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Injury and Violence: A Public Health Perspective

by Ian R.H. Rockett

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Injury and Violence: A Public Health Perspective

By Ian R.H. Rockett

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An injured mineworker is faced with supporting his young son and family. The health and financial burdens of injury extend far beyond the death toll.

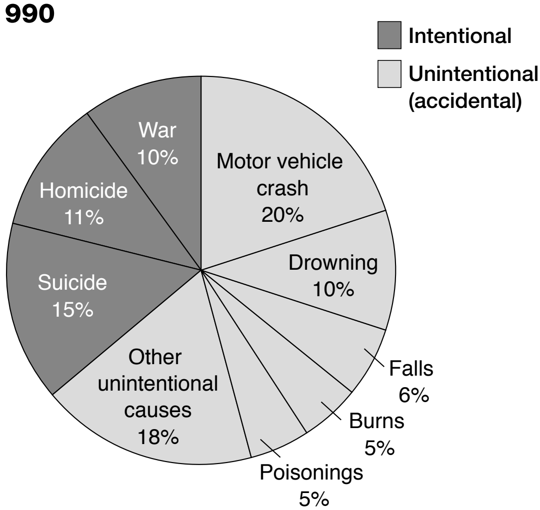
Injuries are a leading cause of death for people worldwide. Automobile crashes, homicides, suicides, and other sources of physical injury kill about 5 million people each year. They harm and disable millions of others and in so doing exact enormous psychological, social, and economic costs. Because injuries often strike down otherwise healthy children and young adults, they are a leading cause of premature death.

There is a growing awareness that injuries are predictable and preventable. Injuries can be predicted because they occur more often in some population groups than others. The injury death toll is highest among very young children, teenagers, young adults, and the elderly. It is higher among males than females, among the poor than the wealthy, and among people in some occupations, such as commercial fishing and construction. People who abuse alcohol and other drugs or have certain health problems are more likely to become injured than those without these problems.

Injuries are preventable. Injury control experts stress that "injuries are not accidents" and they have identified ways to avoid them. Injury prevention in the past several decades has shifted from trying to change individuals' behavior to ensuring that the products people use and the environment in which they live and work are safe. Safety features introduced on the highways, in babies' cribs, on children's playgrounds, and at the workplace have extended thousands of lives.

Injury experts have demonstrated that even intentionally inflicted

Figure 1
Injury Deaths Worldwide by Leading Causes and Intent, 1990



Source: Christopher J.L. Murray and Alan D. Lopez, eds., *The Global Burden of Disease* vol. 1 (1996): Annex table 6i.

injuries like suicide and homicide are preventable through proven control measures. While the challenge is greater, many of the injuries and deaths from such human causes as war and terrorism and from such natural disasters as hurricanes, tornadoes, and earthquakes are also preventable.

This thinking runs counter to the common notions that unintentional injuries are random events over which individuals have no control or, alternatively, that people are at fault for their own injuries. The past two decades have witnessed an expansion in knowledge about preventing injuries. This revolutionary change in attitudes toward injury control and prevention is credited to one American scholar, William Haddon, Jr. Haddon perceived injury as a solvable problem and introduced practical ways to attack it. Talented and committed colleagues and successors have carried on Haddon's work.

Because of Haddon and others, health experts in the United States and other countries have come to view injuries and violence as a public health problem similar to communicable diseases like AIDS and tuberculosis. The World Health Organization (WHO) has sponsored four international conferences on injury and violence since 1989. In the United States, the Centers for Disease Control and Prevention (CDC) has assumed the leadership in identifying, labeling, and confronting injury as a major public health problem. Initially, these scientific activities targeted unintentional injury, better known as "accidental injury." But in 1985, then-U.S. Surgeon General C. Everett Koop asserted that intentional injury must not be confined to the domain of criminal justice. By the 1990s, most health scientists and public health leaders agreed that violence could be reduced with some of the same methods used to prevent unintentional injury.[1] In 1996, WHO recommended that member countries treat violence as a public health matter.

This *Population Bulletin* examines the overlapping phenomena of injury and violence from a public health perspective. Epidemiology—the study of patterns of disease and injury—forms the core of this perspective, but many other disciplines also contribute. Engineering, biomechanics, ergonomics, demography, the biomedical sciences, and the social and behavioral sciences are all involved in the study of injuries and injury prevention. The *Bulletin* focuses on the United States, where scientists have forged many of the major breakthroughs in the epidemiologic study of injury and violence. But these principles may be applied universally.

Magnitude of the Problem

Worldwide, injuries account for about one in eight male deaths and one in 14 female deaths. An estimated two-thirds of these fatalities are unintentional—from motor vehicle crashes, drowning, falls, and many other ways individuals sustain physical harm (see Figure 1). The remaining one-third of fatal injuries are caused intentionally, primarily through self-inflicted wounds, assault, or military or civil violence.

Automobiles and other motor vehicles kill just over 40,000 Americans annually in the 1990s but injure more than 3 million others. The death toll tends to be much higher in less developed countries where emergency medical care is not widely available and safety features are not standard.

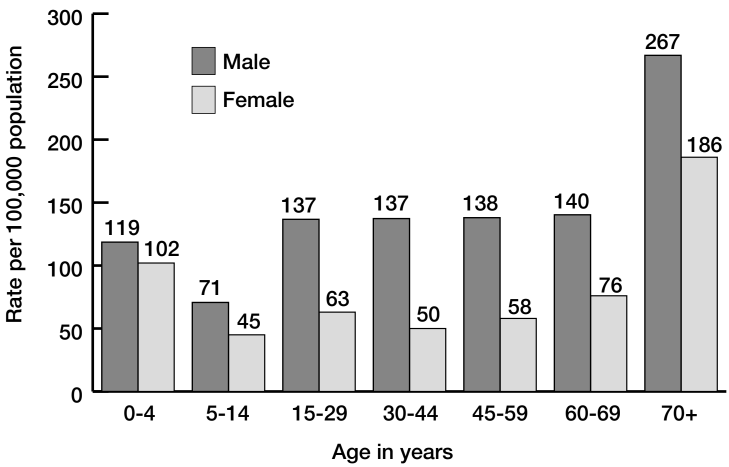
The toll of injuries on the lives and health of people around the world far exceeds the number who die. Statistics on health are sorely inadequate in many countries. Many serious injuries go unreported even in countries with good health reporting systems. No one knows the full extent of injuries, but based on surveys and existing data, health experts estimate that for every injury death, thousands of people are physically disabled or emotionally scarred because of injuries. In a given year, the number of suicide deaths, for example, is probably only one-tenth or one-twentieth the number of people who deliberately harm themselves during the year.[2]

The authors of the seminal Global Burden of Disease Study introduced a measure to calculate injuries' total "burden" on human life and well-being—disability adjusted life years (DALYs).[3] DALYs measure the number of years of life lost because of premature death plus the number of years individuals live with a severe disability from injuries. The study's authors estimate that injuries account for about 15 percent of the world's DALYs. This study, sponsored by the World Bank, WHO, and the Harvard School of Public Health, also provides the most comprehensive global and regional assessments of injury and disease patterns.

Age Patterns of Injury Mortality

The health burden of injuries waxes and wanes over the life cycle. Children under age 5 are particularly vulnerable to unintentional injuries, especially from suffocation, falls, poisoning, and motor vehicle crashes. Life is less hazardous for children ages 5 to 14, but injury death rates increase again for older teens and adults and peak among the elderly (see Figure 2). Young men in particular tend to engage in risky behaviors that can lead to serious injury and death. Violence (especially homicide and war) claims its largest share of deaths among this group.

Figure 2
Injury Death Rates by Age and Sex: World, 1990

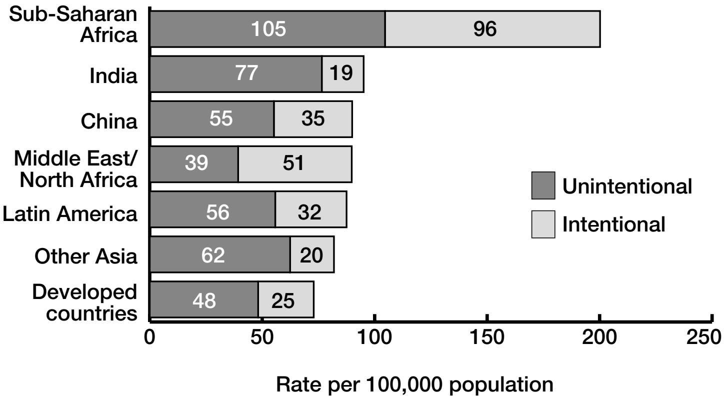


Source: Adapted from Christopher J.L. Murray and Alan D. Lopez, eds., *The Global Burden of Disease* vol. 1 (1996): Annex table 6i.

Worldwide, injury death rates are high throughout middle age, as motor vehicle crashes, alcohol abuse, and violence claim lives prematurely. The age pattern is somewhat different in more developed countries (except the former socialist countries), where injury rates tend to fall after the high-risk young adult ages before rising again among the elderly.

The elderly suffer the highest injury death rates, primarily from falls. Many elderly people have health conditions that make them prone to falls, and they are the age group most likely to fracture a bone when they do fall. In addition to the high probability of injury deaths, the elderly also face a high likelihood of disability from hip fractures and other injuries. Elderly men in the United States and a number of other countries also have high suicide rates.

Figure 3
Death Rates from Unintentional and Intentional Injury by Region or Country, 1990



Source: Adapted from Christopher J.L. Murray and Alan D. Lopez, eds., *The Global Burden of Disease* vol. 1 (1996): Annex tables 6a-6h.

Regional Patterns

Injuries cause the greatest mortality in the countries at the lowest levels of economic development and in areas rife with war and civil violence. Sub-Saharan Africa manifests the highest injury death rate among major world regions and countries (see Figure 3). Its rate is more than twice that of India's, primarily because of sub-Saharan Africa's extraordinarily high rate of intentional injuries from war and other violence. More developed countries (including all of Europe, Australia, Canada, Japan, New Zealand, and the United States) register the lowest injury death rate.

The regional differences between unintentional injuries ("accidents") and intentional injuries (war, homicide, and suicide) are intriguing. Worldwide, intentional injuries account for about 36 percent of all injury deaths, but they make up 56 percent of injury deaths in the Middle East and 48 percent of the injury deaths in sub-Saharan Africa. Suicide, homicide, and war account for one-third of injury deaths in China, Latin America and the Caribbean, and the more developed countries, and fewer than one-fourth of the injury deaths in India and the Other Asia group (consisting of Asia except Japan, India, and China).

The mix of the causes of injury differs among these regions. Suicide is the primary cause of injury mortality in China and accounts for one-third of all injury deaths in that country. The toll is highest among Chinese women living in rural areas.[4] Suicide is also higher in other parts of Asia and in more developed countries than in the rest of the world.

Homicide is the leading cause of intentional injury deaths in Latin America and the Caribbean and is the second-leading cause in sub-Saharan Africa. Homicide accounts for an estimated 26 percent of injury mortality in Latin America and 20 percent in sub-Saharan Africa.[5]

Injury death rates and the major causes of injury vary even within the same region. The homicide rate is extremely low in England and Wales, Germany, and Sweden, for example, but high in Russia (see Table 1). Among Latin American countries, the homicide rate is much higher in Colombia and Mexico than in Costa Rica. The gender differences in injury death rates are also remarkable in some countries. Men nearly always have higher injury death rates than women, but the gap is enormous in some countries, especially for homicide rates.

Researchers have been unable to unravel the cultural, economic, political, and other factors that might account for regional variations in violent death rates. Social scientists and health researchers have not explained, for example, why suicide is a major cause of injury mortality in China but is rare in Latin America or Africa. The lack of comparable international data makes it difficult to conduct scientific inquiries that might explain some of these regional patterns.

Some of the difference in the burden of injury among world regions stems from their age structures. Countries in less developed regions such as sub-Saharan Africa have much younger population age structures than do more developed countries.

Table 1

Death Rates for Major Causes of Injuries for Selected Countries, 1995

Country	Motor vehicle crash Deaths per 100,000 Total	Males	Females	Suicide Deaths per 100,000 Total	Males	Females	Homicide Deaths per 100,000 Total	Males	Females
Australia*	10.5	14.7	6.4	12.6	20.9	4.6	1.8	2.2	1.3
Colombia*	21.5	35.2	8.8	3.9	6.5	1.5	75.9	143.5	11.2
Costa Rica*	21.7	35.8	8.2	6.0	10.1	1.9	6.0	10.5	1.4
England and Wales	5.6	8.2	2.9	6.6	10.6	2.7	0.7	0.9	0.5
Germany	10.7	16.0	5.5	13.9	21.8	7.1	1.1	1.4	0.8
Israel	11.3	17.0	6.0	7.4	11.2	4.0	1.4	2.3	0.6
Mexico	18.8	30.8	7.8	3.9	7.1	1.0	19.8	36.9	3.8
Portugal	23.2	37.9	9.8	7.5	11.9	3.9	1.7	2.4	1.1
Russia	21.8	34.6	10.2	41.2	74.4	12.7	29.9	47.9	13.4
Sweden	5.3	7.4	3.3	14.2	20.3	8.4	1.0	1.3	0.7
United States*	15.6	21.7	9.9	11.8	19.9	4.4	9.2	14.5	3.8

Note: Death rates were adjusted for differences in age structure based on the European population.
*1994 data.

Source: World Health Organization, *World Health Statistics Annual, 1996* (1998): table B-4.

Because the young are a high-risk group for fatal injuries, the young age structures in less developed countries keep their injury mortality rate relatively high. More than 40 percent of the populations of most African countries are under age 15 and less than 4 percent are age 65 or older. In Europe, less than 20 percent of the population is under age 15, while 14 percent are age 65 or older.

Other known risk factors, including the level of economic development, extent of poverty, abuse of alcohol and other drugs, and access to firearms, may also explain some of the regional differences in injury death rates. Less developed countries have fewer resources to spend on occupational health and safety or automobile safety features. Deaths and disability caused by workplace injuries are estimated to be four times higher in Latin America and the Caribbean than in more developed countries.[6] And many less developed countries have higher road traffic fatality rates than more developed countries, even though they have fewer motor vehicles per capita.[7]

War Mortality

The proportion of war-related deaths can be linked to events and circumstances in a region. The Middle East, North Africa, and sub-Saharan Africa have endured decades of war, terrorism, and social unrest. Their populations have unusually high injury death rates (including civilian deaths from land mines or military action), even after accounting for their young age structures. War casualties account for one-third of injury deaths in the Middle East and North Africa and one-fourth of injury deaths in sub-Saharan Africa. In contrast, one-tenth of injury deaths worldwide were attributed to war in the Global Burden of Disease and Injury study.

War casualties account for a small fraction of deaths in Europe and the United States in the 1990s. Europeans suffered millions of deaths during World War I and World War II, but military actions since then have claimed few European lives compared with the number fatally injured in automobile crashes or other events.

About 350,000 Americans died from combat injuries in World Wars I and II,[8] but a greater number died of injuries during three years of peace, 1993 to 1995. Before World War I, more soldiers died of disease than from combat wounds.

Motor Vehicle Crashes

Motor vehicle crashes are the most important single cause of injury death in every region except China. Motor vehicle-related deaths are high in the

Table 2
Leading Causes of Injury Death by Manner of Death: United States, 1995

	Injury deaths		Manner of death				
Cause of death	Number	Percent	Total	Unintentional	Suicide	Homicide	Undetermined[b]
All injury deaths[a]	147,891	100	100.0	61.1	21.2	15.2	2.5
Motor vehicle	42,452	29	100.0	99.7	0.3	—	—
Firearm	35,957	24	100.0	3.4	51.5	43.2	1.1
Poisoning	16,307	11	100.0	55.6	31.6	0.3	12.5
Fall	11,275	8	100.0	93.0	6.3	0.2	0.5
Suffocation	10,376	7	100.0	40.9	50.3	8.1	0.7
Drowning	5,071	3	100.0	85.8	8.1	1.3	4.8
Fire/burn	4,345	3	100.0	88.8	4.0	5.4	1.8
Cut/pierce	3,367	2	100.0	3.5	13.5	82.6	0.4

—less than 0.1 percent
[a]Includes injury deaths from other causes.
[b]Includes deaths from legal intervention.

Source: National Center for Health Statistics, *Health United States, 1996-97 and Injury Chartbook* (1997): 57-58.

United States, which has one of the world's highest ratios of automobiles to people, but motor vehicle death rates are even higher in Russia, Mexico, and Portugal (see Table 1, page 7). The other major causes of "accidental" death are fire, drowning, suffocation, falls, and poisoning.

Natural Disasters

Natural disasters produce the most publicized and often most sensational examples of death and disability from injuries. The death toll can be alarmingly high, as when a tsunami in Papua New Guinea drowned an estimated 2,000 people in July 1998, and a volcanic eruption in Colombia in 1985 killed an estimated 22,000 people. But mortality from such events accounts for a small fraction of the injury deaths from less dramatic causes. In India, for example, a 1995 earthquake claimed a staggering 10,000 lives, but an estimated 175,000 or more died from motor vehicle crashes that same year.[9]

Natural disasters pose less risk of serious injury and death in more developed countries than in less developed countries. Americans, Canadians, Europeans, and other residents of more developed countries usually live and work in safer buildings and have better emergency relief systems than do people in less developed countries.

Deaths from natural disasters are relatively rare in the United States, although they are usually widely publicized when they occur. The 33 major hurricanes that struck the East Coast of the United States between 1900 and 1992 accounted for about 12,000 fatalities, fewer than 130 per year.[10] An average of 91 Americans died annually from tornado-related injuries between 1950 and 1994. The most devastating earthquake on record in the United States took 700 lives in San Francisco in 1906. In 1989, the second most deadly earthquake, also in the San Francisco area, killed approximately 275 people. In contrast, more than 40,000 Americans die in traffic crashes each year.

Trends in Injury Deaths

Epidemiologists have little comparable data about trends in injury deaths for most of the world, but trend data are available for the more developed countries and for some less developed countries. At the beginning of the 20th century, average life expectancy at birth was 45 years to 50 years in much of Europe and the United States. Smallpox, measles, tuberculosis, and other infectious and parasitic diseases caused about 30 percent of all deaths. As many as 5 percent of women died as a result of pregnancy and childbirth. As nutrition and public health improved, these diseases became less prevalent and less lethal. In the more developed countries, communicable diseases claim less than 5 percent of deaths in the 1990s, and fewer than 0.1 percent of women die because of pregnancy or childbirth. Life expectancy is above 75 years in most of Europe, the United States, and a few other countries. Noncommunicable diseases such as heart disease, cancer, and stroke claim an increasing percentage of lives.

Throughout this epidemiologic transition in the levels and causes of death, the share of deaths from injury was fairly stable, at between 6 percent and 8 percent of all deaths.[11] But the causes of injury deaths changed dramatically over the century. For men, industrial injuries were the leading cause of injury deaths at the turn of the century. Improvements in occupational safety and the modernization of the labor force caused occupational injury deaths to plummet.

Workplaces became safer, but more people died getting to and from work. Motor vehicle crashes claimed increasing numbers of lives, especially among young men. Data from 22 industrialized countries show that fatality rates from motor vehicle crashes soared after 1910. Rates declined after 1970, reportedly because of improved highway conditions and stricter control of drunk driving. Still, motor vehicle crashes are the leading cause of injury deaths in many countries. Any large reductions in injury death rates are likely to come from improved traffic safety.

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Guatemalans rebuild their homes after a devastating 1976 earthquake that killed an estimated 22,000 people.

U.S. Injury Trends

Injury from all causes kills about 150,000 Americans every year. Injuries cause about 7 percent of all deaths in the United States and 70 percent of deaths to Americans ages 5 to 24. While injury's share of all deaths has remained fairly constant for the past few decades, the proportion of fatal injuries from homicide and suicide has risen—from about 22 percent in 1950 to 39 percent in 1995. Motor vehicle crashes claim the most American lives, followed closely by firearms (see Table 2). These two causes account for more than one-half of all injury deaths in the United States. Poisonings, falls, and suffocations account for another one-fourth of fatal injuries.

The cause of injury is closely related to the manner of death, that is, whether or not the injury was intentionally inflicted. The vast majority of deaths from motor vehicle crashes and falls are unintentional, while most deaths from knives (and other cutting and piercing implements) are homicides. Nearly all firearm deaths are homicides or suicides; only 3 percent are unintentional. One-third or

Table 3
Ten Leading Causes of Death by Age: United States, 1997

Rank	Cause and number of deaths by age (in years)						
	<1	1-4	5-14	15-24	25-44	45-64	65+
1	Congenital anomalies 6,063	Unintent. injuries 1,958	Unintent. injuries 3,330	Unintent. injuries 12,958	Unintent. injuries 25,477	Cancer 130,894	Heart disease 607,703
2	Low birthweight[a] 3,727	Congenital anomalies 596	Cancer 996	Homicide 5,793	Cancer 21,555	Heart disease 100,051	Cancer 381,810
3	SIDS 2,705	Cancer 458	Homicide 437	Suicide 4,146	Heart disease 15,800	Unintent. injuries 16,689	Stroke 140,693
4	Respiratory distress 1,262	Homicide 345	Congenital anomalies 424	Cancer 1,583	Suicide 12,008	Stroke 15,267	Bronchitis[c] 95,997
5	Complications of pregnancy 1,242	Heart disease 195	Heart disease[b] 313	Heart disease 1,013	HIV 11,166	Bronchitis[c] 13,057	Pneumonia & influenza 79,395
6	Placenta cord membranes 927	Pneumonia & influenza 168	Suicide[b] 313	Congenital anomalies 383	Homicide 8,287	Diabetes 12,652	Diabetes 47,109
7	Perinatal infections 756	Perinatal infections 90	Pneumonia & influenza 139	HIV 276	Liver disease 3,892	Liver disease 10,653	Unintent. injuries 30,933
8	Unintent. injuries 753	Septicemia 66	Bronchitis[c] 127	Pneumonia & influenza 223	Stroke 3,358	Suicide 7,656	Alzheimer's disease 22,209
9	Intrauterine hypoxia 456	Benign tumors 60	HIV 102	Bronchitis[c] 190	Diabetes 2,405	Pneumonia & influenza 6,120	Nephritis 21,962
10	Pneumonia & influenza 397	Stroke 50	Benign tumors 76	Stroke 167	Pneumonia & influenza 1,933	HIV 4,632	Septicemia 18,263
Deaths from all causes[d]	27,692	5,471	8,044	30,945	133,612	375,454	1,733,070

[a] Disorders related to short gestation and low birthweight.
[b] Tied for 5th rank.
[c] Includes emphysema, asthma, and allied conditions.
[d] Preliminary data.

Source: National Center for Health Statistics, *National Vital Statistics Report* 47, no. 4 (Oct. 7, 1998): Tables 17-18.

more of poisonings are suicides. And some of the 13 percent of poisoning deaths with intent "undetermined" in 1995 may have been suicides also.

Fatalities are a small fraction of all injuries (see Figure 4). Most injuries are not reported and are not treated by physicians. Smaller numbers of injuries result in hospitalization or long-term disabilities. Americans report about 62 million injuries annually; 92 percent of these receive medical attention. These injuries account for 37 million emergency department (ED) visits and at least 2.6 million hospital stays annually. This translates into about 247 ED visits and 17 hospitalizations for every injury death.

Brain and spinal cord injuries generate the most disabilities. There are 2 million new cases of brain injury and 10,000 new cases of spinal cord injury each year in the United States. Most are caused by motor vehicle crashes, falls, and firearms. Injuries also cause thousands of other serious disabilities each year, including loss of hearing, sight, or limbs.

The costs that injuries inflict on society continue to escalate and have reached staggering dimensions. In addition to the social and psychological burden, injuries cost about $224 billion annually in 1996 dollars, including medical care, rehabilitation, lost income, and lowered productivity.[12]

Trends in U.S. Injury Deaths

The death rate from injury has declined in the United States, as have death rates from other causes, but the rate of this decline has slowed over the past decade. Accounting for changes in the U.S. age structure, the National Center for Health Statistics (NCHS) calculated that the death rate from all types of injuries fell 16 percent between 1980 and 1985 but only 6 percent between 1985 and 1995.

These overall declines mask contradictory trends. In general, unintentional injury deaths declined while intentional injury deaths rose. After adjusting rates for the changes in the age structure, the death rate from motor vehicle crashes declined by 16 percent between 1985 and 1992, from 18 deaths per 100,000 Americans to 15 deaths per 100,000. But the rate halted its decline after 1993, and stood at 16 in 1995.

The U.S. homicide rate rose by nearly 29 percent between 1985 and 1993, from 8.3 deaths per 100,000 to 10.7 deaths per 100,000, after adjusting for age. The age-adjusted homicide rate then declined to 9.4 by 1995, the latest year available. More recent reports indicate the homicide rate has dropped further.

The death rate from poisonings, which include drug overdoses, rose slightly between 1990 and 1995. More than 16,000 injury deaths were attributed to poisonings in 1995.[13] The death rate from falls and suffocation remained fairly constant over the decade. There was more success in lowering the death rate from drowning and from fires. These rates fell by about 30 percent between 1985 and 1995, according to the NCHS.

Figure 4
The Injury Pyramid

Note: The categories are not mutually exclusive. The relative sizes of the segments are illustrative and are not to scale.

Source: Modified from Herbert G. Garrison and George Rutherford, "Morbidity," in Centers for Disease Control and Prevention/National Center for Health Statistics, *Proceedings of the International Collaborative Effort on Injury Statistics* vol. 1 (PHS) 95-122 (1995): 28-4.

Age Patterns

Injury is the leading cause of premature death for Americans. Premature death can be measured by years of potential life lost before age 65 (see Box 1, page 12). Injury is one of the top 10 causes of death in every age group and accounts for a majority of deaths among children and young adults (see Table 3). Children are much more vulnerable to death from injury than from the health problems that claim the most adult lives, such as cancer and heart disease. Injuries from motor vehicle crashes were the leading single cause of death among children ages 1 to 14 in 1997. They accounted for 20 percent of all deaths in this age group. Drowning and fires are two other major causes of injury deaths for ages 1 to 14. Suffocation is the top cause of injury death for children under age 1.

The adolescent and young adult years are particularly hazardous, for these are the ages when many young people begin to drive and experiment with drugs and are especially vulnerable to violence and depression.

Unintentional injuries, homicide, and suicide are the top three causes of death for Americans ages 15 to 24 in the 1990s. The top two specific causes of fatal injuries are motor vehicle crashes and firearms. Twenty-three percent of all motor vehicle-related deaths occurred among this age group in 1997, as did 30 percent of homicides. Adults ages 45 to 64 are less likely to die from an injury, and those who do are more likely to die

Box 1

Measuring Premature Mortality: Years of Potential Life Lost

Public health professionals have long deemed life expectancy at birth and the infant mortality rate to be the best summary measures of a population's health status. One of the newer generations of health status measures is years of potential life lost (YPLL). YPLL measures premature mortality and assigns weights or values to deaths according to the ages at which they occur. These weights vary inversely with the age of the decedent up to an age ceiling.

Theoretically, premature deaths are any deaths that occur before the end of the human life span. Age 122 is one logical ceiling for premature mortality. This was the age of Jeanne Calment, a French woman who had the longest authenticated life on record when she died in 1997. Life expectancy at birth—76 years in the United States—is another potential age ceiling for computing YPLL. The U.S. Centers for Disease Control and Prevention (CDC) recently raised the upper age limit for YPLL from 65 to 75 to bring it closer to the U.S. average life expectancy.

There are a number of reasons for using the lower age ceiling of 65 for the YPLL, however, especially for international comparisons. The reported cause of death tends to be more accurate for people who die before age 65, which is another justification for setting 65 as the age ceiling. The elderly are more prone than younger people to suffer from multiple health problems that can contribute to a death, which makes it harder to diagnose a single underlying cause of death.[1] When the YPLL is used to calculate the years lost because of a specific cause, such as motor vehicle crashes, the measure is less valid for people of advanced age. A 75-year-old driver killed in a crash may also have suffered a stroke that initiated the crash and would itself have been fatal.

Using age 65 as a ceiling in YPLL calculations also sidesteps the complication of competing causes of death.[2] The method assumes that if a motor vehicle crash victim, for example, had not died from crash injuries, he or she would have survived to the age ceiling. In fact, even if the crash death had been averted, the individual would have been at risk of dying from a heart disease or another cause. Because the risk of dying is much higher above age 65 than below it, the error from ignoring competing causes is greater with an older age ceiling.

The basic rate of YPLL before age 65 per 1,000 population can be calculated using the following formula:

$$\text{YPLL before age 65 per 1,000 population} = \sum_{i=0}^{64} a_i d_i * 1{,}000/N$$

d_i = number of deaths between ages i and $i + k$ in the population where i = the age at the beginning of the age interval and k represents the length of interval; a_i = the number of additional years a person who dies between ages i and $i + k$ would have needed to live to have reached exact age 65. The deaths are assumed to occur, on average, in the middle of the age interval, thus $a_i = 65 - (i + 0.5\,k)$. Deaths to persons ages 50 to 54, for example, are counted as occurring at age 52.5, the midpoint of the five-year interval; a_i would equal (65 – 52.5) or 12.5 years.
N = the population ages 0 to 65.

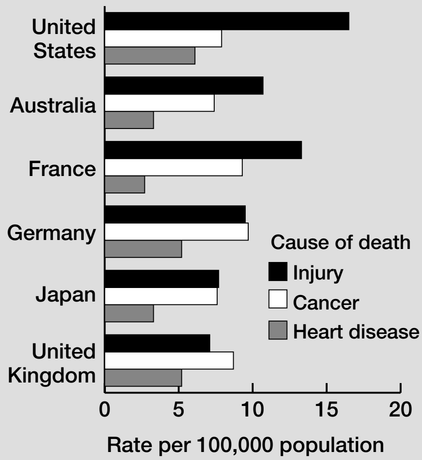
because of a traffic crash than from other types of injuries. But suicide and homicide are still leading causes of death in these ages. Injury death rates are highest for people ages 65 and older, but the elderly are much more likely to succumb to heart disease, cancer, and stroke than from injury.

Racial and ethnic differences in injury rates are most pronounced among adolescents and young adults.

YPLL rates can be calculated for individual causes of death to find, for example, the share of potential life lost because of firearm deaths. These rates are additive. Thus YPLL rates for firearm and cutting and piercing could be added. And YPLL rates can be adjusted for differences in age structure.[3] In more developed countries, heart disease and cancer kill far more people than does injury. The British crude heart disease death rate was 10 times the corresponding injury rate in 1993. The U.S. heart disease and cancer death rates were five times and three times the injury death rate, respectively. But because injury also kills many younger people, injury claims far more years of potential life. The injury YPLL rate surpasses the YPLL rate for heart disease and cancer in most industrialized countries (see figure). Injury emerges as a major public health problem in all the countries in the figure, especially in the United States and France. The U.S. YPLL rate for injury was more than twice the rate for cancer. In France, the injury YPLL rate was almost 1.5 times greater than the corresponding cancer rate.

If injury mortality were eliminated, how would this affect the life expectancy of the people whose deaths would be averted? In 1993, saving an American male from an injury death would have given him an additional 31 years of life, on average; an American female would gain 27 years.[4] Eliminating injury mortality would also add 2.1 years and 0.8 years, respectively, to male and female life expectancy at birth in the United States.

Rate of Years of Potential Life Lost Before Age 65 by Selected Cause: Six Countries, 1993



Source: Author's calculations based on data files from the World Health Organization.

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3. J-M Romeder and J.R. McWhinnie, "Potential Years of Life Lost Between Ages 1 and 70: An Indicator of Premature Mortality for Health Planning," *International Journal of Epidemiology* 6, no. 2 (1977): 143-51.
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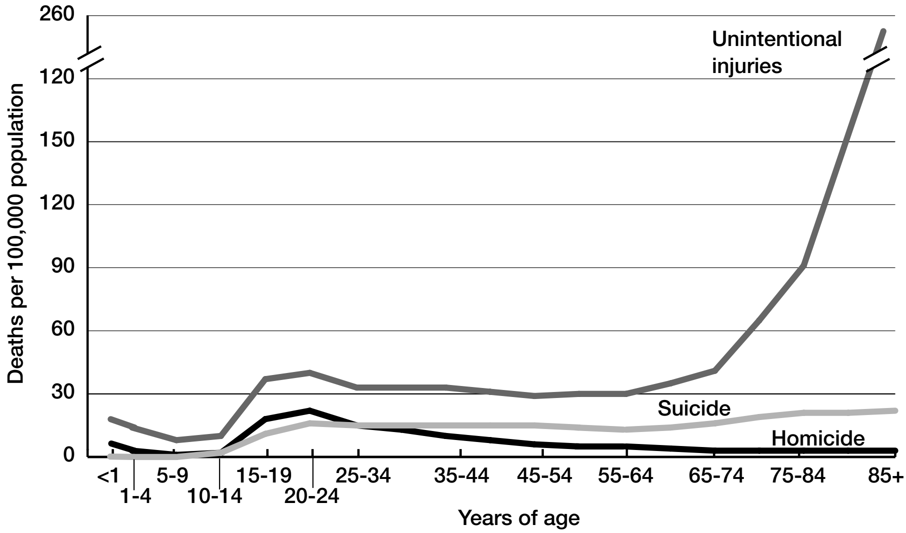
Eliminating injury mortality would add 2.1 years to male life expectancy at birth in the United States.

Figure 5
Injury Death Rates by Age and Manner of Death: United States, 1995



Note: Excludes injuries caused by medical treatment and theraputic use of drugs (ICD-9 codes E870-E879 and E930-E949).
Source: National Center for Health Statistics, *Health United States 1996-97 and Injury Chartbook* (1997): 20, 57.

Among Americans ages 15 to 34, the homicide rate is 12 times higher for blacks, five times higher among Hispanics, and three times higher among Native Americans than among non-Hispanic whites. Racial and ethnic differences in injury deaths are much smaller among older Americans.

Intent of Injury

Unintentional injury mortality rates peak in the older ages and among people in their early 20s (see Figure 5). Intentional injuries follow a different age pattern. Homicide rates peak at ages 15 through 24, and then decline. Suicide rates increase during the adolescent years, plateau between ages 20 and 65, and increase again for those age 65 or older. In the United States, the suicide rate is high among elderly men but not for women, although this suicide gender gap is less pronounced in France, Japan, and many other countries. The marked age pattern for specific causes of injury death provides valuable clues to injury control experts about which age groups they need to target for preventive measures.

History and Conceptualization

Injury was first designated a public health problem in western countries in 1788 by the German physician Johann Peter Frank.[14] The now controversial idea that successful injury prevention requires a change in individuals' behavior can be traced to Frank's era. Reflecting the totalitarian political climate in which he lived, Frank emphasized the use of laws and enforcement to induce people to practice safe behavior. His focus on individual behavior as the cause of injury ignored factors that create hazardous conditions, such as exposed machine parts or flimsy construction.[15]

The belief that individuals are largely responsible for their injuries predominated until the middle of the 20th century. Most data systems that included injury data reflected this view. The records of such systems might implicate a driver's alcohol impairment in a motor vehicle crash injury but omit other pertinent information like adverse weather and a steep, winding highway.

Dissent from this narrow behavioral focus in injury prevention surfaced in 1942 with the publication of a paper by Hugh DeHaven, an engineer at Cornell Medical College.[16] DeHaven's paper focused on ways to minimize injuries by modifying the environment rather than individual behavior. His insights evolved from grave injuries he suffered in a plane crash in 1917. DeHaven linked the pointed seat belt buckle he had worn during the crash to serious wounds to his liver, gall bladder, and pancreas. At that time, seat belts were installed in open-cockpit planes primarily to keep pilots from falling out during inverted flight; surviving a plane crash was attributed to luck or divine intervention. DeHaven later described the style of belt he wore as "five to six inches wide, with a narrow pointed six-inch buckle in the middle. It was called a safety belt, but in reality it was about as safe in a crash as holding a stiletto in the middle of your abdomen."[17]

DeHaven examined the effects of kinetic or mechanical energy on survival from falls involving heights of 50 to 150 feet and concluded that aircraft and cars could be designed to soften the impact from a crash and to distribute the pressure exerted on occupants. These design changes, he said, could "enhance survival and modify injury within wide limits in aircraft and automobile accidents."[18]

DeHaven inspired researchers to study body resilience and injury thresholds—the amount of impact, for example, that the human body can absorb before it sustains an injury. His work led to the development of such safety devices as automobile air bags and automatic seat belts. In a car crash, seat belts spread the force of impact over more body surface and keep the occupant from being thrown out of the car or from hitting the windshield. In this way, seat belts raise the "injury threshold" of automobile travel.

For DeHaven, luck had no place in injury or survival outcomes, and he worked hard to convince engineers and health professionals to accept his ideas. His efforts were instrumental in the evolution both of biomechanics—which blends biology, physics, mathematics, and engineering—and ergonomics—the science of designing safe and comfortable workplace environments.

Biomechanics and ergonomics embrace injury prevention as part of a perpetual quest to optimize the fit between human performance and the technological environment. The quest is perpetual because technology continually evolves, often more rapidly than humans can adapt. The larger the discrepancy between technology and human adaptation, the greater the potential for injury.

Among the intellectual descendants of DeHaven was John Stapp. In experiments he conducted for the U.S. Air Force during the 1950s, Stapp and other volunteers demonstrated the capacity of humans to avoid permanent physical disability during the rapid deceleration that pilots might encounter in experimental aircraft. Stapp and the other volunteers were strapped into rocket sleds with a shoulder harness, accelerated to 632 miles per hour, and then slowed to a complete stop in just 1.4 seconds. The harness protected Stapp and the other occupants from severe injury. This research proved crucial for the National Aeronautics and Space Administration (NASA) to establish that astronauts could withstand the force of re-entry from space into the earth's atmosphere.[19]

A contemporary of Stapp's, John Gordon, contributed to injury prevention by applying to injury the same methods epidemiologists used to study disease.[20] Gordon saw parallels between patterns of injury incidence and patterns of communicable diseases and other health disorders. Both

For DeHaven, luck had no place in injury or survival outcomes.

Box 2

Neither Accidents nor Acts of God

Injury derives from the Latin phrase *in jus*, which literally means "not right." The word's origins suggest a connection to injustice and reflect the perspective that unintentional injuries are random phenomena—accidents—that can neither be predicted nor prevented.[1] Some attribute "accidents" to bad luck that strikes without reason; others see them as fate or divine will.

But injuries are both predictable and preventable—not for an individual but for a population as a whole. Injury deaths in the United States in 1995 numbered 150,809, and we can confidently predict a similar number of injury deaths for the next several years. We can also predict—with less certainty—the numbers or rates of injury deaths from homicides, suicides, and motor vehicle crashes among Americans in various age, sex, and race categories. This predictability enables epidemiologists and other public health professionals to identify groups at a high risk of injury and target these groups in injury prevention efforts.

The U.S. Centers for Disease Control and Prevention (CDC) coined the slogan "injuries are not accidents" to reinforce the idea that injuries are preventable. They strongly recommend that the term unintentional be substituted for accidental to describe injuries.[2]

The CDC perspective was eloquently espoused in a sermon by theologian William Sloane Coffin, Jr., shortly after the death of his 24-year-old son in an automobile crash. Dr. Coffin, whose activism brought him into the public spotlight during the Vietnam War, dismissed divine intervention as the cause of his son Alex's death:

"Do you think that it was the will of God that Alex never fixed that lousy windshield wiper of his, that he was probably driving too fast in such a storm, that he probably had had a couple of 'frosties' too many? Do you think it is God's will that there are no streetlights along that stretch of road, and no guardrail separating the road and Boston Harbor?"[3]

Coffin attributed the crash to the rainy weather, Alex's drinking, poor car maintenance, and inadequate road design and construction—all factors central to injury control efforts.

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injuries and diseases vary over time and by geographic location, demographic factors, and socioeconomic characteristics. Both diseases and injuries can be manifested as epidemics.[21] Gordon pointed out that because the incidence of injuries conformed to patterns, injuries could be predicted (see Box 2). This predictability makes it easier to target at-risk groups and design effective preventive measures.

Gordon also recognized that injuries have multiple causes. Drivers are more likely to be killed by a train at a railroad crossing if they are hearing impaired and if no warning lights or barrier are present. Gordon conceptualized the multiple factors involved in injury using the elements of the epidemiologic triad: host, agent, and environment.

Energy as Injury Agent

The epidemiologic triad is a model that health scientists use primarily to better understand communicable disease. Within the triad, humans and other animals (hosts) become afflicted with a disease when the homeostasis, or equilibrium, among the host, the agent (necessary to cause the disease), and the environment becomes destabilized. Host characteristics, such as immunity, physical conditioning, genetic endowment, and lifestyle, can affect an individual's risk for contracting a given disease, as does the nature of the environment that harbors the agent. The agent for leprosy, for example, is the bacterium *M. leprae*. Characteristics of the host and environment that increase the risk of contracting leprosy include unsanitary living conditions, malnutrition, and genetic predisposition. A person must be exposed to *M. leprae* to contract leprosy, but his or her risk of getting the disease after exposure to the agent varies according to personal and environmental characteristics.

In the 1960s, psychologist James Gibson specified that physical energy was the agent in the epidemiologic triad of injuries—enabling a great "etiologic leap" in injury research. Injury can occur when our capacity to control energy is compromised, such as when a person falls asleep while driving, or when task demands exceed our capacity to control energy, such as when someone swims into a riptide or drives onto an ice patch. Too much or too little energy can harm the body. Injury occurs when the release and transfer of energy exceeds the injury threshold. The injury threshold is the point at which the body cannot tolerate the transfer without damage or when energy flows are suppressed below levels necessary for normal functioning. Injuries sustained in motor vehicle crashes or from a bullet are examples of injuries associated with excess energy transfers. Drowning and hanging are injuries related to energy suppression. With these and other forms of asphyxiation, a lack of oxygen causes essential cells in the heart and the brain to be damaged within minutes, interrupting normal energy flows.[22]

All five forms of physical energy—electricity, kinetic energy, chemical energy, thermal energy, and radiation—are injury agents. Disease and injury agents must be distinguished from their conveyances—what epidemiologists call vectors or vehicles. A vector involves the action of a living organism, while a vehicle does not. If a dog bites a person, then that dog's jaws and teeth are the vectors of the injury agent, kinetic (or mechanical) energy. Similarly, when a person is electrocuted by touching a live wire, then the wire is the vehicle of the injury agent, electricity.

Photo removed for copyright reasons.

A chemical worker exposed to a large dose of toxic chemicals can sustain injury to body tissues. Exposure to small doses over a longer time period may cause cancer, underscoring the complex relationship between disease and injury.

Injury–Disease Nexus

Injury shares a number of characteristics with disease—although most people think of injury and disease as distinct phenomena. The process of transmitting disease and injury agents to the body is similar.[23] The distinctions lie in how long the body is exposed to the agent, the amount of exposure, and the body's response to the agent. Transfers of energy can cause injury in milliseconds—a knife slips and cuts a hand nearly instantaneously. The onset of disease takes longer—from a few hours (as with food-borne *E. coli* bacteria) to many decades (as with cancer) after exposure to a disease agent.

Diseases and injuries can share agents. A large, rapid dose of ionizing radiation can cause burns, an injury, while smaller accumulated doses can cause various kinds of cancer. All five forms of physical energy, the injury agents, have been linked to disease as well as to injury.

Both disease and injury can be chronic as well as acute. Calluses and lumbar disc lesions represent chronic injuries that can result from prolonged exposure to kinetic forces. Injury and disease also possess direct health connections to each other. For example, if its causal agent, *C. tetani,* is

Figure 6
Haddon's Matrix Applied to Motor Vehicle Crash Injury

Phases	Factors		
	Human	Vehicle	Environment
Pre-event	Educate public in the use of seat belts and child restraints	Safe brakes and tires	Improve road design; restrict alcohol advertising and availability at gas stations
Event	Prevent osteoporosis to decrease likelihood of fracture	Air bags and a crash-worthy vehicle design	Install breakaway utility poles and crash barriers
Post-event	Treat hemophilia and other conditions that impair healing	Safe design of fuel tank to prevent rupture and fire	Ensure adequate emergency medical care and rehabilitation

Source: Adapted from Gordon S. Smith and Henry Falk, "Unintentional Injuries," *American Journal of Preventive Medicine* 3, no. 5 (Supl) (1997): 143-63.

present, tetanus can occur in a puncture wound contaminated by soil, dust, or animal waste. And researchers have linked head trauma with an increased risk for Alzheimer's disease.[24] Just as injury can promote disease risk, disease can promote injury risk. People with the degenerative disease of the bones, osteoporosis, for example, are at increased risk of fracturing their hip in a fall.

Rethinking Injury Prevention

The epidemiologic triad strongly influenced the thinking of William Haddon, Jr., a pioneer in the field of injury prevention. In the 1960s, Haddon was named the first head of what is now the National Highway Traffic Safety Administration. In 1969, he assumed the presidency of the Insurance Institute for Highway Safety, a position he retained until his death in 1985.

Aided by formal training in engineering, medicine, and epidemiology, Haddon revolutionized the way researchers approach injury control and prevention. Perhaps most important, he demonstrated how to conceptualize injury as a solvable problem. He expanded the concept in a theoretical framework in which he trisected injury events or episodes into pre-event, event, and post-event phases. These phases constitute the rows in what became known as the Haddon Matrix.[25] The Haddon Matrix originally applied to motor vehicle safety, but eventually it was applied to other areas of unintentional injury and to intentional injury.

Haddon's Matrix

The columns of the matrix are labeled human (host), vehicle (or vector), and environmental factors. For Haddon, the environment included social as well as physical factors. The Haddon Matrix illustrates how injury from a motor vehicle crash could be averted or ameliorated by the interaction of human, vehicle, and environmental factors in each of the three event phases (see Figure 6). These phases coincide generally with the three levels of prevention commonly used in health programs: primary, secondary, and tertiary.

Primary prevention implies avoiding exposure to the hazard, while secondary prevention limits damage at the time the injury event occurs. Tertiary prevention reduces disability from injuries through timely and appropriate medical treatment and by rehabilitation and retraining for the injured. The term "injury control," which is commonly used by injury epidemiologists and public health professionals, envelops the secondary and tertiary levels of prevention.

Haddon endorsed passive injury countermeasures over active ones because he believed injury control was most effective when it removed the responsibility for prevention from the individual. An automatic sprinkler system in a building or an automobile airbag are passive countermeasures. A motorist's decision to drive only when sober and with seat belts fastened is an active countermeasure. This active measure is less reliable than the passive measures.

Haddon's strong advocacy for preventing injuries and reducing their severity by changing the environment rather than behavior is reflected in the following 10 strategies:[26]

1. *Prevent creation of the hazard*; for example, prevent the manufacture of nuclear weapons.
2. *Reduce the amount of the hazard*; for example, reduce motor vehicle speeds and the concentration of chemical reagents in high school laboratories.
3. *Prevent release of the hazard*; for example, prevent the unintentional discharge of firearms by installing safety devices and applying sand and salt to icy roads and sidewalks.
4. *Modify the rate of spatial distribution of release of the hazard from its source*; for example, ski on gradual rather than steep slopes and use parachutes to slow race cars.
5. *Separate in space and time the hazard from the person to be protected*; for example, construct tunnels and overpasses to separate pedestrians from trains and motor vehicle traffic.
6. *Interpose physical barriers between the hazard and the person to be protected*; for example, use hockey face masks and install lightning rods.
7. *Modify the contact surface, subsurface, or basic structure which can be impacted by the person to be protected*; for example, install breakaway roadside poles and goal posts.
8. *Strengthen the resilience of the person to be protected against the hazard*; for example, combat osteoporosis through dietary calcium supplements to minimize injuries in a fall.
9. *Move rapidly to counter existing damage*; for example, activate automatic sprinkler systems and fire exits and stop bleeding in the injured person.

Photo removed for copyright reasons.

Strategies to reduce head injuries for bicyclists include giving helmets away and fining parents who let their children ride without helmets.

10. *Stabilize, treat, and rehabilitate the injured person*; for example, provide acute medical care, rehabilitation, and retraining.

Although Haddon did not conceive of these strategies as a prescription, they have guided policymakers and program planners in formulating injury reduction strategies (see Box 3, page 20). Their success, however, requires commitment and action from individuals in many fields: corporate heads, politicians, police, physicians, and educators. These people often do not agree on the necessity of particular injury control measures. Some oppose control measures as a violation of individual civil liberties or as unjustified expenses that will harm businesses. The tension between injury control proponents and civil libertarians and business interests in the United States is illustrated by the prolonged and heated political battles over seat-belt laws and gun-control legislation. Haddon's approach does not address the need for appropriate and enforced legislation and regulations to back up environmental measures. Automobile makers probably would

[Haddon] believed injury control was most effective when it removed the responsibility for prevention from the individual.

Box 3

Regulating Occupational and Consumer Safety

William Haddon and other scientists transformed injury control theory during this century when they shifted the focus to making the physical environment safer, rather than relying on people to adopt safer behavior. The application of this new approach, however, required comprehensive legislation, regulation, and enforcement. Public safety laws are not new, but they were created in a piecemeal fashion in response to isolated situations, and they were not enforced uniformly. Moreover, the U.S. government has been slower than some other national governments, such as that of the United Kingdom, to develop a systematic approach to public safety legislation.[1]

Occupational and consumer safety are two areas in which the U.S. government has concentrated its regulatory energy. The Walsh-Healey Public Contracts Act of 1936 included some federal regulation of workplace safety,[2] but the Occupational Safety and Administration Act, passed by Congress in 1970, marked the first major involvement of the federal government in injury control. This act created a regulatory agency, the Occupational Safety and Health Administration (OSHA), and a research agency, the National Institute of Safety and Health (NIOSH). OSHA relies on data from NIOSH, which is administered by the Centers for Disease Control and Prevention (CDC), when it sets standards for protection from exposure to physical and chemical hazards in the workplace.

OSHA has many critics, including labor unions, that allege the agency has been ineffective in setting and enforcing safety standards.[3] Critics point out that the downward trend in occupational injury fatality rates began before OSHA was created and suggest it was not related to OSHA's actions.

Consumer safety, like occupational safety, has not been a high priority of the federal government. But consumer advocate groups, reinforced by scientific evidence on the hazards posed by many products, helped pass the Consumer Product Safety Act in 1972.[4] This legislation created the Consumer Product Safety Commission (CPSC). The CPSC establishes standards for certain products with input from the private and public sectors, guided by data from various sources, most notably the National Electronic Injury Surveillance System (NEISS). Toys, power tools, furniture, and certain poisonous substances are within CPSC's sphere of responsibility. Tobacco, firearms, motor vehicles, and insecticides, however, are regulated by other federal agencies. Critics of the CPSC claim that its close links to product manufacturers undermine its commitment to consumer safety.

OSHA and the CPSC promote the strategy of reducing injury risk by modifying the physical environment. But many health advocates claim that these regulatory agencies require much more political and economic support to be truly effective.

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3. Dade W. Moeller, *Environmental Health*, revised ed. (Cambridge, MA: Harvard University Press, 1997): 57.
4. Miller, *Safety: Principles and Issues.*

not have installed seat belts in all new cars if they had not been required to do so by law, and some drivers will not use seat belts unless they know they will be fined if they do not.

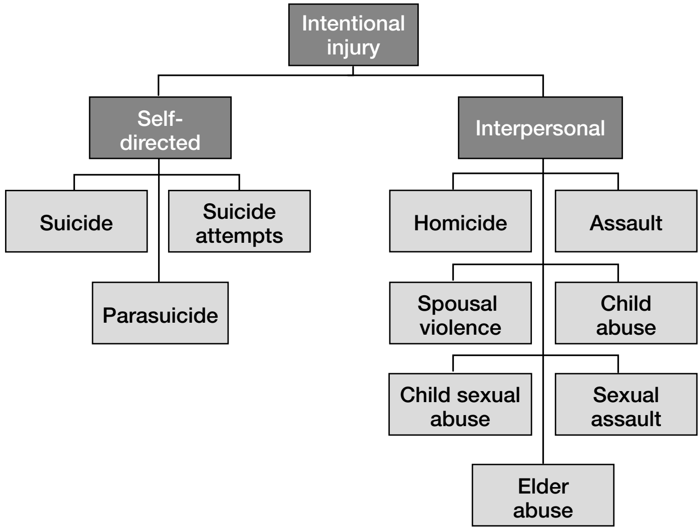
Some newer injury models are more sensitive than the Haddon Matrix to the social, cultural, political, and economic milieu in which prevention must occur. Two such models are the OPSKARBO and PRECEDE models.[27] The OPSKARBO model helps health planners and programmers realize that in order to reduce injury, they frequently need to enhance the skills and knowledge and change the attitudes and behavior of social gatekeepers as well as the at-risk populations. OPSKARBO successfully guided a community intervention project in Rhode Island that implemented and evaluated a program to reduce alcohol-related injury. In that project, the social gatekeepers were the mayor, police, and establishments that sold and served alcohol, and the at-risk population included everyone who drank alcohol in bars, restaurants, and other public places.[28]

The PRECEDE model was created by health educator Lawrence Green for community health education and health promotion.[29] The model involves voluntarily altering behavior that leads to injury by weakening the predisposing, enabling, and reinforcing factors. In the case of bicycle injuries, for example, injury control interventions might target children who do not wear helmets. They can counteract the factors that might keep children from wearing them by giving helmets away free and enforcing regulations that require bicyclists to wear helmets.[30]

Preventing Violence

These approaches to prevention of unintentional injury also can be applied to intentional injuries. Intentional injuries may be self-directed or interpersonal (other-directed), as shown in Figure 7. Self-directed injury includes suicide, attempted suicide, and parasuicide. Parasuicide is deliberate self-harm or mutilation without suicidal intent. The three self-directed injury categories are conceptually distinct, but these distinctions tend to blur in practice. Interpersonal injury includes categories that do not always entail physical injury, such as sexual assault.

Figure 7
Categories of Violence



Source: Adapted from Centers for Disease Control and Prevention and National Center for Injury Prevention and Control, *Violence Prevention: A Briefing for Sen. Sam Nunn*, March 28, 1994.

Collaboration among diverse groups of professionals can create a broad-based attack on the causes of violent injury. One example of such collaboration is the framework for strategies to combat an extreme outcome of domestic violence—spousal homicide—which is shown in Table 4, page 22. This example prescribes actions for countering the structural, cultural, and interactionist factors that can predispose a person to kill his or her spouse. Structural factors are characteristics of society. Factors that have been associated with violent behavior include poverty, racial discrimination, and residential segregation.

Cultural factors include the norms, beliefs, and values of societal members—for example, attitudes toward alcohol and other drugs, women's status, and physical force. Cultural factors can be affected by the media and

Table 4
Factors That May Predispose Murder of a Spouse, and Proposed Prevention Strategies

Predisposition factors	Prevention strategies
Structural	
• Poverty • Male dominance over females • Isolation of nuclear family	• Eliminate poverty • Eliminate sexual inequality (especially in child rearing and employment) and notions that masculinity requires dominance • Reduce isolation of nuclear family
Cultural	
• Male belief in physical prowess, toughness, that he is "head of house" and has control over females • "Hands-off" view of domestic disputes by criminal justice system • Televised violence and other media supports	• Increase verbal skills and means of problem solving • Initiate criminal justice and social service interventions • Reduce media violence
Interactionist	
• Alcohol and drug consumption • Weapons possession • Male use of force to compensate for verbal disadvantage • No safe place for women to go	• Reduce alcohol and drug consumption • Reduce firearm injuries • Teach how to "fight fair" and resolve conflicts nonviolently • Teach how to walk away from a potentially violent situation

Source: Mark L. Rosenberg, et al., "Violence: Homicide, Assault, and Suicide," in *Closing the Gap: The Burden of Unnecessary Illness*, eds. Robert W. Amler and H. Bruce Dull (1987): 170.

outside influences. Attitudes toward violence and domination, for example, can be reinforced through films, television shows, and sports events by portraying physical aggression as normal behavior. The media may reinforce drinking and drug use when it downplays their negative effects.

Interactionist factors refer to interactions among the individuals involved in a violent act. Interactionist factors center on increasingly hostile encounters between perpetrator and victim. If a husband berates his wife for alleged personal inadequacies, for example, the relationship can deteriorate and, when combined with drug use and proximity to firearms, turn lethal.

The antidote to violence prescribed for preventing spouse abuse involves reversing or diluting the set of predisposing, enabling, and reinforcing factors that incite spousal homicide. Mediation, counseling for drug or alcohol abuse, and gun control can also help defuse this type of potentially violent situation.

Public Health Approach

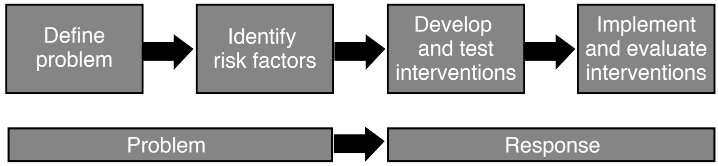
The public health approach to injury and violence prevention promoted by CDC involves at least four stages of action (see Figure 8). In the first stage, epidemiologists define the problem and identify the high-risk populations. In the second stage, the risk factors are identified. At this stage also, the emphasis shifts from descriptive to analytic epidemiology. During the third stage, a diverse group of professionals such as engineers, physicians, psychologists, and health educators collaborate to develop and test ways to reduce injury risk factors in the target population. In the final stage, these interventions are implemented and then evaluated.

Surveillance Systems

Data from surveillance systems are the best way to define health problems and profile populations at a high risk for injury and violence. The most sophisticated surveillance systems integrate data sources that generate current injury mortality and morbidity rates; detect unusually high incidence of injuries (injury clusters); identify risk groups and factors; facilitate research and planning; and provide the longitudinal data necessary for evaluating prevention measures.

Surveillance systems function best when they produce timely, accurate data; are acceptable to those administering the systems; and represent a clearly defined population.[31] Injury surveillance systems will become more comprehensive and accessible as injury data sources are linked electronically.

Figure 8
A Public Health Approach to Injury and Violence Prevention



Source: Adapted from U.S. Department of Health and Human Services, *Youth Violence Prevention: Developing Strategies That Work. A Briefing for Walter Broadmax, Deputy Secretary, DHHS*, Dec. 1994; and *Healthy People 2000* (1991): 271-93.

In the absence of sophisticated surveillance systems, public health researchers and practitioners draw upon a myriad of sources for their work. These sources include international, national, state, and local health agencies, trauma centers, hospitals, clinics, universities, police stations, fire marshals' offices, workplaces, and newspapers. These agencies and organizations produce data in many forms, including death certificates, survey questionnaires, and hospital records. In addition, an increasing amount of information is available on the Internet (see Box 4, page 24). The data sources usually contain records either of injury mortality—such as death certificates—or injury morbidity, some of which will eventually end in death. Because fatal injuries are more likely to be recorded than nonfatal injuries, there are more international data on injury mortality than morbidity. But information on injury morbidity is becoming more abundant.

The United States is particularly rich in sources of data on both injury mortality and injury morbidity, as described below. Each of these sources, however, has its own limitations for research.

Injury Mortality Data

Death certificates are the major source of injury mortality data in any country. The WHO sets the standard for coding and recording the causes of deaths in its detailed International Classification of Diseases (ICD). The death certificate can record a single underlying cause of death, multiple contributing causes, and contributing factors. Injuries are classified according to two sets of codes that describe the diagnoses (N codes) and external causes (E codes). The N code explains the nature of the injury (a gunshot wound, for example) while the E code describes the circumstances (whether the gun was discharged intentionally or unintentionally). Only the E code is used to classify injury as the underlying cause of death.

Both sets of codes provide valuable information about injury patterns (see Box 5, page 26). A study of motor vehicle crash-related fatalities in the United States in 1979, for example, revealed that almost 50 percent of the deaths had involved intracranial injuries. This information provided valuable insight into ways to reduce highway deaths—seat belts with shoulder straps can prevent car occupants from hitting their heads against the windshield during a crash or sudden stop, and helmets can reduce head injuries among cyclists.[32]

WHO collects, analyzes, and disseminates national mortality data for more than 100 countries. But many countries report less than 90 percent of their deaths, and a large share of death certificates issued do not include valid cause-of-death codes. Only about 35 percent of the world's 50 million annual deaths are incorporated into the WHO mortality data set.[33]

In the United States, NCHS collects mortality records from state health departments. Death certificates in fatal injury cases record personal sociodemographic characteristics; the date, time, and place of event; the circumstances of the injury; and whether the injury was related to work. The E code shows whether the death was considered a homicide, a suicide, an unintentional injury, or of undetermined intent. Only after homicide, suicide, and unintentional injury have been

Box 4

Injury Information on the Internet

The Internet is a rich source of information on injury and violence.[1] Students and researchers can find data, funding opportunities, names of professional organizations, abstracts, publications, bibliographies, charts, maps, glossaries, videos, slide presentations, and other items useful in injury research, teaching, and prevention. Many uniform resource locators (URLs) also provide links to other relevant sites.

The U.S. Centers for Disease Control and Prevention (CDC) operates the leading U.S. government Web site for injury information: **http://www.cdc.gov**. It is a major gateway to related Web sites, including those of CDC's National Center for Injury Prevention and Control, **http://www.cdc.gov/ncipc,** and the National Center for Health Statistics (NCHS), **http://www.cdc.gov/nchswww.**

The CDC site allows users to view and download articles from the Morbidity and Mortality Weekly Report (MMWR), which frequently features injury. MMWR can be accessed via Adobe Acrobat Reader, which can be downloaded free of charge. CDC site users can also access CDC Wonder, a comprehensive information system on injury and other public health issues.

Other Web sites related to injury and violence include:

http://www.injurycontrol.com/ICEHS *(Injury Control and Emergency Health Services Section, American Public Health Association)*

http://www.injurycontrol.com/icrin/ *(Injury Control Resource Information Network)*

http://www.edc.org/HHD/csn/ *(National Injury and Violence Prevention Center, Education Development Center)*

http://www.traumafdn.org *(Trauma Foundation, San Francisco General Hospital)*

http://www.sph.emory.edu/CIC *(Rollins School of Public Health, Emory University)*

http://www.server.to/hit *(Health Information Tennessee, Community Health Research Group, University of Tennessee, Knoxville)*

http://weber.u.washington.edu/~hiprc/ *(Harborview Injury Prevention and Research Center, University of Washington)*

http://www.ch.search.org *(The National Clearinghouse for Criminal Justice Information Systems)*

Web users frequently can obtain answers to injury-related questions through subscription to mailing lists that focus on injury or violence, including:

INJURY-L listserv@wvnvm.wvnet.edu *maintained by the Center for Rural Emergency Medicine and the Injury Control Center at West Virginia University*

EPIDEMIO-L listproc@cc.umontreal.ca *of the Department of Epidemiology at the University of Montreal, Canada*

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ruled out is a death classified as "natural" in legal terms. The assessment of intent and blame is of more interest to legal authorities than to health researchers. Likewise, criminal investigators are more interested in the legal aspects of a death than in the multiple factors that contributed to the fatal injury, such as high alcohol levels in the victim and adverse weather.[34]

Injury data from death certificates have a number of drawbacks for researchers. The individuals filling out the forms do not always use uniform procedures and language for recording the circumstances of an injury. The forms do not provide explicit information on alcohol and other drug involvement that might have directly contributed to the episode. There are long delays in reporting the data—often two or more years. Moreover, not all deaths are reported, especially among poor minority populations.

Under the ninth revision of the ICD (ICD-9), which is used by most countries, E coding of homicides does not capture the relationship between perpetrator and victim—whether they were related or even acquainted. Additionally, it does not differentiate criminal homicides from homicides committed in self-defense. Suicide is especially susceptible to misclassification on death certificates. Deaths recorded as unintentional drownings, unintentional poisonings, and of undetermined intent may have resulted from self-inflicted injuries. The same may be true for some deaths classified under the vague disease category of symptoms, signs, and ill-defined conditions. Pressure from family members who want to avoid the shame associated with suicide or to collect life insurance on the deceased, for example, might discourage officials from classifying a death as a suicide. And many officials have little incentive to investigate such deaths fully once homicide is ruled out.

There is considerable variation across countries in the validity of suicide certification. Health researchers sometimes calculate the upper limit for the "true" suicide rate in a population by adding in all the deaths coded as unintentional poisonings, unintentional drownings, and "undetermined intent," because research has confirmed that many such deaths are self-inflicted. One study found that the true suicide rate for Austrian males was at most 10 percent higher than the official rate, whereas the true rate for Israeli males ages 15 to 24 may be 2.6 times higher than the reported rate. The true suicide rate for U.S. men ages 35 to 44 may be 60 percent higher. For U.S. women ages 75 and older, the true rate could be 80 percent higher than the reported rate.[35]

Medical Examiner and Coroner Records

In most of the United States, a fatality becomes a medical examiner (ME) or coroner case when the death is thought to have resulted from an unintentional injury, homicide, or suicide, or from suspicious circumstances. MEs and coroners also investigate occupational deaths, deaths of persons in custody or confinement, and deaths attributed to agents or diseases that are officially considered hazardous to the public's health.[36]

MEs and coroners conduct postmortem examinations on many of their cases, which furnish much more about the nature and circumstances of a fatal injury case than a death certificate. A postmortem examination includes an autopsy and laboratory tests to determine whether the death involved alcohol or other drugs. If the postmortem concludes that the nature or intent of injury differed from what was recorded on the death certificate, however, the death certificate may not be corrected.

Epidemiologists consider autopsies to be the "gold standard" for cause-of-death information on individual cases, although the accuracy and completeness of autopsies vary.[37] A relatively small percentage of deaths lead to autopsies in the United States—only 12 percent, as reported to the WHO.[38] Autopsy rates published for other countries in 1996 ranged from 49 percent in Hungary and 37 percent in Sweden to 8 percent in Germany and 4 percent in Japan—but the U.S. rate was below the average for more developed countries.

The quality and interpretation of traditional autopsies can be enhanced by psychological autopsies. These are especially valuable when investigators need to determine whether a death was a suicide. The psychological autopsy attempts to evaluate what was on the victim's mind before death by profiling the deceased person's lifestyle, personality, recent causes of stress, mental illness, and evidence of suicidal thoughts. Investigators gather this information by examining personal documents and police, medical, and coroner's files, and by interviewing family, friends, co-workers, and physcians.[39] Psychological autopsies are still rarely performed, however, probably because they are costly and because many officials are unfamiliar with them.

Epidemiologists consider autopsies to be the 'gold standard' for cause-of-death information

Other U.S. Mortality Data

Injury epidemiologists at the National Center for Injury Prevention and Control at CDC have compiled the most complete inventory of data systems in the United States. This inventory is extremely valuable for the study of injury and violence.[40] Among the most prominent data sources are:

- **The National Mortality Followback Survey (NMFS)** was first conducted in 1961 and most recently in 1993. The NMFS uses a sample of death certificates to delve into the circumstances surrounding deaths. The results enable researchers to link an individual death to injury risk factors, such as socioeconomic status, occupation, health care in the year prior to death, disability, alcohol and other drug use, motor vehicle use, and firearm storage and safety practices.
- **The National Death Index, or NDI,** maintained by NCHS, contains death certificate data for reported deaths and is accessible to qualified researchers.

- **The National Traumatic Occupational Fatality Surveillance System (NTOF)**, administered by CDC's National Institute for Occupational Safety and Health (NIOSH), includes mortality records for deaths resulting from injuries in the workplace. The value of these data is limited by the fact that occupation is misclassified or uncodable on about 20 percent of death certificates and because the type of industry in which the decedent was employed is incorrect on about 13 percent of certificates.
- **The Census of Fatal Occupational Injuries**, administered by the Bureau of Labor Statistics, is another more restricted data source on work-related injury mortality. It is compiled from multiple sources, including death certificates and work compensation records.
- **The Fatality Analysis Reporting System (FARS)**, managed by the National Highway Traffic Safety Administration (NHTSA), publishes data on motor vehicle-related fatalities and includes data on drivers, passengers, vehicles, and environments. FARS relies primarily on police accident reports with supplemental information from motor vehicle license and hospital records. Police

Box 5

Injury E Codes and N Codes

Injury diagnostic codes, or N codes, classify the nature of an injury, such as a fractured femur or an open wound of the hand. When patient records include these codes hospitals can better gauge their needs for medical personnel, equipment, and facilities to treat injury victims. But N codes do not provide enough information for injury control experts to design and implement effective injury prevention strategies. External cause of injury codes, or E codes, can fill this void.[1]

E codes summarize the specific circumstances of an injury episode. They can tell researchers how, when, and where the injury occurred, whether or not it was intentional or involved a weapon or drugs. Under the ninth revision of the International Classification of Diseases (ICD-9), a system for coding disease and injury sponsored by the World Health Organization (WHO), there are E codes to distinguish unintentional falls from escalators (E880.0), ladders (E881.0), scaffolding (E881.1), from falls into a well (E883.1) or storm drain (E883.2). Similarly, if the injury mechanism is identified as a bite, E codes can specify whether the vector was, for example, a venomous snake or a spider.

The specific information recorded in N codes and E codes may be provided by emergency medical technicians, paramedics, physicians, surgeons, social workers, and other medical personnel connected to an injury case. It may be recorded at the scene of the injury, in the hospital, and even in the morgue.

A few countries require the use of E codes in hospital discharge records when injury is the principal diagnosis. In the United States, 36 U.S. states and the District of Columbia routinely E code their hospital discharge injury data as of September 1998.

The detail provided by the E coding of hospital data helps hospitals plan cost-effective services and educate emergency medical service personnel, physicians, and police.[2] When planners can document the number of serious injuries from specific causes, they can better design health education programs and assess health needs. Trend data from E code analyses enable injury control experts to evaluate the effectiveness of safety laws, regulations, and other injury countermeasures. Health professionals also use E code data to compute the costs imposed by specific injury causes.

reports, however, often include few details about the circumstances of an injury, and they use nonstandard terms that make them less valuable for research.

- **The Supplementary Homicide Reports**, part of the Uniform Crime Reports (UCR) of the FBI, contain national homicide data. FBI data cover the relationship between victim and perpetrator and their sociodemographic characteristics. The data also record the circumstances and timing of the injury event and the type of weapon involved. The UCR probably underestimate the total number of homicides by a few percentage points, based on NCHS data, but they are released more quickly than NCHS data.[41] The FBI releases their homicide data within 10 months of the end of a calendar year, while NCHS can take 18 months or longer to publish their data.

Injury Morbidity Data

The vast majority of injuries do not cause death, but the circumstances of nonfatal injury events can teach valuable lessons about how to prevent

Although E codes are recorded on a minority of hospital patient records, the E coding of injury mortality data on death certificates is far more common. At a minimum, E codes distinguish the manner of death: homicide, suicide, or unintentional injury. Frequently they record the mechanism of the death; for example, motor vehicle crash, fall, poisoning, drowning, burn from a fire or flame, or surgical procedure.

The 10th revision of the International Classification of Diseases (ICD-10), which is being phased into use around the world, provides added flexibility for coding the details of injury events, such as place of occurrence.[3] The new classification yields many more codes, which allows recording of more specific information about the circumstances of an injury.

A WHO working group has proposed a hierarchical classification for E coding injuries that can identify consumer products and sports involved in an injury.[4] Within the United States, public health professionals representing the Centers for Disease Control and Prevention and the American Public Health Association have refined a matrix, or framework, for presenting injury mortality data using ICD codes.[5] This matrix cross-classifies injury cases by intent and mechanism or external cause of death.

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Box 6

Measuring Injury Severity

Depending on its severity, an injury may cause immediate death, lifetime disability, or temporary pain. Information about the severity of injuries from a specific cause and occurring under specific circumstances is vitally important to researchers looking for ways to limit or prevent injuries.

The severity of an injury may be measured according to several scales and indices, including the Glasgow Coma Scale, Anatomic Profile, Revised Trauma Score, and Pediatric Trauma Score.[1] One of the most widely used is the Abbreviated Injury Scale (AIS), developed by the American Medical Association and the Association for the Advancement of Automotive Medicine.[2] The AIS assesses severity according to the likelihood that an injured person will die from a given injury. The scale ranks injuries as (1) minor; (2) moderate; (3) serious, but not life threatening; (4) severe and potentially life threatening; (5) critical with an uncertain chance of survival; and (6) maximum—untreatable and virtually unsurvivable. A superficial abrasion would qualify as a minor injury; decapitation would rank as a maximum injury.

Trauma patients often sustain multiple injuries of various severity, and the AIS for a given injury may not depict a patient's total condition or survival chances. Researchers can summarize a patient's major injuries with the Injury Severity Score (ISS).[3] The ISS is computed from AIS scores for the three most severely injured regions of the body. (The body regions are the head; neck; thorax; spine; abdomen and pelvic contents; extremities (upper and lower limbs and the bony pelvis); and external structures (skin and muscles)). The ISS equals the sum of the three squared AIS scores, and it ranges from one to 75. An AIS of six automatically yields an ISS of 75.

The ISS provides valuable information for research and is used to set priorities for patient care, to select appropriate treatment, and to determine hospital or physician charges.[4] But the ISS has several limitations for researchers. It omits moderate or minor injuries that might provide important information for injury prevention. It factors in a patient's state of consciousness, which is not always related to the severity of an injury. (An injury victim may lose consciousness if he or she goes into shock, for example, or is under the influence of drugs.) Also, the ISS primarily measures injuries caused by only one of the five energy agents: kinetic, or mechanical, energy. And the ISS excludes deaths and injuries from asphyxiation.

The ISS and AIS are anatomically based, meaning that they pertain only to parts of the body and not to physiology, or the systems that sustain life. Neither measure considers the general health of the injury patient—pulmonary and cardiac capacity, nutritional status, or immune system responsiveness—which also influences survival chances.

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injuries. Yet many injuries, especially minor injuries, go unrecorded and unreported. In many less developed countries, only the injury deaths and most serious injuries are recorded. The United States and other more developed countries have made enormous progress in expanding and improving their injury data collection and reporting systems in recent years. Four of the most prominent sources are:

- **The National Health Interview Survey (NHIS)** is administered by NCHS to assess the health status of the entire civilian, noninstitutionalized population. This survey of 48,000 households comprises core items to monitor trends and a flexible component that can address current concerns. Recent NHIS supplements have examined disability, occupational and home safety, and helmet and seat-belt use. NHIS injury data are E coded and N coded, which makes them valuable for injury research and prevention. The data record how injury restricts individuals' activities and show the differences among work-related, school-related, and motor vehicle-related injuries. The NHIS has some drawbacks, however. It relies on proxy respondents for information on other household members, and it does not cover the homeless. Also, self-reported information on such behavior as seat-belt and alcohol use is often inaccurate.
- **The National Hospital Discharge Survey (NHDS)** provides annual estimates of patient care and service use from a sample of short-stay nonfederal hospitals. Since 1965, NHDS has surveyed patients' sociodemographic characteristics, length of hospital stay, diagnostic and surgical procedures, expected source of payment, and N codes. But NHDS does not include less severe injury cases and injury deaths occurring before hospitalization. And E codes are often missing from the records of injury patients.
- **The National Electronic Injury Surveillance System (NEISS)** was established in 1972 by the Consumer Product Safety Commission to describe the hazards and assess the injury risks posed by consumer products. NEISS data are abstracted from the records of about 100 hospitals, representing the approximately 5,400 U.S. hospitals with at least six beds and a 24-hour emergency department. NEISS has contributed valuable information to special studies of intentional, nonfatal firearm, and work-related injuries, but it lacks N codes and E codes and uses nonstandard codes for the nature and severity of injury (see Box 6).
- **The National Hospital Ambulatory Medical Care Survey (NHAMCS)** provides place of occurrence, drug use, firearm involvement, E codes, and N codes from hospital records in which injury is the principal diagnosis. Hospital participation is voluntary and the results are valid only for large regions. Also, the hospital visit is the unit of analysis, rather than injuries or injured persons.

Violence Morbidity Data

Collecting valid data on intentional injury and violence presents special challenges for researchers. Victim fear and embarrassment and denial by victims and their families are probably the largest barriers. Physicians and other staff who treat injured patients often miss clues suggesting that an injury may have been inflicted intentionally. A number of national surveys and data systems collect and disseminate information on violent episodes, but all admittedly underestimate the problem. Nevertheless, victims of violence are more likely to go to a hospital than to go to the police, which makes hospital records a primary source of data on violence. A landmark population-based hospital emergency department study, the Northeastern Ohio Trauma Study, detected four times as many nonfatal violence cases involving assault as did the local police.[42]

Leading sources on violence morbidity include the National Crime Victimization Survey, National Child Abuse and Neglect Data System, and

The circumstances of nonfatal injury events can teach valuable lessons about how to prevent injuries.

Photo removed for copyright reasons.

Drug use has increased among young Americans since 1990. Use of illegal drugs increases the risk of injury and of violent behavior.

the National Incidence Study of Child Abuse and Neglect.

Tracking Risky Behavior

Alcohol-related motor vehicle crashes have declined … because of new policies …

The Behavioral Risk Factor Surveillance System (BRFSS) and the Youth Risk Behavior Surveillance System (YRBSS) are CDC-administered surveys that monitor behavior that increases the likelihood of injury or disease. They are early warning systems for new trends in injury and violence. The BRFSS is a telephone survey of adults ages 18 years and older. The YRBSS compiles data largely through a questionnaire self-administered by students in grades nine through 12. Both surveys include information on sociodemographic characteristics and on potentially high-risk behavior, for example, use of weapons and drugs and nonuse of seat belts and helmets.

These two surveys are marred by measurement error from self-reporting and by the undersampling of minorities, males, and low-income people. The adult survey misses the homeless and people without telephones, and the youth survey underrepresents groups with high dropout rates. African Americans and Hispanics are less likely than non-Hispanic whites to own phones and are more likely to be homeless and to drop out of school. Also, boys are more likely than girls to drop out of school.

Risk Factors and Interventions

Injury control practitioners typically devise intervention strategies in three general areas: engineering and technology, education and behavioral change, and legislation, regulation, and enforcement. Economic penalties and rewards make up a fourth area that can promote injury control. Collectively, these strategies represent the "four Es" of injury intervention: engineering, education, enforcement, and economics. An engineering countermeasure could be a divided highway, an educational countermeasure would include classes on motor vehicle safety, and enforcement would encompass the arrest of a driver for speeding. Finally, economic countermeasures include discounts on insurance premiums for nondrinkers or fines imposed on construction companies for violating building codes.

The best strategies are based on an analysis of each situation and the needs of the population to be served. They also are sensitive to local standards and the "public acceptability of the various behavioral, environmental, or engineering and infrastructural changes necessary to reduce injuries."[43]

These strategies have been applied to many target populations with varying success. The most important target abuse of alcohol and other drugs, nonuse of seat belts and motorcycle helmets, access to firearms, and poverty.

Alcohol and Other Drugs

Use of alcohol and other drugs increases an individual's risk of injury.[44] The link between alcohol consumption and automobile crashes is widely known. Not only do drivers have slower reaction times and impaired judgments when they are drunk, but they are more likely to drive too fast. Among U.S. drivers involved in fatal crashes in 1997, 43 percent of intoxicated drivers were driving above the speed limit, compared with 14 percent of sober drivers.[45]

Alcohol-related motor vehicle crashes have declined in the United States because of new policies and stricter enforcement of laws and sentencing. Regular police patrols and sobriety checkpoints caught more drunk drivers, and mandatory license suspensions, prison sentences, and community service requirements provided stronger disincentives for driving when drinking.[46]

Many states increased their minimum drinking age over the past decade to deter teenagers from drinking and driving. Age 21 is now the minimum age to purchase alcohol throughout the United States. These laws have saved an estimated 17,359 lives since 1975, according to NHTSA.

Other countries have also strengthened efforts to discourage drinking and driving and have seen declines in alcohol-related crashes. In Australia, traffic police conduct random breath testing, which has proved highly effective in deterring people from driving while intoxicated.

Fatalities from motor vehicle crashes involving alcohol declined by 32 percent between 1987 and 1997. Alcohol is still involved in more than one-third of all motor vehicle crashes, but this share is down from more than one-half of crashes in 1987.

Each U.S. state sets its own cutoff point for determining whether a motorist is driving under the influence of alcohol (DUI). There is evidence that driving skills become impaired by a blood alcohol concentration (BAC) of 0.02 percent,[47] the minimum level enforced in Sweden. Most U.S. states have much more liberal limits. As of October 1997, the minimum BAC was 0.10 percent in two-thirds of the states and the District of Columbia. The minimum is 0.08 percent in the remaining states.

In addition to the higher risk of injury on the highways, people who abuse alcohol and other drugs often suffer an unusually large number of injuries at home and in the workplace. People labeled as "accident prone" often are alcohol and drug abusers.[48]

Alcohol abuse and dependence also confer added injury risk to the families of alcoholics. Two studies, one using medical records and the other using survey data, found that children of alcoholics face increased risk for injury and illness. The use of alcohol and illegal drugs at home increases the risk for homicide and suicide.[49]

Drug use also shares a well-documented relationship with homicide and assault among low-income populations, especially for minorities.[50] Alcohol, phencyclidine (PCP), and methamphetamine (speed) can trigger violent behavior. And addicts sometimes commit violent acts to obtain drugs or the money to buy them. Such motives are described as economic-compulsive in the health literature.[51]

Because many social, psychological, and biological factors contribute to alcohol and drug abuse, strategies to reduce injury among drug abusers are diverse. The hospital emergency room setting provides a unique opportunity for physicians to diagnose a substance abuse problem and persuade an injury victim to seek treatment. Treating parents' alcohol abuse can lower injury risks for the children of alcoholics.[52]

The violence surrounding the territorial struggles, or turf wars, in the marketing of illicit drugs in some urban areas calls for very different strategies. Drug dealers often wield substantial economic and social power in disadvantaged neighborhoods, which further complicates efforts to prevent drug-related injury and violence. Strategies to stem drug use and trafficking in such areas need to address broad community problems as well as criminal activity. Injury control efforts must consider the effects of a lack of job opportunities and inade-

Photo removed for
copyright reasons.

Laws requiring motorcyclists to wear helmets engender strong opposition, but helmet use has been shown to save lives and reduce injury.

quate public services on drug use in many low-income neighborhoods.[53]

Motor Vehicle Safety

Whether or not they are sober, drivers and passengers are less likely to sustain serious injuries in a crash when they use seat belts, car seats, and other safety devices. The design and maintenance of roads and the design and quality of motor vehicles are also vital to preventing crashes and crash injuries. Motorists are less likely to crash if they comply with traffic laws. There are fewer crashes when traffic and other safety laws are enforced.

All U.S. states have implemented laws that require use of child seats and seat belts in cars. As of May 1997, however, police can apprehend motorists solely for not wearing seat belts in only 13 states. The national prevalence of seat-belt use has been increasing but had reached only 68 percent by 1996. The rates are higher in many other developed countries. Buttressed by strong police enforcement and stiff fines, at least 90 percent of motorists use seat belts in Canada, Germany, and Australia. Highway speeds are also directly related to injury rates. When the speed limit was reduced to 55 mph on U.S. highways during the 1970s, the number and severity of motor vehicle crashes fell. The lower speed limits saved an estimated 5,000 lives annually. A temporary oil shortage, not safety, motivated this law, and the law was later relaxed. Many states increased their speed limits on rural highways to 65 mph or even higher. Fatalities rose by 15 percent between 1982 and 1986 and increased again after 1992. Most analysts linked the increases to faster driving speeds.[54]

The use of motorcycle helmets provides a second example of the effect of laws on highway safety. In 1976, Congress eliminated a financial incentive that had encouraged states to enact laws requiring motorcyclists to wear helmets. Motorcycle groups had lobbied vigorously against these laws as an infringement of their civil rights. Twenty-seven states either repealed or weakened their helmet-use laws. Helmet use plummeted and motorcycle fatalities escalated by 43 percent between 1976 and 1979.[55] Many states later reinstated helmet-use laws. In 1997, laws in 22 states, the District of Columbia, and Puerto Rico required all motorcyclists to wear approved helmets. Three states had no helmet law, and the remaining 25 states required that persons under a specific age (usually 18) wear helmets.[56]

Air bags are the most controversial safety aids in motor vehicles. Authorities have attributed a number of child deaths to air bags activated in crashes, including crashes at speeds as slow as 15 mph. Small adults also face injury risks when air bags deploy. Nevertheless, air bags substantially diminish death and injury risk in head-on motor vehicle crashes for most people.[57]

Much more could be done to reduce the number of people killed on highways around the world every year. Education, an active prevention measure, can help people avoid injury. Experts recommend, for example, that young children always ride in the rear seat of an automobile with air bags. Prominently displayed warning labels inside vehicles with air bags could complement education about related injury risks. In the near future, safer "smart air bags" will be available that can inflate according to occupant weight, use or nonuse of seat belts, and vehicle speed. But these smart air bags are costly, which may delay their adoption by manufacturers.

Firearms

U.S. homicide rates generally dwarf corresponding rates in other developed countries, as do firearm injury death rates among the high-risk 15-to-24-year-old male population (see Figure 9).[58]

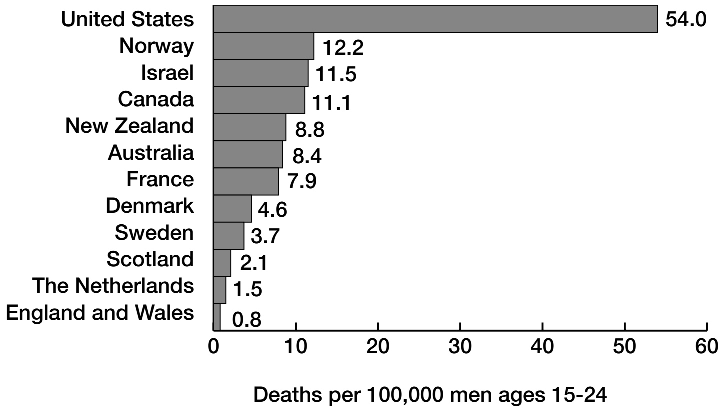
Many experts in violence and injury believe that easy access to firearms, especially handguns, accounts for much of this difference. Other developed countries have enacted stringent gun ownership laws, while most states in the United States have relatively liberal regulations on the sale and ownership of guns. Handguns cause 25,000 U.S. fatalities each year. By comparison, in 1992, handguns killed only 13 Australians, 13 Britons, 60 Japanese, and 128 Canadians.[59]

Proponents of gun control point to statistics showing that firearms are not effective at protecting householders from harm. Homes with guns are almost three times more likely to be the scene of a homicide and almost five times more likely to be the scene of a suicide than comparable homes without guns.[60] Firearms cause about 70 percent of the 20,000 homicides that occur each year in the United States. Almost 60 percent of the 30,000 suicides annually involve firearms.

The criminal justice system alone cannot end firearm-related violence in the United States. And the U.S. Congress is unlikely to enact more restrictive handgun regulations in the near future. But some firearm deaths may be prevented by educating the public about the risks of keeping guns in the home, by promoting safe storage of firearms, by proactive enforcement strategies to reduce gun violence, and by requiring that new handguns meet specific safety standards. Requiring truth in gun advertising, promoting development of child-proof or user-specific firearms, increasing the tax rate on new firearms, and increasing manufacturers' liability for harm are other actions that may prevent firearm deaths.[61] In the long run, the public health strategy to reduce firearm violence must also target drug abuse and poverty.

Figure 9

Firearm Injury Death Rates Among Young Men in Selected Countries, 1992 to 1995



Source: National Center for Health Statistics, *Health United States 1996-97 and Injury Chartbook* (1997): 32.

Poverty

Throughout the world, low-income people have lower life expectancies and higher disease and injury rates than middle- or upper-income people. Among the most developed countries, mortality rates are highest in those countries with the most unequal income distributions—that is, the most poverty.[62] In the United States, chronic socioeconomic inequality and poverty are associated with lower life expectancies for some population groups, especially black males.[63] The alarmingly high homicide rates among black men explain much of the racial gap in life expectancy. Among all racial and ethnic groups in the United States, however, less-educated and low-income individuals are more likely to sustain serious injuries.

Injury control interventions can target unsafe environmental conditions in poor communities and make injury prevention an integral part of school curricula. Better access to appropriate medical care would limit damage once injury occurs.

Over the long term, however, public health professionals seeking to improve the health of the poor will need to tackle factors that perpetuate poverty, including racial discrimination, residential segregation, unemployment, and inferior educational opportunities.

More equitable education opportunities for residents of low-income areas may hold the best promise for reducing their injury risks and improving their health. If high-risk students in poor school districts receive a high-quality education, they will have more employment options as adults and will be less vulnerable to the lure of gang membership and drug trafficking. Some analysts call for more equitable dispersal of education funds among state school districts as a step toward eliminating the structural causes of poverty.[64]

Medical Care for Injuries

When prevention fails, injuries can occur that require medical care. Most injured individuals find their own way to treatment, but more serious cases require the assistance of an Emergency Medical Services (EMS) team. EMS personnel use a triage procedure to determine whether a patient needs to be transported to a trauma center, rather than a closer community hospital.

Triaging also occurs as part of patient processing in hospital emergency departments to identify patients who need immediate care. The concept of triage was initiated in the 19th century by Napoleon Bonaparte's chief military surgeon (and inventor of the ambulance), Baron Dominique Jean Larrey, when he ordered treatment for soldiers based on their injury severity and survival prospects.[65]

The speed with which EMS teams can reach individuals at the scene of injury is often key to the survival of the injured. About one-quarter of severely injured motorists die. But survival chances improve appreciably if appropriate treatment can be administered within 60 minutes of injury—what health personnel call the "golden hour." Faster treatment prevents fatalities primarily through restoring and supporting breathing and secondarily by controlling bleeding and averting shock.

Severely injured people may be taken to a trauma center with specialized services for the injured. (Trauma is the medical term for injury.) Trauma centers serve only a small fraction of injury victims. Less than 1 percent of the more than 3 million Americans injured annually in motor vehicle crashes required trauma center treatment. But trauma surgeons assert that organized trauma centers save an additional 20 percent of trauma patients over the number who could be saved in a traditional hospital setting.[66]

There are over 400 trauma centers in the United States, which are ranked from one to four according to the level of medical services they provide. The most comprehensive trauma centers, Level 1, have a greater involvement in research and physician outreach than other centers. Their hallmarks are around-the-clock trauma surgeons and access to surgical subspecialty services, including microsurgery and cardiopulmonary bypass surgery. The outreach efforts of Level 1 centers can dramatically enhance the treatment available to trauma patients, for example, by linking specialists with care providers in remote rural areas.

Many injury control advocates favor expanding trauma services in all hospitals to hasten treatment of injury victims and save more lives. The time lost in transit to a trauma center can be fatal for a severely injured person.

EMS services alone cannot counteract damage from mass disasters such as hurricanes, floods, earthquakes, and wars. These circumstances generally require large-scale transportation, medical treatment, housing, and food services, and may require international, national, and regional aid as well as local aid. Such mass disasters often bring a greater risk of communicable disease as well.

Future Directions

Injury control is gaining acceptance in the United States and in many other parts of the world. CDC and a growing number of universities have established injury research and prevention centers; injury control curricula are proliferating in schools, colleges and universities; the Internet is facilitating the exchange of injury and violence-related information; international researchers are regularly convening and collaborating; and data collection is becoming more standardized. Furthermore, surveillance efforts are expanding rapidly; the number of successful interventions is multiplying; the activities of injury control practitioners and advocates are widening; and trauma care systems are becoming increasingly sophisticated. But there is no unified public health or injury control policy, and political and economic considerations frequently override public safety concerns.[67]

Emerging Technologies

The future will bring new challenges for injury control experts. A number of emerging technologies will help injury experts meet these challenges by substantially improving the quality, richness, and versatility of injury data sets. Among these newer technologies are automated data entry at injury sites by EMS teams, video imaging for generating diagrams of an injury event, and the Global Positioning System (GPS).

The GPS is a constellation of 24 high-orbiting satellites maintained by the U.S. Department of Defense. Computerized ground receivers access three or four of these satellites simultaneously to enable police, ambulance drivers, and other emergency response personnel to locate their position to within a few meters. When the GPS is used along with a navigation system, authorities can dispatch emergency vehicles rapidly and safely to motor vehicle crash and other probable injury sites. A GPS receiver permits accurate geocoding of the injury events, which is invaluable for subsequent analyses.

Another emerging technology, geographic information systems (GIS), enhances research on disease-, injury-, and violence-related phenomena by creating multidimensional maps that integrate information on time, space, and place. GIS maps allow users to layer data sets on digital maps electronically. A digital map of fatal motor vehicle crashes, for example, could be examined in relation to the crash site's socioeconomic level, population density, topography, and road systems geocoded at the zip code or neighborhood block level; the location of hospital trauma centers and highway patrol stations; and weather and light conditions at the time of the crash. GIS can also incorporate individual level data such as age, sex, race, residential history, and health and risk exposure status. GIS is likely to prove increasingly valuable to epidemiologists and other public health professionals in drawing appropriate survey samples and in planning and evaluating injury prevention strategies and countermeasures.

The most significant technological change is probably the digital revolution, which has dramatically speeded the collection, processing, analysis, and dissemination of information. In particular, this technology is transforming injury surveillance and information dissemination in less devel-

The time lost in transit to a trauma center can be fatal for a severely injured person.

oped countries and in remote areas of more developed countries.

Role of Macro-Epidemiology

Global ecological instability and socioeconomic changes are creating immense research challenges for epidemiologists that will require extraordinary interdisciplinary cooperation. These challenges are strengthening the need for a broad, or "macro," approach to epidemiology.

Injury and violence are influenced by the same ecological shifts and socioeconomic changes that have caused a resurgence of communicable diseases around the world. Climate change, pollution, deforestation, soil depletion, and increased population density and mobility have expanded the niches for microbial disease agents.[68] HIV, ebola, and new strains of tuberculosis are just some of the new disease threats to world health. Calls for a macro-epidemiology that can decode the new reality need to encompass injury and violence.

Population-based research on injury and violence needs new paradigms as much as population-based research on disease. While founded in the physical and biomedical sciences, macro-epidemiology benefits from such disciplines as demography, economics, political science, anthropology, and sociology. GIS is sure to feature prominently in its growth and development.[69]

The health effects of energy unleashed or suppressed by injury vehicles cross national borders just as do the causes of communicable disease—as wars and hurricanes often remind us. To remain in the vanguard of research and prevention of injury and violence, epidemiologists must study the shifting proximity of potential hazards to vulnerable populations.

The digital revolution in communications has fostered a global diffusion of beliefs, values, and practices that can promote or inhibit injury and violence. The movement of capital, technology, and personnel within and across national borders also carries potential health effects. Both globalization and the diffusion of ideas are in the domain of macro-epidemiology.

Past and Future Success

Organized injury control efforts have already extended many lives.[70] Alcohol-related motor vehicle crashes have fallen in many developed countries because of efforts to curb drunk driving. Occupational injuries have declined because of improved work conditions and stricter safety standards. Many products that harmed young children have been modified or removed from the market.

Much more can be accomplished. If current knowledge about injury prevention and control were applied throughout the world, injury mortality, morbidity, and disability would fall dramatically. But application of this knowledge requires global coalitions and partnerships. Such ventures work best when they are endorsed by the entire society, from local neighborhoods to the highest echelons of business and government. But all stand to benefit. The potential rewards for reducing injury and violence are enormous and will be shared by all levels of society—governments, businesses, communities, and individuals.

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