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Injuries, injury prevention and public health

D. Sleet
Karen Liller, *University of South Florida*
D. White
K. Hopkins

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David A. Sleet, PhD, FAAHB; Karen D. Liller, PhD; Dionne D. White, MPS
Krista Hopkins, MPH

***Objectives*: To introduce the readers to the field of injury prevention and comprehensive public health intervention approaches. *Methods*: A review of injury epidemiology, statistics, definitions, intervention approaches, and the importance of health promotion is provided. *Results*: Behavioral, environmental, and technological solutions will be necessary to reduce or eliminate the factors that lead to injury. *Conclusions*: Reductions in injury and their costs will need the support, collaboration, and partnering of several disciplines. The use of sound behavioral and social science theories and methods will be an essential component of intervention effectiveness.**

***Key words*: injury, accidents, public health, health promotion, behavioral science**

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The health of Americans has changed significantly during the past 50 years. Widespread immunization programs have nearly eliminated the threat of infectious diseases such as polio, diphtheria, and measles. A major public health problem that continues to threaten the health of all Americans, however, has no vaccine. Injuries—including unintentional injuries, homicide, and suicide—are *the* leading cause of death for all persons aged 1 to 44 and will likely be a major public health problem for years to come.[1]

Injuries are the fourth leading cause of death for people of all ages and the leading cause of years of potential life lost before age 65. The consequences of injuries can be extensive and wide-ranging. The effects are physical, emotional, and financial; and in the case of disabling injuries, the consequences are enduring. In 2000, nearly 150,000 people died from injuries in the United States, and in 2001 approximately one in 10 people experienced a nonfatal injury serious enough to require a visit to the emergency department. Today, more than 5 million people in the United States. suffer from chronic disability caused by injury.[1]

In 2000, more than 40,000 motor vehicle traffic fatalities accounted for 43% of unintentional injury deaths, with poisoning at 13%; falls, 14%; suffocation, 6%; drowning, 4%; and fire, 4%. Adverse events, including errors in medical set-

David A. Sleet, Associate Director for Science; Krista Hopkins, Health Communications Specialist, Division of Unintentional Injury Prevention, National Center for Injury Prevention and Control, Centers for Disease Control and Prevention, Atlanta, GA. Karen D. Liller, Associate Professor, Department of Community and Family Health, College of Public Health, University of South Florida, Tampa, FL. Dionne D. White, Information Technology Specialist, Office of Statistics and Programming, National Center for Injury Prevention and Control, Centers for Disease Control and Prevention, Atlanta, GA.

Address correspondence to Dr Sleet, Division of Unintentional Injury Prevention, National Center for Injury Prevention and Control Centers for Disease Control and Prevention, 4770 Buford Hwy, NE, MSK63, Atlanta, GA 30341. E-mail: dsleet@cdc.gov

tings, resulted in an additional 2,804 fatalities.[1]

The impact of violence-related injuries also is great. Homicide is the second leading cause of death for people aged 15 to 24 years and the third or fourth leading cause for every other age group between 1 and 34 years. Suicide is the 11th leading cause of death across all ages; it ranks second for people aged 25 to 34 years and third or fourth for every other group between 10 to 44 years.[1] Intimate partner and sexual violence, violence against women, assault, and youth violence are among the other important violence problems.

Many injuries do not result in death but nevertheless place a considerable burden on individuals and society. Approximately one third of all emergency department visits and 8% of all hospital stays are due to injuries. An estimated 300,000 people in the United States are hospitalized annually from traumatic brain injury, and of these, 70,000-90,000 are permanently impaired. It is estimated that 11,000 people are hospitalized with spinal cord injuries each year, and about 200,000 people live the rest of their lives with these injury-related disabilities.[2]

The costs of injuries are staggering. The National Safety Council estimated that unintentional injuries in the United States during 2001 cost $516.9 billion. This figure included the costs of fatal and nonfatal unintentional injuries, employer costs, vehicle damage costs, and fire losses. If lost quality of life were included, those injuries would be valued at an additional $1,172.3 billion.[3] Moreover, costs associated with treatment of injury account for 12% of Unted States medical spending.[4]

In response to the public health burden of injuries, the National Center for Injury Prevention and Control (Injury Center) was established at the Centers for Disease Control and Prevention (CDC) to prevent premature death and disability and to reduce the human suffering and medical costs caused by injuries. To do this, the Injury Center uses the public health approach—a systematic process to

- define the injury problem,
- identify risk and protective factors,
- develop and test prevention interventions and strategies, and
- ensure widespread adoption of effective interventions and strategies.

The CDC Injury Center is the only organization in the federal government with the responsibility to address all phases of the injury problem, from foundational research through the dissemination of effective interventions for all major causes of injury among all persons.

A New Century of Injury Prevention

According to the National Academy of Sciences, injury is the most under-recognized public health problem facing the nation today.[5] Yet, the science of injury control demonstrates that the public health approaches used to address other diseases can be effectively applied to injury. Injury results from interactions between persons (host factors), energy (agent and vector/vehicle factors) and the environment (physical and social environmental factors).[6] This epidemiologic approach to understanding injury forms the foundation upon which health promotion strategies are applied.[7-9]

Control of injuries requires preventing the occurrence or reducing the severity of the injury event. In the case of a soccer-related injury, for example, damage to the host (the person harmed) is brought about through a rapid transfer of kinetic energy. Changing this pattern of energy transfer can be modified in many ways, for instance by making the host more resistant to it (by increasing injury tolerance), by reducing the amount of energy transferred to the host (by interposing protective gear), or by creating a safer playing-field environment.

The practice of successful injury prevention requires the application of health promotion strategies such as modifying individual and population behavioral risks, reducing exposure to hazardous environments, and removing or modifying harmful products. Individual and community actions are required for these strategies to succeed; and they are fostered by education, stimulated by social and organizational change, and encouraged through public policy, legislation and enforcement activities. These actions, by their diversity alone, require the involvement of many professionals including coaches, criminologists, law enforcement, nurses, hospital administrators, playground designers, product engineers, psychologists, social workers, athletic trainers, surgeons, teachers, transportation engineers, and many others.

Injury or Accident?

An injury is distinct from an accident. Accidents are not usually considered predictable or preventable. In fact, The *Oxford English Dictionary* defines the term *accident* as "an unusual event, which proceeds from some unknown cause...unexpected...happening by chance or fortune."[10] Typically, accidents have been viewed as random and uncontrollable acts of fate, unpredictable and unavoidable. Even outside public health, for instance in geology, an accident is defined as an irregular feature in a landscape for which there is no known explanation.[10]

On the other hand, the word *injury* has its root in the Latin term *injuris,* which literally means "not right." The *Oxford English Dictionary* defines injury as "harm of any kind, done or sustained." Injury in public health is defined as unintentional or intentional damage to the body resulting from acute exposure to thermal, mechanical, electrical or chemical energy or from the absence of such essentials as heat or oxygen.[11]

Because the term *accident* indicates an unexpected, and therefore unavoidable event, it is not appropriate to use in reference to injury. We know from the science of injury prevention that injuries and the events that cause them are not random: they are predictable and most of them can be prevented through changes to products, behaviors, and environments. Using terms such as *injury prevention* rather than *accident prevention* helps make clear the potential for preventing such events. Former United States Surgeon General C. Everett Koop[12] underscored this distinction when he said:

> *We must accept that the injuries associated with motor vehicles are not "accidents" and that much can be done to reduce them. We must realize that violence in the forms of abuse, assault or suicide is within the purview of the health system. An informed and aroused public can change the behavior of each of us, but more importantly it must lead to community outrage and action in regard to unsafe playgrounds, automobiles, highways, work places, toys, homes and use of handguns.* (p. v)

Causes and Types of Injury

The specific proximal cause of injury is the transfer of energy to a person at rates and in amounts above the tolerance of human tissue. The amount of the energy concentration outside the tolerance of tissue determines the severity of the injury. The 2 generally recognized categories of injuries are *unintentional injuries* (caused by unintentional means as in a fall, drowning, poisoning, or motor vehicle crash) and *violence*, (intentionally inflicted as homicide, assault, murder, or suicide).

The terms *injury* and *trauma* are often used interchangeably. Although there are many kinds and causes of injury, 2 main categories prevail.

1) *Acute exposure to energy* refers to injuries resulting from falls, motor vehicle crashes, assault, and sports injury (kinetic energy); fires and burns (thermal energy), poisonings (chemical energy); electrocution (electrical energy); and from radiation.

2) *Absence of essentials* includes lack of oxygen (as in asphyxiation, strangulation or drowning) and lack of heat (as in hypothermia or frostbite).

Trends and Variations

Incident rates for injuries, like those for diseases, demonstrate long-term trends, and geographic, socioeconomic and seasonal variations. Injury rates also vary according to characteristics among individuals (eg, age, gender, income) and environments (eg, neighborhood, workplace, home, etc). Injury epidemiology helps us understand and explain these variations and enables us to target specific interventions.

Table 1 compares the 10 leading causes of death in 2000 by age group. In the United States, injuries are among the top 10 causes of death in each age group throughout the lifespan. Unintentional injuries are the leading cause of death for people ages 1-34 years. Within the 15- to 24-year-old age group, the top 3 leading causes of death, (unintentional injuries, homicide and suicide) accounted for 23,046 deaths. The total number of deaths from the remaining 7 leading causes of death for this age group total only 3,942. Unintentional injuries dominate the picture across all age groups, and violence (from homicide and suicide) occupies the second position as the major cause of death for those between the ages of 15 and 34.[1]

Table 1
10 Leading Causes of Death, United States 2000
All Races, Both Sexes

Rank	Age Groups										
	<1	1-4	5-9	10-14	15-24	25-34	35-44	45-54	55-64	65+	All Ages
1	CA	UI	UI	UI	UI	UI	MN	MN	MN	HD	HD
	5,743	1,826	1,391	1,588	14,113	11,769	16,520	48,034	89,005	593,707	710,760
2	SG	CA	MN	MN	HO	SU	UI	HD	HD	MN	MN
	4,397	495	489	525	4,939	4,792	15,413	35,480	63,399	392,366	553,091
3	SI	MN	CA	SU	SU	HO	HD	UI	CL	CV	CV
	2,523	420	198	300	3,994	4,164	13,181	12,278	10,739	148,045	167,661
4	MP	HO	HO	HO	MN	MN	SU	LD	CV	CL	CL
	1,404	356	140	231	1,713	3,916	6,562	6,654	9,956	106,375	122,009
5	PC	HD	HD	CA	HD	HD	HI	CV	DM	IP	UI
	1,062	181	106	201	1,031	2,958	5,919	6,011	9,186	58,557	97,900
6	RD	IP	BN	HD	CA	HI	LD	SU	UI	DM	DM
	999	103	62	165	441	2,437	3,371	5,437	7,505	52,414	69,301
7	UI	SE	CL	CL	CV	DM	HO	DM	LD	AD	IP
	881	99	48	91	199	623	3,219	4,954	5,774	48,993	65,313
8	BS	PP	IP	CV	CL	CV	CV	HI	NE	NE	AD
	768	79	47	51	190	602	2,599	4,142	3,100	31,225	49,558
9	CS	BN	SE	IP	IP	CA	DM	CL	SU	Ul	NE
	663	53	38	40	189	477	1,926	3,251	2,945	31,051	37,251
10	IH	CL	TT	BN	HI	LD	IP	VH	SE	SE	SE
	630	51	25	37	179	415	1,068	1,894	2,899	24,786	31,224

Note.
Source: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control. Available at www.cdc.gov/ncipc/wisqars, accessed January 1, 2003.

AD=Alzheimer's Disease
BN=Benign Neoplasms
BS=Bacterial Sepsis
CA=Congenital Anomalies
CL=Chronic Low Respiratory Disease
CS=Circulatory System Disease
CV=Cerebrovascular
DM=Diabetes Mellitus
HI=HIV
HO=Homicide
HD=Heart Disease
IH=Intrauterine Hypoxia
IP=Influenza and Pneumonia
LD=Liver Disease
MN=Malignant Neoplasms
MP=Maternal Pregnancy Complications
NE=Nephritis
PC=Placenta Cord Membranes
PP=Perinatal Period
RD=Respiratory Distress
SE=Septicemia
SG=Short Gestation
SI=SIDS
SU=Suicide
TT=Two Tied
UI=Unintentional Injury
VH=Viral Hepatitis

Table 2
Number of Deaths Caused by Injury and Rates per 100,000 United States Population - All Ages and Races, by Sex, 2000

Cause	Males		Females		Total		
	No.	Rate	No.	Rate	No.	Crude Rate	Age-Adjusted Rate*
Motor Vehicle	28,352	21.1	13,642	9.7	41,994	15.3	15.2
Suicide	23,618	17.5	5,732	4.1	29,350	10.7	10.6
Homicide/Legal Intervention	13,168	9.8	3,956	2.8	17,124	6.2	6.2
Fall	7,122	5.3	6,200	4.4	13,322	4.8	4.8
Poisoning	9,138	6.8	3,619	2.6	12,757	4.6	4.6
Drowning/ Submersion	2,735	2.0	747	0.5	3,482	1.3	1.3
Fire/flames	2,025	1.5	1,352	1.0	3,377	1.2	1.2
Other Injury Deaths	17,096	12.7	9,707	6.9	26,803	9.7	9.7
Total	103,254	76.7	44,955	32.0	148,209	53.8	53.7

Note.
*** Age-adjusted rate excludes those whose ages are unknown. Standard population is 2000 United States all races and both genders.**
NCHS ICD-10 Preliminary Data are used for number of deaths; Demo-Detail preliminary postcensal estimates are used for population numbers.
Centers for Disease Control and Prevention. Web-based Injury Statistics Query and Reporting System (WISQARS) (2001). National Center for Injury Prevention and Control, Centers for Disease Control and Prevention. Available: www.cdc.gov/ncipc/wisqars. Accessed November 19, 2002.

Table 2 shows the number of injury deaths by cause and rates per 100,000 population (including age-adjusted and crude rates) for males and females in the United States during 2000, the most recent year for which data are available. Motor vehicle crashes (including injuries to occupants, motorcyclists, pedestrians and bicyclists) were the leading cause of injury death for all ages, followed by suicide, homicide, falls, poisoning, drowning, and fires. When suicide and homicide are combined for both genders, violence exceeds motor vehicle crashes as the leading cause of injury death.[1]

Deaths are only a part of the devastating effect of injury on society. Table 3 displays nonfatal injury data from the National Electronic Injury Surveillance System. Falls are the leading cause of injury-related emergency department visits for people of all ages, accounting for an estimated 7.8 million visits in 2001, or more than 25% of all injury visits. Another 4.5 million visits (15%) are transportation related and nearly 1.8 million (6%) result from assaults.[1]

Many injuries have consequences well beyond the initial need for medical attention. For instance, in a national survey, 25% of female participants reported being raped or physically assaulted by an intimate partner at some time in their lives.[13] Although motor vehicles, firearms, falls, poisoning, fires and burns, and drowning typically account for 80% of deaths from injury, they represent only 36% of treated injuries not requiring hospitalization.[2]

Health Promotion and Injury Prevention

Injury prevention has received less than its share of coverage in the health promotion literature, perhaps because it does not fall within the traditional domains of preventive medicine and public health.[14] This may have been due partly to the way the first Healthy People docu-

Table 3
Number of Nonfatal Injuries and Rates per 100,000 United States Population - All Ages and Races, by Sex, 2001

Cause	Males		Females		Total		
	No.	Rate	No.	Rate	No.	Crude Rate	Age-Adjusted Rate*
Fall	3,686,549	2714.8	4,148,790	2921.5	7,836,956	2821.1	2823.9
Struck by/ Against	2,937,798	2163.4	1,671,513	1177.1	4,610,361	1659.6	1665.4
Overexertion	1,902,192	1400.8	1,584,791	1116.0	3,487,316	1255.3	1255.0
MV-Occupant	1,406,989	1036.1	1,634,104	1150.7	3,041,622	1094.9	1092.7
Cut/Pierce	1,593,813	1173.7	877,999	618.3	2,472,325	890.0	890.4
Assault/Legal Intervention	1,121,904	826.2	717,836	505.5	1,840,003	662.3	662.5
Self-Harm	144,023	106.1	179,323	126.3	323,370	116.4	116.2
Other Nonfatal Injuries	3,760,681	2769.4	2,355,208	1658.5	6,117,522	2202.1	2206.4
Total	16,553,949	12190.4	13,169,564	9273.8	29,729,475	10701.7	10712.6

Note.

*** Age-adjusted rate excludes those whose ages are unknown. Standard population is 2000 United States all races and both genders.**

The number of nonfatal injuries presented in WISQARS Nonfatal are national estimates based on weighted data from the U.S. Consumer Product Safety Commission's (CPSC) National Electronic Injury Surveillance System (NEISS).

*** The total No. column represents males, females, and unknown sex.**

NEISS-AIP Data are used for number of nonfatal injuries; Demo-Detail preliminary population projections are used for population numbers.

Centers for Disease Control and Prevention. Web-based Injury Statistics Query and Reporting System (WISQARS)(2001). National Center for Injury Prevention and Control, Centers for Disease Control and Prevention (producer). Available: www.cdc.gov/ncipc/wisqars. Accesed November 19, 2002.

ment categorized injuries as "accidents" and placed them in the "health protection" category, along with other environmentally oriented problems considered to be beyond individual control.[15,16] As injury prevention and health promotion have become more closely aligned in recent years, however, the potential benefits of comprehensive injury prevention strategies, including behavioral change, have become clearer and more widely accepted.[8] Health promotion strategies, including those involving injury prevention, use a combination of approaches including educational and behavioral, engineering and technology change, and legislation, policy, and enforcement.[7,14]

The National Academy of Sciences Institute of Medicine Report, *Reducing the Burden of Injury*[4] reemphasized the importance of using a scientific approach to injury prevention and called for CDC and others to work with foundations, states and communities, businesses, and other federal agencies to pursue alliances that would help reduce injuries. These types of alliances will increase the opportunity to reduce injuries by applying multiple strategies in a variety of settings.

CONCLUSIONS

Although injuries have plagued societies since the beginning of time, they have only recently been recognized as an important public health problem. Injuries are seldom distributed randomly. They are concentrated in physical space and time, and they affect definable popula-

tions at risk. Using a public health approach that includes both epidemiological and behavioral and social science theories and methods stands the best chance of succeeding.[17] Targeting the host, agent, and environmental factors that contribute to injury will help reduce overall injury rates. Behavioral, environmental and technological solutions will be needed to reduce or eliminate hazardous energy exchange. Because there are so many different injuries and with varied causes, tailored approaches to interventions are needed. Although environmental modification has the potential for protecting whole populations, the use of individual, social, and behavioral strategies also have an important role in injury prevention. It is difficult to imagine any injury that does not have a behavioral component. Caregivers and other health promotion professionals can be instrumental in implementing a variety of population-based and individual injury-prevention interventions.

Further reductions in injuries and their associated medical care costs will rely on collaborations among many disciplines. Building partnerships with public and private organizations, and increasing the capacity to work across many sectors worldwide, will help foster the prevention activities necessary to reduce injury-related morbidity and mortality in the future. In recognition of the global problem of injury, the World Health Organization has designated "Road Safety" as the theme of World Health Day, April 17, 2004, and will issue a World Report on Road Traffic Injury Prevention. More information on global activities to commemorate these events can be found at http://www.who.int/world-health-day/2004en/. ■

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