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CHAPTER 26

Injury Control

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INTRODUCTION

We normally think of health problems or diseases as those conditions associated with exposure to infectious agents (e.g., HIV, malaria) or environmental agents (e.g., tobacco, lead), or due to genetic disorders. Yet, the leading cause of years of potential life lost, the fourth leading cause of death, and one of the top causes of disability in the U.S. population has nothing to do with those conditions. These deaths and morbid and disabling conditions relate to acute exposure to some form of energy in amounts that exceed the individual's tolerance thresholds, therefore resulting in injuries. This is a health problem as old as humankind.

Given the magnitude of this problem, it would seem natural, then, that as public health practitioners we should turn our attention to injuries and their control. Unfortunately, this has not been always the case.

Injuries and their prevention have not traditionally been embraced as a public health issue. One obstacle

has been the belief that injuries are the result of "accidents," which has placed them in that awkward position of being considered by many to be unpredictable and therefore unpreventable. In the instances in which they were "investigated," the conclusion was often that they were primarily due to some irresponsible behavior on the part of the injured individual or someone else. As a result, injury control has been retarded by the "accident" folklore, including the notion of reckless, selfish, careless, and intoxicated people as primarily responsible for injuries.¹ Thus, until the last quarter of the twentieth century, the field of injury control was characterized by misunderstanding, lack of progress, and scarcity of relevantly trained scientists.

In this chapter we will provide a brief overview of the injury problem. The chapter is designed to provide a general orientation, rather than an exhaustive discussion. The goal is to facilitate a clearer understanding of the role of the public health practitioner and public health agencies in the reduction of the burden

related to injuries. To achieve that goal we will present useful definitions and conceptual frameworks, a summary of the magnitude of the problem, and examples of the use of public health tools in its prevention. Emphasis is placed on the preventability of these injuries and wherever possible we have provided examples of prevention efforts. It is not our intent to provide a detailed account of the epidemiology of injuries, nor the effectiveness or efficiency (or lack thereof) of all interventions tested to date. Many other references are available to the reader interested in those matters.²⁻⁵

DEFINITION OF INJURY

We will use the term *injury* to describe any damage to the body due to acute exposure to amounts of thermal, mechanical (kinetic or potential), electrical, or chemical energy that exceed the individual's tolerance for such energy, or to the absence of such essentials as heat or oxygen. We have, therefore, adopted the broad definition first described in *Injury Prevention*⁶ and recently

endorsed by the latest Institute of Medicine report⁷ which includes intentional injuries (e.g., homicide, suicide) as well as unintentional injuries. This chapter also encompasses injuries regardless of where they occur (e.g., outdoors, at home or school), the activity that was taking place when the injurious event happened (e.g., occupational, recreational, sports-related), or the object that was involved in the energy transfer (e.g., motor vehicle, consumer product, gun). Table 26.1 lists energy types, their frequency as the source of fatal injuries in the U.S. population, the vehicles (or vectors) that most frequently transfer the energy, and the most common types of resulting injuries.

DIMENSIONS AND MAGNITUDE OF THE PROBLEM

In the United States, approximately 150,000 people die every year because of injuries.⁸ Injuries, therefore, constitute the fourth leading cause of death in our population, right behind cancer, heart, cerebrovascular, and respiratory diseases (Table 26.2). However, injuries are

Table 26.1. Examples of Energy, Vehicle, Injury Types and Their Incidence in the 1998 U.S. Fatally Injured Population (N = 150,445)

Etiology of Injury	Vehicle (vector)	Type of Injuries	Percentage of Deaths
Kinetic energy	Motor vehicle, train, other vehicles, guns, knives, machinery	Abrasions, contusions, sprains, strains, dislocations, fractures, concussion, blunt, open wounds (cuts, piercing), crushing	54.7
Chemical energy	Drugs, cleaning products, poisonous animals	Poisonings, burns	13.5
Absence of oxygen	Water, foreign objects	Strangulation, suffocation, drowning	8.1
Potential energy*	Falling person	Same as kinetic	11.1
Thermal energy	Fire	Burns, heat stroke	2.5
Electrical energy	Wires, appliances	Electrocutions	0.4
Ionizing energy		Radiation damage	<0.1
Absence of heat		Frostbite	0.3
Unknown			9.4

SOURCE: CDC Wonder, compressed 1998 (online). Available at: <http://wonder.cdc.gov>.

*It has been argued, however, that potential energy causes injury only when transformed into kinetic energy.

Table 26.2. Five Most Common Causes of Death by Age Category, 1998

Rank		Age Groups							Total	
		<1	1-4	5-9	10-14	15-24	25-34	35-44		45-54
1	Congenital Anomalies 6,212	Injuries 2,377	Injuries 1,736	Injuries 2,368	Injuries 23,332	Injuries 22,709	Injuries 26,817	Malignant Neoplasms 45,747	Malignant Neoplasms 87,024	Heart Disease 724,859
2	Short Gestation 4,101	Congenital Anomalies 564	Malignant Neoplasms 487	Malignant Neoplasms 526	Malignant Neoplasms 1,699	Malignant Neoplasms 4,385	Malignant Neoplasms 17,022	Heart Disease 35,056	Heart Disease 65,068	Malignant Neoplasms 384,186
3	SIDS 2,822	Malignant Neoplasms 365	Congenital Anomalies 198	Congenital Anomalies 173	Heart Disease 1,057	Heart Disease 3,207	Heart Disease 13,593	Injuries 18,534	Injuries 11,283	Cerebro-vascular 158,448
4	Maternal Complications 1,343	Heart Disease 214	Heart Disease 156	Heart Disease 170	Congenital Anomalies 450	HIV 2,912	HIV 5,746	Liver Disease 5,744	Bronchitis Emphysema 10,162	Injuries 150,445
5	Respiratory Distress Synd. 1,295	Pneumonia & Influenza 146	Pneumonia & Influenza 70	Bronchitis Emphysema 98	Bronchitis Emphysema 239	Cerebrovascular 670	Liver Disease 3,370	Cerebrovascular 5,709	Cerebrovascular 9,653	Pneumonia & Influenza 82,989

SOURCE: Adapted from report by Centers for Disease Control and Prevention.

the leading cause of death for individuals ages 1 through 44. Therefore, injuries become the most important cause of Years of Potential Life Lost (YPLL), almost 20 and 25 percent higher than the YPLLs associated with cancer and cardiovascular diseases, respectively (Figure 26.1).

In addition to deaths, injuries result in some 2.5 million hospital admissions (fractures alone represent 3 percent of all hospital discharges) and more than one-quarter of all emergency room visits, for a total of almost 100 million physician contacts every year.⁹ The relationship between mortality and morbidity (or different degrees of severity) is referred to as the "iceberg" or "pyramid" of injury (Figure 26.2) and the actual ratio between each of the levels of that pyramid varies depending on the specific injury or the specific injury mechanism, as some injuries are more lethal than others. For example, gun-related injuries are much more likely to be fatal than fall-related injuries. Table 26.3 further illustrates this point by presenting the crude death and hospitalization rates per 100,000 population by several mechanisms of injury. In the table, homicide/legal interventions have a death:hospitalization ratio of 1:1.9, whereas fall-related injuries have a ratio of 1:16.4.

Injuries are also a leading source of short- and long-term disability. It is estimated that some 7 percent of individuals who are injured sustain some degree of disability, which means some 4 million new cases per year.¹⁰

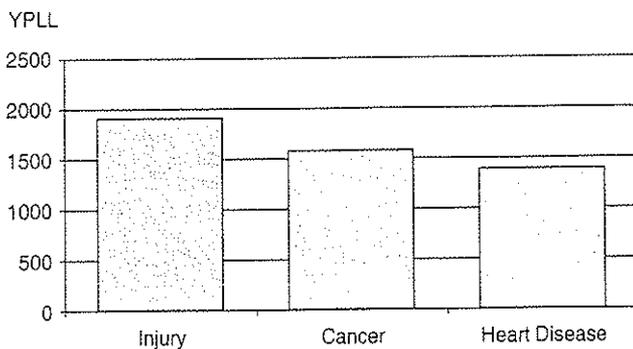


Figure 26.1. Years of Potential Life Lost* by Cause of Death

Adapted from Institute of Medicine report, 2000.

*Years of Potential Life Lost calculated up to age 75.

When one combines mortality, morbidity, and disability in a metric such as the Disability Adjusted Life Years (DALYs), injuries are responsible for approximately 15 percent of all DALYs lost in the developed world. Worse yet, it is estimated that by the year 2020, injuries (road traffic crashes and self-inflicted injuries) will be the second leading cause of DALYs lost in the developed world—right after ischaemic heart disease. Worldwide, road traffic injuries alone are anticipated to be the third cause of lost DALYs, right after ischaemic heart disease and unipolar major depression.¹¹

The economic impact of injuries is significant also. It is estimated that the aggregate lifetime costs of all injuries produced in a year amounted to nearly \$180 billion dollars in 1988.¹² In a 1994 study done by the National Highway Traffic Safety Administration (NHTSA), the injury-related costs of motor vehicle crashes were \$94 billion¹³, an approximate \$30,000 per each of the 3,215,000 police-reported victims for that year.¹⁴ In 2000, the most recent year for which official statistics are available, the number of police-reported victims was 3,231,000.¹⁵

Last, a summary on the impact of injuries cannot be complete without reference to the largely unmeasured but immense burden that they impose on families and communities. The literature in this field is peppered with evidence of higher divorce rates among parents of injury victims, higher school dropout rates among

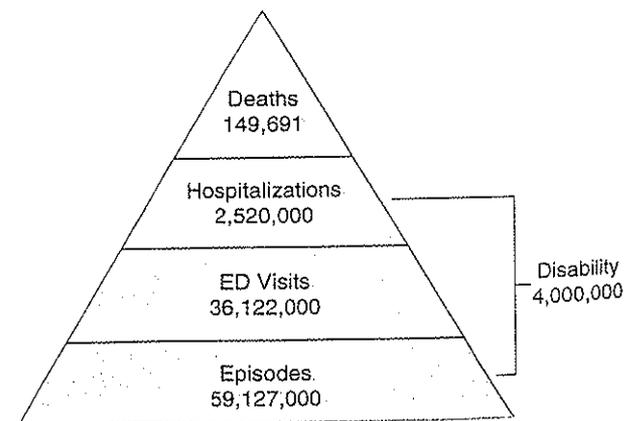


Figure 26.2. The Pyramid of Injury (United States, 1997)

Sources: CDC Wonder, 1997; Warner et al., 2000.

Table 26.3. Crude Rates of Deaths and Hospitalizations Due to External Cause of Injury per 100,000 Population

	Deaths	Hospitalizations
Motor Vehicle E810-E825.9	16.08	46.3
Falls E880-E888.9	6.02	98.7
Drowning E830 E832 E910.9	1.63	0.1
Fires/Flames E890-E899.9	1.2	1.2
Poisonings E850-E869.9	3.99	0.5
Homicide/Legal Intervention E960-E978.9	6.76	13.4
Suicide E950-E959.9	11.3	3.3
Other	8.64	8.7
Total E800-E999.9	55.62	251.3

SOURCE: Death rates: 1998 CDC Wonder (online). Available at: <http://wonder.cdc.gov>. Hospitalization: analysis of the 1998 or 1997 hospital discharge data of the following eight states: Michigan, North Carolina, South Carolina, Massachusetts, Washington, Wisconsin, Maryland, and Colorado (not published), State Population 1997 or 1998 U.S. Census. Injuries were classified using E codes (*International Classification of Diseases*, 9th rev. Geneva, Switzerland: World Health Organization 1997).

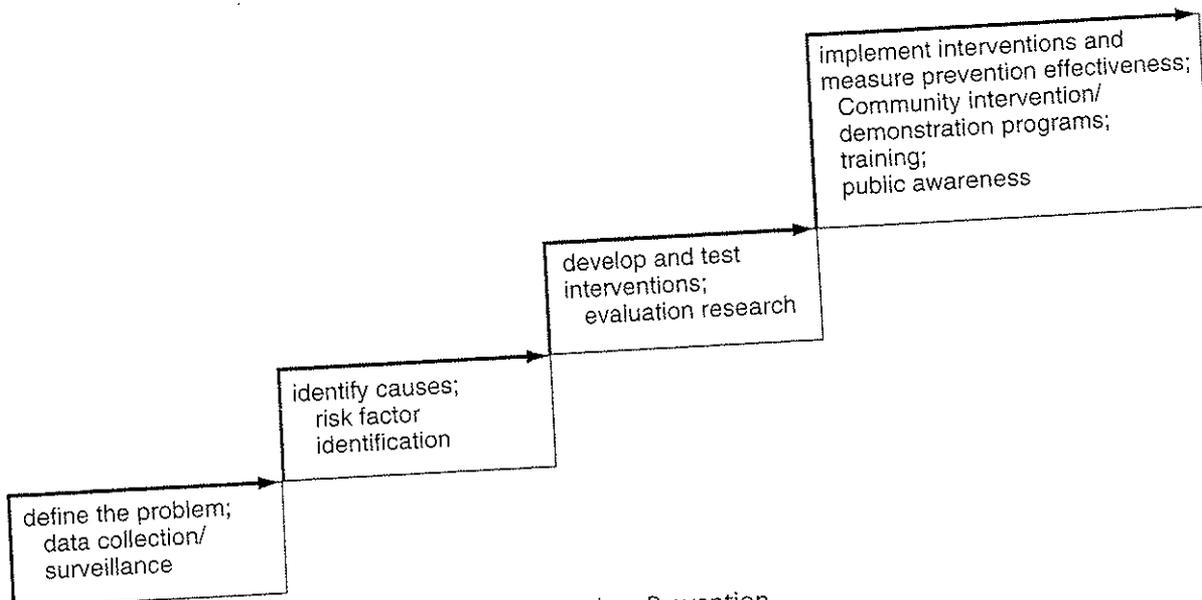


Figure 26.3. Public Health Model of a Scientific Approach to Prevention
Source: National Center for Injury Prevention and Control, Centers for Disease Control and Prevention.

siblings of victims, and higher alcohol and drug involvement among relatives and others.¹⁶

THE ROLE OF PUBLIC HEALTH

As with any other population health problem, one can apply the public health model of a scientific approach to prevention (Figure 26.3).

During the remainder of this chapter, we will follow this model. Under "Epidemiological Framework", we will discuss issues related to the definition of the problem: data collection and surveillance, the identification of causes and risk factors, and the development of interventions. Under "Choice and Evaluation of Countermeasures" we will present issues related to the testing and selection of interventions.

Issues that relate to the last step of the public health model will be presented in the "Axioms to Guide Injury Prevention" section and in our discussion on the roles of public health practitioners and public health agencies.

Epidemiological Framework

Injury epidemiology allows for investigation of the interaction between the host (or individual injured), the etiological agent (energy), the vehicle or vector that transmits the energy, and the physical and socio-cultural environment where the interaction occurs. (*Vehicles* are the inanimate objects that transmit the energy [e.g., cars, matches, guns] whereas *vectors* are the plants, animals, or persons that transmit the energy [e.g., biting animals, poisonous snakes, human fists].) The use of epidemiology has helped demonstrate that injuries, like diseases, display long-term trends and demographic, geographic, socioeconomic, and seasonal patterns. However, it was not until 1949 that Dr. John Gordon first acknowledged that injury occurrence and severity, much like any other health condition, could be measured and related to different characteristics of individuals, the sources of injuries, and their environments. It was only in 1961 that Dr. James Gibson separated the role of the vehicles or vectors from that of the energy they transmit, thus enabling the application of the analytical framework of epidemiology to the study of injuries. (Readers interested in a more extensive review of the history of injury control are referred to the work of J. A. Waller.)¹⁷

Data Collection and Surveillance

Effective injury control requires collection of appropriate detailed data (e.g., frequency, location) related to the injury under study and the events or circumstances surrounding that injury. The analysis of such data helps us to understand the epidemiological patterns of these problems, identify risk factors, suggest causal factors, and guide us in the development of preventive interventions. At times, researchers develop unique data collection efforts to better address the issues under investigation. Most commonly, though, existing datasets are used, despite the fact

that most of these datasets are administrative in nature and tend to be oriented either toward the injuries (i.e., the medical aspects) or toward the events (i.e., the incidents or "accident" aspects), and rarely include enough detailed information for both. Several U.S. government and private agencies maintain data systems that collect injury data on a continuous basis as part of their public health practice. Table 26.4 lists some of the most commonly used data systems, as well as their Web addresses.

Identification of Causes and Development of Interventions

We have indicated, thus far, that injuries involve an unfavorable interaction between etiologic agents and the individual. Therefore, the essence of injury prevention involves keeping the etiologic agent from reaching the potential host at all (i.e., preventing the interaction) or from reaching it at rates and amounts that would produce damage (i.e., minimizing the consequences). Under some circumstances, prevention is aimed at modifying the agent; under others, at reducing exposure to the agent or the susceptibility of individuals. Several conceptual models have been developed over the past 30 years to facilitate understanding of injury-producing events and possible countermeasures. Before we present these models, let us revisit the sequence of injury events.

We live in a particular environment. In this environment, we conduct our lives: we walk, drive, exercise, prepare meals, and do countless other things. On each occasion, we are exposing ourselves to the possibility of undergoing a fortuitous event that may lead to an injury. This is what could be referred to as the *exposure* component of the chain of events. For example, consider every minute a child spends enjoying a playground. Every so often, an *event* may happen. (Events are what many people would refer to as accidents.) Following our example, the child falls from the swing. In only a fraction of these falls will the event lead to any *injury*. Some of these injuries, however, may be severe enough to cause death or disability. This chain of events is depicted in Figure 26.4. This sequence of events is very similar to what has been labeled as the Domino Model¹⁸ because of the linear relationship between the different

Table 26.4. Selected Surveillance Systems Used in Injury Control

Data System	Acronym	Federal Agency	Web Address
Census of Fatal Occupational Injuries	CFOI	Bureau of Labor Statistics	http://www.bls.gov
Survey of Occupational Injuries and Illnesses	SOII	Bureau of Labor Statistics	http://www.bls.gov
National Crime Victimization Survey	NCVS	Bureau of Justice Statistics	http://www.ojp.usdoj.gov
National Ambulatory Medical Care Survey	AMCS	Centers for Disease Control and Prevention	http://www.cdc.gov/nchswww
National Hospital Ambulatory Medical Care Survey	NHAMCS	Centers for Disease Control and Prevention	http://www.cdc.gov/nchswww
National Hospital Discharge Survey	NHDS	Centers for Disease Control and Prevention	http://www.cdc.gov/nchswww
National Health Interview Survey	NHIS	Centers for Disease Control and Prevention	http://www.cdc.gov/nchswww
National Mortality Followback Survey—1993	NMFS93	Centers for Disease Control and Prevention	http://www.cdc.gov/nchswww
National Vital Statistics Systems—Current Mortality Sample	NVSSS	Centers for Disease Control and Prevention	http://www.cdc.gov/nchswww
National Vital Statistics Systems—Final Mortality Data	NVSSF	Centers for Disease Control and Prevention	http://www.cdc.gov/nchswww
Behavioral Risk Factor Surveillance System	BRFSS	Centers for Disease Control and Prevention	http://www.cdc.gov/nccdphp/brfss
Youth Risk Behavioral Surveillance System	YRBSS	Centers for Disease Control and Prevention	http://www.cdc.gov/nccdphp/dash/yrbs
National Traumatic Occupational Fatality Surveillance System	NTOF	Centers for Disease Control and Prevention	http://www.cdc.gov
National Electronic Injury Surveillance System	NEISS	Consumer Product Safety Commission	http://www.cpsc.gov
Law Enforcement Officers Killed and Assaulted	LEOKA	Federal Bureau of Investigation	http://www.fbi.gov/ucr
National Incident Based Reporting System	NIBRS	Federal Bureau of Investigation	http://www.ch.search.org
Uniform Crime Reporting System—Supplemental Homicide Report	UCRSHR	Federal Bureau of Investigation	http://www.fbi.gov
Nationwide Personal Transportation System	NPTS	Federal Highway Administration	http://www.bts.gov/ntda/npts
Healthcare Cost and Utilization Project	HCUP-3	Agency for Health Care Policy and Research	http://www.ahcpr.gov/data

(continued)

Table 26.4. Selected Surveillance Systems Used in Injury Control (*continued*)

Data System	Acronym	Federal Agency	Web Address
Healthcare Finance Administration	CMS	Centers for Medicare & Medicaid Services (formerly the Health Care Financing Administration)	http://www.cms.hhs.gov
Indian Health Service—Ambulatory Care System	IHSACS	Indian Health Service	http://www.ihhs.gov
Indian Health Service—Inpatient Care System	IHSICS	Indian Health Service	http://www.ihhs.gov
National Child Abuse and Neglect Data System	NCANDS	National Center for Child Abuse and Neglect	http://www.ndacan.cornell.edu
National Incidence Study of Child Abuse and Neglect	NIS	Office of Child Abuse and Neglect (formerly the National Center for Child Abuse and Neglect)	http://www.ndacan.cornell.edu/Flyers
Fatal Accident Reporting System	FARS	National Highway Traffic Safety Administration	http://www.nhtsa.dot.gov/fars
National Accident Sampling System—Crashworthiness Data System	NASSCDS	National Highway Traffic Safety Administration	http://www.nhtsa.dot.gov/people
National Accident Sampling System—General Estimates System	NASSGES	National Highway Traffic Safety Administration	http://www.nhtsa.dot.gov/people
National Occupant Protection Use Survey	NOPUS	National Highway Traffic Safety Administration	http://www.nhtsa.dot.gov
Monitoring the Future Study	MTFS	National Institute of Drug Abuse	http://www.health.org/mtfs
Drug Abuse Warning Network	DAWN	Substance Abuse and Mental Health Services Administration	http://www.health.org/pubs/dawn
Census of Agriculture—1997	BCCOA	Bureau of the Census	http://www.nass.usda.gov/census
National Fire Incident Reporting System	NFIRS	Fire Administration	http://www.usta.fema.gov/nfdc

components of this model. Injury prevention will consist of intervention(s) aimed at blocking the progression of the events. In our example, we could have prevented the event from happening by eliminating the swings from the playground area or by designing them in such a fashion that prevents ejection

of the child. We could have minimized the impact of the fall by using an energy-absorbing flooring underneath the swing. Finally, we could have minimized the consequences of the injury by providing quick care at a pediatric facility with expertise in head injury.

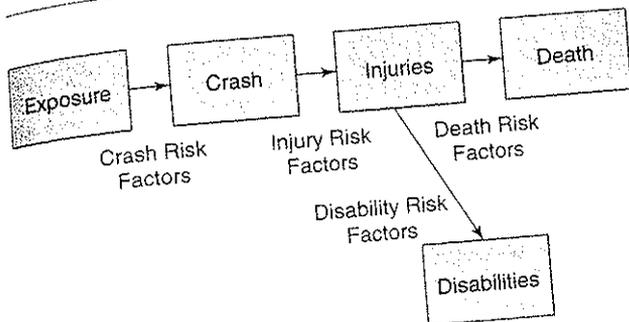


Figure 26.4. Chain of Injury Events

The Haddon Matrix

Dr. William Haddon, a pioneer in the field of injury prevention, proposed a framework that integrates the role of the *individual*, the *vehicle* or vector carrying the energy, and the *environment* in which the interaction occurs with the sequence of events associated with the injury.¹⁹ This sequence of events is divided into *pre-event* (i.e., preventing the event or incident from occurring), *event* (i.e., preventing injury while the event is happening), and *post-event* (i.e., minimizing the adverse results after the event has occurred). For example, interventions aimed at eliminating motor vehicle crashes or falls from windows are pre-event interventions. Event interventions are aimed at either preventing the injury or at reducing the resulting injury by minimizing its severity. Examples of interventions at this stage would include bicycle helmets that protect children when they fall from bikes, or pills with smaller medication doses so that they are not as toxic if ingested inappropriately. The variety and effectiveness of countermeasures at this event stage highlight the point that even if the event (e.g., crash) is not prevented, damage to passengers and occupants can be reduced or eliminated. Post-event interventions can be directed to two goals: reducing any further damage or restoring the health of the individual who sustained injuries.

In Table 26.5 we have listed potential interventions to prevent motor vehicle-related injuries, particularly child occupant injuries, using the Haddon Matrix.

Haddon's Ten Basic Strategies

After developing the matrix, Haddon described 10 basic strategies for injury control, presented here with examples relating to injury produced by chemicals (in parentheses):

1. Prevent the initial marshaling of the agent. (Do not produce lead paint.)
2. Reduce the amount of the agent marshaled. (Package medicine in small quantities.)
3. Prevent release of the agent. (Use childproof caps on bottles of medicine.)
4. Modify rate or spatial distribution of release of agent from its source. (Devise containers that release poison at limited rates.)
5. Separate, in space or time, the agent from the susceptible person. (Keep children out of orchards while spraying.)
6. Separate the agent from the susceptible person with a material barrier. (Use gas masks.)
7. Modify the contact surface, subsurface, or basic characteristics of the agent. (Reformulate detergents to make them less caustic.)
8. Strengthen the resistance of the person who might otherwise be damaged. (Immunize susceptible people against insect stings.)
9. Counter the continuation and extension of the damage. (Provide and make use of first-aid treatment and poison control centers.)
10. Repair and rehabilitate. (Institute intermediate and long-term therapy.)

Obviously, there are some commonalities between these 10 countermeasures and the matrix described in the previous section. Several of these countermeasures relate to the host,^{5,6,8} some to the vehicle or vector,^{1-4,7} and some to the environment.^{5,6,9,10} They could also be classified as pre-event, event, or post-event. Actually, some authors have indicated that countermeasures 1 through 3 could be described as pre-event interventions, 4 through 8 as event interventions, and 9 and 10 as post-event interventions,²⁰ although Haddon himself disagreed with such categorization. For example, countermeasure 1 could also be an event intervention, and countermeasure 5 could also be considered a pre-event intervention.

Table 26.5. Haddon Matrix with Selected Examples of Motor Vehicle Occupant Injury Prevention Interventions

	Host (Child and Adult Occupants)	Vehicle (Car)	Environment Physical (road)	Socioeconomic
PRE-CRASH	Avoid behaviors that may distract driver Driver's age, gender, driving experience, drug or alcohol use, fatigue	Antilock brakes Speed Daytime running lights	Traffic patterns (e.g., exit ramps, crossings) Weather, visibility	Children in rear seats Legislation regarding child restraint Speed limits, licensing laws
CRASH	Adequate child restraint Safety belts, airbags	Seating position Built-in child car seats Sensors detecting occupant's size/weight Vehicle speed, size, and mass Interior surfaces	Separation from other lanes Energy-absorbing roadside fixtures	
POST-CRASH	Exercise and other health enhancement to reduce comorbidity	Crash detection systems that notify EMS (and indicate type of occupants on board) Designs to facilitate extrication Improve location of fuel tank	Designated lanes for emergency vehicles Reduce distance from EMS	Insurance system EMS system prepared to handle children Societal acceptance of residual disabilities

Human Performance and Environmental Demands Model

Another system-oriented model was described in the ergonomics literature by Blumenthal.²¹ This model is centered on the dynamic interaction between the subject and his or her environment (Figure 26.5). The lower line represents the variable demands of a particular task, for example, driving a car, and includes the limitations and deficiencies in the vehicle and the environment (including other drivers). The upper line represents the performance of the subject of interest. The injurious event occurs when the system demands increase and/or the subject performance decreases simultaneously to levels at which they overlap. At times, it is the individual's behavior that fails dramatically, such as in the situation of a driver who suffers a myocardial infarction or stroke. At other times, it is the system that becomes overwhelming, as in the case where another vehicle on the road has a tire blowout. The third, and most common situation, involves neither cataclysmic human failure nor overwhelming demands, but rather a simultaneous decrease in performance and increase in task demand. Such would be the situation where an intoxicated driver (who may be able to drive in a straight line) fails to negotiate an unexpected curve or a teenager is distracted by a passenger.

Historically, efforts in injury prevention have focused on the individual's performance. It is only recently that attention has been focused on simplifying the task (i.e., the demands).

Choice and Evaluation of Countermeasures

The role of epidemiology in identifying modifiable risk factors is closely related to the identification of countermeasures. Modifiable risk factors become the basis for intervention design. It should be emphasized that factors playing an important role in minor injuries are not necessarily the same as factors that are important in severe or fatal injuries. Consequently, the choice of countermeasure may change as the severity of injuries changes. It should also be emphasized that countermeasures should not be determined by the relative importance of causal or contributing factors or by their earliness in the sequence of events. Rather, priority and emphasis should be given to

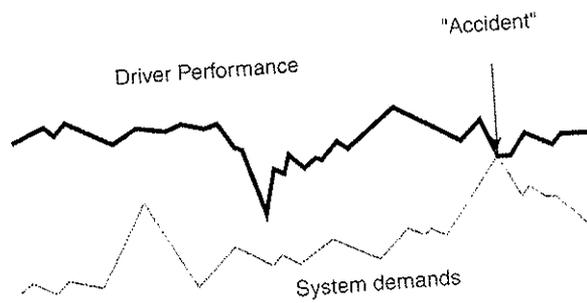


Figure 26.5. Hypothetical Localized System Failure
Source: Blumenthal, 1968.

measures that will most effectively and efficiently reduce injury losses. For example, although psychological factors may be important in the initiation of motor vehicle crashes, it does not follow that psychological screening of drivers would be fruitful.

It is also important to discuss the assumption that anything that sounds reasonable will be effective; this has been the rationale for countless programs, from "defensive driving" training to holiday death counts. Safety programs not only may lack effectiveness, but under certain circumstances they could even increase the number or severity of injuries, as in the case of driver education programs that enable teenagers to drive at an earlier age than they otherwise would.²²

Numerous safety measures have been adopted without proof of their effectiveness, or have not been evaluated. The resulting entrenchment of untested measures makes improvement difficult and comparison with alternatives impossible. Millions of dollars can be wasted in unsuccessful safety campaigns, and without adequate preplanned evaluation, no one will ever know whether a campaign was effective and guidance for the future will be lost. In contrast, many other interventions have been evaluated. Table 26.6 lists selected injury control interventions that have been proven effective. For a review on the issues involved in evaluating injury more detailed prevention interventions, refer to Dannenberg and Fowler's article in *Injury Prevention*.²³

Another issue to keep in mind when selecting countermeasures is that, very frequently, a "mixed

Table 26.6. Examples of Injury Prevention Strategies of Known Effectiveness¹²

Motor vehicle	Child passenger restraint Child passenger restraint laws Safety belts Safety belt laws Sobriety check points Laceration protective windshields Nighttime curfews for teenage drivers Pedestrian-friendly front end of automobiles Minimum drinking age laws Breakaway utility poles
Firearm	Absence of handguns in homes
Fires/burns	Manufacture of fire-safe cigarettes Smoke detectors Automatic sprinklers Fire-resistant pajamas for children Legislation regulating flammability of children's clothing Fire exits and fire drills
Recreational	Four-sided barriers for swimming pools Bicycle helmet use Promoting bicycle helmet use (e.g., laws) Break-away bases for softball
Sports injuries	Mouthguards Protective equipment (e.g., knee and elbow pads, wrist pads for inline skating)
Falls	Window guards in high-rise buildings Prevention or treatment of osteoporosis in women Protective hip pads for elderly Weight-bearing exercise among elderly Fall-cushioning materials underneath playground equipment
Poisonings	Packaging of children's aspirin in sublethal doses
Farm	Rollover protective structures on farm tractors
Choking and suffocation	Legislation and product design changes (e.g., safe refrigerator disposal, warning labels on thin plastic bags)
All injuries	Minimum drinking age of 21 Increase in excise tax for alcohol 911 response systems

strategy" should be employed, incorporating countermeasures that address complementary aspects. Here the challenge will be in choosing the right type, intensity, and order of interventions to make the "combined" countermeasures most efficient. For example, whether airbags should be designed to protect even unbelted occupants in a frontal collision or as a supplement to safety belts became the issue of a long

and intense dispute among motor vehicle safety specialists in the early 1980s. Once it was decided that they should be supplemental restraints, the issue of which crashes were severe enough to warrant airbag deployment in a belted occupant became the new topic of debate.²⁴

Choices must be made, by default if not consciously, on such matters as these or on the question

of how many dollars to spend in preventing a given number of lost days or injury hospitalizations or deaths. More complicated still are decisions as to how many hundreds of drivers a state will attempt to take off the road in an effort to prevent one of them from killing himself or herself or someone else. This conscious weighting of alternatives is often lacking in the safety field.

AXIOMS TO GUIDE INJURY PREVENTION

Over the years, enough experience has been gathered to establish several axioms that can help guide efforts in controlling injuries. These were explained and illustrated in the first edition of this chapter by Sleet and Rosenberg and are presented again²⁵ in the sections below:

A. Injury Results from Interactions between People and the Environment

The agent of injury will cause little damage if the amount of energy reaching tissues is below human tolerance levels. For example, tap water temperature of less than 120 degrees Fahrenheit is not likely to acutely damage human tissue, although higher temperatures may. The importance of this interaction is recognized by approaches that control the environment by reducing hot water temperatures at the tap and that simultaneously target the elderly and parents of small children for education about hot water scald risk, including the need for reduced tap water temperatures.

B. Injury-Producing Interactions Can Be Modified through Changing Behavior, Products, or Environments

Modifying the weakest or most adaptable link in the chain of causation can reduce injuries. Unsanctioned swimming in a home swimming pool is more easily reduced by placing an isolation fence or barrier between the child and the pool than by supervising the child's behavior all the time. During sanctioned swimming, supervision is the most

important strategy. Changing the environment, the laws, the person, or the product can each lead to reductions in injuries.

C. Environmental Changes Have the Potential to Protect the Greatest Number of People

Changes to the environment that automatically provide protection to every person have the potential to prevent the most injuries. Automatic protection includes, for example, barriers built into roads, automatic sprinkler systems in buildings, collapsible steering wheel columns in vehicles, fuses in homes, and child-resistant packaging of consumer products. Such passive interventions have even more success when the public is informed and convinced of their need and benefits.

D. Effective Injury Prevention Requires a Mixture of Strategies and Methods

Three primary strategies—education/behavior change, technology/engineering, and legislation/enforcement—are widely recognized as effective in preventing injuries. Individual behavior change, product engineering, public education, legal requirements, law enforcement, and changes in the physical and social environment work together to reduce injuries. The challenge in intervention planning is to select the most efficient combination of strategies to produce the desired results.

E. Public Participation Is Essential for Community Action

Effective public policy requires the support and participation of community members. Local conditions and resource availability often determine the direction of injury prevention programs. Injury prevention is most successful when there is public participation, support for, and understanding of injury prevention methods. Without public support, laws that are designed to protect the public, such as laws requiring the use of bicycle or motorcycle helmets, or safety belt

use, may be ignored and/or repealed. This was clearly seen in the Massachusetts legislature regarding mandatory safety belt use; the law was repealed by popular vote in 1986, 11 months after the legislation had been enacted, and enacted again in 1994.

F. Cross-Sector Collaboration Is Necessary

Injury prevention requires coordinated action by many groups. Participation by community leaders, in addition to health officials, is necessary in planning and implementing injury prevention programs. There are a number of ways that other community members can contribute to a program's success, ranging from identifying problems to mobilizing community action and evaluating intervention effectiveness.

THE ROLE OF THE PUBLIC HEALTH PRACTITIONER

Public health professionals can play a vital role in injury prevention from a variety of positions:

Research

Public health practitioners are particularly well positioned to collect and analyze local data to identify injury patterns, trends, and risk factors. They are also well positioned to introduce scientific methods to injury control by insisting that new countermeasures be evaluated and that, where relevant, they first be subjected to testing in the field.²⁶

Service

Public health practitioners can assist community organizations in analyzing data and choosing countermeasures that are known to be effective.

Education

It is essential to educate not only individuals in the community but also, and even more important, the public and private decision makers (e.g., legislators,

designers, executives, builders) whose decisions affect the risk of injury for large numbers of individuals. Every day, these decision makers are confronted with issues such as whether to delay implementation of vehicle standards; whether to make an appliance safer or depend upon users always to follow directions; or whether to promote products on the basis of their potential for reducing injury or assume that "you can't sell safety." Public health practitioners can be of great assistance in these processes. It is also particularly important to educate the members of the media.

Influencing Legislation and Regulation

Public Health practitioners are particularly well positioned to assist (or initiate) local policy discussions and assist in evaluating the appropriateness or quality of the facts presented by the different parties involved in policy discussions. For a public health practitioner to be successful in all these areas, he or she must also be aware of the barriers to the implementation of injury prevention activities; namely, funding limitations, organizational difficulties and turf battles.²⁷

THE ROLE OF PUBLIC HEALTH AGENCIES

Information Collection

Effective injury control depends upon adequate information systems. National agencies play a major role in the response to injury-related issues, but the quality of their basic data is determined, predominantly, at the local level. Health departments should stimulate uniform reporting and prompt analysis of injury data and make appropriate use of injury data in administration. Numerous issues that related to injury definition, coding, case inclusion criteria, event definition and coding and its standardization remain unresolved and prevent further advance of the injury field.

National public health agencies must also reinforce these activities by ensuring that information devel-

oped from local data eventually gets back to the local level.

Regulation and Legislation

Safety standards have long been applied to many kinds of products and operations. Standards may be descriptive in nature, specifying such things as materials, design, and process, or they may be performance standards, indicating what a product should do (and what it should never do) no matter how it is made. For safety purposes performance standards are generally preferable, although both types sometimes contribute little except a false sense of security. Most commonly, standards are voluntary and industry-wide. Yet, voluntary standards are often insufficient. A 1970 report found that of 44 product categories causing the most injuries, only 18 were covered by industry-wide standards and many of those were deficient.²⁸ Whether the situation has improved since then is unknown, since this issue has not been reviewed recently (Consumer Products Safety Commission, personal communication). When public attention is drawn to an industry's failure to keep its products from being unreasonably hazardous, the government may consider issuing regulatory standards.

In addition to product and environmental standards, laws regulating human behavior are also intended to reduce injuries. As with other regulations, whether they succeed depends upon whether they are enforced, whether the penalties are effective, and whether the basic assumptions underlying the regulations and their enforcement are valid. State-level safety belt laws provide a wonderful example of this point. As of 2001, all states except New Hampshire have some form of safety belt law for motor vehicle occupants. The degree of coverage, details, and enforcement of these laws varies widely from state to state; however, one of the most distinguishing factors of these laws' effectiveness is whether they are primary (i.e., not wearing safety belts is reason enough for arrest and punishment) or secondary (i.e., some other offense is needed for the safety belt regulation to be reinforced). Figure 26.6 shows safety belt use as reported from observational surveys by state. States

with secondary safety belt laws have significantly lower safety belt use.

Emergency Systems

When primary prevention strategies fail, secondary and tertiary strategies become imperative. Municipal, state, and federal agencies are taking an increasing interest in emergency care and transport. Local and regional planning is required for successful organization of emergency communication systems, transportation, trauma units, poison control centers, and specialized units such as those for burns. Public health agencies have a role in organizing such systems; for example, by categorizing emergency facilities on the basis of what kind of injury cases they are equipped and staffed to treat, so that seriously injured patients can have the optimum chance of receiving adequate care. Lately, this role has expanded into development of triage criteria and establishment of regionalized trauma systems where not only the emergency facilities are categorized, but hospitals are too.

Education

Even though we have said before that priority in injury prevention should be given to measures that require little or no human action or cooperation, education must supplement some forms of injury control.²⁹ Public health agencies must devise and implement educational efforts directed to the general public that address all three phases of the injury sequence: pre-event, event, and post-event. Another very important function of education is to convince the public as well as private and public organizations that the hazards of their environment can be controlled, reduced, or eliminated. Public support is often needed before a preventive measure can be introduced; people must be persuaded of the benefits of a motorcycle helmet law before they support it. Finally, individuals (e.g., legislators, regulators, administrators) whose decisions can determine the likelihood of injury to thousands of people need to be educated to take advantage of their role in injury prevention.

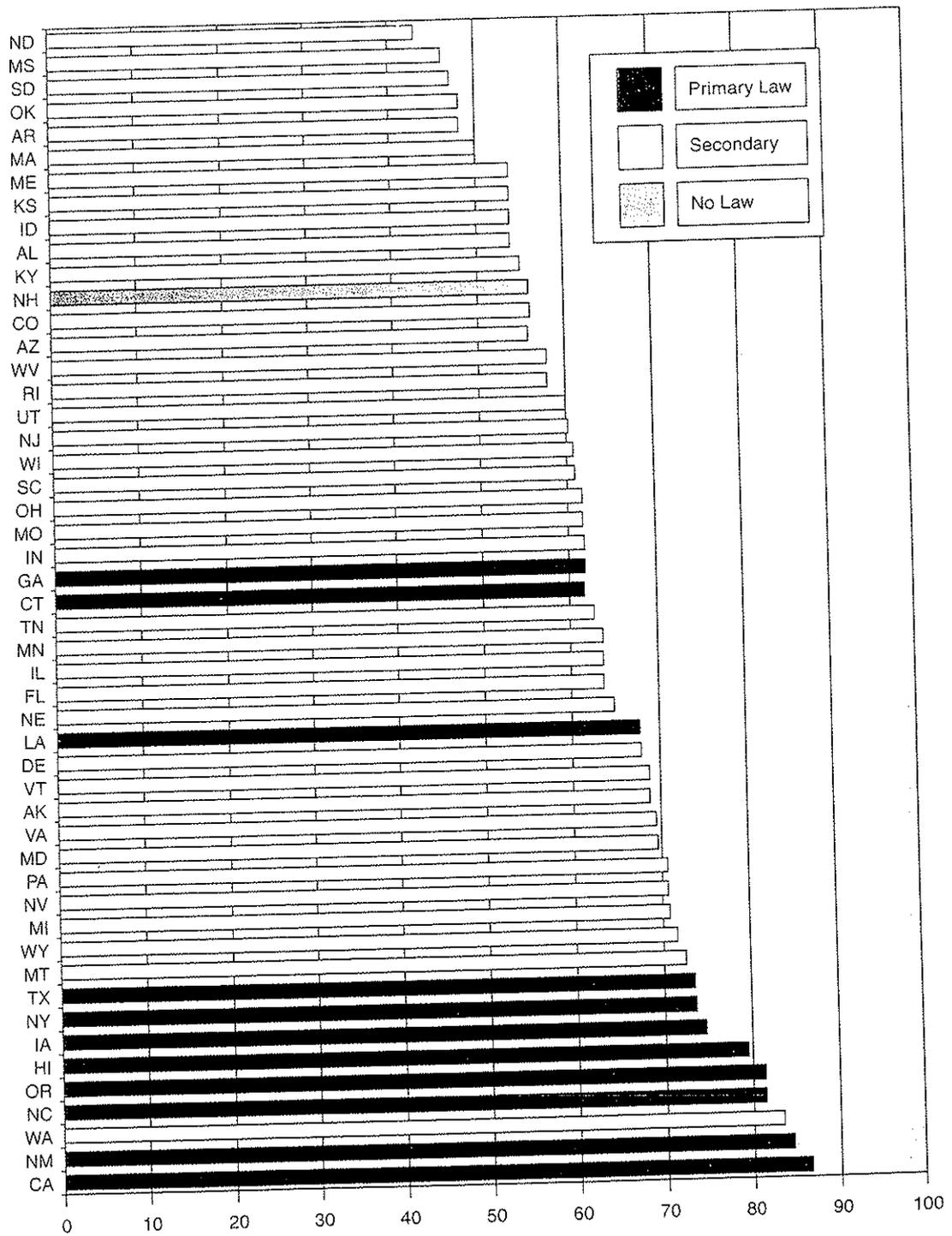


Figure 26.6. State Safety Belt Use Rates by Law Type
 Source: NHTSA, Presidential Initiative for Increasing Seat Belt Use Nationwide, 1996.

CONCLUSIONS

Injury is a public health problem that can be controlled with the application of public health tools such as epidemiology, program design and implementation, and evaluation. Major achievements over the past 25 years or so reinforce this point. Further reductions in both unintentional and intentional injuries and their associated medical, psychological, and economic burden will require continued efforts by the public health community in surveillance and research, in building partnerships with public and private organizations, and in the development of state and local health department injury control programs.

Those public health practitioners who understand the issues and scientific concepts involved in injury occurrence can contribute effectively to substantially reducing this huge problem.

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