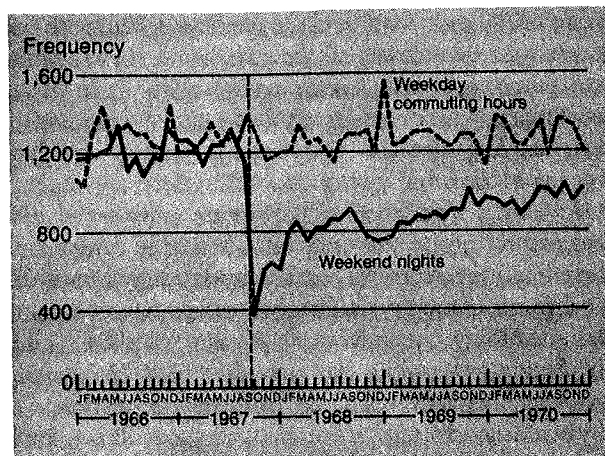
Prevention of Alcohol-Related Injuries Through Law Enforcement and Legislation

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POLICY MAKERS WHO must address the problem of the association of drugs, especially alcohol, with injury frequently resort to the law, which when used to implement social change, has capabilities and limitations. There are three traditional approaches to using the law to reduce injuries due to impairment by alcohol and other drugs: server liability, regulation, and deterrence, which focus on changing individual behavior.

Deterrence has been at the center of the contemporary movement against drunk driving, which is indisputably the most notable development in the area of injuries related to drugs. Mothers Against

Crash-related fatalities and serious injuries in England and Wales during weekend nights and weekday commuting hours, corrected for differential month length and with seasonal variations removed



SOURCE: Reference 4.

Drunk Driving (MADD) identifies and blames the "killer drunk" (1) for the toll of injury and death on the highway, promotes the contemporary idea of individual responsibility for social problems, and avoids attack on the powerful interests vested in the production and distribution of alcohol and automobiles. The programs of the Presidential and national commissions concerned with drunk driving and the actions of the Federal Government through the National Highway Traffic Safety Administration and of virtually all State legislatures center on the deterrent prescription of providing severe, swift, and certain punishment for violators of drunk-driving laws.

Threat-based campaigns, designed to convince the driving public that drunk drivers are likely to be caught and punished, have frequently produced important decreases in drunk driving. However, these accomplishments have almost always been short-lived because of the low actual risk of punishment—about 1 arrest per 1,000 impaired miles—prevailing nearly everywhere (2,3). A typical instance of a reaction to a deterrent intervention is presented in the figure, which shows the aftermath of the British Road Safety Act of 1967 (4). An initial decline of more than 50 percent in serious injuries and fatalities during drinking hours after enactment of the law was followed by a trend toward the prior level as drivers learned that they had overestimated the risk of punishment with this highly publicized law.

Major difficulties in using legal threats to reduce drunk driving include the facts that both drinking and automotive transportation are institutionalized in U.S. society and that deterrence-based programs

fail to address these basic institutional causes of the problem. Moreover, increasing the likelihood of legal punishment is apt to be extremely expensive in terms of police manpower and equipment and intrusive to the point of unconstitutionality (5, 6). Legal controls directed at behavior that is private or not publicly evident (for example, drunk driving) and exhibited in huge numbers of separate instances tend in general to be inefficient and ineffective (7).

The regulatory approach, which focuses on changing the distribution of alcohol, has a narrower focus than deterrence: it addresses thousands of distribution points rather than millions of drivers. Moreover, the behavior being regulated, such as serving intoxicated or underage people, is often not as difficult to observe as is impaired driving.

Because of its direct assault on a valued institution, the regulatory approach has not been central in addressing the drunk-driving problem in the United States. Its historical position as heir to the Prohibition movement (8) has also handicapped regulation. Perhaps its most successful expression has been in Federal encouragement of laws prohibiting the sale of alcoholic beverages to people under age 21, which according to most observers (9) have significantly reduced serious crashes in the age group affected. Additional increments in regulating the sale and service of alcoholic beverages have occurred mainly where the industry has been divided on an issue. For example, the prohibition of reduced-price "happy hour" sales of alcohol has been fought by restaurateurs but endorsed by tavern owners; restriction of beer sales at convenience stores has been bitterly fought by those establishments, but welcomed by supermarket and liquor store interests. In contrast, proposals for major increases in price to deter consumption and limitations on advertising have not been successfully implemented on State or national levels because of united industry opposition.

Server liability, imposed on sellers and servers of alcoholic beverages by legislative statute or court decisions, could effect the occurrence of injury related to intoxication if servers and sellers adopted responsible serving practices. The Model Alcoholic Beverage Retail Licensee Liability Act of 1985 (10) encourages training of staff and adoption of several specific serving practices. Laws based on the act are currently being urged with some success, and Michigan, Maine, New Hampshire, Rhode Island, and Vermont have enacted key portions of the act. Soon it will be possible to

study the aftermath of adoption of the laws for evidence of effectiveness.

An alternative and radically different legal approach to alcohol- and drug-related injury on the highway is concerned with modifying nonhuman elements of the traffic system (the highway and the vehicle). Authorities with responsibility for the highway can be given the incentives and resources to make driving easier for the driver. This vehicle and highway engineering approach, clearly cost-effective with present technology, should always be kept in mind when considering the traditional policies, which are more directly aimed at alcohol and other drugs, but not necessarily more effective than other approaches in reducing injuries caused by these substances.

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Impact of Drug-Related Violence

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ALTHOUGH AT PRESENT there are no national data bases on the relationship among drugs and alcohol and violence, a wide variety of local studies support the contention of a strong relationship between drugs and violence (1-7). Only recently have attempts been made to assess these relationships on a national level. In one such effort, researchers estimated that 10 percent of the homicides and assaults nationwide were the result of drug use (8). However, the authors qualified their estimate as a conservative approximation "in the face of inadequate empirical data to support an estimate derived in a systematic fashion."

Another recent report estimated that in the United States, in 1980, more than 2,000 homicides were drug-related and, assuming an average lifespan of 65 years, resulted in the loss of about 70,000 years of life (9). The report further estimated that in 1980 more than 460,000 assaults were drug-related and that in about 140,000 of these assaults the victims sustained physical injury leading to about 50,000 days of hospitalization.

Drugs and violence may be related in three different ways: psychopharmacologically, economic-compulsively, and systemically (10-12). The psychopharmacological model suggests that some persons, as a result of short- or long-term ingestion of specific substances, may become excitable, become irrational, and exhibit violent behavior. The most relevant substances in this regard are probably alcohol, barbiturates, stimulants, and phencyclidine (PCP).

Psychopharmacological violence may involve drug use by either offender or victim. Drug use may contribute to a person behaving violently, or it may alter a person's behavior so as to bring about that person's violent victimization. Previous research indicates relatively high frequencies of alcohol consumption by victims of rape (13,14) and homicide (15, 16). Public intoxication may invite robbery or mugging. Sparks (17) suggested that use of alcohol, drugs, or both may be one reason why a small minority of respondents to victimization surveys report multiple victimizations. According to one study, in rapes where only the victim was intoxicated, the victim was significantly more likely to be physically injured (18).

Anyone may become a victim of psychopharmacological violence. Those persons in close rela-

study the aftermath of adoption of the laws for evidence of effectiveness.

An alternative and radically different legal approach to alcohol- and drug-related injury on the highway is concerned with modifying nonhuman elements of the traffic system (the highway and the vehicle). Authorities with responsibility for the highway can be given the incentives and resources to make driving easier for the driver. This vehicle and highway engineering approach, clearly cost-effective with present technology, should always be kept in mind when considering the traditional policies, which are more directly aimed at alcohol and other drugs, but not necessarily more effective than other approaches in reducing injuries caused by these substances.

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Anyone may become a victim of psychopharmacological violence. Those persons in close rela-

Classification of drug-related violence in New York City¹ and New York State²

Classification of violence	New York City, N = 193		New York State, N = 309	
	Percent	Number	Percent	Number
Psychopharmacological ..	18	35	25	76
Economic-compulsive	3	6	1	4
Systemic	16	30	9	27
Other drug-related ³	5	10	1	4
Nondrug-related	45	86	40	123
Multidimensional ⁴	5	10	6	18
Unknown	8	16	18	57
Total	100	193	100	309

¹ Drug-Related Involvement in Violent Episodes (DRIVE) data for New York City (1984-86).

² Drug-Related Analyses—Homicide (DRCA-H) data for New York State homicides (excluding New York City) in 1984.

³ Involves drug relationships that could not be classified according to the tripartite conceptual framework.

⁴ Involves 2 or more dimensions of the tripartite conceptualization.

tionship to the user may be at especially high risk. This includes spouses, children, and lovers.

The economic-compulsive model suggests that some drug users engage in economically oriented violent crime (for example, robbery) to support costly drug use. Heroin and cocaine, because they are expensive drugs typified by compulsive use, are the most relevant substances in this category. Economically compulsive drug users are not primarily motivated by impulses to act violently but by the need to obtain money to purchase drugs. Violence generally results from some factor in the social context in which the economic crime is perpetrated (for example, the perpetrator's own nervousness, the victim's reaction, weaponry carried by the offender or victim [or lack of weaponry], and the intervention of bystanders).

Research indicates that most drug users avoid violent acquisitive crime if viable nonviolent alternatives exist (19-25). This is because violent crime is more dangerous, embodies a greater threat of prison, and because perpetrators of acquisitive crime may lack a basic orientation toward violent behavior. The most common victims of economic-compulsive violence are people residing in the same neighborhoods as the offender (25,26). Frequently, the victims are also engaged in illicit activities.

In the systemic model, violence is intrinsic to involvement with any illicit substance. Systemic violence refers to the traditionally aggressive patterns of interaction within the system of drug distribution and use. Victims of systemic violence are usually those involved in drug use or traffick-

ing. Although occasionally there are innocent victims, the vast majority of victims of systemic violence are those who use or sell drugs or are otherwise engaged in some aspect of the drug business.

The table presents preliminary findings from two ongoing studies. Drug-Related Involvement in Violent Episodes (DRIVE) data refer to 193 violent events that involved a sample of 152 street-level male drug users and distributors in New York City (Unpublished report, Goldstein, P. J., et al.: Drug Related Involvement in Violent Episodes (DRIVE): interim final report submitted to the National Institute on Drug Abuse, Rockville, MD, July 1987). Each subject was interviewed over a period of at least 8 weeks between 1984 and 1986. The violent events ranged from threats to actual assaults and homicides. Subjects may have been involved in these events—as victims or perpetrators.

Drug-Related Crime Analyses—Homicide (DRCA-H) data for 1984 refer to 309 New York State homicides, none of which occurred in New York City (Unpublished report, Goldstein, P. J., and Brownstein, H.: Drug-Related Crime Analyses—Homicide (DRCA-H): final report submitted to the National Institute of Justice, Washington, DC, July 1987). The table indicates the following:

- About 47 percent of the DRIVE violent events and 42 percent of the DRCA-H homicides were clearly drug-related.
- In both studies, psychopharmacological violence was identified as the predominant mode of drug-related violence, followed by systemic violence. Economic-compulsive violence was rare in both studies.

Clearly, drugs and violence are related. Researchers must move beyond simple correlations between drug use and violence and understand better how drug use and trafficking contribute to violence.

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Identifying and Prosecuting Persons for Driving Under the Influence of Drugs

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IS THERE REALLY a serious problem of driving under the influence of drugs other than alcohol? What determines whether there is a problem? Unfortunately, there are few hard data to examine. For example, the Atlanta Police Department reports no incidence of driving under the influence of drugs (DUI-drugs). Although this does not mean some drug abusers have not been arrested, it does mean that the information has not been captured. There is a strong likelihood, however, that the department has made very few such arrests.

Atlanta is no different from any other city in the nation. The only national or State statistics applicable to DUI-drugs were compiled in 1984 by the State of Virginia (1). That State carefully tallied all of its prosecutions for DUI-drugs separately from prosecutions for driving under the influence of alcohol (DUI-alcohol). The data are significant: there were 43,000 arrests and prosecutions for DUI-alcohol, but only 4 for DUI-drugs. How, then, can the extent of the DUI-drugs problem be determined? The only way I know how to do it without specific DUI-drugs data is to make a comparison of other alcohol and drug data. Maybe then we can logically draw some conclusions.

The House Select Committee on Narcotics and Abuse Control has estimated that about 35-50 million people regularly abuse drugs other than alcohol (2). From these data, one could safely believe that drugs are a significant problem on U.S. highways.

In California, 440 male drivers, ages 15-34 who had been in traffic accidents in 1983, were studied (3). Although one must take into account that this

'A handful of arrests for DUI-drugs with an approximate 30 percent filing rate has risen to almost 3,000 arrests annually in Los Angeles with a 95 percent filing and conviction rate.'

is the high-risk age group for those who could be expected to be driving under the influence, the study showed that alcohol was present in 70 percent of the victims, and that two or more drugs, including alcohol, were present in 43 percent.

What is the relationship of drugs to crime? A study conducted by the Los Angeles Police Department for several years examined the relationship of homicides to drugs (4). The study consistently indicated that 50-55 percent of all homicides were directly related to drugs other than alcohol. Given the homicide statistics for Los Angeles, this equals more than 400 murders yearly. It was further estimated that between 60 and 70 percent of all property crimes in Los Angeles are directly related to drugs. This includes residential burglaries, car burglaries, and thefts.

How then do the alcohol problem and drug problem compare? The National Institute on Alcohol Abuse and Alcoholism estimated that there are 12 million alcoholics and another 6 million problem drinkers in the United States (Telephone communication, National Institute on Alcohol Abuse and Alcoholism, National Clearinghouse for Alcohol Information, Rockville, MD, December 1986). That totals 18 million problem drinkers. Note that those alcohol abusers are less than half the estimated 35-50 million abusers of drugs other than alcohol.

Arrest data and drug seizure data for drugs other than alcohol cannot be easily compared with alcohol data. Each year about three-quarters of a million injuries from DUI-alcohol accidents and almost 2 million DUI-alcohol arrests occur nationwide. How then can we logically compare these data to incidents for DUI-drugs when almost no arrests for DUI-drugs are reported? What conclusion can be drawn from this comparison of data on alcohol and drug abuse? The differences in the data can be explained in two ways.

First, most often those who abuse drugs do so in combination with alcohol, and alcohol masks

the drug-related symptoms. Police officers have found that those who have been drinking can usually be prosecuted solely for DUI-alcohol even if other drugs are suspected to be present. An alcohol-related arrest is easier to process through the criminal justice system than is a DUI-drug case. The very few prosecutions for DUI-drugs that occur are generally the result of law enforcement officials removing people from serious traffic accidents and taking a blood sample, either for the criminal investigation or when blood is drawn during medical treatment. Analysis of the blood sample determines whether drugs, alcohol, or both are present.

The second reason police officers do not arrest for DUI-drugs is that they are not trained to recognize the subtle symptoms of drug abuse. The Drug Recognition Expert Program developed by the Los Angeles Police Department over the last 15 years may serve as a model for identifying, arresting, and prosecuting people for DUI-drugs. This program has been tested and validated by the National Highway Traffic Safety Administration. Recently, the Secretary of the U.S. Department of Transportation, Elizabeth Dole, stated that the Los Angeles Police Department had the only program in the nation that was successful in prosecuting people for DUI-drugs.

This program requires almost 100 hours of police officer training (60 classroom hours and 40 field training hours) to recognize the symptoms of DUI-drugs. After suspected drug-impaired drivers are transported to the police station, officers check blood pressure, pulse, and temperature at various intervals and perform detailed eye examinations. Officers also perform psychomotor examinations—balance tests—and divided attention tests.

Through its research, the Los Angeles Police Department has identified seven broad categories of drugs that cause impairment: narcotics and analgesics, central nervous system (CNS) depressants, CNS stimulants, inhalants, marijuana, phencyclidine (PCP), and hallucinogens. The results of this program have been outstanding. A handful of arrests for DUI-drugs with an approximate 30 percent criminal filing rate has risen to almost 3,000 arrests annually in Los Angeles with a 95 percent filing and conviction rate.

It is not cost-effective, however, to train all police officers in Drug Recognition Expert Program procedures. The program trains just enough officers so that adequate coverage can be provided day or night. The rest of the officers are trained to recognize impairment greater than what the alco-

hol test indicates; at that point, a drug recognition expert is called.

How can a law enforcement agency establish a DUI-drugs program? The following prerequisites must be met:

- An absolute commitment from the Chief of Police or the chief law enforcement executive to such a program.
- Resources to train the police officers and provide basic equipment (approximately \$100 per officer),
- Existing proficiency in DUI enforcement (for example, alcohol gaze nystagmus investigations),
- Successful traffic enforcement liaison between the police and prosecutors, politicians, the courts, and the public,
- Accurate laboratory services to process a high volume of blood and urine samples, and

• An implied consent law for a second chemical test, such as is found in the California statute. In California when an officer having drug expertise can give specific reasons why he believes that a drug other than alcohol is present, the person suspected of DUI-drugs must provide a blood or urine sample for detailed chemical analysis. Many States must work toward passing such legislation.

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Interventions: Other Approaches to Injury Control

Emergency Medical Services, Trauma Care Systems, and Injury Prevention

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IN 1966, THE NATIONAL Research Council published the landmark study "Accidental Death and Disability: The Neglected Disease of Modern Society" (1), which described major deficiencies in the care of accident victims. This study became a major motivating force behind today's emergency medical services (EMS) system. EMS is the arrangement of services, personnel, and organizations that responds to calls for help for traumatic or medical emergencies.

In most cases, this involves a 911 or other centralized public safety access telephone number that is advertised to the public. A trained dispatcher receives the call, determines what elements of the public safety team are needed, and dispatches the appropriate personnel to the scene. Increasingly, most public safety personnel have at least some emergency medical training, ranging

from a 40-hour "First Responder" program to more than 800 hours of paramedic training. Personnel at the scene provide immediate resuscitation as needed, patient assessment, initial stabilization, and limited treatment. As they administer aid, personnel operate under written protocols or direct voice contact with a medical control physician at a medical facility. Depending on the severity and nature of the injury, ambulance transportation is provided to the most appropriate facility. Emergency care continues en route with consultation from the physician via radio. Increasingly, the option for medevac helicopter evacuation is available through hospital-based services, public safety helicopters, or the Military Assistance to Safety and Traffic (MAST) Program.

With advance notice, the receiving medical facility should have time to organize the appropriate resources to provide optimal care to the incoming victims. Hospital emergency departments are increasingly staffed by specially trained emergency physicians and nurses who team up with surgeons and other specialists to provide care. Studies in the last 20 years have documented that perhaps 20-30 percent of trauma deaths were preventable (2). Furthermore, the American College of Surgeons has developed consensus standards as guidelines for achieving optimal care (3). Research demon-

strates that regionalizing trauma care through establishing systems with leadership from designated trauma centers will improve care to critically injured patients (4,5). When organized in this way, trauma care systems lend themselves to capturing essential epidemiologic and quality of care data through a trauma registry data base. Such data can greatly improve our understanding of the incidence and severity of injuries and the elements of optimal care. Trauma systems can generate information on injury morbidity that may not be available from other sources except intensive and expensive retrospective studies.

Unfortunately, trauma care systems are not yet the norm in the United States, despite the understanding of system components and benefits. Such systems exist only in selected, mostly urban, areas. A recent unpublished survey by the National Association of State EMS directors indicated that only 21 States have a program to develop trauma care systems and designate trauma centers ("State trauma centers: the current status," National EMS Clearinghouse, Lexington, KY, July 1986).

The reasons it has been so difficult to develop trauma care systems and achieve optimal care are varied. At the heart of the problem is the basic free enterprise nature of our medical care system. It is difficult for hospitals and practitioners to agree that only certain facilities should specialize in specific areas and that patients should be preferentially routed for optimal care. Administrators and clinicians are reluctant to give up their share of trauma treatment for the sake of the system. In small towns and rural areas, the obstacles have more to do with the willingness to make the commitment to optimal care. For administrators, trauma care systems require resources; for providers, they imply additional education, quality assurance, responsiveness, and accountability. Regardless of the location, there is also a problem with trauma care reimbursement under the current prospective payment mechanisms, and this problem needs to be addressed.

An essential part of the EMS mission is in primary prevention. Increasingly, it is recognized that it is simply too difficult for emergency medical technicians (EMTs), nurses, and emergency physicians to deal with preventable traumatic injuries after the fact; it creates stress and burnout and contributes to cynicism. When motivated and mobilized, the EMS community is a geographically pervasive cadre of expert and highly credible prevention advocates. Injury control and prevention are appropriate and integral aspects of

EMS, with benefits accruing to both the public and health care providers.

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Technological Approaches to Injury Prevention

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MORE THAN 90 PERCENT of U.S. travel is by motor vehicle. Although our society is highly mobile, we pay for it in property damage, injuries, and death. Part of these losses can be measured (for example, the property damage costs, medical and legal costs, and lost family income), but the truly human costs resulting from the disability, the diminished quality of life, and the pain and grief are unmeasurable.

Improvements in vehicle safety features can significantly reduce these human losses. Thus far, safety technology research and intervention have yielded many significant safety features, for example, collapsible steering columns, safety belts, and air bags. Federal safety standards require minimum safety features that are usually unknown to the new car buyer. These include dual braking systems, side door beams for side impact, roof crush strength for rollovers, and fuel tank integrity for fire prevention. Vehicle safety improvements have saved more than 100,000 lives since 1966, when Federal intervention by safety standards began. There are currently many additional tech-

nologies that could be used to reduce deaths and injuries, and many others are yet to be invented.

Those persons in the public health and the medical fields can help those in the engineering and data analysis fields to make these technological improvements a reality. Help from the medical, economic, and public health professions is needed to conduct research to measure the costs of injuries and the benefits of safety. Such research is needed to focus efforts on those particular safety problems that are most pressing and susceptible to solution.

Research on the cost of injuries is needed to find a scale to measure the total cost of injuries and to assess how the burden is distributed. In particular, the human costs of injuries need further definition from the broader perspective afforded by public health experts who are more familiar than safety engineers with the long-term consequences of injuries—physical, psychological, social, and economic.

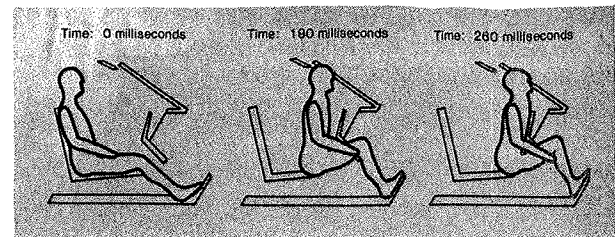
With regard to the benefits of safety, research is needed to assist in measuring the effectiveness of safety systems. One of the principal research tools for measuring the effectiveness of safety systems is the crash dummy. These dummies have instruments to measure the safety level when motor vehicles are crash tested. Safety engineers need better knowledge of how these dummy measurements relate to injuries and their consequences. This is a field in critical need of interdisciplinary research.

A key question is how to calibrate crash dummies to measure the injuries that a human would receive under the same circumstances. In the past, the interpretation of dummy instrumentation data has been based on biomechanics data that are extremely expensive to obtain and limited in extent. Recently, computer simulation has provided a new basis for obtaining biomechanics information.

Today, vehicle crashes can be simulated inexpensively by computer, so that a wider community of public health researchers can study the mechanisms of injuries and the potential for injury prevention and mitigation. A typical simulation is shown in the figure. Actual crashes now can be studied to understand what happened to the person in that crash. Consequently, each motor vehicle crash becomes a possible source of biomechanics and injury prevention information.

The National Highway Traffic Safety Administration has capabilities to help medical and other public health researchers contribute to the preven-

Computer simulation of occupant motion during a crash



tion of motor vehicle injuries. Large data bases of motor vehicle accidents and resulting injuries have been established. Computer models are freely available, as are the data needed for operating the models. Now the job is to link talents and resources to produce insights into the consequences of crashes and the potential for preventing injuries.

The Role of Epidemiology in Evaluating Intervention

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INJURY INTERVENTION STRATEGIES can be evaluated effectively with epidemiologic studies if they are conducted mostly in well-defined populations and are sufficiently large and diverse to measure patterns and trends over extended periods. The need for effective evaluation has been well stated in the literature over the last 15–20 years. However, this need has not yet been translated into methodologically sound evaluation initiatives. Evaluations have largely been limited to mortality analysis of specific causes and outcomes, using available data sources rather than developing data sources specifically tailored for evaluation. Observations from recent population-based studies indicate that mortality cannot always be used to predict morbidity in the study of injuries. Therefore, continued reliance on mortality data for evaluative purposes can result in missed opportunities to document the efficacy of a broad range of interventions.

Policies and programs are needed to address concerns about the efficacy of interventions, in-

'There is further need to convince decision makers of the merit of supporting the equivalent of controlled clinical trials (such as in infectious and chronic disease epidemiology) in the evaluation of strategies to prevent or ameliorate injury.'

cluding before, after, and concurrent measurement of cause-specific injury occurrence or severity and, in particular, their direct and societal costs. Hospital-based epidemiologic surveillance that begins with emergency and outpatient departments and continues through admissions and followup treatment can determine shifts in occurrence and outcomes and can provide much greater information on nonfatal injuries and their sequelae.

One approach is to consider establishing community laboratories or population laboratories by defining geographic regions with defined data bases for long-term surveillance and in-depth assessment of morbidity and mortality, interventions, and their costs. There is a need for rapidly translating injury prevention policy into strong programs; the community can serve as an ideal laboratory for evaluating experimental intervention strategies systematically before recommendations are made for national implementation. Hospital-based epidemiologic surveillance, which includes emergency department and outpatient data, can provide the population-representative data for such laboratories.

The history of the hospital-based, population-representative activities over the past 15 years can serve as an example of this community-laboratory concept. A specific example is the 1970-71 Pittsburgh Burn Study, which was conducted before promulgation of the children's flame-retardant nightwear standards (1). This study was designed to measure incidence and outcome both before and after promulgation of the standard. It also sought to identify primary or secondary methods of intervention to reduce thermal trauma generally, and burns involving the ignition or melting of fibrous materials specifically. The immediate issue was straightforward: to resolve the relative importance of clothing as a means of transmitting thermal energy to a host in his or her environment. In this study, researchers defined one large county of more than a million people as the study

area and developed the methodology for obtaining data from all hospitals with emergency departments serving the county. The key to the success of this approach was the use of special studies in defined populations.

A second example is the Northeastern Ohio Trauma Study, which applied this approach not only to burn injuries but to all cause-specific injuries in a well-defined, large, and diverse population (2,3). Today, the same techniques for conducting hospital-based emergency department studies are being used to evaluate the before and after impact of the New York State seatbelt law.

A number of other key issues need to be addressed: the use of existing data bases versus development of new ones, allocating sufficient resources dedicated to evaluation, and reducing duplication of effort by improving coordination and collaboration. Research orientation needs to be changed from short-term, fragmented intervention approaches to long-term strategies for effective intervention. There is further need to convince decision makers of the merit of supporting the equivalent of controlled clinical trials (such as in infectious and chronic disease epidemiology) in the evaluation of strategies to prevent or ameliorate injury.

The establishment of community or population laboratories for long-term surveillance and in-depth assessment of exposure, morbidity, mortality, interventions, and related cost is an approach that merits serious consideration. One message comes across clearly: a little progress has been made. However, researchers must continue to look at the evaluation of the results of these studies. Such evaluation must be built in ahead of time and not be thought of after the study. In summary, there is still need to learn which interventions are effective and which are not for all causes of injury.

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Legislation, Regulation, and Litigation To Prevent Injury

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THREE DIFFERENT FORMS of the law—legislation, regulation, and litigation—have worked as important forces in the prevention of injuries. This paper will briefly illustrate how each form can be used for injury prevention.

In the area of motor vehicle occupant protection, child restraint laws are a good example of legislative intervention that has produced favorable results. The first child restraint law became effective in 1978, and in the short time since then, such laws have been enacted in all 50 States. The process of overcoming the individual liberties arguments against the passage of such laws proved useful in the subsequent enactment of adult seatbelt use laws in many States.

Regulations regarding motor vehicle safety (the Federal Motor Vehicle Safety Standards) have saved thousands of lives. These regulations are sometimes more easily brought into being than legislation. The recent regulation requiring a high center-mounted rear brake light is a good example of an injury prevention regulation based on good data. Several studies carried out prior to the promulgation of the regulation showed an approximate 50 percent reduction in rear end collisions among cars with such a light compared with cars in the same fleets without the light.

In some areas of motor vehicle safety, progress through legislation or regulation has been very slow, to the detriment of the public's health. In such instances, some persons have advocated that the judiciary should act through litigation that is protective of the public's health. An example is the attempt to get air bags installed in cars. In the face of legislative and regulatory failures to introduce air bags, a suggestion was made to the plaintiffs' trial lawyers that the costs of injuries that would have been prevented by an air bag could be assessed to the car maker that refused to offer an air bag as an option, thus providing an incentive for the car maker to invest in prevention. One such case resulted in a \$1.8 million verdict against a car maker. Shortly thereafter, that same company reported that it had more than \$1 billion

in air bag claims pending against it, and it then decided to offer air bags as an option in some of its cars.

It would be in error to assume that litigation alone is the force that has permitted the public now to avail itself of the lifesaving properties of air bags. The threat of litigation, however, certainly was a key ingredient in the corporate decision making process.

In addition to the field of motor vehicle injuries, there are vast opportunities for advances in injury prevention in which the law can be and should be helpful. This can be illustrated by examining issues regarding handguns.

The United States has an enormous public health problem with gun deaths. Guns are the leading cause of death for certain subsections of the population; black males ages 15-34 are more likely to die by gunshot than by any other cause.

How can the law help with this seemingly intractable problem? In examining legislation, one finds a Federal gun law that is rife with loopholes. Legislation against the manufacture and sale of plastic handguns, labeled the tool of the terrorist, may be a clear and feasible inroad against the carnage caused by handguns. One should also look to local legislation such as the Morton Grove type, which prohibits the possession and use of guns, as a legitimate local approach to a local public health issue.

With regard to regulation, guns are regulated by the Treasury Department's Bureau of Alcohol, Tobacco and Firearms, which is less concerned with the safety and health of the population than with raising revenue.

Again, litigation is a possibility. Maryland's highest court, in *Kelley v. RG Industries*, held that the manufacturer of a gun used disproportionately in crime should not be able to profit from the sale of that gun and then be totally free of responsibility when the foreseeable injury occurs. RG Industries was the nation's leading producer of "Saturday Night Specials." As the result of exposure to liability, RG Industries now has gone out of business.

Clearly, advocacy can accomplish a great deal in the field of injury prevention. More training in advocacy is needed in schools of public health, medicine, and nursing, so that the graduates of these schools are able to defend the public's health in the adversarial situations that frequently arise.

The National Safety Council's Estimates of Injury Costs

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THE COST OF INJURIES must be considered by health and safety professionals and others who are involved in making public policy and setting priorities. Because of the growing emphasis on fiscal responsibility, annual estimates of injury costs can be as meaningful and relevant to safety and health professionals as data on injury incidence and severity.

This paper is a brief introduction to the philosophical foundations of the National Safety Council's cost estimates, their scope, and the definitions of some cost elements. The term "injury" as used in this paper means only unintentional injuries. Council estimates do not include the costs of suicide, homicide, or occupational illnesses. "Accident" as used in this paper means an event that results in unintentional injury or property damage.

There is considerable debate among economists on the general framework and components of accident costs. The foundation on which council estimates are based is that accident costs should measure the economic losses to society that result from accidents. Under this principle, cost estimates measure the dollars that had to be spent and dollars that will not be received because of accidents. The figures generated can reasonably be used alongside such items as the Gross National Product, per capita income, and other economic measurements.

Economic components of accident costs in this framework would be wage losses, medical expenses, insurance administration costs, fire losses, motor-vehicle property damage, and indirect loss from work accidents. Excluded are court-awarded damages, income tax losses, and transfer payments, which are a redistribution of dollars rather than a loss of dollars. Also excluded as non-economic losses under this concept are such items as the costs of pain and suffering, loss of parental guidance, inconvenience, and mental anguish.

Various approaches are used to measure wage losses of fatally injured persons. Wage losses

expressed as the present value of future earnings potential is the oldest and most commonly used method of estimating the cost to society of an individual's premature death. Under this "human capital" approach, workers are valued according to average earnings at each age. Although this approach has the advantage of being actuarial, critics justifiably argue that it ignores an individual's natural desire to live longer (1).

Under the "willingness-to-pay" concept, estimates are developed to approximate the value persons place on their own lives (2). Through labor market or consumption activity studies, these values are developed from the amounts that persons are willing to spend for a specific reduction in the probability of death or disability or from the wage differentials persons that must be paid to assume risky jobs (3).

Criticism of this approach centers on whether this monetary compensation differential can be applied to deaths and whether individuals can understand, evaluate, and make decisions based on perceived differences in small probabilities (4). It is also unclear whether "value" dollars are appropriate in any "cost" methodology (5). Although the value that society places on a statistical life may be appropriate when justifying the cost of safety features on highways, for example, it is inappropriate when calculating the aggregate cost of goods and services consumed by or not produced because of accidents. Even if one accepts the theoretical basis for the "willingness-to-pay" approach, work is only now underway in attempting to reconcile the wide disparity in values produced by various studies (6).

The "social consumption equivalents" approach is yet another methodology recently presented (1); it attempts to include intergenerational economic transfers across society, such as Social Security, that are affected by prolongation of life. Under this method, saving of a life would be valued by summing the enjoyment value of expected additional years and the value of expected additional labor product and subtracting the consumption cost of the additional years. Although the latter two terms can be directly estimated, assumptions must be made in calculating the enjoyment value of additional years before cost estimates can be computed.

The purpose of this overview of various cost concepts is not to debate economic theory, but to

show that the human capital approach best matches the concepts normally associated with accident costs. It is sufficiently developed at this time for use in a cost framework.

In addition to the value of wage losses due to premature death, the total wage loss figure includes the value of injured homemakers, as estimated by the cost of replacing their services in the home, and the value of time lost due to nonfatal injuries, as measured by average wages and average days of disability. The council has estimated that total wages lost due to unintentional injuries in 1985 to be \$31.2 billion (7).

Other components of the council's accident cost estimates are less controversial than wage losses and somewhat easier to explain. Medical expenses for unintentional injuries include physicians' fees, hospital charges, the cost of medicines, ambulance and emergency medical services, and future medical costs. The estimates are based on work done by Hartunian and coauthors (8) and the National Highway Traffic Safety Administration (9) on the cost of motor vehicle crashes. National Health Interview Survey data on injuries are used in extending the estimates to nonmotor vehicle injuries. The council has estimated that medical expenses due to unintentional injuries in 1985 came to \$17.8 billion (7).

The next cost component is insurance administration costs. This is the difference between premiums paid to insurance companies and claims paid out by them; it is their cost of doing business and is a part of the accident cost total. Claims paid by insurance companies are not identified separately, because every claim is compensation for losses such as wages, medical expenses, and property damage, which are included in other categories. In 1985, the insurance administration cost amounted to \$14.2 billion (7).

Property damage in motor vehicle accidents includes the value of damage to vehicles from moving motor vehicle crashes. Damage is valued at the cost to repair the vehicle or the market value of the vehicle when damage exceeds its market value. The cost of minor damage such as scratches or dents incurred while parking is considered part of the normal wear and tear to vehicles and is not included. The cost of vehicle damage in 1985 was estimated by the council to be \$19.3 billion (7).

Note that this estimated cost does not include some kinds of damage that are probably very costly, such as damage to public property (signs, signals, and other highway appurtenances), private property other than vehicles (for example, fences,

landscaping, and buildings), and cargoes of commercial vehicles. Satisfactory ways to estimate these costs do not exist.

Rather than making its own estimate of fire losses, the council uses the estimate developed by the National Fire Protection Association (10), which for 1985 was \$7.3 billion. Of that total, \$6.4 billion was for structure fires. More than half of the total is for damage to residential structures.

The final component included in the council's cost estimates is indirect losses from work accidents. These are uninsured costs borne by the nation's businesses and industries. The component is the money value of time lost by noninjured workers. It includes time spent investigating accidents and preparing reports, giving first aid to injured workers, time lost due to production slowdowns, and other uninsured costs. Specifically excluded is the value of property damage in work accidents, which cannot be reasonably estimated. This component is conservatively estimated as being equal to the sum of the lost wages, medical expenses, and insurance administration cost of work accident insurance. For 1985, this amounted to \$17.5 billion (7).

The sum of the six components gives total measurable accident costs of \$107.3 billion in 1985. The council's estimates do not cover all costs nor do they cover all economic costs. Some costs do not fit into our framework, and some simply cannot be measured at this time. But it is clear that unintentional injuries and property damage place a heavy financial burden on society.

There is much work still to be done in this field. The human capital approach to valuing a life is not appropriate for cost-benefit analysis. It undervalues the worth of the young and the old because they have little, if any, earned income. The willingness-to-pay and social consumption equivalents approaches are conceptually more satisfying for use in cost-benefit analyses, but both are difficult to evaluate empirically, and little has been done with them.

Given the hard choices that must be made among the many competing injury control priorities and programs, public health officials and other safety and health professionals would be wise to invest now in developing cost-benefit tools that will help them in making those difficult choices later.

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The Unmeasured Costs of Injury

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A DISCUSSION OF THE COSTS of injury leads almost immediately to the problems of determining these costs, a subject of intense political debate in recent years. Generally, this debate has been conducted in the language of economics, providing a narrow view of the social consequences of loss due to injury. This paper addresses the human loss resulting from injury and suggests strategies for identifying the social consequences of injury in the current climate of cost-benefit decision making.

Unmeasured costs are usually assumed to be unmeasurable and are relegated to the domain of "pain and suffering." Once various losses due to injury are labeled unmeasurable, discussion of them is narrowed to a focus based on economic valuation. Within this context, social loss from injury is equated with economic loss and translated into dollars.

In estimating injury costs, the largest component

is attributed to wage loss or other symbols used to identify the value of life (1,2). The usefulness of cost estimates diminishes as the limitations for placing market values on the loss of life deepen the separation between social reality and economic value.

Two competing methods monetize the loss of life in a cost-benefit assessment: the human capital approach and the willingness-to-pay method. In the former, valuation is determined by prices related to market transactions (that is, the lost wages of the injured person). In the willingness-to-pay method, a surrogate for market prices (that is, the amount a person is willing to pay to reduce the probability of death or wage differentials paid for risky jobs) is used to estimate the demand for safety and health (2). Both price and demand are market-driven symbols of value, and as such, reduce the meaning of loss to market value.

Because some agencies are incorporating a willingness-to-pay method into their injury cost estimates, concerns with this newer approach should be noted. First, this method assumes that because the issue is one of demand and not price, people make a conscious choice when faced with a risk to "buy" safety. However, this choice cannot happen unless the public has the knowledge and time to consider the alternatives, which is not always a guarantee.

Second, this approach ignores the important fact that a dual labor market exists for the compensation of hazardous work (3). Workers in the primary market—characterized by high wages, job stability, and skilled labor—may be willing to buy safety. But workers in the secondary market—characterized by low wages, poor job stability, and unskilled labor—may not.

Third, in an effort to arrive at a more accurate accounting of the public's willingness to avoid risk or buy safety, this approach tends more readily to place a dollar value on nonmonetary things such as grief, pain, and family stress. The once unmeasured costs then enter the equation. Cost estimates may be enhanced, but the opportunity to identify and understand the true consequences of injury is lost. What role should economic values play in determining priorities for injury control? This is a political decision and not an economic one. Where economic cost is used to define the social consequences of injury, it is likely that it may become the primary basis for political decision making, despite its limitations. How can this be avoided?

New research puts our traditional cost estimates

into some perspective. Much of this research has focused on automotive injuries (4-8), and significant findings are emerging in head-injury research (9-13). Generally, this research has emerged from disciplines other than economics (for example, psychology, sociology, and anthropology) and has focused on injury victims and their families. These studies have assessed economic, social, and psychological consequences of injury and have been conducted over extended periods.

This research has yielded two important insights into the effects of injuries and hence their costs. First, loss is experienced not only by the victim but by others as well (particularly family members). In fact, the losses (or costs) that accrue to family members eventually significantly overshadow those experienced by the injured individual (10).

Second, the types of loss experienced by the injured persons, their families, and their communities are complex and terribly disruptive, fundamentally altering the lives of those affected. As injury victims shift from being contributing members of families and society to dependents, some of this loss can be measured quantitatively (lost time) and monetarily (depletion of family economic resources), but much is not adequately reflected through economic measures.

These insights illustrate that the value of life stems from its purpose in a societal-cultural context. Therefore, the loss of life and the loss of health must be assessed in the same context. This is the premise of what might be called a "social consequences" model of loss. Such a model would incorporate the calculation of economic losses based on market prices, as well as consider the importance of an individual's life to others. However, much needs to be done to measure effectively the societal losses that result from injury. New categories of loss must be introduced into the discourse, and new measures of loss need to be developed to allow comparison of losses by those who set priorities in injury control and health and safety programs. Sociomedical indicators might be used to extend descriptions beyond the more rudimentary indicators of mortality and morbidity (14-16).

Changing the framework from one dominated by economic values of loss to one that appears less precise and manageable may appear formidable in a world that demands assessments of costs prior to regulatory decision making. However, if the United States wants to reduce injuries and the resulting harm, the real costs to society must be understood.

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The Costs of Family Violence

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THE RELATIVELY FEW ATTEMPTS to estimate the degree of injury and the monetary cost of family violence (1-4) are based on limited or questionable data and undemonstrated assumptions. Estimates based on the National Crime Survey (1), for example, are meaningless because of severe underreporting of intrafamily assaults.

The data on intrafamily homicides, however, are much more complete and are probably the most accurate figures on family violence. Intrafamily homicides reached a peak in 1980 (approximately 5,800 cases) and declined steadily to approximately 4,400 cases in 1984. Inclusion of spouse-like relationships (nonmarried cohabiting couples, boyfriend-girlfriend) could increase the number substantially. One estimate put the 1984 cost of intrafamily homicides at \$1.7 billion (4). This estimate, however, can be highly misleading.

First, although the incidence rate data may be accurate, the cost estimates are necessarily based on a series of questionable assumptions. An even more important problem comes from taking the death and the incidents immediately surrounding the death as the starting point for the cost analysis. It is important to know the economic cost of the long period of nonlethal family violence that typically precedes the lethal violence.

The true accounting of the cost of family violence must also include the cost of providing mental health and social services to victims and the cost of treating aggressors. This paper makes a start toward the true cost by providing preliminary data on the increased risk of psychological problems (such as psychosomatic symptoms, depression, and suicide attempts) associated with wife beating and child abuse.

Methods

The data are based on a 1985 epidemiologic survey of a nationally representative sample of 6,002 American families (5,6). The survey used the conflict tactics scales (7) to obtain the data needed to estimate incidence rates for physical abuse of children and spouses. The survey also included

data that enabled comparison of certain aspects of the physical and mental health of physically abused family members with persons in the sample who reported no instances of physical abuse.

Spouse Violence and Wife Beating

The estimated annual incidence rate of spouse violence (defined as any physical assault on a spouse) for the 5,349 survey couples was 161 victims per 1,000 couples. Most of these incidents involved minor assaults, such as slapping and throwing something at the spouse.

The rate of wife beating, defined as one or more violent acts that pose a serious risk of injury (for example, kicking, biting, punching, choking, beating, and use of weapons) was 34 victims per 1,000 couples, or an estimated 1.8 million seriously assaulted wives per year in the United States. Although these are extremely high figures, they are almost certain to be an underestimate because not all respondents are willing to reveal such incidents; nonreporting is especially likely in the cases of the most serious violence. Underreporting of the most serious cases of violence may be one reason why medical intervention was reported for only 2.1 percent of the wife-beating incidents.

Although immediate medical intervention for acute conditions was rare, survey findings suggest that wife beating has important adverse effects on the mental and physical health of women who experience severe violence by their partner. For instance, severely assaulted women averaged almost double the days in bed due to illness than did other women (fig. 1); a third fewer severely assaulted wives reported being in excellent health than other women, and three times as many severely assaulted wives reported being in poor health (fig. 2). Severely assaulted women had much higher rates of psychological distress than other women, including double the incidence of headaches, four times the rate of feeling depressed, and five-and-a-half times more suicide attempts (fig. 3).

Child Abuse

If the same criteria were used for child abuse as were used for wife beating, the rate (based on the 3,334 children in the survey) is 110 incidents per 1,000 children, which is an estimated 6.9 million children severely assaulted each year in the United States. If "hitting with an object" is dropped from the list of physically abusive acts (because

Figure 1. Relationship between women who experienced violence in last year and mean number of days in bed due to illness in last month

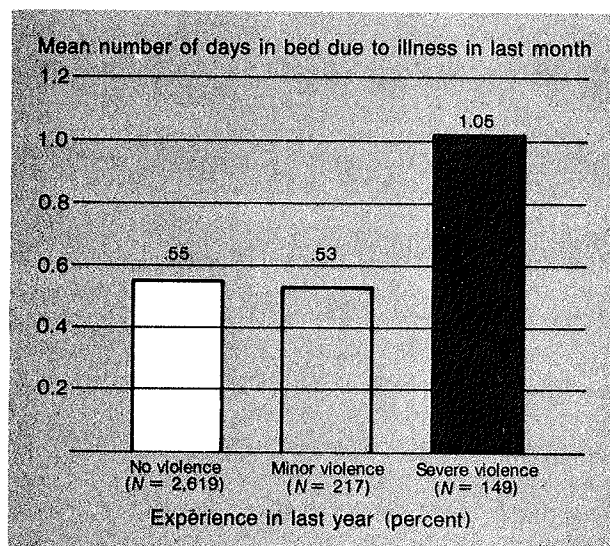


Figure 2. Relationship between women's health and experience with violence in the last year

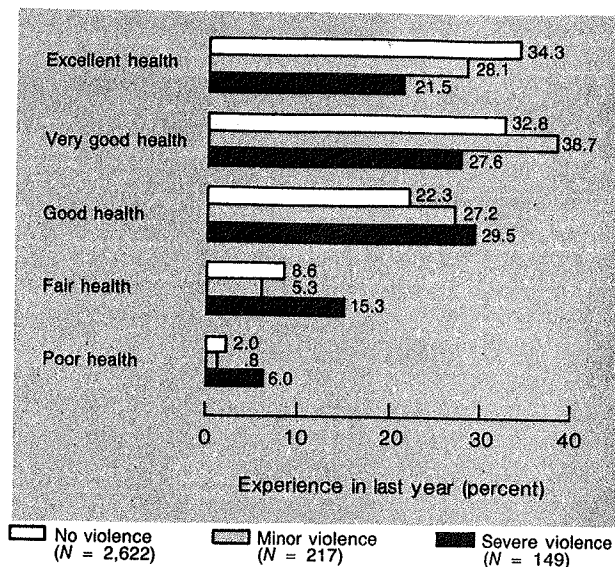
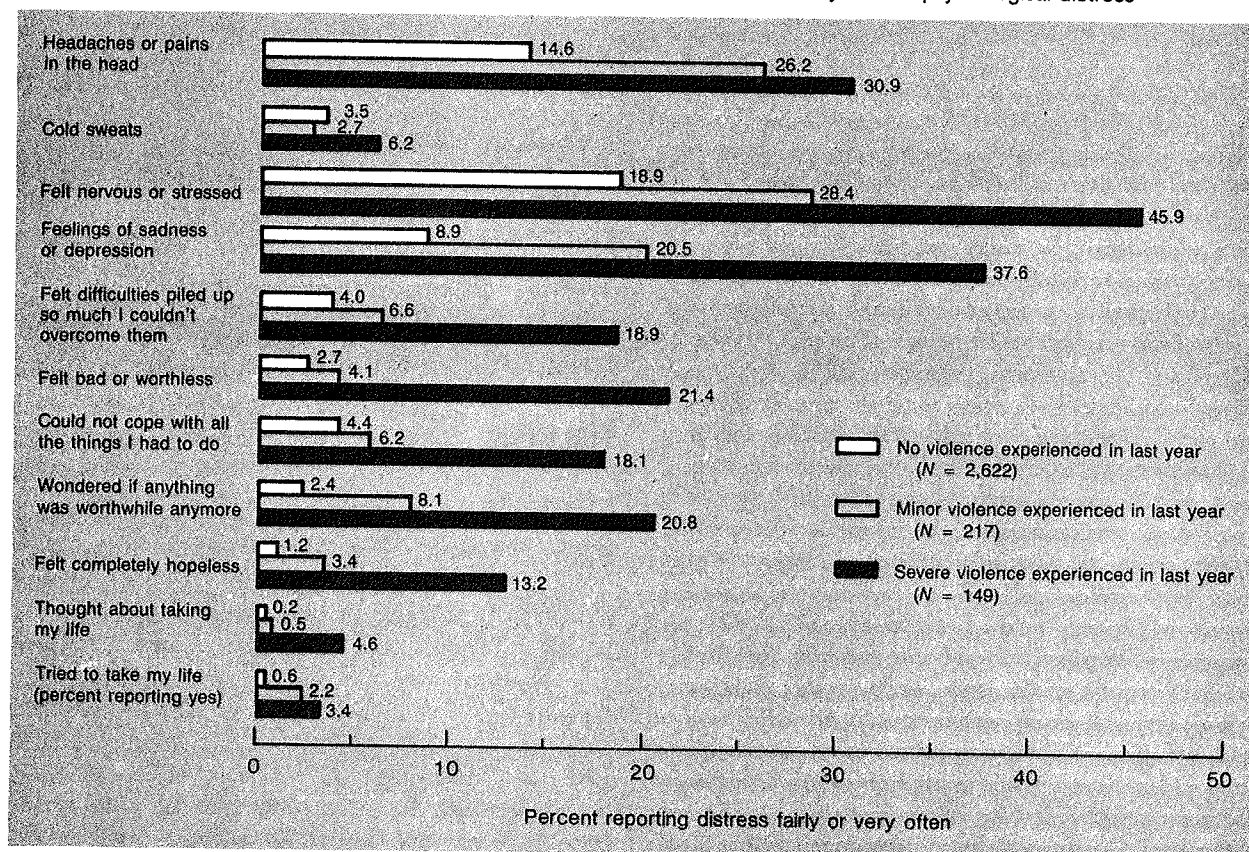


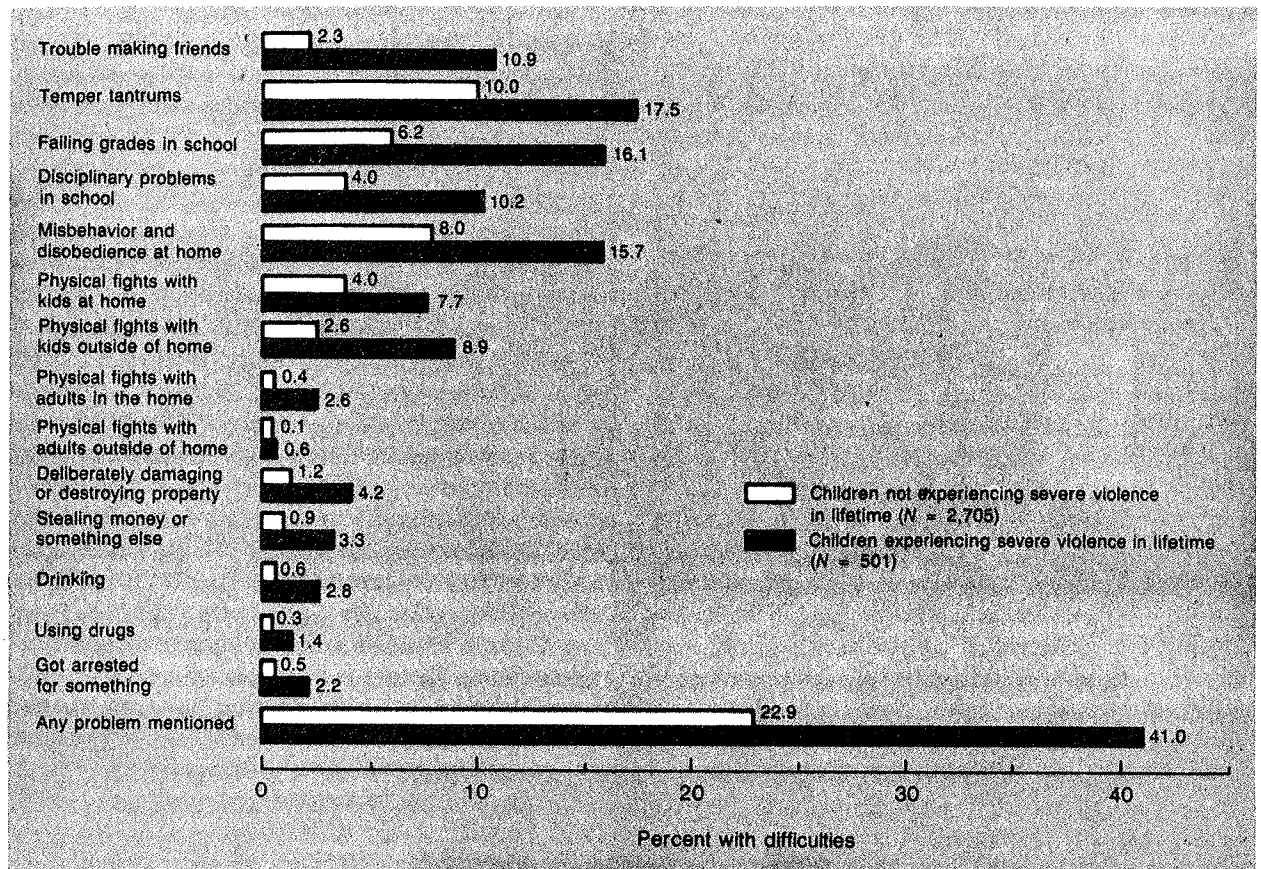
Figure 3. Relationship between women who experienced violence in last year and psychological distress



many people do not consider that as necessarily abusive with children), the estimated rate is 23 incidents per 1,000 children, or 1.5 million children seriously assaulted each year in the United States.

As with spouse violence, these child-abuse rates are almost certainly underestimates; they are based on reports by parents, not all of whom are willing to reveal incidents in which they severely assaulted

Figure 4. Relationship between experiencing severe violence and special difficulties of the child



their children. In addition, physical abuse of children often starts before birth because assaults on wives tend to increase during pregnancy (8).

For each of the 3,334 survey children, researchers asked the parent whether there were any "special difficulties" with the child during the past 12 months. Figure 4 shows that abused children consistently experienced more of these difficulties than did other children. For example, the child victims of severe violence had two to three times higher rates of trouble making friends, temper tantrums, failing grades in school, disciplinary problems in school and at home, physically assaultive behavior at home and outside the home, vandalism and theft, and drinking and drug use.

The last bar of fig. 4 shows that these misbehaviors are part of a cumulative pattern more often than is the case for nonabused children. Moreover, the next-to-the-last bar shows that abused children were arrested four times more often than other children. Because it is well established that it typically takes many repetitions of a criminal behavior for an arrest to be likely, this is further evidence of the much more serious behavior

problems characteristic of children who are victims of severe violence. A multivariate analysis shows that the differences between abused and other children reported in this section hold regardless of socioeconomic status.

The Costs

Methods are currently being developed for using these incidence rates as the basis for rough estimates of the dollar costs of the medical and nonmedical expenses of intrafamily violence. Some of the findings presented in figs. 3 and 4 suggest that mental health (9) and nonmedical costs may be much greater than the cost of treating physical injuries. Examples of other costs are psychiatric and other psychological services; police services; social services, including the cost of child-abuse investigations and remedial actions; legal costs, including divorce; and the cost of the violence and other crimes committed by those abused in childhood (10). There is also the cost of imprisonment or other institutionalization that occurs at a much

higher rate for victims of intrafamily violence than for the general population.

Although the cost estimates being developed will be subject to a wide margin of error, even the minimum estimate will show that the United States is paying a huge price for the violence that occurs in so many American families. The tragedy is compounded by the fact that these are preventable costs.

There has now been enough research on the etiology of intrafamily violence to suggest plausible programs of primary prevention (11,12). Such programs are likely to reduce the costs of violence to society by many times the cost of the program—to say nothing of their effect on reducing human suffering and enhancing the quality of family life.

NOTE: Findings reported in this paper are part of a larger study reported in a book to be published in 1988 by Simon and Schuster that is tentatively titled "Intimate Violence." The research was conducted with aid of the National Institute of Mental Health Grant No. RO1MH40027. The paper is a publication of the Family Violence Research Program of the Family Research Laboratory, University of New Hampshire. The program has been supported by agencies that include the National Institute of Mental Health (Grant No. T32MH15161), the National Science Foundation (Grant No. SES8520232), the National Institute of Justice (Grant No. 851JCX0030), the National Center on Child Abuse and Neglect, and the University of New Hampshire.

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Workers' Compensation Costs

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OREGON'S EXPERIENCE with workers' compensation serves as a microcosm of what is occurring in several States. Oregon's workers' compensation system is one of the most costly in the United States; the average insurance premium level for workers' compensation is now \$4.36 per every \$100 of payroll. Employers in Oregon will spend about half a billion dollars on workers' compensation premiums alone in 1987. This figure is most significant when one considers that only about 1 percent of the nation's population live in Oregon. Furthermore, during the next year, almost one in eight workers will seek recovery through Oregon's workers' compensation system. These facts outline the enormity of a health and accident problem that has literally reached epidemic proportions in Oregon and many other States. This issue also involves noninsurance costs that result from decreased production and others that are incurred by the injured workers or their families.

What has happened to the system that was created more than 70 years ago, a system that was supposed to be administratively simplistic and nonlitigious? A major cause of this system's failure may be found in studying certain societal expectations.

Many industrial accident claims have become for many workers a means of solving social and mental, as well as a physical, problems. For the past two generations, U.S. society has told its young people that they are failures unless they go to college. In many instances, instead of emphasizing the pride and satisfaction of manual labor, it has been pictured as demeaning and of lower status.

Nevertheless, a sizable segment of the population ends up in labor-oriented positions. In their middle years, as the physical competition with younger people becomes harder, many laborers realize that the "success" goals that society has assigned to them will never be achieved.

The socially acceptable ways to solve their problem are to have a bad back, to develop psychological problems from work-related stress, or any one of the more common afflictions that now fill a large part of the workers' compensation disability claim files. Once off the work treadmill, with a schedule of medical treatment, physical therapy, and disability income, workers find a new world in which they get special attention. After a few months, the thought of reentering the world they left becomes unbearable. The difference between the paycheck at the mill and the disability check is not enough to force them back on to the treadmill.

The back gets worse and often the psychological problems add complications. The problems become chronic and eventually permanent. And if the workers' attending physicians will not certify them as disabled, they have the right—at least under Oregon law—to search for a physician who will.

This type of medical problem and the traditional caseload of disabled workers, rising medical costs, and the increased size of awards account for the expensive epidemic alluded to. How, then, does the workers' compensation system provide for the injured workers without destroying the very job market to which the system is supposedly helping them return?

Although there are no easy answers, there are obvious steps that can be taken to improve the system without any loss of substantial fairness to all parties involved. First, the worker's attending physician must begin to play a more positive and aggressive role in returning a worker to employment. With few exceptions, our medical community is abysmally ignorant about workers' compensation.

The second major area deserving attention is to get the lawyers out of the system. Lawyers do not

add much of a positive nature to the workers' compensation system. Throwing an injured worker into an adversarial climate is counterproductive to rehabilitation. How can a person be rehabilitated when the underlying theme is to reward that person for hurting and to encourage him to hurt to increase an ultimate award for permanent disability?

However, these few suggestions do not address the deeper problem of providing job satisfaction, reinforcing the status of manual labor, and establishing greater incentive to return to work. Until these problems are solved, the workers' compensation cost burden is not likely to decline.

Cost of Farm and Rural Injuries

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WITH AN ANNUAL DEATH RATE of 49 work-related fatalities per 100,000 workers, agriculture ranks second only to mining as the most hazardous industry in the United States in which to work (1). Historically, agriculture has been one of the three most dangerous industries, along with mining and construction. Table 1 gives 1976-85 data for the three industries.

Causes of Accidents

Fatal and permanently disabling agricultural accidents typically involve tractors and other farm machines, which have potentially dangerous components. Because machines and systems are operated inside and outside and in climatic extremes ranging from arid deserts to severe winters, poor operating conditions can compound the danger. Other significant causes of serious agricultural accidents include electrocutions, falls, entrapments in flowing grain, and exposure to toxic materials (2). Table 2 provides a distribution of fatal accidents by type for a 10-year period in Indiana.

Regardless of the cause of the accident or the job being performed, farming remains essentially independent work, with no supervisor present to

offer safety training or ensure that safe practices are followed. Farm families' high level of tolerance for injuries in the workplace has also contributed to high injury levels.

Impact on Children and Older Persons

Although the fatality rates reported by the National Safety Council only include persons ages 14 and older (1), data from several States indicate that 14-24 percent of all fatal agricultural accidents involved persons ages 15 and under (3,4). Thirty-three percent of the fatal farm accidents in Indiana occurred to persons age 60 and older, and rates for age 60 and older from other States where data were available ranged from 21 to 33 percent (5). Table 3 shows the distribution of fatal Indiana farm-related fatalities by occupation. Comprehensive data are not available for nonfatal farm accidents; however, based on the fatality data, it can be assumed that persons age 15 and under and age 60 and older account for a disproportionate share of farm accidents as compared with those age groups in nonfarm occupations.

Government Programs and Funding

Only farms with 11 or more employees fall under the jurisdiction of the Occupational Safety and Health Administration (OSHA), which estimates that more than 90 percent of all U.S. farms are not covered by OSHA regulations (6). No other Federal safety agencies are charged with doing agricultural health and safety research; thus, little has been done in this area, with the exception of several hazard alerts and limited research on agricultural respiratory problems.

The Federal budget funds agricultural safety through only one source. Each year since 1976, the Federal Government has provided \$1.02 million to the U.S. Department of Agriculture's Extension Service for agricultural safety. This line-item funding is divided among the 50 States and Puerto Rico, amounting to \$20,000 each. However, because the future of the Extension Service farm safety funding is in doubt, several States have eliminated their Extension Service safety position or cut it back to a part-time position. According to Schnieder (7), only 36 of 50 States have an Extension agricultural safety specialist. In marked contrast, 1985 Federal spending for occupational safety totaled \$472.4 million, which included \$188.8 million for mining alone (8).

Table 1. Ten-year comparison of the 3 most hazardous industries in the United States

Year	Deaths			Deaths per 100,000 workers		
	Agriculture	Mining	Construction	Agriculture	Mining	Construction
1985	1,600	500	2,200	49	50	37
1984	1,600	600	2,200	46	60	39
1983	1,800	500	2,000	52	50	37
1982	1,800	600	2,100	52	55	40
1981	1,900	600	2,200	54	55	40
1980	2,000	500	2,500	61	50	45
1979	1,900	500	2,600	54	56	52
1978	1,900	500	2,600	54	57	63
1977	1,800	500	2,500	53	63	60
1976	1,900	500	2,100	54	63	57

SOURCE: National Safety Council: Accident Facts. National Safety Council, Chicago, IL, 1977-88 editions.

Table 2. Distribution of fatal Indiana farm-work-related accidents by type, 1970-79

Type	Number	Percent
Tractors	228	53
Farm machinery (including combines)	84	22
Asphyxiation	24	6
Falls	21	5
Cutting and trimming trees	19	4
Electrocution	13	3
Livestock	9	2
Fires and burns	4	1
Drowning	3	1
Other	14	3
Total	428	100

SOURCE: Field, W. E., Durkes, J. F., and Tormoehlen, R. L.: Summarization of Indiana's farm-related fatalities, 1970-79. In Engineering a safer food machine: a collection of agricultural safety papers and speeches presented at the 1980 winter meeting of the American Society of Agricultural Engineers, December 2-5, 1980, St. Joseph, MI.

To date, the most significant share of accident prevention efforts have been undertaken voluntarily by major farm organizations; agribusiness; agricultural equipment manufacturers, through such avenues as the American Society of Agricultural Engineers cooperative standards program; and youth programs such as 4-H and Future Farmers of America.

Cost of Agricultural Accidents

Little research has been conducted to determine the economic losses associated with injuries occurring in the agricultural workplace. Tormoehlen documented the costs of several cases, one of which is shown in table 4 (9). These data reflect the potential magnitude of the problem.

Table 3. Distribution of fatal Indiana farm-work-related accidents by occupation 1970-79

Occupation	Fatalities	Percent of total	Peak year
Full-time farmers (ages 17-64) . .	103	24	16 in 1979
Retired farmers (older than 65) .	69	16	11 in 1975
Farm wives	8	2	3 in 1972
Students (ages 6-23)	62	14	11 in 1976
Children (5 years of age or less)	24	6	6 in 1973
Full-time farmer holding part-time off-farm job	22	5	4 in 1977
Farm employee	14	3	3 in 1972
Employed in off-the-farm occupation but involved in farm activity at time of accident	104	24	16 in 1973
Unknown	22	5	...
Total	428	100	...

SOURCE: Field, W. E., Durkes, J. F., and Tormoehlen, R. L.: Summarization of Indiana's farm-related fatalities, 1970-79. In *Engineering a safer food machine: a collection of agricultural safety papers and speeches presented at the 1980 winter meeting of the American Society of Agricultural Engineers*, December 2-5, 1980, St. Joseph, MI.

Table 4. Summary of injury-related expenses incurred by a farmer involved in an agricultural machinery accident, 1984

Type of cost	Amount
Medical	\$63,198.52
Rehabilitation	70,375.00
Mileage (to obtain medical and rehabilitation services)	5,576.00
Lodging	232.00
Lost earnings	1,200.00
Property damage	200.00
Total	\$140,781.52

SOURCE: Reference 9.

Recommendations

To reduce the human and economic losses resulting from serious agricultural injuries, the following activities should be considered:

- Increase the effectiveness of injury control planning efforts through developing more reliable data collection techniques for agricultural accidents involving fatal and serious traumatic injuries,
- Increase the number of agricultural health and safety educators and researchers through graduate-level instruction and interdisciplinary research on high-risk areas of agricultural production,
- Reduce the severity of agricultural-related injuries through meeting critical response and training

needs of farm family members and emergency medical and rescue personnel most likely to respond to traumatic injuries in agricultural workplaces, and

- Reduce the disabling effects and costs of traumatic injuries in the agricultural workplace through integrating existing rural rehabilitation technology into agricultural health and safety education programs and disseminating this information to rural rehabilitation professionals.

Summary

It is time that the expertise developed in other industries to address the injury problem is applied to agriculture. More farmers die or are left permanently disabled due to their work than are longshoremen, fire fighters, police officers, pilots, and persons in other high-risk occupations, including the Armed Forces. Approximately four farmers die every day, and a much larger, unknown number are left with serious physical impairments. Agricultural fatalities must be followed up, just as fatalities in other high-risk occupations are.

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The Cost of Alcohol Abuse and Associated Injuries

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THREE MAIN POINTS arise from the analysis of the cost of injuries. First, economic information can be extremely useful to those persons in the health professions, although it may not necessarily be considered important. Second, alcohol abuse and alcoholism are arguably the most expensive health problem in the United States. Among the problems caused by alcohol abuse, trauma, accidents, and injury constitute a significant minority of the total costs. Third, there is a payoff to U.S. society and its Government in preventing alcohol abuse and its consequences.

Although many researchers in the field of alcohol abuse and alcoholism are driven by issues and values related to the quality of life, legislators and public policy makers are not necessarily driven by the same issues. Their actions are more likely to be motivated by fiscal issues.

Specific examples of this have occurred in the last few years in Washington, DC. First, Public Law 98-509 called for the National Institute on Alcohol Abuse and Alcoholism (NIAAA) to develop a national plan to combat alcohol abuse and alcoholism. Congress charged NIAAA with studying the costs and the economic implications of alcohol abuse in addition to studying policy. The charge was also to examine tangible goals and objectives for reducing those costs, to identify specific needs that were necessary to achieve the goals and objectives, to determine the cost of those needs (that is, needs for personnel, research, strengthening the treatment service sector, and prevention) and to estimate the savings that U.S. society could expect from achieving those goals.

A more recent example of the motivating force of fiscal issues in Washington is the Drug Abuse Act of 1986, which allocated about \$1.5 billion to the substance abuse field. Passage of this bill followed soon after much media attention to issues of the costs and economics of alcohol abuse in U.S. society. As a result of this attention, Congress dedicated more resources to substance abuse prevention, treatment, and education.

As part of the NIAAA national plan, cost estimates were made of the economic implications

of alcohol abuse. These estimates were compared with available data for other health problems. Alcohol abuse was estimated in 1980 to cost the nation \$90 billion (1), whereas it was estimated that

- Circulatory system problems cost \$80 billion (2),
- Digestive systems cost \$45 billion (2),
- Neoplasms cost \$43 billion (2),
- Smoking cost \$65 billion (3), and
- Motor vehicle crashes cost \$60 billion (4).

Some costs overlap; for example, alcohol abuse causes some motor vehicle crashes.

What costs are generated by alcohol abuse? In 1983, reduced productivity (that is, disability) in the workplace cost \$55 billion, with another \$10 billion in productivity lost at home (5,6). Motor vehicle crash costs related to alcohol abuse were \$13 billion. Costs from unintentional injuries, excluding those associated with motor vehicles, were an additional \$8 billion. Costs from violent crime amounted to \$5 billion. Injury-related costs total about \$26 billion—more than 20 percent of the \$117 billion total cost of alcohol abuse in 1983. Note that trauma-related costs were heavily weighted toward indirect costs (that is, productivity kinds of costs). Mortality cost about \$12 billion. Lost employment due to disability cost another \$4 billion. Expenditures on health treatment to deal with disability cost about \$2.5 billion, a rather negligible amount out of a total of \$26 billion for injury-related costs.

The national plan adopted by the Public Health Service set 1990 objectives for preventing problems related to alcohol abuse (7):

- Reduce the incidence of motor vehicle crashes by about 20 percent,
- Reduce the incidence of alcohol-related traumatic injuries by about 20 percent,
- Reduce the incidence of alcohol-related illnesses, such as cirrhosis of the liver and fetal alcohol syndrome, and
- Reduce the prevalence of adult and youth alcohol abuse and alcoholism.

By achieving just the trauma-related objectives for motor vehicle crashes and injuries, the United States would save \$6 billion a year (5,6). More savings would be achieved should the other prevalence- and incidence-related costs be reduced.

There is an economic payoff to prevention, and there will be a payoff to treatment. Although

economic information is not as important as are issues of life and the quality of life to researchers in this field, it can be very useful in motivating those persons who must enable researchers to do more to fight accidents and injuries.

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Bearing Trauma Care Costs

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AS COST-CONTAINMENT EFFORTS continue to pressure hospitals and physicians and as interest in trauma care systems evolves, resulting in the regionalization of trauma care services, questions about the compatibility of the two initiatives arise.

Over the past few years, cost-containment success has largely been measured by comparing the consumer price index (CPI) with a medical care cost index. The information for 1986 to date indicates that the yearly CPI increase approached 1.3 percent, whereas the overall medical care cost increase was 7.7 percent. Even with the pressures and the promotion of "competitive" health care

delivery in the United States, relatively significant cost increases continue. The President's recently submitted budget proposal cuts about \$6 billion from the Medicare budget for 1988, with an anticipated \$45.5 billion cut spread over 5 years. These cuts will result in a significant shortfall of payments to hospitals over those years based on projected increases in hospital costs. In fiscal year 1987, the hospital increase is projected at 3.7 percent, whereas the actual allowance within the Medicare reimbursement schedule is at 1.5 percent—a 2.2 percent shortfall. Fifty-seven percent of the shortfall will be felt by hospitals, and physicians will witness a 13 percent shortfall. As such, cost-containment initiatives will continue to squeeze hospitals and physicians. It appears that application of a diagnosis-related reimbursement (DRG) system will prevail, although probably with modification. The form of modification is in question.

Clearly, there are problems with the Medicare reimbursement methodology when considering trauma systems development. The reimbursement system fails to reflect severity differences, because it is based on an assumption of an average case mix in hospitals adjusted by region. This creates potential fiscal complications for hospitals with a skewed caseload that is more severe than average, as is the case for hospitals that are a part of a trauma system. The concept of a trauma system is to consolidate the few severely injured patients within a region to as few qualified hospitals as is reasonably possible.

At those facilities, a higher volume of the severely injured will be seen by practitioners; consequently, the skills of those practitioners will be enhanced. Higher volume will also lead to more efficient use of trauma resources as generally prescribed by the American College of Surgeons Committee on Trauma. The cost per case should diminish with higher volume. Preventable death from trauma is decreased and, although studies are incomplete, it would appear that disability is radically diminished, particularly for those persons entering a trauma system with a strong rehabilitation program. Consequently, the long-term outcome and cost to society of a patient entering a trauma system compared with one not entering a trauma system are significantly greater.

Given that it makes medical and financial sense to develop a system of trauma care, the question arises of whether the present payment system supports the development of that system of care and, if not, what modifications are needed.

Clearly, Medicare's postulate of an average case mix in a hospital is no longer valid when a regionalized trauma system is implemented that forces a higher number of patients requiring complex care to enter specified facilities. Trauma hospitals under the DRG-type payment systems will suffer financial problems.

It is anticipated that with continued application of trauma systems concepts, trauma centers will be paid below present levels, whereas community hospitals will receive payments at higher than current levels. In effect, this payment method is counterproductive to the concept of developing regional trauma systems. Studies increasingly support this conclusion. Findings in a General Accounting Office report to Senators Cranston and Kennedy indicate "recent changes being phased in under Federal and State health financing programs to contain health care costs might have the effect of discouraging hospitals from specializing in trauma care because the reimbursement rates do not reflect the higher cost of treating the most severely injured patients" (1a).

Of great concern to hospital administrators with a trauma program as a major part of their facility is the endless targeting of payment limitations on hospital costs, not costs for episodes of care. In a trauma system, the intensity of services in the hospital phase of care will be significant because it is anticipated that the delivery of those intense services will dramatically diminish the disability and, therefore, diminish the costs associated with postacute care. Unfortunately, the focus on hospital costs only, as opposed to costs of an episode of care, is counterproductive—it forces hospitals to compromise trauma care in the acute setting in order to meet "bottom line" pressures, resulting in enhanced potential for long-term clinical problems (and greater costs) in the postacute setting.

This concern is highlighted when considering the impact of Health Maintenance Organizations (HMOs) and Preferred Provider Organizations (PPOs). With rapidly increasing enrollment, these organizations are increasingly sending their representatives to trauma centers to move patients from those facilities to their contract hospitals, where they can control fiscal impact. As such, although HMOs and PPOs generally will assure their beneficiaries of emergency care at any emergency facility, they have great potential for disrupting the continuum of trauma care by moving the trauma patient out of the spectrum of trauma services provided through that trauma center.

Some persons will say the payment methodology

employed by Medicare is not of major concern because trauma is a "young disease." However, the payment methodology used by Medicare has conceptually been adopted by other third-party payors; in particular, Medicaid programs are adopting such structures. The Medicaid population and the Medicare population generally comprise a high percentage of trauma admissions, regardless of geographic location.

Furthermore, statistics are already indicating an increase in the number of elderly patients suffering from major injury. Therefore, modifying Medicare payment methodology to support implementation of trauma system concepts would have broad, direct impact, while continuing to raise the national consciousness of the trauma issue. What, then, is the best approach to modifying these payment systems? First and foremost is for the trauma system designers to correct a major void—lack of data on outcome and cost related to an episode of trauma care for patients in a trauma versus a nontrauma system. Until those data are more clearly described, it will be difficult to convince cost-conscious third-party payors and HMOs that the high level of payment for hospital trauma care is ultimately to their benefit.

Within that data base, there must be a good functional assessment index tool to measure wellness at time of discharge from the acute care facility (a productivity measure that is better than just an assessment of life or death). Information related to trauma cases must also be comparable nationwide; that is, consensus must be reached on which "severity measure" is to be used. Johns Hopkins University and the Maryland Institute of Emergency Medical Services Systems (MIEMSS) are studying long-term outcome with an emphasis on developing a functional assessment tool. They are also studying the reliability of an Injury Severity Scale (ISS)-adjusted DRG to predict resource consumption patterns. Furthermore, proposals exist to work with the insurance industry to review information on their beneficiaries who have suffered major injury categorized by trauma versus nontrauma system care. However, the insurance industry has not been responsive.

While continuing to review the impact of DRGs on financing and quality of care, the Health Care Finance Administration (HCFA) is studying whether a change in Federal policy under Medicare should be made to adjust payment rates for the care of severely injured patients and whether trauma centers suffer an adverse financial impact. This was mandated by the General Accounting

Office report. The report also states that although Medicare's trauma caseload is low, HCFA has a role in approving State Medicaid programs where the trauma caseload is considerably higher. Considering the larger financial impact of Medicaid on trauma centers, HCFA therefore was also charged to explore the impact of State Medicaid reimbursement methods on trauma care when it reviews criteria and methods used by States to set Medicaid reimbursement rates (1b). HCFA has already initiated such studies.

The Department of Transportation, in trying to develop consensus on national emergency medical service standards by using the American Society for Testing and Materials (ASTM) process, has provided a forum for all involved in delivery of emergency medical services to address the issue of payment to trauma centers for trauma care. The payment standard is in the process of review and reflects the need to structure appropriate payment systems for trauma centers. Assuming this standard is finally approved through the ASTM process, a significant, potent statement of the problem with recommended solutions will have been made.

The question yet to be answered is what the solution is. Efforts to date have resulted in the introduction of Senate Bill No. 10 in Congress, which provides for \$75 million for 1988 through 1990. Of that amount, 80 percent would reimburse trauma centers designated through a formal competitive process pursuant to a State plan for the portions of their uncompensated trauma care costs, and the remaining 20 percent would be

applied to other EMS activities. The only trauma centers that would be eligible to receive the block grant funds would be those that meet criteria consistent with the guidelines of the American College of Surgeons and that serve areas in which triage transport and transfer policies have been implemented. This effort would require the Department of Health and Human Services to study the long-term economic and social impacts of trauma.

Clearly, headway has been made in highlighting the payment problem, and studies are underway to assess different methods that could be employed and might be adopted. But apparent in all approaches to the resolution of this payment problem is the need for a process of selecting facilities to be trauma centers in a nondiscriminatory manner. This process will require the development of a National Commission for the Accreditation of Trauma Centers which, working with the States, would provide the necessary assurance to third-party payors that those hospitals designated would be equipped to provide care for the severely injured patient and would be continuously evaluated. In addition, the commission would demonstrate appropriate outcomes through a continual process.

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Injury Prevention Grants and Demonstration Projects

Injury Prevention Research and Demonstration Grants: An Overview of the Process

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WHEN THE CONGRESSIONALLY mandated report, "Injury in America" (1) was transmitted to the Secretary of the Department of Transporta-

tion, that Department's National Highway Traffic Safety Administration began working with the Centers for Disease Control (CDC) to develop a grant program to support research and demonstration projects and injury prevention research centers (IPRCs). One stipulation of this program was that half of the funds would be directed toward controlling injuries related to traffic and motor vehicles.

This report reviews activities carried out in stimulating the submission of grant proposals and comments on the IPRC proposals. Others will provide their appraisals of the various groups of

proposals submitted. The applications for demonstration grants were reviewed by panels having particular expertise in one of several fields: acute care, biomechanics, epidemiology, prevention, and rehabilitation.

Program Announcement

The Centers for Disease Control's program announcement provided information regarding definitions, goals, eligibility requirements, and program elements. An injury prevention research center was defined as "an organizational unit within an academic institution that works toward the development of an interdisciplinary, comprehensive approach to the injury problem involving physicians, epidemiologists, engineers, behavioral scientists, public health workers, and others, and is organized in such a manner that multiple aspects of the injury problem can be addressed by this unit (for example, research in epidemiology, prevention, biomechanics, treatment and rehabilitation; information gathering and dissemination; and the ongoing provision of training opportunities to students, researchers, and public health agency personnel)."

Review of Grant Proposals

The peer review mechanism used for injury prevention proposals followed the well-established procedures used by the National Institutes of Health (NIH). CDC established a 20-member Injury Research Grant Committee for the peer review process. Because 381 injury research and demonstration grant applications were received, this committee was assisted by 69 consultant reviewers, chosen for their knowledge and expertise in the fields addressed by the applications.

Thirty-nine IPRC grant proposals were reviewed by the 20-member committee, and 13 were approved. Five of those approved were chosen for site visits by CDC personnel to negotiate actual grant awards. The approved grants were not concentrated in one or two regions of the nation.

Peer review of the 381 research and demonstration proposals submitted was more complex. Members of the committee and consultant reviewers were assigned to one of seven different panels, with two panels established in epidemiology and in prevention to distribute the work load better. The proposals are grouped by field or area of emphasis in table 1, along with the number of panelists who worked in each area.

Table 1. Peer review panel members and research grant applications by field of emphasis

Field of emphasis for panel	Number of panel members	Number of grant applications
Acute care.....	14	60
Biomechanics.....	11	42
Epidemiology.....	30	138
Prevention.....	27	113
Rehabilitation.....	7	28
Total.....	89	381

Table 2. Research and demonstration grant projects approved and funded according to review panel

Review panel	Approved		Funded		Percent of those received that were funded
	Percent	Number	Percent	Number	
Acute care.....	32	19	26	5	8
Biomechanics.....	48	20	25	5	12
Epidemiology-1....	30	21	24	5	7
Epidemiology-2....	23	16	25	4	6
Prevention-1.....	26	16	25	4	6
Prevention-2.....	31	16	25	4	8
Rehabilitation.....	21	6	67	4	14
Total.....	30	114	27	31	8

The panels met in Atlanta, GA, in early November 1986 to discuss the scientific merits, strengths, and weaknesses of each proposal and to make recommendations to approve or disapprove each of the 381 applications. These recommendations were then presented to the 20-member committee, and 114 proposals were recommended by this committee for approval. In December 1986, 31 of the approved proposals were recommended for funding by the internal review committee (table 2).

Thirty percent of the projects received were approved; 26 percent of these (8 percent of the grant proposals received) were funded. At least one grant was funded in each field of emphasis; however, the percentages of grant applications submitted that were funded were highest for rehabilitation and biomechanics.

General Comments on the Peer Review

Those participating in the peer review process were asked by CDC staff to submit their comments on the grants program and the peer review process. My general observations which follow do not necessarily reflect the views of other participants.

The response to the invitation to submit grant applications was most encouraging even though CDC staff were not able to assist in the development of applications. Many capable persons from different institutions worked effectively on short notice to submit a large number of worthy research and demonstration grant proposals. It was apparent that many had benefited from prior peer review. This observation suggests that the quality of grant applications is likely to improve further in future years if the program continues. It is also likely that the number of groups interested and involved in injury research will increase.

The response to the invitation to submit grant applications was greater than expected. The percentage of grants approved was not very different from the results of similar efforts made by long-established NIH peer review groups. Because available funds were limited, the percentage of approved grants recommended by the internal review committee for funding was less than the percentage funded by most research grant programs.

The peer review mechanism established by CDC worked reasonably well. A multidisciplinary group composed of persons who had not, for the most part, worked together was asked to accomplish a great deal of work in their first two meetings. CDC staff also gathered many suggestions for improving the peer review process.

One problem that was not addressed was inadequate funding. Lack of assured continuity of support is a major problem for the research and demonstration grants program.

Further, there were major differences in the proposals submitted by governmental units and those submitted by research-oriented universities. If a single peer review mechanism is to be used for applications from these two groups, then CDC should consider working more closely with governmental units in developing future grant applications.

The panels frequently identified groups with useful insights, enviable skills, or the ability to work with research questions not now being addressed very well. Yet, these were not always the groups that had the best developed and most readily approvable grant proposals. Therefore, CDC staff should assist such groups in developing their ideas, skills, and opportunities so that a wider range of approved and fundable grant proposals can be submitted in the future.

A final general comment relates to the attitude perceived during the review process. The magni-

tude of the effort needed in injury prevention was generally appreciated, and there was support, concern, and interest in the program.

Comments Regarding IPRCs

Universities and government have long employed centers or institutes as a way to focus and accomplish missions that involve academic disciplines from several schools or departments. A principal advantage of such centers is that they should be more readily sustainable than are individual investigator grants. Centers vary considerably in their administrative arrangements, especially in the provisions made for review and oversight; they are most useful when great flexibility is required. Two major determinants of a center's success are the previous experience and attitudes of each university community toward such endeavors and the approach of the funding agency.

There was no model center grant application that completely fulfilled the perceived requirements and thoroughly dealt with each program element. However, many very good proposals showed promise in addressing the issues raised in "Injury in America." As might be expected, applicants had differing degrees of expertise in the various fields and areas of activity. A common problem of the IPRC applications was that many applicants did not, in the opinion of the review panel, meet the requirements for expertise in biomechanics.

Conclusions

CDC and the newly funded centers need to reach consensus on several key issues, including continuity, the role for such centers in the overall injury control effort, and how to develop cooperative programs among several centers. Without ensuring the continuity of Federal funding for longer periods, the center concept is not likely to be effective.

If the initial centers develop into a tightly knit group dedicated only to perpetuating their own existence, then a great opportunity will have been lost. On the other hand, if CDC and the academic centers can work together so that the centers become truly regional resources, a unique opportunity exists. CDC's experience in working cooperatively with the States is well recognized. This experience can help university centers become effective outside their own community or State. Similarly, cooperative efforts involving several cen-

ters can be a valuable national resource (for example, encouraging faculty exchanges, placing researchers with innovative ideas in a setting where their work is facilitated, sharing educational materials, and overcoming obstacles that impede governmental efforts).

Reference.....

1. Committee on Trauma Research: Injury in America. A continuing public health problem. National Academy Press, Washington, DC, 1985.

CDC's Extramural Program for Injury Control Research

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IN RESPONSE TO THE REPORT, "Injury in America" (1), Congress appropriated \$10 million for Fiscal Year 1986 for research on injury control and repeated that appropriation for Fiscal Year 1987 (2,3). These monies, appropriated to the National Highway Traffic Safety Administration (NHTSA), were designated for subsequent transfer to the Centers for Disease Control (CDC). CDC was charged with establishing an extramural research grant program, responding to the recommendations in "Injury in America," and with developing mechanisms to ensure NHTSA concurrence with at least 50 percent of the research grants monies awarded.

Process

The grant review and decision-making process was a two-step system. Initially, a peer review committee of technical experts reviewed the applications for technical merit using the criteria specified in the program announcement (4). Applications were recommended for approval or disapproval, based on this review, and then a priority score was assigned to reflect the interest in the proposed research. A secondary review was done to ensure balance in the grant program across the areas outlined in the program announce-

ment. The secondary review group included three persons from NHTSA and three persons from CDC.

Results and Discussion

The program announcement, which was published in the Federal Register on June 10, 1986, called for the submission of applications by August 11. We received 420 applications, including 39 proposals for academic centers and 381 for research and demonstration projects.

The peer review committee met in late September 1986 and recommended approval of 13 applications for injury prevention research centers. At a subsequent meeting in early November, the peer review committee, with the assistance of additional ad hoc experts, reviewed and recommended for approval 119 of the 381 injury research and demonstration projects. Following each peer review meeting, the secondary review group met and made recommendations for the award of funds to 5 injury prevention research centers and 31 injury research and demonstration projects.

A variety of factors were considered during the secondary review of applications. To ensure high-quality research, the top-ranked application within each of five categories was recommended for funding.

The report, "Injury in America" had identified the importance of acute care, biomechanics, epidemiology, prevention, and rehabilitation, to adequately address research on injuries. All five academic centers had contributions from diverse academic disciplines, including the fields of medical care, engineering sciences, social sciences, and public health; focused on different aspects of the injury problem; and are located in diverse academic settings. Approximately \$2 million was awarded to these centers:

Harborview Medical Center, University of Washington, Seattle

Harvard School of Public Health, Boston, MA

Johns Hopkins School of Hygiene and Public Health, Baltimore, MD

University of North Carolina, Chapel Hill

Wayne State University, Detroit, MI

Applications for research and demonstration projects were not evenly distributed among the five areas identified in "Injury in America" (see table). The secondary review group sought to ensure support for each area of research, as well as to provide equitable opportunities for competing applications in their recommendations for awards.

Injury research and demonstration projects grant titles, fiscal year 1987

Acute care

Secondary injury factors and prevention treatment in central nervous system trauma, San Francisco, CA
Validating the AIS/ISS (Abbreviated Injury Score/Injury Severity Scale) for penetrating injuries, Houston, TX
Emergency Medical Service System factors, Valhalla, NY
Major trauma outcome study, Washington, DC
The rural use of pneumatic anti-shock garments, Boulder, MT

Biomechanics

Biomechanical aspects of spinal trauma, Durham, NC
Biomechanics of side impact, Detroit, MI
Biomechanics of neural and neurovascular injury, Philadelphia, PA
Biomechanics, epidemiology treatment of hip fractures, Boston, MA
Development of a multisized hybrid III-based dummy family, Columbus, OH

Epidemiology

Fall-related fractures and use of medications, Nashville, TN
Fatal and nonfatal injuries among Kentucky farmers, Lexington, KY
Traffic-related injuries among children, Irvine, CA
Occupational injury surveillance by health centers, Chicago, IL
Violent death in the home in relation to gun ownership, Memphis, TN

Brain injuries in children, Los Angeles, CA
Epidemiology of severe injury to urban children, New York, NY
Oklahoma demonstration projection injury control, Oklahoma City, OK
Olmsted farm injuries—a pilot incidence study, Minneapolis, MN

Prevention

Evaluation of drunk-driving interventions, Boston, MA
Intervention to increase children's use of safety belts, Blacksburg, VA
Hydroplaning with lightly loaded truck tires, Ann Arbor, MI
Experimental studies of falls, Lubbock, TX
The children's safety research project, Elk Grove Village, IL
Evaluation of adolescent suicide prevention programs, New York, NY
Preventing injuries from marital violence, Madison, WI
Injury prevention: evaluating server intervention, San Francisco, CA

Rehabilitation

Development of an outcome-oriented health injury database, Birmingham, AL
Outcome of closed head injury in childhood, Seattle, WA
Cognitive implications of closed head injury, Washington, DC
Neuropsychiatric factors in injury, San Francisco, CA

NOTE: Summary information on the centers and research and demonstration projects being supported is available on request from the Extramural Research Grant Coordination Activity, Division of Injury Epidemiology and Control, CDC, Atlanta, GA 30333.

Injury research and demonstration projects applications received and awards made by categories

Category	Applications received	Grants awarded	Funds awarded (1,000s)
Acute care.....	60	5	\$1,000
Biomechanics.....	42	5	1,200
Epidemiology.....	138	9	1,500
Prevention.....	113	8	1,300
Rehabilitation.....	28	4	800
Total.....	381	31	\$5,800

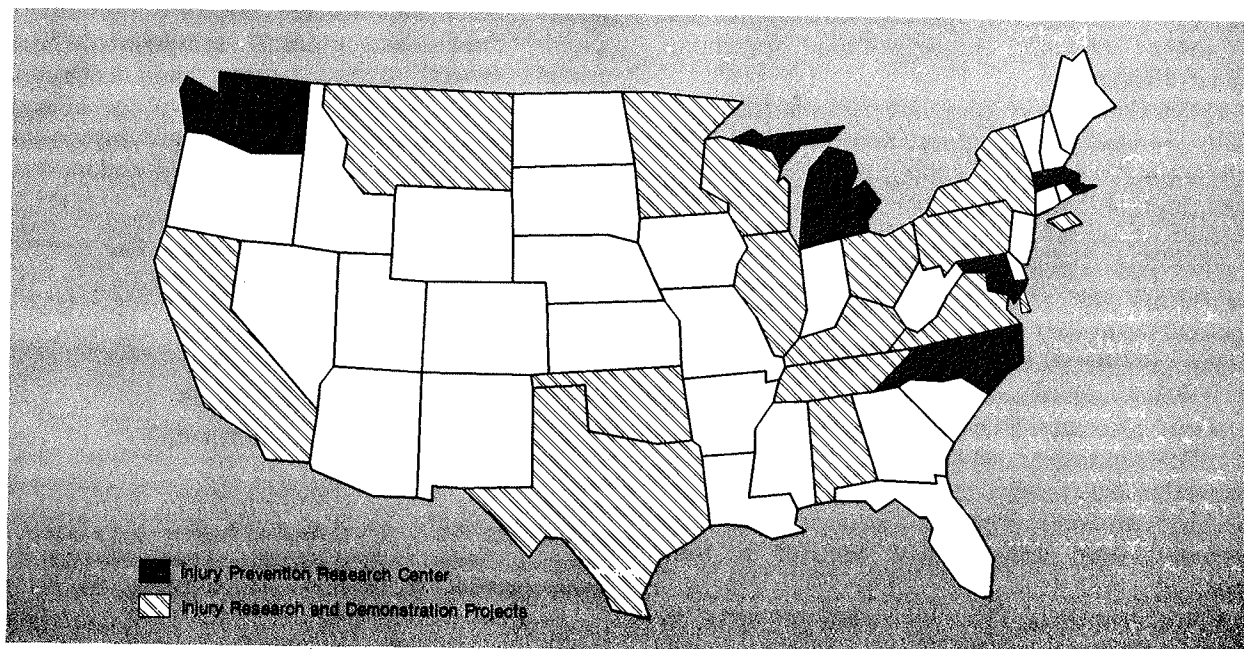
priority risk groups in these grants, as the following tabulation shows.

Category	Number of projects
<i>Cause of injury</i>	
Motor vehicle, traffic safety.....	8
Other unintentional cause.....	4
Intentional.....	4
Occupational.....	4
<i>Priority groups</i>	
Children.....	6
Adolescents.....	2
Elderly.....	3
Minorities.....	2
Rural.....	4

Approximately 8 percent of all applications received were funded.

We sought to include all major injury types and

Many funded projects address the overall injury problem and will develop information relevant to all high-priority groups.



NOTE: Some States with injury prevention research centers also have research and demonstration projects.

Finally, we sought to distribute grants throughout the country. Injury problems differ from locale to locale; consequently, competence in injury research is needed in many geographic areas. The 36 funded projects and centers are located in 20 different States, and in 9 of the 10 Public Health Service regions (see map).

Summary

The Injury Prevention Research Grant program has touched on many facets of research during its initial funding cycle in fiscal year 1987. The grants are listed by title and location in the box. However, research on injury must encompass an even broader spectrum of knowledge to address adequately this largest cause of death and disability of children and young adults (1).

References.....

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3. Public Law 99-591: Department of Transportation and Related Agencies Appropriation Bill, 1987. U.S. Government Printing Office, Washington, DC, 1987.
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Directions for Research and Development in Acute Care

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ACUTE CARE IS ONE of the designated five areas of injury control requiring continuing research. Treatment, research, and education are all necessary for improving the acute care of injured patients. Systems for acute care of injured patients, referred to as trauma care systems, constitute subsystems within the larger sphere of emergency medical services (EMS) systems. Currently, only 5 percent of patients receiving EMS system care, or 1 person per 1,000 population per year, require the resources of trauma care systems. Providing optimal acute care for injured patients requires understanding of each component of the trauma care system and the interrelationships of the components, as follows.

- **Medical direction.** Trauma care systems must be under the direction of physicians who are qualified in system planning, implementation, operation, and evaluation.
- **Prevention.** Injury prevention encompasses primary, secondary, and tertiary approaches. Primary prevention focuses on limiting access to hazards, such as prohibiting manufacture of firearms. Secondary prevention—seatbelts, for example—protect victims from existing hazards. Tertiary prevention constitutes the realm of acute care, providing medical treatment for victims who are injured despite primary and secondary prevention efforts.
- **Training.** Acute care necessitates the services of a broad spectrum of health professionals, including first responders, dispatchers, emergency medical technicians, nurses, physicians, and a host of ancillary personnel. Optimal specialized education, including team techniques, is required in acute care.
- **Communications.** Communication networks, including ambulance dispatch, provide contact with the patient. They also allow the physician to direct prehospital care and facilitate transport to the hospital and interhospital transfer.
- **Triage.** Injured patients must be directed to facilities with specially trained teams. Therefore, trauma care systems attempt to identify all patients who have sustained injuries requiring trauma care.
- **Prehospital care.** Timely dispatch, evaluation, resuscitation, and transportation constitute expedient prehospital care and transport.
- **Transportation.** Transport and interhospital transfer are performed by ground ambulances or helicopter or other aeromedical ambulances.
- **Hospital care.** Patient management during the hospital phase occurs in three settings. Level I hospitals (for example, teaching hospitals) serve as regional referral centers. Level II hospitals, represented by community hospitals, provide the majority of trauma care. Level III hospitals, located primarily in rural areas, provide initial evaluation and stabilization, referring patients with serious and complex conditions to higher levels of surgical and intensive care.
- **Rehabilitation.** Rehabilitation remains inadequate in many communities. Injured patients require physical and psychosocial services.
- **Public education.** This component seeks to reduce the incidence of traumatic injury. For those who sustain injuries, it facilitates access to the trauma care system and promotes realistic expectations of outcomes.
- **Medical evaluation.** Medical evaluation provides

quality assurance for trauma care systems. Research components include structure (resources), process (care), and outcome (results). Methods include clinical studies, tracers, and registries. Viewed in this context, acute care of the injured represents an integral part of a comprehensive care system that encompasses research, education, and treatment.

Directions for Research and Development in Biomechanics

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BIOMECHANICS IS THE INTERFACE between engineering and injury, and it should be used to modify environments, human activities, and attitudes to minimize injuries to exposed persons. Defining injury in quantitative terms such as force and acceleration, instead of the usual qualitative terms of minor and severe, is one of the major endeavors in biomechanics, and bringing about this change must be given high priority in the allocation of research efforts. Establishing human tolerance to impact requires extensive laboratory facilities, complex instrumentation, and highly trained personnel. Maximum returns in terms of results will be achieved if the funds for research are allocated to organizations having the necessary personnel and equipment.

Distribution of Injuries and Fatalities

The greatest reductions in injuries and fatalities will be achieved by applying biomechanics to the sites with a high incidence of injuries (see table). The differences between classes of injury lie in the exposures to injury and the methods of intervention. Generally, motor vehicle crashes can be classified as high-speed accidents occurring in a relatively well-defined, albeit severe, environment, with protection provided by controlled crush, padding, and restraint systems.

Workplace, home, and public place accidents usually occur at lower velocities than do motor vehicle accidents. However, because the environ-

ment in which these accidents occur is not as limited or defined, the application of biomechanics to injury mitigation is not as well defined. Further, because the environments of the workplace, home, and public place injuries are so diversified and the exposure so varied, it is not feasible to pad all impact surfaces or to use restraint systems. Solutions then include padded clothing, elimination of sharp corners, installation of railings, use of tempered glass, issuing of warnings, and education of the public.

Dissemination of Data and Techniques

Data on human tolerance to impact in quantitative physical terms, including information from additional research, must be disseminated to designers of motor vehicles, sports equipment, protective clothing, prostheses, and other devices. However, the best method for reducing injury is to prevent it by educating the public.

Illustrations employing biomechanics can be useful educational tools. For example, most people consider 30 miles per hour to be a safe urban driving speed. But if they are made to understand that this impact is identical to that of a 30-foot fall (that is, from the fourth floor of a building), that the mean equivalent barrier test speed for fatal frontal force collision is only 33 mph (1), and that seatbelts are extremely effective at these speeds, people should be more amenable to buckling up. Educating lawmakers would be more effective than educating the public if they would make certain safety features mandatory and would spend the available money in those areas where the most benefits will accrue. For example, a mandatory Federal seatbelt law could ensure uniformity in use and enforcement.

Recommended Strategies for Control

Recommended strategies for the application of biomechanics to injury control follow:

- Support biomechanics research with an emphasis on the human tolerance to impact and its application to mitigation of injury
- Concentrate injury prevention and mitigation efforts in areas where major benefits can be achieved
- Disseminate data and techniques to product manufacturers
- Educate the public
- Solicit the active support of lawmakers.

Summary of 1985 accidental deaths and disabling injuries by major classes

Injury class	Deaths	Disabling injuries
Motor vehicles	46,500	1,700,000
Work	7,500	1,800,000
Home	20,300	3,100,000
Public	19,000	2,400,000
Total	92,500	9,000,000

SOURCE: Accident facts—1986 edition. National Safety Council, Chicago, IL, 1986.

Reference

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Directions for Research and Development in Epidemiology

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RECENTLY, I HELPED TO EVALUATE 138 research grant proposals on the epidemiology of injuries that were submitted to the Centers for Disease Control. These proposals provided a good indication of the current state of knowledge of the epidemiology of injuries and the directions in which its practitioners think it should be developing.

The proposals revealed that injury epidemiology is clearly still in its infancy: many proposals involved the collection of extremely basic data. Many of the proposals discussed the inadequacy of existing data sources and the difficulties of developing more adequate data sources. Most proposals were attempts to determine the extent of the injury problem and how injuries are distributed in the population to be studied. Although such descriptive epidemiologic studies are important as a first step, they are not an end in themselves. Rather, descriptive epidemiologic studies are a prelude to the real business of injury epidemiology, which is determining the causative factors that are amenable to intervention.

High-quality descriptive epidemiologic studies that look in detail at injuries and their circum-

stances are still needed. Yet, it is not enough simply to describe the extent of the problem and its distribution. In planning an injury epidemiology study, one must think in terms of what factors might be discovered that could lead to effective injury-reducing measures. In this regard, the collection of appropriate data on uninjured or unexposed populations is key.

Several of the proposals reviewed concentrated on correlating personality traits or other behavioral factors with injuries. In focusing solely on behavioral factors, some of these proposals did not adequately exploit accepted epidemiologic methods, which can allow for the investigation of multiple factors and the exploration of additive and multiplicative effects. In addition, a study design that excludes nonbehavioral factors may be less likely to lead to effective countermeasures.

As the authors of "Injury in America" pointed out, "Much more attention has been paid to identifying the role of people in initiating injury events than to identifying the role of products, vehicles, and other environmental factors. Only minimal information is available on the often subtle interaction of human and environmental factors in event initiations, because the necessary epidemiologic studies have never been done" (1). It is my view that these necessary epidemiologic studies were, for the most part, not proposed.

Reference.....

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Directions for Research and Development in Prevention

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THE 1985 REPORT, "Injury in America" (1) identified the prevention of injury as one of five activities fundamental to injury control. The promotion of research on injury prevention was one of the goals listed in the Centers for Disease Control's (CDC) announcement of grants for injury control research and demonstration (R & D)

projects. Of 381 R & D project applications received by CDC, 113 addressed prevention. Among the strategies proposed were relatively few trials of existing interventions, some development of new intervention strategies, and studies to identify elements of future interventions. Many proposals presented weak study designs that failed to specify goals and methodologies.

Perspective on Successes and Failures

An examination of past efforts at injury prevention will modulate some of the rigidity that has arisen around the juxtaposition of behavioral, legal, and engineering approaches. Although injury control experts have accepted that there is a hierarchy of effectiveness of interventions, with automatic protections at the top and voluntary behaviors at the bottom, the public must also understand these controls so as not to dismantle them or legislate against them. Understanding human behaviors that entail injury risk-taking, violence, and self-destructive actions is as essential a part of the growth of this field as is the design of new and better protection devices. In fact, interdisciplinary approaches to specific hazards by teams composed of engineers, clinicians, epidemiologists, and social scientists hold exciting possibilities for productive research.

Needed New Models

The traditional host-agent-environment model needs modification to generate appropriate frameworks for research in injury prevention. More precise epidemiologic definitions of a case (that is, the target injury to be prevented) and of the population at risk are needed for designing and evaluating good intervention studies. Appropriate numerators and denominators in injury research need to be refined if evaluations of intervention strategies are to be meaningful. Population-time denominators may not be adequate. Issues of risk and exposure need to be built into denominators.

Measures of Effect in Prevention Studies

Studies of efficacy of interventions under experimental conditions are necessary but not sufficient in injury research; effectiveness in the real world is essential for scientific purposes and subsequent political action.

Community-based studies showing reductions in the incidence of injuries of specific types are

difficult to do and expensive. However, such demonstrations of injury reduction are essential. Intervening variables concerning knowledge, attitudes, and behaviors may be useful to understand changes observed in injury rates or the failure to change the incidence of injuries. In addition, the knowledge and perceptions of the public and policymakers may be essential to the acceptance of even highly effective injury control measures.

Finally, cost-effectiveness and cost-benefit analyses must be integrated into intervention designs to provide the additional information needed to influence policymakers.

Study designs. Many R & D proposals submitted to CDC were particularly weak in study design. Injury prevention research needs the equivalent of the double-blind, randomized clinical trial to study interventions in the community. However, specific injuries may be relatively rare events, making it difficult to launch intervention studies with adequate power to demonstrate an effect. Therefore, multicenter trials like those that are used in medical treatment intervention studies are needed. Further, case-control epidemiologic methods should be adapted to the study of injury epidemiology and to the evaluation of intervention efforts.

Priorities for prevention studies. In this new field of injury prevention, there is a need to study all types of interventions and a need to begin setting priorities. We need to concentrate on low-incidence injuries with a high potential for prevention and on high-incidence, highly visible injury hazards for which effective prevention strategies may or may not be currently available. Additionally, the complex problems of intentional injury, interpersonal violence, and suicide need to be incorporated in the prevention research agenda.

Conclusion

In the future, the quality of prevention proposals must be improved and the adequacy of resources to support such research must be ensured. This expanded support must come from Federal as well as private and foundation sources. With the support of the injury control community, CDC can lead in securing this support.

Reference.....

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Directions for Research and Development in Rehabilitation

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IN "INJURY IN AMERICA," rehabilitation is defined as "the process by which physical, sensory, and mental function capacities are restored or developed after damage and the process by which biologic, psychologic, and social functions are restored or developed to permit an injured person to achieve maximal personal autonomy in an independent noninstitutional lifestyle" (1). Although this definition is comprehensive and denotes the breadth of the rehabilitation field, it tends to be deceptive about the complexity of the rehabilitation process. Viewed on a continuum, the process of rehabilitation becomes more complex as more of the body's anatomical structures and physiological systems are impaired by injury. However, the increases in complexity, as well as the increases in economic and societal costs, appear to expand geometrically as more structures and systems are affected.

Because the rehabilitation process is the simplest when a single organ system is affected, it is in these cases that the process is best developed and understood. Such injuries are usually treated by a single team of physicians and therapists throughout the entire acute and rehabilitative process. As a result, their management tends to be more effectively organized and understood than is the management of more complicated injuries.

At the other end of the continuum, the rehabilitation process becomes the most complex when managing injuries to the central nervous system, spinal cord, and head. In patients with these types of injuries, function of the limbs, sensation, and mobility are usually impaired, as well as neural control of various organ systems.

In both spinal cord and head trauma, neural recovery may occur up to several years after the injury; however, permanent disability is commonly severe and affects many daily activities. In addition, the injured person is dependent on others in whole or in part for his or her remaining lifetime. Furthermore, although our experience with aging in severely disabled populations is limited, it appears that these populations will require greater

services from the rehabilitation community as time passes.

As injuries that require or may benefit from rehabilitation become more severe, more physicians, allied health specialists, and other service delivery professionals are needed for patient care and management. In addition, these needs increase from onset of the injury through rehabilitation and beyond. Unfortunately, as severely injured patients move from emergency care to acute care to physical rehabilitation to vocational rehabilitation to community services and back into society, the care and management of their conditions are typically fragmented, inefficient, and often inappropriate.

The Model Spinal Cord Injury Systems, initiated in 1970, are the only examples of an organized program that addresses severe injury comprehensively and categorically. Established to examine costs, treatment outcomes, complications, and other factors related to spinal cord injury, each model system links emergency, acute, rehabilitation, and lifetime care to provide an organized system of care. Moreover, each regional center contributes standardized data on the injury and its management within the system to a common data base.

This approach has had a remarkable impact on the understanding of spinal cord injury and its management and has allowed considerable improvement in controlling the consequences of the injury. Because of the knowledge, awareness, and organization provided by the model systems approach, persons with spinal cord injuries who enter the system immediately after injury develop fewer complications acutely and during rehabilitation. As a result, these individuals are discharged from the

inpatient rehabilitation program of the system an average of 1 month sooner than are patients who receive acute care elsewhere. This early discharge amounts to an average cost savings of about \$30,000 per patient.

From the perspective of rehabilitation, to control adequately the consequences of severe injury, it is imperative to establish similar model systems of care for other complex injuries such as head trauma, burns, multiple complicated fractures, and major limb and multiple amputations. This step should be the strategy of choice, because these severe injuries are the most costly in human and economic terms.

Currently, substantial basic sciences and clinical research is supported and conducted by many investigators in the different subcomponents that collectively constitute the rehabilitation process. However, because this research is supported by various agencies with specific interests and is investigator-oriented, there is no broad focus on the rehabilitation process. Although the current research efforts should not be discouraged, the Centers for Disease Control (CDC) should encourage examination of the rehabilitation process from the broader perspective of injury control within a systems approach. CDC should lead in fostering the establishment of such systems through its injury control research and demonstration programs.

Reference.....

1. Committee on Trauma Research: Injury in America. A continuing public health problem. National Academy Press, Washington, DC, 1985.

Sources of Funding for Injury Control

State Agencies and Health Departments

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THE FUTURE OF INJURY epidemiology and injury control activities in State and local health

departments is uncertain. The potential of these much-needed activities will not be realized unless dedicated leadership and sufficient funding are available at the State and local levels. Although the primary purpose of this paper is to consider these two factors and how they influence current injury control practice, the genesis of these activities must also be considered.

In 1955, at least 12 States received grants from the U.S. Department of Defense and the Public Health Service and participated in a study designed

"to contribute vital information on crash injury factors as a means of preventing death and disability through highway accidents" (1). At the same time, several communities were involved in home hazard appraisals and many local safety councils and programs were developed.

Some State and local health departments had injury control programs during the 1960s and 1970s, but most were not very active. The early 1980s were a time of renewed emphasis on injury prevention. The sociopolitical context led to the recognition that injuries were preventable. Public health officials no longer were willing to accept that Americans aged 15-24 had a higher death rate than had been the case 20 years earlier. It was recognized that injuries are not random events but occur as the result of predisposing factors.

The 1980s have thus far witnessed the creation of injury control sections in several State health departments; data acquisition comprises a major activity. Although several of these new sections are in maternal and child health bureaus, others are in epidemiology units. There is a renewed spirit of purpose and togetherness among injury control leaders, researchers, and specialists. Nevertheless, those involved in injury control at the State level must constantly defend injury prevention as a legitimate public health function, because the notion that the State should attempt to influence or actively intervene in lifestyle decisions has never been completely accepted by the government, policy makers, or the general public.

Some degree of public resistance to injury control can always be expected, but even larger obstacles face State and local health departments.

Organizational Issues

When President Reagan took office, he implemented two policies that have significantly curtailed State and local activities in health. The first was to substantially reduce nondefense spending in the Federal budget; the second was to restructure the roles of local, State, and Federal governments. The new Federalism resulted in the consolidation of 21 health programs into four block grants. By 1983, State and local health departments found themselves with less money of their own, less Federal money, and greater responsibility.

It was against this background that several States tried to initiate injury prevention activities. However, ideas do not translate into action unless funding and other resources are available to attack specific objectives. In fiscal year 1984, funding for

injury control represented less than 0.3 percent of prevention funding by the Department of Health and Human Services (2). Nevertheless, in 1984, State agencies spent \$6.53 billion providing services in four budget areas of public health: personal health, environmental health, health resources, and public health laboratories (3). State agencies spend the largest proportion of their funds for personal health services—70 percent in 1984.

Funding Issues

Health departments have taken several ways to turn the crisis of limited dedicated funds for injury control into opportunity. One way is to communicate, cooperate, compromise, and share resources with other public and private organizations.

In attempting to plan, develop, and implement injury control programs, State and local health departments have been forced into the grantsmanship arena. Competitive bidding for limited dollars is a new experience for health departments, and many are not able to compete. Some agencies are not able to apply for funding because they have no internal support; especially lacking is a consensus that grant writing is an important activity. Other agencies are not able to apply for funding because no one has the time to prepare a grant application. Still other agencies are not able to apply for grant monies because they have no one experienced in grant writing. If public health departments are to become active or remain active in injury control, agencies must be provided with the kind of support that will enable them to survive in the competitive world of grantsmanship.

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Federal Funding

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INJURY CONTROL ACTIVITIES conducted by Federal agencies are as diverse as the agencies

themselves. Some agencies have regulatory, rulemaking, and recall functions; others provide technical assistance and consultation; and some operate field programs that attempt to prevent injuries. Agencies operate surveillance systems as well as support intramural and extramural research, provide training for professionals, and foster education of specific target groups and the general public.

Different agencies focus on different facets of the injury problem (for example, consumer product injuries, highway traffic injuries, and criminal offense injuries). These emphases on different, specific facets help to ensure that substantive expertise is developed in particular high-priority areas. Thus our national effort to control injuries, as it has evolved, employs mixed strategies, ensuring a flexible response to change. Each agency focuses on unique sets of entities, professional and lay groups, and other supporters. And each agency has activities that complement and strengthen its specific injury control efforts.

Nevertheless, this diversity of Federal efforts poses barriers to injury control. The fragmented approach fails to convey the enormous magnitude of the problem; important gaps are left when Federal agencies focus on specific parts. Finally, it is a challenge to create linkages among agencies, whether there is a need to address new hazards or to develop new ways to address old ones. Congress has identified the Centers for Disease Control (CDC) as a Federal catalyst to help overcome barriers to injury control.

In this paper I cannot answer all the questions that have arisen about injury control funding; only the particular agencies can provide specific details. Rather I have sought to identify the various interests and resources of the Federal agencies.

Department of Health and Human Services

The Department has a broad array of injury control activities. CDC, the lead prevention agency of the Public Health Service, has the following injury control activities underway:

- The Center for Environmental Health's (CEH) activities include the leadership and coordination of 5 injury prevention research centers and approximately 31 injury control research and demonstration projects. CEH also develops or improves State and local surveillance systems and evaluates the effectiveness of injury control programs nationally. In addition, it develops evaluation plans, analyzes

control programs, and disseminates key findings to other agencies and develops training for program staff and researchers.

- The National Institute for Occupational Safety and Health (NIOSH) is the lead agency for research in preventing occupational injuries. NIOSH develops surveillance and interprets this information to describe the scope of occupational injuries. This agency also conducts investigations of high-priority injury factors and disseminates recommendations for strategies to prevent and minimize injuries in the workplace. In addition, NIOSH supports investigator-initiated extramural research projects and education and training activities in academic institutions through its extramural grant program.

- The Epidemiology Program Office has assisted health agencies in investigating injury outbreaks or clusters and in developing injury surveillance.

- The Center for Health Promotion and Education has developed a national behavioral risk factor surveillance system that tracks key behaviors associated with injuries within States. These include seatbelt use, use of child restraints, and alcohol use before driving. The Center staff has also developed community-based projects focused on priority health problems for particular communities, usually including injury control. In addition, school-based education activities address the causes and prevention of injuries.

- The Training and Laboratory Program Office has developed training for public health professionals that encompasses injury control.

- The National Center for Health Statistics collects and disseminates information on health, including many aspects of injuries.

The National Institutes of Health (NIH), the lead biomedical research agency of the Public Health Service, has many activities in injury control. The mechanisms most often used at NIH are grants for investigator-initiated projects, centers, new investigators, and research training. Four NIH institutes support injury research.

- The National Institute of General Medical Sciences supports research and research training in basic studies of the body's systemic response to trauma and burns. Ninety grantees received approximately \$16 million in 1986 for injury-related research.

- The National Institute of Neurological and Communicative Disorders and Stroke supports research to solve neurological and communicative

disorders. Trauma is an important cause of such disorders. In 1986, this Institute provided more than \$39 million to support 220 grantees in the trauma field. Research emphasizes investigations in head injury, spinal-cord injury, and neural regeneration, but the grants also support traumatic coma data banks and training of researchers.

- The National Institute on Aging investigates problems of aging, including injury. In 1986, the Institute supported 20 injury-related grantees with more than \$2.5 million and set aside \$1.25 million to fund research on fundamental aspects of falls of the elderly.

- The National Institute of Child Health and Human Development supports research to develop basic knowledge, especially of behavioral factors, that predict or prevent disease or retard development among children. Although injury-related research is limited, the Institute hopes to develop a new initiative focused on children's injuries in 1987.

The Health Resources and Services Administration, another agency of the Public Health Service, provides direct health care and technical and financial assistance to others who provide health care. The Administration oversees injury-related activities in two bureaus.

- The Bureau of Health Care Delivery and Assistance emphasizes injury control targeted toward children and adolescents. This work includes professional training, development and dissemination of educational materials, evaluation of child passenger restraint laws, and development of State programs to control injuries among children. In 1986, \$2 million was awarded to four recipients to address the emergency medical services needs of the injured child. Funds available under this focus may increase to \$4 million in 1987. Eight injury control projects of regional or national significance related to children were also supported in 1986. Other groups—the elderly and migrant workers—for whom injury is an important problem have received the Bureau's attention.

- The Indian Health Service has emphasized the causes and consequences of injury throughout its public and professional activities. The Service directly supports four community-based demonstration prevention projects and, through an interagency agreement with CDC, three additional community-based projects.

The Alcohol, Drug Abuse, and Mental Health Administration supports research, information dis-

semination, and programs in alcohol, drug abuse, and mental health. Injury control activities of this Administration are predominantly in two Institutes.

- The National Institute of Mental Health supports basic and clinical research on interpersonal violence and suicide. This Institute spent approximately \$4 million in 1986 for extramural research on the mental health aspects of antisocial behavior, individual violent behavior, rape and sexual assault, and law and mental health interactions. It also supports intramural and extramural basic research on suicide.

- The National Institute on Alcohol Abuse and Alcoholism provides extramural and intramural support focused on excess use of alcohol and its effects. One prevention project uses injury as the outcome of interest. In 1985, the Institute announced its special interest in applications focused on effects of alcohol on performance and traumatic injury.

- The National Institute on Drug Abuse similarly has an intramural and extramural research and support program focused on excess or illicit drug abuse and its effects.

The Office of the Assistant Secretary for Health provides broad-based support for many of the Department's activities as follows.

- The Office of Disease Prevention and Health Promotion coordinates tracking of the 1990 health objectives for the nation, including those focused on injury; has supported a public education program for older Americans, including injury prevention; and is developing recommendations for clinicians concerning the prevention of injuries.

- The Office of Minority Health was established to focus on the excess premature loss of life suffered by minorities. Homicide and unintentional injuries were identified as one of the six most important areas to be addressed.

- The National Center for Health Services Research and Health Care Technology Assessment supports extramural research, including projects related to injury control.

Department of Transportation

This Department conducts the Federal Government's largest and most comprehensive injury prevention program focused on transportation-related injuries. The National Highway Traffic

Safety Administration (NHTSA) works to prevent transportation-related injuries. Nonetheless, many of its studies provide the firmest estimates of costs, numbers of disabilities, and long-term consequences of a wide range of injuries. Research and Development, NHTSA, conducts an active intramural research program supplemented by extramural contract work. The staff maintains surveillance of fatal highway injuries, collecting comprehensive information on each such fatality. They also operate a system of surveillance of nonfatal crashes that produces national estimates of factors involved in these crashes.

The Agency's Traffic Safety Programs include technical assistance and grants to individual States to strengthen the evaluation of the effectiveness of car passenger restraint legislation, support programs to decrease alcohol use by drivers, and strengthen programs to promote the voluntary use of passenger restraints. Increasing attention is being given to correcting roadside hazards on thoroughfares that are not part of the interstate system. The provision of emergency medical services to highway crash victims is also an area of interest and targeted support.

Consumer Product Safety Commission

This Agency is charged with protecting the public from serious product-associated injuries. The Commission operates surveillance systems through emergency room data collection and other mechanisms that identify consumer product injuries and allow trends to be analyzed. It also conducts and supports research focused on priority problems, develops standards for consumer products, and conducts information and education programs to encourage consumers to judge product safety and to use the products they buy more safely.

Department of Justice

This Department's mission is to control crime through direct operations, assistance to State and local agencies, research, and education. The Department oversees two divisions. The Federal Bureau of Investigation collects crime information from 98 percent of all jurisdictions in the country, conducts analyses of this information, and provides this information to the public. The National Institute of Justice, the research arm of the Department, supports research in priority areas, including the reduction of violent crime. In 1986,

the Institute awarded more than \$9 million to extramural grantees. It also disseminates information, trains practitioners, and evaluates new programs for their effectiveness.

Department of Education

The Department's National Institute on Disability and Rehabilitation Research (NIDRR) is a major source of support for rehabilitation research, although the Veterans Administration also does important work in this area. The NIDRR's research program seeks ways to minimize the medical, social, economic, and family consequences of disabling injuries. The Institute supports model spinal-cord injury research centers and rehabilitation research and training centers, including those with a focus on brain injury, spinal-cord injury, and childhood trauma. NIDRR also supports investigator-initiated projects. It recently announced new research and demonstration priorities for traumatic brain injury. In 1986, NIDRR provided more than \$50 million to research activities, and it supported research and training support for developments in engineering, fellowship programs, career development projects, and other types of centers.

Conclusions

Substantial support is available for injury control. We hope that, beginning with the 1987 Conference on Injury in America, we will be able to facilitate new partnerships between those in the field and the Federal agencies with interest in aspects of injury control. This conference also offered an opportunity to begin clarifying the gaps in this support and specifying priorities for further action.

Equitable Payment for Trauma Care Using Patient Management Categories

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THERE IS MUCH ANECDOTAL information but little systematic evidence of the inadequacy of Medicare's Prospective Payment System (PPS). This observation is made frequently about patients

with relatively high costs (such as tertiary trauma patients) that are not well-defined by Diagnostic Related Groups (DRGs), the patient classification basis of Medicare's PPS. The extent to which hospitals are adequately reimbursed for trauma care has been difficult to assess, however, for the following reasons:

- First, DRGs do not classify patients effectively, especially severely injured trauma patients who are more likely than other patients to have multiple problems that are managed in a single hospitalization (co-morbidity).
- Second, most hospitals know only what they charge for the services provided to each patient, not what it costs to care for clinically specific patient types.

For these reasons, hospitals have not been persuasive in demonstrating the systematic inequity of the DRGs and PPS.

The Pittsburgh Research Institute has already addressed the first problem by developing Patient Management Categories (PMCs), a clinically specific patient classification that incorporates distinctions of severity among patient types and identifies co-morbidity and multiple trauma more accurately than do other classifications (1-3). Patient care costs (as opposed to charges) associated with PMCs have also been identified in a sample of acute care hospitals in western Pennsylvania. Research funded by the National Center for Health Services Research (NCHSR) and two Blue Cross Plans in Pennsylvania is underway to apply this methodology to the costs of trauma care, particularly in trauma center hospitals.

In this paper I will outline the inadequacies of DRGs in the analysis and financing of trauma care and show how PMCs provide an analytic tool for defining trauma patient types and for measuring the costs of trauma care.

Defining Categories and Severity Levels

There is ample evidence that DRGs do not categorize patients accurately from a clinical perspective, nor do they incorporate distinctions of severity (1,2) or identify co-morbid conditions adequately (3). For example, use of the DRGs labeled as trauma DRGs identified only 48.6 percent of the patients in one trauma registry as trauma patients, whereas use of trauma PMCs identified 95 percent of that trauma registry's patients as trauma patients.

Table 1. Classification of a multiple trauma patient using Diagnostic Related Groups (DRGs) versus Patient Management Categories (PMCs)

Diagnoses and procedures	ICD-9-CM code	ICD-9-CM narrative description
Principal diagnosis .	80701	Contusion of chest wall
Diagnosis A	92210	Closed fracture of 1 rib
Diagnosis B	82300	Closed fracture of upper end of tibia
Diagnosis C	89100	Open wound of knee, leg (except thigh), and ankle, without mention of complication
Principal procedure .	79.36	Open reduction of fracture of tibia and fibula
Procedure A	78.07	Bone graft of tibia and fibula
Procedure B	77.79	Excision of other bone graft

Classification results:

Using DRGs, the patient is assigned to 1: DRG 468 Procedure unrelated to diagnosis

Using PMCs, the patient is assigned to 2: PMC 3303 Thoracic injury: rib fracture/pulmonary contusion and PMC 3008 Lower extremity injury: closed fracture tibial plateau with ORIF.

NOTE: ICD-9-CM = International Classification of Diseases Ninth Revision Clinical Modification.

In addition, 6.2 percent of trauma patients seen in one trauma center hospital were assigned to DRG 468, defined as "diagnosis unrelated to operative procedure performed." Patients are assigned to this DRG when the principal procedure is unrelated to the principal diagnosis listed. When these patients were assigned PMCs, however, 86.5 percent were identified as having co-morbid conditions. For all of these patients, the procedures performed were in fact related to at least one of the conditions for which the patient was hospitalized. Table 1 is an example of the very different results that are obtained for one such multiple trauma patient.

Unfortunately, the overall inadequacy of DRGs cannot be fixed by further subdivision of categories or through the use of other variables or severity scales. Because the DRG computer algorithm is driven by the principal diagnosis, the inappropriate patient sorting that results represents a structural problem that affects all types of patients rather than just a few problem DRGs (4,5).

Not only are patients within a DRG clinically diverse but, in general, patients with similar injuries are assigned to different DRGs depending on the particular diagnosis code that is listed as principal on the discharge abstract. This is a subtle but important distinction because it implies that

Table 2. Distribution of trauma patients among hospitals in the Pittsburgh, PA, Metropolitan Statistical Area

Hospital	Percent of trauma patients	Percent of high-cost trauma patients
Nonteaching:		
A	12.5	1.2
B	10.0	1.8
C	11.2	2.3
Advanced teaching:		
X	8.4	12.4
Y	7.5	8.6
Z	8.5	5.3

DRGs as now defined cannot be used effectively for analysis of patterns of trauma care.

Comparing DRGs and PMCs

To illustrate this point, the DRG labeled "craniotomy for trauma" does not include all craniotomies associated with trauma. Because of legitimate coding variations, craniotomies due to trauma can be classified in many different DRGs. Conversely, DRGs labeled "craniotomy" also include, for example, spine-injury patients (fractures with cord injury) who have skull tongs inserted for immobilization. This example is not just a single problematic DRG; rather, it represents the structural problem that occurs across all patient types, making DRGs unacceptable for use in data analysis and especially problematic as the basis for hospital payment.

PMCs are the only computerized classification of trauma patients that is both clinically specific and linked to required levels of care. PMCs were developed for use in hospital cost analyses and reimbursement, but they are also useful in many other applications (for example, institutional and facilities planning, comparative analyses of utilization, and quality assessment). In current research funded by NCHSR, PMCs are the basis for analyzing the cost and regionalization of trauma care—is it occurring, is it effective, and what does it cost? These questions are particularly important in an era characterized by the proliferation and documented high costs of trauma centers, trends toward low occupancy, and a general emphasis on reducing hospital losses incurred because of certain types of patients.

Because of the inadequacy of DRGs in classifying trauma patients, Medicare's PPS is having a differential impact on trauma center hospitals. When PMCs are used, that differential impact can be quantified and assessed. For example, in an

analysis of Fiscal Year 1984 data from all hospitals in the four-county Pittsburgh metropolitan area, approximately 7.1 percent of all 441,293 patients were assigned to at least one trauma PMC, while 15.4 percent of the region's trauma patients were assigned to high-cost PMCs. Almost a third of these complex cases, representing 4.8 percent of all trauma cases, were treated at hospitals with specialized trauma capability.

Table 2 shows the percentage of all trauma patients at each of six Pittsburgh hospitals—three acute care community hospitals without teaching affiliation and three advanced teaching facilities. The percentage of all complex high-cost trauma patients at each hospital is also shown. Although the community-based nonteaching institutions treat relatively more trauma patients than do the advanced teaching facilities, management of the complex patients requiring more intense and more costly care is concentrated in the advanced teaching hospitals.

Because accidental injury is the leading cause of death in persons under age 38, it is critical that the health care system be mobilized to provide injured patients the care that they need. It is difficult, however, to establish this level of care or evaluate its effectiveness without having information that is clinically specific enough to be useful in making policy decisions.

The lack of a computerized and clinically based patient classification that identifies trauma patients appropriately has impeded efforts to describe varying levels of trauma managed at different hospitals. It has also prevented efforts to evaluate the effectiveness of trauma centers in terms of patient outcomes and costs. The use of PMCs to analyze the costs and effectiveness of inpatient trauma care has the potential of closing this research gap and making a significant contribution to regional and national policy development.

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The Insurance Industry

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THIS PAPER MUST FIRST ESTABLISH three disclaimers. One, the insurance industry has no readily available data of use to those in the injury control field. Because the industry was established to settle claims, the data it has are highly oriented toward claims settlement, rather than epidemiology, causal relationships, and so forth.

Second, the insurance industry does not give out many research grants. However, it does support about \$1 million a year in research efforts outside the industry.

Third, the insurance industry is not expert in biomechanics, although it does attempt to use new

technologies in that area. The industry is, however, a principal funding mechanism for a large proportion of the injury costs in this country. For example, it is the largest writer of workers' compensation insurance. Injuries claimed under workers' compensation represent approximately \$60 billion a year. Most of these claims are for traumatic injuries; very few (that is, less than 3 percent) are for occupational disease. Of the claims paid, at least \$4 billion a year is associated with low back pain, which is not necessarily classified as a traumatic injury.

The workers' compensation industry's single greatest area of loss is back pain; injuries from slips and falls are the second most prevalent problem; and automobile injuries are perhaps the third most prevalent problem. Researchers seeking insurance money should probably focus on these areas.

Advocacy Groups and Key Organizations in Injury Control

Consumer Federation of America

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INDIVIDUALS AND INSTITUTIONS play different roles in the prevention and treatment of injuries. The role of consumer advocates is directed to the prevention of injuries and deaths involving consumer products. Thus, they focus mostly on motor vehicles and household products and on those agencies (the National Highway Traffic Safety Administration and the Consumer Product Safety Commission, respectively) that were established by Congress to improve safety in these areas.

Since the establishment in the early 1970s of these two agencies, motor vehicle death rates per 100,000 population are about 30 percent lower and household death and injury rates have fallen by about 40 percent. But there remains much improvement that can and should be made. Of particular concern is that these deaths and injury rates have leveled off in this decade. Perhaps this plateau occurred because a point of diminishing

returns has been reached, and further reductions are just too costly, or perhaps U.S. society is just not trying hard enough.

Also of concern is that the number of those killed and injured in product-related accidents is still appallingly high. Together, household and motor vehicle deaths exceed 60,000 a year. Although this number is far fewer than those who die from disease, it should be remembered that a much higher proportion of those dying in accidents are in the prime of their lives.

Finally, it should be emphasized that accidents impose economic costs on society. We have rough estimates of the economic loss from motor vehicle and household accidents, which include such factors as wage loss; legal, medical, and funeral expenses; insurance; administrative costs; and property damage. For motor vehicles, this expense exceeds an estimated \$60 billion annually; for household accidents, \$14 billion in 1985. These costs average \$700 for each U.S. household.

For years, there has been vigorous debate about whether people or products cause these injuries. This argument is not without value to the extent that it motivates us to analyze exactly why and how injuries occur, but it can obscure the fact that changing the design of a product can often

improve safety much more quickly and much more efficiently than can changing human behavior.

This possibility is why consumer advocates, while strongly supporting consumer education and appropriate behavioral restraints, have stressed the improvement of products. Top priority for redesign must go to the three products that kill and injure far more citizens than all other products combined: cigarettes, alcohol, and motor vehicles.

In this decade, the United States has made strides in reducing risks from the first two products. Although there has been an increase in safety belt use brought on by State seatbelt laws, there is still much room for improvement in motor vehicle safety, stricter enforcement of speed limits and other traffic laws, and more severe punishment of drunk drivers. It may not be realistic to expect U.S. car manufacturers to introduce safer materials and technologies at a time when their industry is hemorrhaging, but far greater efforts should be made to bring down the cost of air bags so that manufacturers can no longer use consumer price resistance as an excuse to keep air bags out of most models.

Of lower priority are several products associated with large numbers of injuries. These include all-terrain vehicles, which have killed hundreds of persons; bicycles, which cause an estimated 500,000 injuries annually; swimming pools, in which about 300 children drown annually; and playground equipment, which is associated with an estimated 200,000 injuries.

Although we live in a world of growing economic constraints, we need to weigh carefully the wisdom of severe reductions of safety agency budgets—reductions that will impose long-term dollar costs on consumers, taxpayers, and even on those manufacturers hit with product liability suits.

Mothers Against Drunk Driving

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THE TOPIC OF THIS PAPER is not to tell the experts how to prevent death and injury. Instead I seek to point out the lack of total care when an injury occurs.

Everyone knows the story of Cari, my daughter who was killed by a drunk driver. I would like to

share with you another story, one that has a happier ending. My son, Travis, at age 4, was run over by a car operated by an unlicensed driver. His injuries, which included a depressed skull fracture, were extensive and critical. Travis was comatose for 5 days. At first, our attention centered solely on whether he would live. When we realized Travis would survive, we became concerned about the extent of his brain damage.

Travis was surrounded by specialists of every kind, except one: a specialist of the mind. Sometimes the emotional injury can be far worse than the bodily injury for the family to handle. Although the physicians and the hospital were wonderful when it came to Travis's physical well-being, they were not concerned with the family's mental well-being. They were anxious to start him in physical therapy, but they never mentioned mental therapy for the rest of the family. Although we were given indepth instructions on how to minister to his injuries once we brought him home, no one gave us instructions on how to manage the emotional distress we were all suffering. A psychiatrist friend, without the support or encouragement of Travis' physician, introduced us to a clinic with a staff trained in working with children with disabilities. Travis not only had to relearn the use of his body, he had to relearn the use of his brain.

I share this story with you to point out the inadequacies in our medical services. There are many hospitals that provide counseling to families who suffer trauma, but there are many that do not. I know because I talk to hundreds of victims each year.

Concerning financial resources, our insurance covered all my son's care. But there are many people who do not have such comprehensive care. How do these people survive? Are children destined to grow up far more handicapped than necessary because needed resources are not available? Are families to suffer needlessly because no one tells them where to go? We now have groups such as the National Head Injury Foundation, but not everyone suffers a head injury.

It is wonderful that more than 500 laws are now on the books that we hope will deter drunk drivers. It is marvelous that seatbelts and air bags are the "in" thing. And I hope we see trauma and burn units in every city. But equally important to prevention is attention to the total needs of those who suffer.

National Head Injury Foundation

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IN 1975, OUR DAUGHTER Deborah was severely injured in an automobile accident. In 1980, 5 years after her head injury, we recognized that there was a lack of understanding of disabilities caused by traumatic head injury among physicians and rehabilitation clinicians. Appropriate rehabilitation services for persons with head injuries did not exist. We concluded that there was a need for a consumer movement to speak to the issues and needs of this population. Out of desire and intense frustration, Dr. Spivak and I called a small group of families and professionals together, and within 6 months the National Head Injury Foundation (NHIF) was created. The NHIF took on significant goals: advocacy, public awareness, an information clearinghouse, education, support, program development, prevention, and research. As members NHIF attracts families, survivors, health care professionals, providers, attorneys, insurers, and all those interested in improving the quality of life after such injuries.

Since 1980, the NHIF has made a significant impact on Federal agencies, particularly the Office of Special Education and Rehabilitation Services, U.S. Department of Education. The Office has developed a Cooperative Agreement, which has spawned specific programs and projects at State and local levels. Thirty NHIF State associations have worked with their legislatures, and injury registries and needs assessment surveys have been established.

As the national clearinghouse for head injury resources, the NHIF has provided information, referrals, and support to hundreds of thousands of families and professionals and has developed a system of conferences for professional and lay audiences. NHIF sponsors at least two national conferences a year, and its State associations sponsor statewide educational conferences. More than 90 conferences have been held this past year.

Today the Foundation is very concerned that medical treatment and management of early rehabilitation are no longer physician dictated but are regulated by Diagnosis Related Groups. This

change has caused premature discharge of patients with traumatic brain damage. Often such discharges lead to a prescription for failure. We would encourage health policy makers to turn the rhetoric of catastrophic care into the reality of delivering rehabilitation and long-term care to young people who are disabled and chronically ill.

What would the NHIF wish to see by 1990?

- We need to have in place a well-coordinated national data base system for traumatic brain injury that will address all the areas just discussed as well as neurorecovery, medical and rehabilitation management, extended rehabilitation services, and needs assessment.
- We need better training programs for physicians, nurses, allied health professionals, special educators, and people in vocational rehabilitation. A system of coordinated care—from acute medical management to rehabilitation leading to the return of optimal function of survivors—is required.
- We need a mechanism to coordinate the activities of all Federal agencies in that system of care. We need interagency collaboration to foster research in neuroscience, biotechnology, rehabilitation technology, pharmacology, behavioral sciences, and educational and vocational methodologies for this population.
- We must use more effectively public and private funding mechanisms, which currently present major obstacles to successful rehabilitation and habilitation.
- We must implement the prevention strategies that have been developed and create public education programs that bring the consequences of trauma to public attention.

National Highway Traffic Safety Administration

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THE NATIONAL HIGHWAY TRAFFIC Safety Administration's (NHTSA) special interest in injury prevention stems from the fact that one-third of the injuries that occur in the United States are due to highway crashes. Yet, NHTSA knows it is possible to reduce injury in America. When the

Highway Safety Act and the National Traffic and Motor Vehicle Safety Act were signed into law in September of 1966, nearly a thousand Americans were dying in traffic crashes every single week. Highway crashes exceeded other forms of violence by 10 to 1. In just 20 years, however, our nation's traffic fatality rate has been cut in half.

Since 1966, NHTSA's Federal Motor Vehicle Safety Standards have resulted in at least 90,000 lives saved and hundreds of thousands of injuries prevented (1). And 1987 marks the implementation of Federal Motor Vehicle Safety Standard 208, or the passive restraint standard, whereby at least 1 million new cars will be equipped with automatic crash protection, (that is, automatic safety belts or air bags).

Highway safety over the past few years has become an American issue. We have received strong support nationwide from Americans in all walks of life, and laws and the changes in attitude are producing very positive results. Ten years ago, no one would have believed that by 1987 all 50 States would have child safety seat laws and that 24 States (now 29) would have safety belt usage laws. Ten years ago, less than 15 percent of infants and toddlers were properly restrained in protective devices. In just 10 years, that usage rate has been raised to 76 percent.

In New York, the first State to pass a safety belt use law, fatalities and serious injuries dropped to their lowest level since 1948 for the first full year that the law was in effect.

Another example of progress is seen in U.S. society's attitude toward the drunk driver. Just a decade ago, the drunk driver was perceived as a nuisance, whereas today that driver is viewed in proper perspective as a potential killer.

For American youth, drunk driving represents the leading cause of death; however, our most recent studies show that the proportion of teenage drunk drivers dropped from 28 percent in 1982 to 20 percent in 1985, the largest drop in any driver age group. The National Minimum Drinking Age Law that was passed and signed by the President in 1984 is being enforced in 42 States now, and there is no question that it is working.

Highway safety has improved so much in this country because broad-based coalitions have worked in partnership to solve the problem. The public and the private sector can make additional progress by using existing highway safety networks to involve citizens and communities in programs that will help reduce injuries and change injury-causing behavior.

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Centers for Disease Control

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PEOPLE ARE MORE WILLING TO ACCEPT risks that they take voluntarily. In some areas of injury control, however, people are unwilling to accept the risk but are also unwilling to accept the changes needed to reduce the risk. For example, although being murdered is not something people volunteer for, there is not much support for gun control activities in the United States, where 60-80 percent of the agents of murder are handguns. Nevertheless, we hope that within the next 10 to 20 years, the owning of handguns will become as socially unacceptable as is driving an automobile while intoxicated. Until that happens, however, one must think about how else the consequences of that activity can be prevented. The tools are available to produce meaningful injury control programs, conduct high-quality research, and move toward real progress in controlling injuries.

The Citizens for Safe America have demonstrated that injuries are relevant on a personal, as well as a professional and statistical, level. They have told researchers in this field that their work in injury control matters. This coalition should be enlisted in efforts to formulate prevention strategies.

The Centers for Disease Control (CDC) is committed to doing precisely that. Further, the 1987 Conference on Injury in America represents the benefit of CDC's collaboration with the National Highway Traffic Safety Administration, whose expertise in motor vehicle safety has proved invaluable in arranging a large portion of this conference. The American Public Health Association (APHA) and the Association of State and Territorial Health Officials have also provided support, making possible a conference of much greater scope. Their unique ability to encompass the interests of public health officials and practi-

tioners and to present a unified voice represents what Federal agencies frequently cannot practice, however much they may want to.

Another very important role that APHA has been playing in the injury area concerns working with members of Congress and others to secure funding for the CDC program. For the past 2 years, the Department of Transportation budget has contained \$10 million which has been given to CDC for this program. APHA is hopeful and somewhat confident that the third-year commitment of that funding will again be available to CDC in fiscal year 1988. In addition, Senator Kennedy last year introduced legislation to authorize another focus of injury control at CDC with a special emphasis on State and local programming and on childhood injuries. APHA also hopes to secure money through the Department of Health and Human Services budget to fund that authorization as well in fiscal year 1988.

The interdisciplinary efforts of workers in biomechanics, rehabilitation, acute care, prevention, and epidemiology offer greater potential for reducing the severity of injury, its long-term disability, and the associated human suffering than if researchers focused only on primary prevention. CDC will promote this approach to injury control as the focal point for injury research within the Federal Government.

The staff of CDC hope that those in this field will follow the development of the five injury prevention research centers, which are intended to be regional and national resources. They also urge researchers to participate in the academic opportunities the centers will sponsor. In addition, some outstanding work has begun with the Injury Research and Demonstration Grant Program.

Even at this level of activity, the CDC staff know that its current programmatic efforts for injury control by no means match the burden of morbidity, mortality, and public costs. The tremendous interest in this field now far surpasses CDC's ability to fund it. CDC will continue to view all research and demonstration as integral parts of the injury control effort and try to coordinate all funding sources to achieve a unified program.

To be successful, it is clear that injury control must become part of the traditional and the innovative public health programs at the local, State, and Federal level. Injury prevention can no longer have a low priority in the public health hierarchy. The public health community must sell this concept of injury control to our leaders and

citizens; must promulgate reasonable laws and regulations; must develop techniques for changing people's behavior to reduce the risk of injuries; and finally must avoid the turf battles that have been so common in the past.

National Association of Governors' Highway Safety Representatives

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THE NATIONAL ASSOCIATION of Governors' Highway Safety Representatives (NAGHSR) is the voice of the States in developing policy for State and community highway safety programs throughout the country. Its members are responsible for conducting statewide and community-based highway safety programs for their governors. These programs seek to reduce motor vehicle fatalities and injuries. The NAGHSR representatives have the toughest job of all: they try to change attitudes and, ultimately, driving behavior.

Each State and Territory has a Highway Safety Representative appointed by its governor. Representatives are located within a State department of transportation, a department of public safety, or even a State policy agency. Sometimes they are connected to the governor's office. Whatever their niche in the State bureaucracy, it is their job to manage the Federal and State highway safety grant dollars and to coordinate highway safety activities in the State. Representatives are in a unique position to make linkage among State agencies with overlapping interests in highway safety and public health issues.

The primary Federal grant program that they administer is the 402 State and Community Highway Safety Grant Program; it is currently funded at approximately \$120 million a year. States receive their portion of the Highway Trust Fund money according to formulas based on road mileage and population, and each State submits a Highway Safety Plan to the Federal Government each year that spells out how it will spend the money. Major emphases of the program since 1983 have been prevention of drunk driving, protection of occupants, police traffic services, traffic records, emergency medical services, and roadway

The National Association of Governors' Highway Safety Representatives increasingly uses the word "crash" instead of accident because it connotes the violence of the event and implies that injuries are not accidents.

engineering programs. Although many other prevention programs and research projects are funded, States have concentrated their efforts in two major areas: anti-drunk and anti-drugged driving and occupant protection.

A major goal of the association is to create forums, collaborative relationships, and methods of communication among diverse groups around key issues, keeping in mind that each State has unique crash-related problems. (NAGHSR increasingly uses the word "crash" instead of accident because it connotes the violence of the event and implies that injuries are not accidents.) It is probably impossible for those at the national level to create or force relationships among State agencies, but NAGHSR intends to promote such linkages.

NAGHSR has two key projects underway. One, the sensitivity index, will help each State to collect data and measure the effectiveness of emergency medical services (EMS) programs in highway safety. NAGHSR and the National Association of EMS Directors are working with the National Highway Traffic Safety Administration to develop this tool.

NAGHSR is also working with the National Association of State Alcohol and Drug Abuse Directors on a similar project to examine and enumerate nationwide highway safety prevention activities. Federal grant 402 program money is also often spent to promote child passenger safety. Many of the programs to implement child restraint laws are being funded through health agencies.

Two major issues were mentioned throughout the 1987 Conference on Injury in America: money and data. Although money and resources for research are absolutely vital to success (and survival), consider the successes of the 402 program projects. First, many of these are funded with a very few dollars, based on the seed money philosophy that strives to use those few dollars as catalysts to leverage more community-wide participation. The 402 program does not have the kind of money that many say is needed, but it has a lot

of experience in getting more "bang for the buck."

For example, an initiative to promote child restraint usage began a loaner program (a program to make child restraint seats available to those who cannot afford them) using 402 dollars as seed money. That program is now self-sufficient. Local corporations and businesses now donate many or all of the restraint seats. Community groups voluntarily staff the program, and the local hospital provides the space for its operations.

Second, on the issue of the need for data, sometimes generalists feel very comfortable saying that they can always wait for the data to catch up with the needs of the times. No doubt better-informed decisions could be made with those data, but sometimes the timing just needs to be right. For instance, if safety belt advocates wait for perfect information from the 24 States with mandatory safety belt laws that explain their usage rates, political forces could take over to reverse the trend toward the passage and public acceptance of those laws. Further, where are the data to show that if States are allowed to change the maximum speed limit to 65 miles per hour on rural interstates, drivers on those roads will magically keep their speeds to 65? Indeed, one can surmise that they will be driving closer to 75 miles an hour on the average, which would make a travesty of the argument that people will obey the law if the limit is higher. The field of highway safety is changing so rapidly that research evaluation and backup are having a hard time keeping up.

Department of Defense (abstract)

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Since the early 1950s, the Armed Forces laboratories have been the focus for most experimental work on biodynamics and crash injury prediction. Researchers in those laboratories have maintained a steady effort to clarify injury mechanisms and test new protection technologies. They have developed unique human-impact test facilities unparalleled by other institutions, and they have provided evaluations of new crash protection devices

through live-human-subject tests to the Department of Transportation, the Federal Aviation Administration, and the National Aeronautics and Space Administration whenever such evaluations were in the national interest. Through broadly based, continuous work, they developed mathematical modeling capabilities to predict probabilities of injury and the effectiveness of new protective designs. They also developed new test dummies with improved biofidelity and took the initial step to establish a biodynamics data bank. It is unfortunate that the National Research Council report,

"Injury in America. A Continuing Public Health Problem" does not acknowledge this national resource. The paper reviews the unique capabilities of the Department of Defense and highlights its recent contributions to the biodynamics field. These contributions concern the strength characteristics of bone and soft tissue; live-human-tolerance testing; the development, validation, and practical use of biodynamic models; advanced manikin development; and the Armstrong Aerospace Medical Research Laboratory's Biodynamics Data Bank.

Future Directions: Where Do We Go From Here?

Roadway Modifications

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THE 1987 CONFERENCE ON INJURY in America gathered representatives of Federal agencies that deal with major types of injuries: occupational, motor vehicle, other unintentional, and intentional injuries. However, one group was missing. That group comprises those who build, maintain, and repair our streets and highways, including the Federal Highway Administration, State and local governments, and private industries.

About 10 years ago, Congress began appropriating money to modify the points where motor vehicles crossed the paths of trains. There were, and still are, many railroad crossings marked only by a little sign saying "Railroad" or "Stop." Therefore, in many areas, bells, whistles, and gates were put in to warn motor vehicle drivers if trains were detected on the tracks.

During the past 10 years, \$1.2 billion has been spent in this program. However, that money has been an investment rather than a cost because, as a result of the program, about 2,500 fewer people have died and nonfatal injuries have been greatly reduced. In addition, this program has saved about \$5 billion in lost wages and other costs to U.S. society. Thus, safety modifications that seem costly can have enormous benefits and actually result in cost savings.

Many road modifications are extraordinarily

effective. For example, intersection collisions involving motorists turning left can be reduced about 60 to 70 percent by channeling traffic and using curbing or some kind of raised bars. Head-on collisions can be reduced by 65 percent by putting no-passing stripes at high head-on collision sites on two-lane roads. Injuries resulting from running off roads can be reduced 50 percent by properly installed guard rails at high-risk sites. Installation of four-way stops reduces intersection crashes by 70 percent.

However, new highway construction, including adding lanes to extant roads, produces only about an overall 20-percent reduction in motor vehicle injuries. Congress recently passed a highway bill appropriating tens of billions of dollars, but more than 95 percent of these funds will go to new construction rather than to these relatively simple modifications.

A few persons with the Indian Health Service are doing something extraordinarily important about roadway modification. They are examining the records of fatalities and those hospitalized with injuries and finding out who was injured on which roads. They then look at the crash sites and construct pin maps indicating where people were injured and the type of crash. Finally, they meet with the appropriate highway department to explore what modifications are needed at those high-incidence sites.

Those in public health may not think of highway modifications as pertinent to their work, but perhaps as much or more can be done to reduce injuries by these kinds of activities as by some other strategies that are more frequently pursued.

Occupational Injuries

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WHERE DO WE GO FROM HERE? The time has come for those working in injury control to come down from the "mountain top" and put their enthusiasm into action. For me, as Director of the National Institute for Occupational Safety and Health (NIOSH), that means finding ways to do a better job of preventing occupational injuries. A stark reminder of the challenge ahead are these statistics: of the approximately 120 million people at work in the United States, about 10 million will be wounded on the job this year and 10,000 will lose their lives.

Occupational injuries account for one-third of all the costs of traumatic injuries in the United States. Somehow, however, occupational trauma has not attracted a lot of attention. For example, in "Injury in America" (1) only three paragraphs in 100 pages are devoted to occupational injuries.

In answering "Where do we go from here?", NIOSH can say precisely where we should be going to prevent occupational trauma. First, however, I offer a brief background on NIOSH. It is a division of the Centers for Disease Control (CDC). Although the Institute was formally established in 1971 by the Occupational Safety and Health Act, its roots in the Public Health Service go back to 1798. The Public Health Service was started then as the Marine Hospital Service, an occupational health program established to treat the injuries and illnesses of merchant seamen. Since 1911, other organizations within the Public Health Service have been dedicated to preventing occupation-specific disease and injury. In 1971, the principal occupational health components of the Public Health Service were renamed NIOSH. In 1973, because of the Agency's emphasis on prevention, NIOSH was made a part of CDC, bringing with it well-honed skills and experience in dealing with occupational trauma.

The mission of NIOSH encompasses research, information, education, and training. In short, NIOSH is a scientific, risk-assessing organization. Within NIOSH, the Division of Safety Research is devoted to control of occupational injuries, and within this Division, NIOSH has a specific program devoted to the epidemiology of fatal occupa-

tional injuries: Fatal Accident Circumstances and Epidemiology (FACE). Since 1982, FACE investigators have gone to various U.S. worksites to do epidemiologic investigations of fatal accidents. Fifty-three FACE investigations were performed last year alone. In almost every instance, investigators have found that Occupational Safety and Health Administration or other safety standards had been ignored. The principal lessons learned from FACE investigations are simple: (a) an inexplicable indifference to risks exists and (b) a failure to follow effective prevention methods is evident.

Because NIOSH views its principal product as information (that is, the results of its investigations and research), its staff believes their duty is to lead by informing those who need to know. To this end, NIOSH has produced a list of the 10 leading work-related diseases and injuries; prominent among them is severe occupational trauma which includes amputations, fractures, severe lacerations, eye losses, acute poisonings, and burns. But a list alone is not enough; to exercise its leadership more meaningfully, NIOSH has also developed for each entry a "proposed national prevention strategy."

To generate feedback on its draft strategies, NIOSH held two National Symposia on the Prevention of Work-Related Diseases and Injuries, one in 1985 and another in 1986. The result was a set of leadership documents that clearly presents what must be done to prevent each work-related problem. In collaboration with the Association of Schools of Public Health, NIOSH published in October 1986 the first five strategies, including the proposed national strategy for preventing severe occupational traumatic injuries (2). Like each of the other strategic documents, it first issues a clear call for improved surveillance.

In regard to control methods, the proposed national strategy provides specific information in the usual categories: engineering controls, personal protective equipment, work practices, and workplace monitoring. The strategy also details proposed actions that can be taken now under four categories: task-oriented, environment-oriented, machine-oriented, and human-oriented strategies. Further, litigious action, whereby manufacturers are forced to comply with safety standards through the threat of lawsuit, has been an effective prevention strategy and should therefore be used more frequently.

Thus, NIOSH believes that where we ought to go from here is to implement this proposed national strategy. Although NIOSH can point the

way, it cannot intervene directly in the workplace. Rather, NIOSH generates information, performs studies, produces concepts, and encourages its allies in this field to ensure that prevention is actually implemented. Therefore, NIOSH needs regulators, labor, management, academia, State and local health departments, lawyers, and the citizenry itself if together we are to succeed in reducing work-related injuries.

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Motor Vehicle Injuries

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WHERE DO WE GO FROM HERE? In 20 years, there is enormous promise that major technical improvements will have come about. The world of electronics in the automobile holds promise that is just beginning to be imagined: collision avoidance radar systems, electronic systems that can sense driver performance and feed it back to the car so that the vehicle can operate differently, and injury mitigation systems that are more effective because of an ability to predict a crash earlier because of electronic surveillance.

Assessments of crash severity, using either onboard electronics or photographic techniques, should provide a plethora of information that can be built into virtually all police accident reports. Instead of paying millions of dollars for thousands of accident reports with less information than researchers want, we will be able to pay much less for a much greater number of sophisticated evaluations of crashes on U.S. highways.

At State and local levels, seatbelt laws and much stronger drunk driving laws should be in effect. States and communities will be willing to set measurable goals in injury control; without targets, progress is usually slower than it should be.

However, where we want to go is a lot less germane than how we are going to get there. The field of injury prevention and control is extremely complex, and those who work in it have little in common. Their training has been in a variety of disciplines, they work for different clients, use a different language, and have different expectations. Therefore organization is the key to progress.

A number of monumental steps have already enabled those in this field to organize themselves and their work better. Dr. William Haddon deserves much credit for the characterization that he brought to the field of motor vehicle and traffic safety. His work provided an intellectual framework that has been used by everyone in this field to organize their efforts for the last 20 years. Congressman William Lehman has provided us, for the first time, with the resources to begin organizing a coordinated, comprehensive Federal effort to address the injury problem with the passage of the appropriations for fiscal years 1986 and 1987.

Much remains to be done. We must organize into groups of goal-oriented practitioners and researchers so that the available information is better organized and more accessible than it has been. For example, the National Highway Traffic Safety Administration, during its 20-year existence, has spent more than half a billion dollars on research, but the information generated is not well organized and not readily available to the entire safety community. I am sure that we are not unique. Other groups that have dealt with a specialized area of injury have done a good job of assembling data but not made the information widely available. Good channels of communication among the various disciplines working in this field are lacking.

Other Unintentional Injuries

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THE STATISTICS ARE WELL known: more than 92,000 deaths from injury and an estimated 60 million injuries in 1986 alone. Roughly half the deaths are classified as motor-vehicle-related, and

Data from the U.S. Consumer Product Safety Commission's NEISS reveal that sports and recreation are responsible for more treatments in hospital emergency rooms than any other category.

about one in eight are occupational. The preponderance of the balance, roughly 40,000 deaths and an overwhelming 45 million injuries, result from other causes.

Although these numbers are not by themselves of great value in developing remedial measures, their principal value is that they provide a crude measure of the scope and magnitude of the problem. Nevertheless, it is virtually impossible to use data such as these to design effective programs targeted at reducing the toll in any of these categories.

Data from the U.S. Consumer Product Safety Commission's National Electronic Injury Surveillance System (NEISS) reveal that sports and recreation are responsible for more treatments in hospital emergency rooms than any other category. The other categories in descending order are home structures and construction materials; home furnishings and fixtures; housewares; personal use items; home workshop apparatus, tools, and attachments; packaging and containers for household products; and yard and garden equipment. Details about the circumstances of injuries within these categories are essential to determine what classes of products are worthy of attention—attention that is myopic by virtue of limited resources. Researchers must know in greater detail and as accurately as possible how many accidents of each type studied occurred and why. This information comes only by selectively following up cases unearthed by surveillance efforts.

One preliminary tentative finding of the midcourse review of the 1990 health objectives (1) offered that "It may be appropriate, in some cases, to continue to pursue improvements in health status . . . without sufficient data to track progress adequately." Although on the surface such a proposal seems almost self-evident, this position seems to set a dangerous precedent. So many solutions to injury problems seem almost self-evident, and solutions could be expedited

considerably if researchers could avoid the time and expense of trying to comprehend the epidemiologic picture of injury problems they are charged with solving. Unfortunately, however, this shortcut would constitute a devastating step backward. The earliest attempts at solving injury problems were constantly hampered by their local focus and an inadequate understanding of how and why accidents occurred.

It has taken those in this field years to get to the present plateau, imperfect as it is. Physicians and other health care providers are more aware now of researchers' needs for their assistance and are more willing to work with them than ever before. Thus, deemphasizing the need for improved data or refined systems would send the wrong signal to these practitioners about the continued need for their close collaboration in halting needless injuries. It would also discourage those who are working so hard to develop better data and data systems.

Continuous data collection is critically needed to help unravel competing priorities. Data and systems are needed that will provide enough information for researchers to identify real problems for study and to avoid those which merely appeal to vested interests or emotions. Researchers must have data that include as much information as possible on the classic epidemiologic elements: host, agent, and environment; they must be able to assess the relative contribution of each of these to the problem under study.

Large systems designed to accomplish such a goal are hard to come by. NEISS is a nationally representative sample of hospital emergency rooms that supply data on a daily basis through its own computer network. NEISS is flexibly designed to permit maximal opportunity to support the needs of others. Several Federal agencies have turned to NEISS for support of their efforts. Notable among these are the Center for Disease Control's National Institute for Occupational Safety and Health and the Division of Injury Epidemiology and Control, as well as the Food and Drug Administration and the Department of Transportation.

Clearly, too many such groups independently converging on a limited number of sources with requests to provide data could cause a backlash of "uncooperativeness." This is why we need a coordinated approach to continuous collection of data. Not only would it provide for more efficient use of the sources of data organizations, but it would foster more cross-fertilization of ideas and technology.

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Intentional Injuries and Violence

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ARE "INTENTIONAL INJURIES" the same as "violence?" Violence is the use of force with the intent to cause harm to oneself (self-directed violence) or another person (interpersonal violence). It is important to note that violence can occur without causing an injury. For example, a young man who survives Russian roulette may have no physical injury, but was he not the target of self-directed violence? One need not have an injury to be scarred by such an experience.

How, then, does one relate violence, which can occur without physical injury, to "intentional injuries?" Researchers do not exactly know. The term "intentional injuries" is clear enough for us to use, but it will be defined much more precisely over the next few years. However defined, researchers are still limited in their understanding of intentional injuries.

For reasons that are unclear, intentional injuries do not get their proportionate share of attention. Consider, for example, that at Yale-New Haven (CT) Hospital the most common source of injury among women seeking care in the emergency room was spouse abuse (1). Spouse abuse was more prevalent than muggings, rapes, and automobile injuries combined. Thus, a paradox: intentional injuries are a large part of the injury problem but receive a disproportionately small part of injury researchers' attention. This anomaly parallels what the National Academy of Sciences states in "Injury in America": injury is the number one public health problem in the United States, but it gets a disproportionately small part of the public health resources and attention (2).

Each area discussed in "Injury in America"—epidemiology, prevention, biomechanics, acute care, and rehabilitation—raised important questions about intentional injury that need to be addressed.

Epidemiology

In the epidemiology of injuries, the most fundamental need is for a common vocabulary that can serve a diverse set of professionals working together on a multidisciplinary endeavor. If police are to work with sociologists and prosecutors with physicians, they must all speak a common language. Those in this field will have to work hard to achieve clarity. For example, there is no clear agreement on what the term "suicide" means. Because people use vague and ill-defined criteria to classify suicides, experts estimate that our national statistics may be missing as many as 50 percent of actual suicides.

Also needed are definitions of terms as basic as "violence." Death certificate classifications reflect the disagreement on whether the category of "accident" is to be included with "homicide" and "suicide" as a violent death. For nonfatal categories, there is even more disagreement.

Another common "language" that has been proposed is the language of dollars. Many speakers have noted that if any progress is to be made in the United States in this field, researchers need to be bilingual: fluent in dollars as well as in English. Workers in this field need to be able to put price tags on injuries and their resultant losses.

In the epidemiology of intentional injury, we also need to focus on large-scale social factors such as racism, sexism, segregation, and poverty. Numerous studies have linked these factors to violence. One must remember that the burden of intentional injury is inequitably borne in U.S. society. Statistics show that 1 out of 28 black male babies will be murdered in the course of their lifetime; of white male babies, only 1 of 164 will be murdered; for white female infants, only 1 of 450 (3).

Because certain communities of racial and ethnic minorities are so disproportionately involved in intentional injury events, those communities and their representatives must participate in planning and implementing programs to prevent intentional injury. Minority researchers, program planners, and practitioners working in the area of intentional injuries are extremely scarce. More support for them is also needed, as are ideas for recruiting qualified people to work in this area.

Other epidemiologic factors that may be particularly germane to intentional injuries are biological: what are the biochemical-neurophysiological bases of violence and aggression? Research suggests that the absence or presence of

certain neurotransmitters such as serotonin makes a very big difference in human behavior.

Prevention

A planned approach to preventing intentional injuries is needed. In one project to prevent youth suicides, researchers were to poll experts about the effectiveness of several interventions. The interventions were education, early identification and treatment, school-based screening, crisis centers and hotlines, improved treatment of depression, and restricting access to the means of suicide. The researchers proposed to estimate the cost of each intervention and produce a list of the most cost-effective interventions. The results of the poll showed that the experts did not agree on the effectiveness of any intervention because the data necessary to estimate effectiveness did not exist. These data are clearly needed.

Biomechanics

The National Highway Traffic Safety Administration has spent about \$100 million studying motor vehicle impact biomechanics (Michael Finkelstein, Associate Administrator, Research and Development, NHTSA, personal communication). How much money, if any, has been or will be spent studying the biomechanics of bullet injuries? There is an epidemic of homicide in Detroit. Perhaps researchers at Wayne State University, an institution where much has been done to examine impact biomechanics, could look at firearm injuries during the epidemic in their own backyard.

Acute Care and Rehabilitation

Health care workers in emergency rooms need to pay attention to the psychological as well as the physical state of patients with bullet or stab wounds and other intentional injuries. How can their psychological as well as physical needs be addressed both immediately and during the process of rehabilitation that goes on well after the event?

Rehabilitation for victims of intentional injury may also require special attention to psychological injury that is not apparent from an examination of the physical injury. The psychological impact of intentional injury may be analogous to the "hidden" aspects of head injury; health care providers may not "see" anything, but the person may be brain injured or brain damaged in subtle ways that can make his or her life a nightmare.

In addition, rehabilitation following intentional injury must include the rehabilitation of the perpetrator. What kinds of detention, deterrence, or education will work, for whom, and under what circumstances?

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