Risks to Students in School

September 1995

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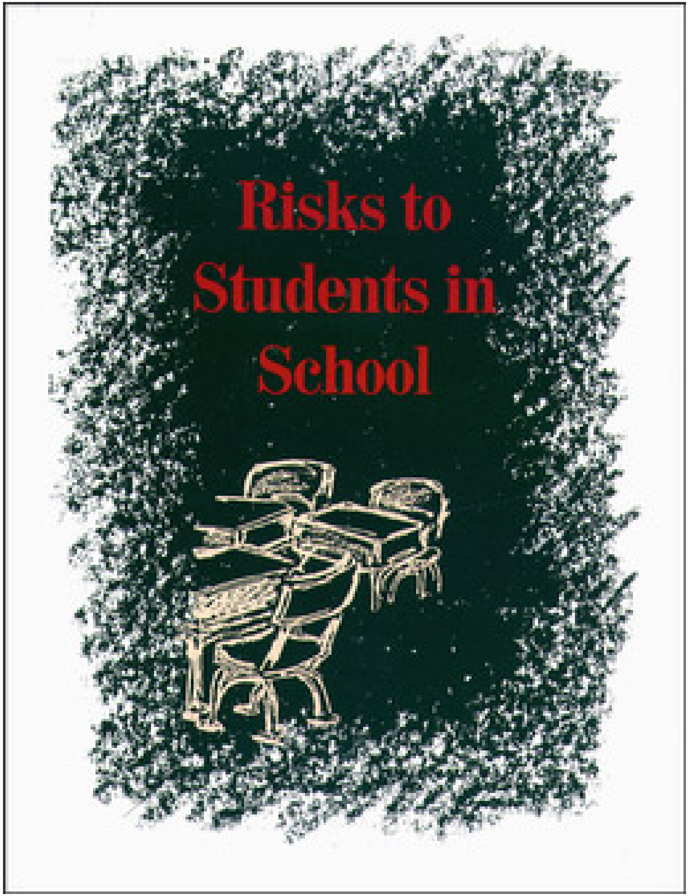

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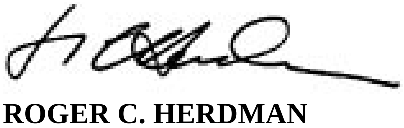
Foreword

School-aged children encounter a wide variety of hazards every day. While the leading causes of mortality for this age group are hazards that typically occur outside of the school environment, many hazards resulting in injury or illness exist in schools. These hazards confront children on their way to school, in the classroom, in the use of potentially hazardous materials in science, art, and industrial arts courses, on playgrounds, in gymnasiums, on athletic fields, and on their way home.

Because of congressional interest in the health and safety of school children, the House Committee on Energy and Commerce and the House Committee on Education and Labor requested the Office of Technology Assessment (OTA) to assess the available data on hazards to children in schools in the United States. A letter of support was received from the Senate Committee on Labor and Human Resources. As directed, this study focuses on unintentional and intentional injuries (particularly violence) and illnesses from infectious diseases and environmental hazards (school materials, indoor air contaminants, and electromagnetic force).

In addition to estimating the likelihood of injuries and illnesses in schools, OTA considered the quality, relevance, and predictive value of the available data about health and safety risks by examining how the data were collected and interpreted. For many of the hazards in the school environment, the underpinning scientific research is incomplete and thus of limited use. This report does not, however, compare or rank risks. Decisionmakers, from Congress to individual school boards, are likely to want much more information than just numbers of deaths, illnesses, and injuries when setting priorities for improving school safety. Public fear of particular risks and the feasibility and cost of reducing the risk are among other very important considerations. As such, this background paper represents the first step in the process of setting priorities in risk reduction.

OTA appreciates the support this effort received from hundreds of contributors. Workshop participants, reviewers, contractors, school administrators, parents, and schoolchildren gave us invaluable support. OTA, however, remains solely responsible for the contents of this background paper.



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Summary 1

Schools, like all buildings and institutions, harbor some risks; inspection of records of illnesses and injuries in schools reveals sometimes preventable or reducible hazards. Nevertheless, compared to other places where children live and play, schools are often safer environments. This finding must be qualified by the paucity and occasional poor quality of data—or even the absence of information about some hazards. For many of the hazards that this study examined, the Office of Technology Assessment (OTA) could not judge whether schools were safer or not.

Of course, children daily confront a variety of risks, in or out of school. In 1992, children ages 5 to 17 suffered 13 million injuries and some 55 million respiratory infections, contributing to their missing about 214 million school days, roughly 460 days for every 100 students. Unknown are the possible long-term health consequences, the impact of the lost learning opportunities, or the care-giving problems faced by families. Averaged over the year, school-aged children spend about 12 percent of their time in school; some portion of their injuries and illnesses arise in connection with the school environment. Parents, teachers and school administrators, and leaders in all walks of life understand that information about the nature of risks is a basic requirement for thoughtful decisions about the interventions necessary to reduce illnesses and injuries.

Since government requires school attendance, it ultimately bears responsibility for children's health and safety while they are there. While local, county, and state governments bear most responsibility for the operation of schools, the federal government has taken a role in health and safety issues, as reflected in the 103d Congress considering 66 bills that referenced the "school environment" and 51 that were directed at the goal of "safe schools." Congressional concern led the House Education and Labor and Energy and Commerce Committees of the 103d Congress to request this background paper, which examines the scientific data on the risks for injury and illness in the school environment.[1]

[1] In the 104th Congress, the House Education and Labor Committee was renamed the Education and Opportunity Committee and the House Energy and Commerce Committee became the Commerce Committee.

SCOPE OF THE REPORT

This report focuses on risks[2] to students between 5 to 18 years old while they are at school, on the school grounds, and, to the extent possible, at school-related activities and traveling to and from school. The ages correspond to grades kindergarten through the 12th grade. About 46.5 million children were enrolled in over 109,000 elementary and secondary schools for the 1990 school year, and a projected 50 million will enroll for the fall of 1995.

Hazards are grouped according to whether they cause *injuries* or *illnesses*. For this assessment, injuries are divided into two kinds:

- those that result from unintentional actions, such as playground activities or organized sports, and
- those resulting from intentional actions, such as homicide or fighting.

Illnesses are also divided into two groups:

- those that arise from environmental hazards, such as asbestos and lead, and
- those that arise from exposure to infectious agents, such as influenza virus and respiratory-disease-causing bacteria.

This report takes one critical step—identifying and commenting on the available data—that may help in developing priorities for the use of limited resources to protect children from health and safety hazards in schools. The report does not attempt to compare and rank risks of a diverse nature; rather, the data are examined—their quality, how they were produced, the assumptions made, and their limitations. After consulting with experts in various fields, OTA staff assembled morbidity and mortality data, along with estimates and measures of exposures or risks, for events ranging from school bus crashes and other accidents to student-on-student violence, and from infectious disease outbreaks to a number of "environmental hazards," including pesticide poisoning and possible lung cancers from asbestos or radon.

Although this report does not rank risks, one section is devoted to discussing comparative risk assessment, a process favored by some to help individuals and organizations decide where resources are to be spent to reduce which risks. Beyond the traditional notions of number and severity of disease or injury, decisionmakers may want to consider other subjective attributes of risk in determining which school-related risks are most worthy of attention.

KEY FINDINGS

In examining the hazards in schools, OTA found:

Risks of Death in School

FINDING *The two leading causes of death in school-aged children are motor vehicles and firearms. Relatively few deaths from these causes occur in schools or on school buses.*

In children ages 5 to 19, motor vehicle-related injuries and injuries due to firearms dwarf all other causes of death for which data are available. In 1992, the approximately 6,720 deaths due to motor vehicle injuries and 5,260 deaths related to firearms accounted for about 50 percent of 22,600 deaths in all children ages 5 to 19 (see table 1-1). Motor vehicle-related deaths include deaths to occupants of cars or other motor vehicles involved in crashes, as well as deaths to pedestrians, bicyclists, and others injured by motor vehicles. Firearm-related deaths include deaths due to intentional injuries (i.e., firearm-related homicides and suicides) and deaths due to unintentional injuries involving firearms. In 1992, the number of intentional injuries due to firearms in school-aged children (about 3,280 firearm-related homicides and 1,430 suicides) far exceeded the number of unintentional injuries due to firearms (470 deaths).

[2] In this report, risk refers to the probabilistic estimate of the likelihood of an adverse health outcome associated with the hazard in question. Hazards are defined as the agent or action capable of causing the health effect.

TABLE 1-1: Leading Causes of Death to School-Aged Children, 1992					
Causes	**Deaths 5–9 Years**	**Deaths 10–14 Years**	**Deaths 15–19 Years**	**Deaths Total**	**Rate per 10,000**
ALL CAUSES	3,739	4,454	14,411	22,604	42.2
ALL NATURAL CAUSES	1,943	1,916	2,891	6,750	12.6
Malignant neoplasms	557	548	738	1,843	3.4
Diseases of the heart	130	154	333	617	1.2
Congenital anomalies	245	203	224	672	1.3
HIV infection	72	32	48	152	0.3
Pneumonia and influenza	53	51	85	189	0.4
Chronic obstructive pulmonary disease	38	62	90	190	0.4
ALL EXTERNAL CAUSES	1,796	2,538	11,520	15,854	29.6
All Unintentional Injuries	1,628	1,760	6,234	9,622	18.0
Motor vehicle-all	907	997	4,818	6,722	12.6
—Motor vehicle-occupant	378	481	3,269	4,128	7.7
—Motor vehicle-pedestrian	348	214	328	890	1.7
—Motor vehicle-bicycle	93	145	62	300	0.6
—Motor vehicle-other	88	157	1,159	1,404	2.6
Drowning	196	218	398	812	1.5
Fire/burn	211	105	95	411	0.8
Unintentional firearm	48	132	285	465	0.9
Poisoning	15	21	155	191	0.4
Fall	21	30	93	144	0.3
Aspiration	23	16	21	60	0.1
Suffocating	35	61	46	142	0.3
All Intentional Injuries	156	745	5,149	6,040	10.9
Suicide-all	10	304	1,847	2,151	4.0
—Firearm	3	172	1,251	1,426	2.7
—Nonfirearm	7	132	596	735	1.4
Homicide-all	146	441	3,302	3,889	7.3
—Firearm	56	348	2,878	3,282	6.1
—Nonfirearm	90	93	424	607	1.1
All Firearm	111	667	4,484	5,262	9.8
Population (000’s)	18,347	18,105	17,102	53,554	

SOURCE: U.S. Department of Health and Human Services, National Center for Health Statistics, Vital Statistics System, 1995.

On the basis of national data from 1992,[3] it appears that relatively few deaths from motor vehicle-related injuries in school-aged children actually occur in school environments, defined here as school buildings and grounds and bus transportation to and from school. Except for school bus-related deaths, estimates of deaths to schoolchildren going to and from school are either unreliable or unavailable. Measured on a passenger per mile basis, the number of occupant deaths from school bus crashes is one-quarter the number from passengers of automobile crashes. Among school bus-related fatalities, children getting on or off the bus are by far at the greatest risk. In 1989, the National Academy of Sciences reported that from 1982 to 1986 an average of about 50 children died in school bus-related crashes, and roughly three-fourths of these died getting on or off a school bus.[4]

About 1 percent of the deaths from firearms in school-aged children occur in school environments. An estimated 100,000 to 135,000 guns are brought to school every day, yet children are much less likely to die from firearm-related injuries in school than out of school. During two recent school years (1992–93 and 1993–94), researchers identified an average of 53 "school-associated violent deaths"[5] per year, about 40 of which were homicides, and almost all were related to firearms. Every single killing in a school—especially the killing of a child—justifiably receives considerable public attention. The fact is, however, that school-associated violent deaths constitute only a tiny portion of the several thousand violent deaths among school-aged children each year.

Most of the deaths from motor vehicle and firearm injuries are concentrated among older teenagers. No health hazard for any age group examined in this report compares in magnitude to the impact of deaths resulting from motor vehicle injuries and firearm use in 15- to 19-year-olds. Combined motor vehicle and firearm-injury-related deaths among this group represent about 40 percent of deaths among *all* school-aged children. Among younger school-aged children (ages 5 to 9 and ages 10 to 14), motor vehicle- and firearm-related deaths are a smaller proportion of total deaths. In these children, deaths from natural causes—i.e., acute and chronic illnesses—exceed deaths from motor vehicle injuries or firearm-related injuries and are roughly equal to deaths from all injuries.

FINDING *There are many other less common causes of death among school-aged children. For these, schools sometimes pose a greater risk than other environments, sometimes about the same risk, and sometimes less. Quite often, the relative safety of schools, on a national average basis, is unknown.*

Less common causes of death among school-aged children include infectious and other diseases (e.g., cancer), congenital anomalies, unintentional injuries other than firearms or motor vehicles (e.g., drowning, fires, poisoning, falls), and nonfirearm-related suicide and homicide (see table 1-1). In the school environment, these hazards do not appear to account for more than 10 to 100 deaths per type of hazard annually. Childhood exposure to environmental hazards such as radon and asbestos in schools and other environments may cause some deaths later in life, in contrast to deaths from many injuries, such as homicides, for which death is more immediate.

Schools probably pose a greater risk to children than out-of-school environments for deaths from infectious diseases. There is no certainty

[3] OTA's findings with respect to risks to students in schools are based on national averages. OTA did not make any attempt to compare regions, districts, or individual schools that may be better or worse than average.

[4] The most recently published National Highway Transportation Safety Administration's school bus crash-related fatality estimates are available in *Traffic Safety Facts*, 1992; except for pedestrians, the data are not published by age so the number of school-aged children fatally injured is not known.

[5] The Centers for Disease Control and Prevention includes homicides, suicides, and unintentional firearm fatalities in "school-associated violent deaths" (12).

that this is true because a school's contribution to disease is rarely determined. But school environments are probably incubators for fatal infections that can be spread through casual contact in classrooms. In 1992, about 190 school-aged children died from pneumonia and influenza, two respiratory infections that can be spread via casual contact in classrooms. In the same year, 150 school-aged children died from infection with human immunodeficiency virus (HIV), the virus that causes AIDS. HIV is spread through the exchange of bodily fluids (blood or semen) during sexual activity or intravenous drug use. Currently, there is insufficient information to evaluate the importance of school contacts in the transmission of HIV.

Deaths from cancer that might be related to in-school exposures to environmental hazards may not occur for many years after the exposure, and in-school exposure data, if they exist at all, are usually inadequate to estimate the risks for developing and dying from cancer. The concentrations of both radon and asbestos in school buildings are about the same as concentrations found in other buildings. Using U.S. Environmental Protection Agency (EPA) estimates of the cancer-causing potential of asbestos, this study extrapolates that for a given school year, average in-school exposures to asbestos may ultimately result in 2 to 60 lung cancer deaths. Similarly, extrapolating from EPA estimates of the cancer-causing potential of radon, average per year in-school exposures to radon may lead to about 60 lung cancer deaths above and beyond those associated with contributions from other sources of radon.

There is considerable uncertainty associated with both of these extrapolations, however, and the actual numbers of deaths associated with in-school exposures to asbestos or radon may be higher than estimated—or zero. There is even more uncertainty associated with estimates of cancer deaths due to exposures to electromagnetic fields (EMF), because the biological effects of electromagnetic fields are not well understood and too few data exist on in-school exposures and their possible impact.

Clearly, schools can contribute to exposures to environmental hazards. While the school environment's contribution to overall risk can sometimes be calculated, though, it must be remembered that other environments—notably, the home—might expose children to these hazards as much or more.

The relative risk to school-aged children of deaths in schools from most unintentional injuries not due to firearms or motor vehicles is not known. For example, it is known that about 20 high school students die in school athletics, but it is difficult to judge whether these activities in schools are safer or riskier than similar ones out of school, because comparable out-of-school data are unavailable for the same activities.

Risks of Injury or Illness in School

FINDING *Schools contribute to the risks of injury or illness in school-aged children. Once again, schools sometimes pose a greater risk than other environments, sometimes about the same risk, and sometimes less. But little is known about schools' contribution to nonfatal illness and injury.*

Data on the incidence of injury or illness in school-aged children—i.e., on the number of new cases of injury and illness in this population in a given time period—are available from the Centers for Disease Control and Prevention. An important measure of the impact of injuries and illnesses on students is the number of school days lost because of an injury or illness. In 1992, illness accounted for approximately 75 percent of the nearly 175 million lost school days from short-term conditions (both injuries and illness). Illnesses were responsible for more lost school days than were injuries (even though injuries resulted in more fatalities than illnesses did).

For most of the hazards related to the incidence of injury and illness in school-aged children, OTA found that the data were inadequate to allow in-school and out-of-school comparisons. While for certain hazards the relative risk is not known because too little information exists, for others the relative risk cannot be determined because the nature of the hazard's effect on children's health precludes the possibility of linkage to a school location. Athletic injuries, for example, are reasonably well documented in school, but the out-of-school data are not particularly useful for comparisons due to inadequate data on location or their single-sport focus. Other risks (e.g., fighting) are difficult to determine because of inadequate reporting on the cause of the injury.

For a few sources of injury and illness, it appears that schools pose a risk greater than that posed by out-of-school environments. Thus, for example, schools may facilitate the spread of infectious diseases, especially of highly infectious diseases such as viral respiratory diseases. Certain disease outbreaks, such as meningococcal infections and food poisonings, can be traced to the school environment. Furthermore, conditions at certain schools exacerbate exposures to substances such as lead. The largest source of exposure to lead comes from younger children eating paint chips at home, but some schools may add to this exposure through the presence of lead in building paint and in water.

For other sources of injury and illness, it appears that schools pose a risk comparable to that posed by out-of-school environments. In the case of elementary school children, for example, about as many injuries occur on school playgrounds during school hours (9 a.m. to 3:30 p.m.) as occur in other locations. Athletic injuries are among the most common causes of school injuries to older students; the few available studies indicate that they occur at similar rates inside and outside of school.

For many sources of injury and illness, schools actually pose less of a risk than out-of-school environments. Thus, for example, schools pose less of a risk than out-of-school environments for many environmental hazards. At most about 7 to 8 percent of reported exposures to poisons among school-aged children occurred in schools. Furthermore, according to a 1989 study,[6] fewer injuries requiring hospitalizations occurred in school than out of school. Moreover, in another study,[7] about 3 percent of injuries presented to the national trauma database were school related. Similarly, school bus crashes did not result in nearly as many injuries as crashes of other motor vehicles. Schools were also less of a risk for violent injuries.

The Risk Assessment Process

FINDING *For many of the risks OTA reviewed, national data were usually inadequate for an assessment of risks in schools. The largest data gaps existed for environmental hazards.*

In addition to estimating the likelihood of injuries and illnesses in schools, OTA considered the quality, relevance, and predictive value of the available data by examining how the data were collected and interpreted. For many of the hazards in the school environment, the underpinning scientific research is incomplete and thus of limited use.

OTA identified several obstacles to the collection of more complete information on the hazards facing children in schools. One obstacle is a lack of resources, whether money, expertise, or both. Another type of obstacle is resistance to data collection on the part of school administrators, perhaps out of fear of being branded a "problem school." Furthermore, epidemiological studies seldom focused on school health and safety risks, and few surveillance systems at the Centers for Disease Control and Prevention and state programs monitored injury or illness in school. The lack of both standardized federal and state definitions for reporting hazards, injuries, and illnesses, and of coordinated reporting efforts over time also impedes accurate portrayal of school injuries and illnesses. With respect to unintentional injury data, for example, there are inconsistent definitions of reportable injuries and designations of severity.

[6] Injury data compiled by the Massachusetts Statewide Comprehensive Injury Program (8).
[7] Data from this study were compiled from September 1979 and August 1982.

The largest data gaps existed for environmental hazards such as radon, asbestos, and EMF. OTA generally did not find comprehensive data on in-school exposures to these types of substances. For most of these agents, the simple presence of a hazard—not the level to which students are exposed—is reported. With few exceptions, efforts to obtain exposure data have been sporadic, and reporting has been anecdotal. The absence of studies documenting exposure in school presents a fundamental gap in the data needed to assess risks nationwide. Because of those gaps, officials and investigators may never link certain observed health effects to exposure to the culpable agent in the school environment.

Unlike injuries or illnesses from environmental hazards, cases of specific infectious diseases must be reported to the Centers for Disease Control and Prevention, but records do not necessarily identify schools as the location of the culpable exposure. For infectious diseases, data are usually reported for school-aged children, but only certain cases of school outbreaks, e.g., meningococcal infections or food poisoning, accurately establish schools as the source of the illness.

FINDING *Decisionmakers, from Congress to individual school boards, are likely to want much more information than just numbers of deaths, illnesses, and injuries when setting priorities for improving school safety. Public fear of particular risks and the feasibility and cost of reducing the risks are among other very important considerations.*

Clearly, 20 deaths from one in-school hazard are worse than 10 deaths from another, but does that information tell us which problem to address first or on which to spend the most money? People naturally tend to order things by their size or severity, and quantitative estimates of the magnitude of risk—i.e., the likelihood of adverse health effects arising from the hazardous conditions—are useful in setting priorities. The magnitude of risk can be quantified in any of several ways (e.g., using measures of the individual probability of risk, the risk to the population, or weighting the risk by age, accounting for the additional years of life lost for the child), each measure stressing a different aspect of the risk.

But quantitative estimates of the likelihood of adverse health effects arising from particular hazards are not all that are needed for local school boards and other decisionmakers to determine what can and should be done to make schools safer. Decisionmakers may want to take into account the social context of the risk.

One aspect of the social context that is particularly important is the degree of public fear associated with a risk. The level of fear of a given hazard varies widely across individuals and communities. One thing that sometimes determines the level of fear is the degree to which individuals feel that they are able to control the risk through personal action. Thus, even though the risk may not be very great, parents may fear their child being killed in school by another student with a weapon because they cannot control the risk; at the same time, parents may have less fear of a comparable risk—that their child will die en route to and from school in a bus crash—because they feel that they can control this; they can drive the student themselves or arrange alternative travel.

Another aspect of social context is the perception that a given hazard—say, playing football—has benefits that make the associated risks more worth taking or bearing. In terms of the number and severity of associated injuries, football is among the most hazardous of athletic activities in which high school students participate. Nonetheless, the perceived benefits of athletic accomplishment and social recognition encourage continued participation in this activity.

Local school boards and other decisionmakers seeking to determine what can and should be done to make schools safer need to take into account the feasibility and cost of reducing different risks. School boards must decide, in some cases, if the risks of firearms and firearm-related injuries in their schools justify the substantial costs of metal detectors. Small risks that are cheap and easy to eliminate may deserve priority attention, whereas even very large risks may not emerge as priorities if reducing them would be technically infeasible or prohibitively expensive.

The remainder of this chapter summarizes the findings and conclusions from the subsequent chapters of this report. The next section covers student injuries, both intentional and unintentional. The illness section examines illnesses arising from environmental hazards and infectious diseases. Finally, the last section looks at how the presented data can be used by decision-makers and those interested in the safety and health of students in school.

INJURY TO STUDENTS IN SCHOOL

This report examined school injuries in terms of "intent"—unintentional (accidental) and intentional (assaultive or suicidal). Unintentional and intentional injuries differ in the type of injury that results, its severity, the manner in which it is recorded at schools, and the level of response or fear it engenders. The types and quality of data collected for unintentional and intentional injuries also vary. While some national and state estimates of school injuries are available, epidemiological studies provide a more detailed picture of injury incidence. In this section, we draw together available school injury data from both types of injury.

In 1992, school-aged children in the United States incurred over 13 million injuries (1).[8] Results of epidemiological studies indicate that from 10 to 25 percent of injuries incurred by the school-aged population occur at school (29). However, epidemiological studies use a broader definition of injury than the national survey. Regardless of the number of injuries, over 10 million school days are lost each year—22 lost school days per 100 students (1). Since 12 percent of a child's year and 15 to 20 percent of a child's annual waking hours are spent in school, the frequency of injury per hour in school or out is about the same. However, most of these injuries are minor. The more severe injuries tend to occur out of school. For certain types of injuries, such as athletic injuries, the percentage of injuries incurred in schools may be higher than outside the school environment; however, for other injuries, particularly fatal injuries such as homicide, it is considerably lower: 1 percent of deaths due to violence for children 5 to 18 occur at schools.

The leading causes of death to children of school age (5 to 19 years) are motor vehicle crashes and injuries, intentional or unintentional, associated with firearms. In 1992, about 6,720 deaths due to motor vehicle injuries and the 5,260 deaths related to firearms accounted for approximately 50 percent of 22,600 deaths in the more than 53 million school-aged children, dwarfing all other causes of death for which data are available. Motor vehicle injury deaths include deaths to occupants, pedestrians, bicyclists, and others injured in automobile crashes. Firearm-related deaths include firearm-related homicides and suicides as well as unintentional firearm injuries.

Unintentional Injury

Given the time students spend at school and the variety of activities in which they are engaged, the school environment presents many opportunities for unintentional injury. Risks of unintentional injury to students occur each school day: in their travel to school; in the controlled, supervised classroom environment; in physical activities in gymnasiums and athletic fields; in the relatively unsupervised play during recess and lunch periods; and finally, on their return home (28). Although many of these injuries are minor cuts and bruises that heal quickly, significant numbers are quite serious. The injuries may result in absence from school, restricted activity, hospitalization, disability, and even death.

[8] This estimate includes only those injuries involving medical attendance and at least half a day of restricted activity.

Incidence and Distribution of School-Related Injuries

Injury rates from school-related injury studies vary and are likely to underrepresent the number of actual injuries because of underreporting in the routine surveillance and reporting of injuries at schools (9). The variations may be attributed to one or more of the following: 1) varying case definitions of injury; 2) reporting methods that vary (e.g., school-based as opposed to hospital-based reporting); 3) inconsistent reporting among study schools; 4) variability among student populations; and 5) implementation of school-based prevention programs.

Population-based estimates of rates of injury to school-aged children range from about 24 to 28.6 injuries per 100 school-aged children in 1992 (1,8,29,30). As shown in table 1-2, the rates of injury in school estimated in several epidemiologic studies range from 1.7 to 9.2 per 100 students. Based on 1988 NHIS data, one study found that 19 percent of all injuries sustained by children under 17 occurred at school (30). Considering the shorter time spent in school each year—about 12 percent of a child's time annually—the data thus suggest that the number of school injuries may be about the same or higher than those out of school.

Playgrounds and athletics (including both physical education and organized sports) account for the highest injury rates in school. Distribution of these injuries, however, changes over time due to students' development of physical skill, strength, size, judgment, balance, and experience with hazards (28). Playgrounds are associated with most injuries to elementary students and athletic injuries account for the most injuries to secondary school students. The rates of playground injuries decrease as children mature, while the rates of athletic injuries increase steadily through middle/junior high school to high school.

The majority of school-related injuries are minor; they also result in fewer hospitalizations than injuries sustained outside the school environment, and fatal injuries are relatively rare in the school environment (28). The percentage of severe injuries—ranging from 18 to 39 percent of the total injuries across three epidemiological studies (two Canadian studies and one United States study)—varies because, among other things, severity is defined differently from study to study. Playground and sports athletic injuries account not only for the greatest number of injuries but also for the majority of severe injuries (2,14,32). Falls (either from the same surface or from elevation), organized sports or athletics, and unorganized play were the activities most frequently associated with injuries (9). Compared to outside of school, in-school injuries were less severe.

Playground-Related Injury Data

The 1990 Consumer Product Safety Commission (CPSC) *Playground Equipment-Related Injuries and Deaths* report (36) provides an analysis of data on playground injuries and deaths associated with playground equipment.[9] Fatalities averaged nine per year for children under 15 years of age, with about 170,200 playground equipment-related injuries in 1988.[10] Using these data, OTA estimated that approximately 13,000 playground equipment-related injuries occurred on school playgrounds, during school hours,[11] to school-aged children. The 1992 CPSC estimates 241,181 playground equipment injuries required treatment in hospital emergency rooms.[12] Poor out-of-school data on playground-equipment injuries prevent comparison with the in-school data.

[9] The CPSC data includes only fatalities and injuries that are product-related and, accordingly, exclude those that occur on playgrounds but are not equipment related. Moreover, CPSC collects only emergency room data and, thus, only the most serious injuries.

[10] From April to December 1988, CPSC completed a special study of a systematically selected sample of playground injury incidents to follow up in depth. The study identified out-of-scope cases, meaning cases involving injuries that were not associated with outdoor playground equipment. Extrapolating the percentage of out-of-scope cases to the 1988 NEISS, CPSC determined that the estimated 201,400 emergency room-treated playground equipment-related injuries should be reduced to 170,200.

[11] School hours are defined as 9:00 a.m. to 3:30 p.m.

[12] CPSC has not adjusted these numbers.

	Lenaway et al. (1992)	Boyce et al. (1984a)	Sheps & Evans (1987)	Feldman et al. (1983)	Taketa (1984)
Years analyzed	1988-1989	1980-1983	1981-1983	1981-1982	1981-1982
Site	Boulder, CO	Tucson, AR	Vancouver, BC	Hamilton, Wentworth, Ont.	Hawaii
No. of schools	9	96	108	212	204
Grades	K–12	K–12	K–12	K–13	K–12
Student population	5,518	55,000	53,000	83,692	157,000
Data collection	Prospective	Prospective	Retrospective	Prospective	Retrospective
Definition: reportable injury	Student accident report forms completed by adult administering first aid (i.e., teacher, nurse, or coach). Reportable injuries were those: "requiring medical or dental attention, head injuries necessitating student dismissal to home and those with persistent symptoms beyond a two hour observation period, poisoning, suspected fractures, human bites, puncture wounds, and injuries sustained from fighting or equipment failure"	Must meet one of the following criteria: (1) required a physician's care and/ or major first aid, (2) resulted in an absence from school, or (3) resulted in restricted participation in competitive sports	If a child sustains or requires: "all head injuries, suspected or definite fractures, and ambulance or inhaler, referral to a physician or dentist, sutures or a foreign body in the eye"	Decision as to reportability "made by school principal, consistent with his interpretation of the school board's policy"	"Any accident which happens at school, or at a school sponsored activity, on or off campus, which (1) interrupts the students' normal or expected activity for that period to any significant degree, (2) causes any property damages or losses of more than $5 in estimated replacement cost and/or (3) can generate a litigation on behalf of the injured"
Incidence per 100 student years	9.22	4.9	2.82	5.4	1.7
Definition: severe injury	*	Amputations, third degree burns, concussions, crush wounds, fractures, multiple injuries	Fractures, loss of consciousness, burns, whiplash, open wounds, foreign body in eye	Fractures, loss of consciousness, dislocations, sprains, torn ligaments and cartilage, chipped/broken teeth, internal injury	"Most severe...foreign bodies in the eye and fractures"
Percentage of injuries that were serious or severe	*	18%	35% elementary 39% secondary	28.6%	

* no definition of severe or serious

SOURCES: Office of Technology Assessment, 1995, Adapted from R.R. Gratz and K. Finison, "School Injuries: What We Know, What We Need," *Pediatric Health Care* 6:256-262, 1992; D.D. Lenaway, et al., "The Epidemiology of School Related Injuries: New Perspectives," *Am J Prev Med* 8(3):193-198, 1992.

School Athletic Injury Data

In 1993, approximately 5.6 million students competed in high school athletics (22), comprising approximately 43 percent of all United States high school students (37). Student participation in athletic activities is a principal cause of junior high and high school injuries and results in a number of debilitating injuries and deaths each school year.

The only national school sports injury mortality figures are compiled by the National Center for Catastrophic Sports Injuries Research. The Center limits its research to certain high school and college sports, and does not include physical education. Over the 10 years of study, 200 deaths were reported (67 direct and 133 indirect),[13] an average of approximately 20 sports-related deaths annually (see table 1-3). Of all the direct deaths in high school sports, only one was a female (21).

Football and soccer resulted in the greatest number of direct deaths each year among high school athletes. On average, of the 20 athletic related deaths each year, about five directly related deaths occur in football and about five in soccer. Football is associated with about five indirectly related deaths per year and basketball with three to four. While those three sports account for more than 90 percent of the fatalities, they are not necessarily the riskiest when judged by number of deaths per participant in a sport per year. In those terms, the riskiest high school sports for males were gymnastics (1.75 deaths per 10,000 participants), lacrosse (0.57), ice hockey (0.43), and football (0.35). Basketball (0.63), lacrosse (0.57), ice hockey (0.43), and wrestling (0.41) had the highest rate of indirect deaths per participant.

TABLE 1-3: Reported Catastrophic Injuries from High School Sports, 1982 to 1992

	Fatal		Nonfatal			Rate/100,000 Participant Years	
Sport	Direct	Indirect	Permanent	Serious	Total	Male	Female
Cross country	0	5	1	0	6	0.6	0.0
Football	48	52	103	113	316	2.4	—
Soccer	2	8	0	4	14	0.5	0.2
Basketball	0	35	2	2	39	0.6	0.1
Gymnastics	1	0	5	3	9	4.8	2.3
Ice hockey	1	1	4	2	8	3.6	—
Swimming	0	3	4	3	10	0.6	0.6
Wrestling	2	10	16	9	37	1.5	—
Baseball	3	5	7	6	21	0.5	—
Lacrosse	1	1	0	0	2	1.0	—
Track	9	12	6	6	33	0.6	0.0
Tennis	0	1	0	0	1	0.1	0.0
Total	**67**	**128**	**148**	**148**	**491**	**16.8**	**3.2**

SOURCE: F.O. Mueller, C.S. Blyth, and R.C. Cantue, Tenth Annual Report of the National Center for Catastrophic Sports Injury Research, Fall 1982–Spring 1992. Chapel Hill: University of North Carolina, 1993.

[13] The Center categorizes injuries as direct or indirect—direct meaning those injuries that resulted from participation in the skills of the sport; indirect meaning those injuries that were caused by systemic failure as a result of exertion while participating in a sport activation or by a complication that was secondary to a nonfatal injury.

For national school sports, including both organized sports and physical education, morbidity estimates disclose that sports account for the greatest number of injuries in school. Of the 1.3 million sports/recreation injuries sustained by children ages 17 and under annually, schools are the location for 55 percent (715,000 injuries) and the cause of 35 percent (455,000 injuries) (30). Another school sports injury study—based on a 1986 injury surveillance study by the National Athletics Trainers Association—estimated 1.3 million injuries annually. Epidemiological studies show that sports-related injuries account for 23 to 53 percent of all reported school injuries. Physical education classes account for a greater number of injuries than organized school sport (13). Injuries sustained in physical education occurred mainly during gym games (e.g., dodge ball and four square) and basketball, with other sports far behind. About 60 percent of the basketball injuries occurred during physical education (45). However, once participation ratios are considered, organized sports (12 injuries/100 students) are riskier than physical education (2.3/100).

Transportation Injury Data

Children and adolescents travel to and from school by school bus or car, ride their bicycles, or walk. The only travel mode for which detailed injury data exists is by school bus. Though information would be useful regarding injuries from other modes of transportation to school, particularly parents' driving students or older students driving themselves, no studies attempt to quantify these injuries for students.

The few studies that report injuries incurred on the journey to and from school estimate the range from 1 to 3 percent of all school injuries.[14] In general, the journey home is more dangerous than the trip to school (37,42). One study attributed this to more children walking home alone or with other children rather than with an adult (37).

School Bus-Related Crashes

Every school day, school buses transport about 25 million students to and from classes and school-sponsored activities (23). Although most crashes involving school buses are minor, catastrophic crashes resulting in student fatalities and serious injuries occur every year. A comparison of school bus-related crash and passenger car crash fatalities and injuries among school-aged children suggests that school buses are much safer than the other forms of transportation that take students to and from school. The National Academy of Sciences (NAS) estimates that occupant fatalities per mile for school buses are approximately one-fourth those for passenger cars (23).[15] Of the more than 650,000 fatal traffic crashes in the past 16 years, less than 0.4 percent were classified as school bus related (41).

The major studies of fatalities in school bus-related crashes are listed in table 1-4. The NAS study reports that on average school bus-related crashes fatally injured about 50 school-aged children each year from 1982 to 1986. Most of the fatal injuries among school-aged children occur while they are getting on or off, rather than while they are riding, the school bus. It also appears that student pedestrians are at a far greater risk of being killed by the bus they were on—usually in the school bus loading zone—than by another vehicle (42).

[14] These estimates are based on the Hawaii Department of Education and Utah Department of Health state estimates of school injuries and the National Safety Council's national estimates. The NSC reported that about 3.1 percent of all school injuries were incurred going to and from school, 1.9 percent were motor vehicle related, and 1.2 percent were non-motor vehicle related. Because these injuries were reported to the NSC by schools, it is likely that a number of transportation injuries occurred but were not reported to the school.

[15] According to the National Safety Council's (25) *Accident Facts* (1993), the difference between school bus and passenger car fatality rates was even more pronounced. NSC reported that in 1989–91 the average fatality rate per hundred million passenger miles was 0.02 for school buses and 1.05 for passenger cars.

TABLE 1-4: Annual Passenger, Pedestrian, and Bicyclist Fatalities in School Bus-Related Crashes, by Study

STUDY	Annual Total Number of Fatally Injured People in School Bus-Related Crashes	School-Aged School Bus (or Vehicle Used as School Bus) Passengers Fatally Injured	School-Aged Pedestrians Fatally Injured	School-Aged Bicyclists Fatally Injured
1992 NHTSA's Traffic Safety Facts (FARS)	124	9	29	2
1983–1992 NHTSA's Traffic Safety Facts (FARS)	157		30	
1977–1990 Summary of Selected School Bus Crash Statistics (FARS) (average)	179	11–12	34	
1982–1988 NAS Report on Improving School Bus Safety (FARS) (average)	149	12	37–38	3.2
1991–1992 National Safety Council	110	10	25	

SOURCES: U.S. Department of Transportation, National Highway Traffic Safety Administration. *Traffic Safety Facts 1992*, September 1993; U.S. Department of Transportation, National Transportation Safety Board, *Summary of Selected School Bus Crash Statistics in 1990*, 1993; National Research Council, Transportation Research Board, Committee to Identify Measures That May Improve the Safety of School Bus Transportation, *Improving School Bus Safety* (Washington, DC: National Academy Press, 1989); National Safety Council, *Accident Facts* (Itasca, IL: 1993).

NAS developed a school bus-related nonfatal injury estimate using selected state data. School bus-related crash data from 14 states were aggregated and analyzed to develop a national estimate of 19,000 total injuries, 9,500 of which were to school bus passengers. The report concluded that school bus passengers sustained 50 percent of the total injuries, of which 5 percent were incapacitating.[16] The majority of the school bus-related crashes were minor. About 800 injuries suffered by school-aged pedestrians in school bus-related crashes were reported; of those, 35 percent were injured by being struck by school buses and the remaining 65 percent were struck by other vehicles. In contrast to fatality estimates, far fewer pedestrians than school bus passengers were injured, but pedestrian injuries were typically more severe.

Pedestrian Injury Data

Fatalities and injuries occur to student pedestrians while walking to and from school. NHTSA collects school-aged pedestrian mortality and morbidity data, but the information does not indicate if the travel was school related. However, databases that record pedestrian injuries by age and time provide some estimates to indicate the scope of the problem. At OTA's request, NHTSA generated time of day data for school-aged pedestrians and bicyclists using 1992 FARS and GES data. Assuming students typically travel to school between the hours of 6:00 and 9:00 a.m. and travel home between 2:00 and 5:00 p.m., 121 school-aged pedestrians were fatally injured; an additional 9,600 suffered nonfatal injuries. Thus, for each death of a school-aged pedestrian during these hours, there were about

[16] Incapacitating injury is defined as "any injury that prevents the injured person from walking, driving, or normally continuing the activities he was capable of performing before the injury occurred" (23). It includes, but is not limited to, severe lacerations, broken or distorted limbs, skull or chest injuries, abdominal injuries, being unconscious at or when taken from the accident scene, and being unable to leave the accident scene without assistance (23).

80 injuries. Twice as many fatalities and injuries occurred in the afternoon as in the morning.

Intentional Injury

Even though the media, parents, students, law enforcement officials, and many other observers have taken it as axiomatic that school violence has increased during the past few years, no comprehensive national surveillance system tracks injuries from intentional violence in the school environment. Many researchers and analysts believe that characterizing physical—and to a lesser extent, verbal and psychological—assaults is a required step in understanding school violence. The National School Boards Association estimates that assaults rank at the top of a list of more than 16,000 violent incidents reported on a daily basis in school buildings (26). Seventy-eight percent of the more than 2,000 school districts reporting to the National School Boards Association survey about violence noted that they have had problems with student-on-student assaults during the past year. This response came from 91 percent of urban districts, 81 percent of suburban districts, and 69 percent of rural districts.

School-Associated Violent Deaths

Homicide and suicide are ever-present threats for children of school age. All killings, especially of children, occurring in school justifiably receive considerable public attention. Yet the 53 "school-associated violent deaths"[17] in 1992 constitute a small fraction of the relative mortality of the school-age population, with the 3,889 homicides and 2,151 suicides occurring outside of school in children ages 5–19 years (34). Currently, the National School Safety Center (NSSC) is the only comprehensive source of information on these incidents in schools, which it compiles from analysis of newspaper clippings.

Preliminary data from a recent Centers for Disease Control and Prevention (CDC) analysis of the NSSC data over a **two-year period** show that 105 violent deaths occurred on school campuses from 1992 through 1994. Of these, 87 were homicides, 18 were suicides, and five were ruled "unintentional" through the legal process (12).

Suicide, the eighth leading cause of death in the United States, is the third leading cause of death for young people 10 to 19 years old (38). Between 1970 and 1984, suicides in this group rose 55.2 percent. Though school does not appear to be a prominent site for the commission of suicide, parents, students, staff, school health officials, and researchers interviewed by OTA stated that depression and general emotional highs and lows are frequently part of the school and adolescent experience.

Weapon Carrying

After motor vehicle injury-related deaths, firearm-related incidents are the next leading cause of death for children ages 5–19 years. In 1992, firearms accounted for 5,262 deaths—about 10 per 10,000 children of school age. Of these, 3,282 were homicides, 1,426 suicides, and 465 were unintentional firearm-related deaths. Moreover, the firearm-related deaths in 1992 account for 23 percent of all deaths, the second leading cause of death for school-aged children (table 1-1). Deaths from firearms occur predominantly in the young adult age group, ages 15 to 19, accounting for nearly 31 percent of all deaths in this population. However, less than 1 percent of these deaths occur from shootings in school.

Estimates of the number of weapons in school vary widely (box 1-A). According to the National School Boards Association and the Center to Prevent Handgun Violence, anywhere from 100,000 to 135,000 guns are brought into schools every day (4, 26). In Cleveland, 22 percent of boys in a sample of 5th, 7th, and 9th graders reported owning a gun to protect themselves

[17] NSSC and the CDC define "school-associated violent death" as any homicide, suicide, or weapons-related death in the United States in which the fatal injury occurred on the school grounds, or at or on the way to an official school-sponsored event.

BOX 1-A: Weapons Confiscated on School Campuses

Weapons possession is tracked differently in school systems that keep such statistics. This area is rife with definitional problems, because many school districts report incidents but not necessarily the type of weapon involved. It is often impossible to discern from local school board incident reports whether a gun, knife, club, or other weapon precipitated disciplinary action against a student.

Characterization of the seriousness of weapons in schools, however, varies from location to location. In some areas, such as South Carolina, the Department of Education reported that possession of weapons was the most frequently occurring offense. For other school districts, including New York City, Los Angeles Unified, and most Connecticut districts, weapons offenses—although not the number one offense—rank high on school crime lists, preceded by vandalism, assault, harassment, larceny, and burglary, many of which involved weapons possession as a secondary offense.

The difficulty in tracking weapons possession in schools stems primarily from the fact that many school districts report the most serious offense as the primary incident. Therefore, weapons are ignored as a secondary offense and consequently are not often reported in school incident data. In South Carolina, for example, from June 1992 through May 1993, weapons possession as the most serious offense accounted for 21 percent (626 incidents) of all incidents. However, the total number of incidents involving weapons was 36 percent (1,055) of all school incidents reported in South Carolina during the 1992–93 school year. Other schools districts, such as Los Angeles Unified School District, further classify weapons incidents to distinguish between assaults and possessions and also to determine at what level (whether elementary, junior high school, or senior high school) such incidents are occurring. Still, the newness of mandatory school crime reporting legislation in South Carolina and other areas means that good baselines are in the process of being created to measure trends in these offenses and incidents.

Although the diversity in mechanisms and definitions used to collect statistics on weapons possession has made it impossible to generalize trends outside a given school district or state, most school districts reporting to OTA stressed that knives and other sharp objects, such as “box cutters,” are the most commonly employed or confiscated weapons. Perhaps this is due to the accessibility and low cost of knives. In the 1992–93 school year, South Carolina’s Department of Education reported that approximately 42 percent of weapons incidents involved knives or sharp objects. Handguns and other firearms are usually the second most popular choice of weapons among students in California, Connecticut, and New York, where more comprehensive statistics have been kept.

SOURCE: Office of Technology Assessment, 1995.

from threats and insults (31). New York City school security officials told OTA that they had confiscated 65 guns from students on school grounds barely four months into the 1993–94 academic school year (35). The State of Florida has admitted similar problems, with a 61 percent increase in handguns between the 1986–87 and 1987–88 school years (4).

With recent shootings in many urban, rural, and suburban communities, concerns about weapons in schools will probably remain a top priority for local school boards. A number of shootings have drawn attention to the problem of guns in school, but it is important to note that knives and razors are the weapons most likely to be found on students in the schools sampled by the Youth Risk Behavior Surveillance System (YRBS) (13). Findings from the CDC also identify a fundamental fact related to the demography of violence in schools: access to weapons and assaults occurs across a spectrum of social groups and in many geographic areas. It is not confined to particular social groups or urban schools.

Physical Fighting

Data on the prevalence and severity of physical fighting among school-aged youth have emerged from recent national and local surveys. A 1990 questionnaire from the YRBS[18] at the CDC (13) asked students, "During the past 30 days, how many times have you been in a physical fight in which you were injured and had to be treated by a doctor or nurse?" Approximately 8 percent of those students reported having been in at least one fight in which they were injured and required medical attention during the previous month. Among students who fought, 53 percent indicated that they had fought one time, while 28 percent of respondents indicated that they had fought two or three times, and 10 percent stated that they fought at least four times.

The preponderance of research about physical fighting has revealed gangs as a leading factor in interpersonal violence in some schools (3,11). According to the northern California-based Center for Safe Schools and Communities, "youth gangs of all races have increased by 200 percent in the last five years and female gangs now represent 10 percent of all gang groups in the nation" (5).

SCHOOL ILLNESS

In 1992, school-aged children missed approximately 154 million school days, 285 days for every 100 students, from illnesses associated with acute respiratory and digestive conditions and infectious diseases alone (1). These illnesses account for about 75 percent of the nearly 175 million lost school days from short-term conditions (both injuries and illness). Although illnesses account for fewer fatalities than injuries in this age group, three illnesses are among the leading causes of death: cancers, congenital anomalies, and heart disease. About 3,130 school-aged children died from these diseases in 1992, but these deaths are not likely to be school related. The leading causes of death from environmental hazards and infectious disease include fatal poisonings, which claimed the lives of 191 children in 1992; the respiratory diseases pneumonia and influenza, which led to 189 deaths; and infection with the human immunodeficiency virus (HIV), which contributed to the deaths of 152.

This report splits health hazards leading to illness between environmental hazards and infectious disease hazards. OTA groups these hazards into four categories, originating from: 1) school materials, 2) indoor air contaminants, 3) school location, and 4) infectious diseases. These categories depend most heavily on the source of exposure, which to a large extent determines the route of exposure—whether the agent is inhaled, absorbed through the skin, or ingested—and the possible health effects (see table 1-5). Such a categorization is useful for removing the focus of attention away from particular hazards and toward finding common strategies for preventing or reducing threats to health from hazards in each category.

Three types of information are needed to associate an agent found in the school environment with illness. First, there must be evidence that exposure to the agent can produce the observed symptoms. Second, there must be evidence that the student was exposed to the agent in the school environment. When these two conditions are met, there remains the task of showing it was the in-school exposure and not an exposure elsewhere that caused the disease.

■ Materials in the School Environment

Some hazardous school materials are intentionally brought to the school environment for use in the classroom, (e.g., art supplies, chemicals used in science courses) and for maintenance and cleaning of the school building and school grounds (e.g., solvents and pesticides). School officials and public health professionals have identified specific school materials that pose

[18] The findings covered 11,631 9th through 10th grade students in the 50 states as well as the District of Columbia, Puerto Rico, and the Virgin Islands.

TABLE 1-5: Environmental Hazards in School

Nature of Hazard	Type of Hazard	Source	Route of Exposure	Possible Effect	Remediation or Prevention Strategies
School Materials: Lead Pesticides Cleaners, solvents, paints Art supplies Lab materials	Chemical/ biological	Intentional appearance in school Result of inadequate handling, use, storage, labeling	Dermal/oral	Exposure at high concentrations: poisoning, chronic illness	Proper handling, use, storage; better education
Indoor Air Quality Asbestos Radon Other air contaminants	Radiation/ chemical/ biological	Unintentional appearance in school; result of inadequate ventilation	Respiratory	Chronic lung disease Sick building syndrome	Redesign; maintain heating, ventilation, and air conditioning
School Location: Electromagnetic fields Hazardous waste sites Noise	Radiation/ chemical/ injury	Siting and location of school	All	Results from low-level exposure: chronic illness/ loss of hearing	Move school/ prudent avoidance
Infectious Disease	Biological	Communicable pathogens	Respiratory/ oral	Infectious disease	Hygiene

SOURCE: Office of Technology Assessment, 1995.

health risks to students in school or are perceived as such by many in the community. The materials covered in this category include lead, pesticides, and other hazards rising from supplies and materials used in arts, industrial arts, and science courses. Exposures to high concentrations of some of these materials can lead to poisoning, but the effects from long-term exposures are more varied and less well understood and documented.

Poisoning

Chemicals that are toxic at very low levels are considered poisons. Exposures to them are often reported to regional poison control centers, and those reports are subsequently collected into a database by the American Association of Poison Control Centers (AAPCC), the professional organization for regional poison centers. In 1993, the AAPCC received about 1.75 million reports of exposure to poison (16), about 55 percent of which were to children under 5 years of age. Approximately 260,000 reported exposures occurred in children ages 5–19, nearly 15 percent of the total.

About 20,000 exposures occurred in schools, but some of these were not to school-aged children. The in-school exposures include all exposures, to staff as well as students, and all schools, including preschools and universities, not just elementary and secondary schools. The data suggest that relative to households, students in schools are at less risk from most poison exposures. At most, 7 to 8 percent of exposures to poison among school-aged children occur in school. In accordance with that estimate, an analysis of the 1988 National Health Interview Survey determined that about 5 percent of poisonings occur in school, compared to 80 percent at home (30).

The AAPCC database recorded exposures to school-aged children to a variety of substances possibly found in the school environment and discussed in this report (15,16). Art and craft materials generated over 4,700 exposures. The AAPCC system reported more than 7,500 pesticide exposures and 16,000 exposures to selected indoor air contaminants in 1992. Presumably, the school environment should have better supervision of the children and better instruction on the proper use and handling of these materials than nonschool environments. However, sporadic in-school inspections revealed that many instructors and others responsible for handling hazardous material were inadequately trained or that the schools failed to develop proper care and storage facilities for these materials. The underlying data and existing studies suggest the presence of toxic materials in schools, yet few efforts are made at determining actual exposures to schoolchildren.

In contrast to the AAPCC data, which reported only possible poison exposures and not the resulting health effects, the National Center for Health Statistics (NCHS) examines hospital discharge records and conducts household surveys to assess impacts of poisoning and injury. For poisoning from drugs and other chemical substances, NCHS estimated that in 1992, poisonings hospitalized about 47,000 school-aged children, of which 191 died. Data are not kept on whether these poisonings occurred in school or at home.

Lead

Lead is recognized by many public health authorities as the foremost environmental health hazard to children (41). Even low levels of lead exposure during preschool years can produce adverse effects on intelligence and behavior. Once absorbed into the child's body, lead can exert adverse effects that vary according to dose and age at exposure. While school-aged children may not be as susceptible as preschoolers to low-level exposures, higher exposures at any age can result in lead poisoning, with the major concerns being adverse effects to the nervous system.

Lead exposure from all sources, whether in the home or the school environment, is cumulative. While it is difficult to rank sources in terms of their contribution to the overall problem of childhood lead poisoning, lead-based paint is considered of premier importance, followed by leaded gasoline fallout into dust and soil, and then by lead in drinking water (23).

OTA was not able to identify any studies that examined the contribution of lead in preschools or schools either to total lead exposure or to adverse health effects in children. The only studies uncovered are those monitoring drinking water or paint lead levels in some facilities in selected areas of the United States. These studies do not systematically and comprehensively assess the presence of lead in preschools and schools nationwide, in contrast to the data available for United States housing. Nor do they examine lead levels in all media combined—paint, drinking water, and soil. They focus primarily on drinking water, despite the fact that this source is not the greatest contributor to the problem of childhood lead poisoning. Finally, the preschool environment, where children are at greater risk because of their age, has been studied far less than the school environment.

The existing data do not demonstrate that the level at which students are currently exposed to lead in classroom or school facilities constitutes a significant risk in itself. **However, given the limited extent of environmental monitoring of preschools and schools where lead is likely to be present, the risks from all sources of lead exposure warrant further evaluation.**

Pesticides

Despite their uses and benefits in schools, pesticides can also pose a public health problem. The health effects known or suspected to arise from pesticide exposure are rather well established. Generally, exposures to high concentrations of pesticides can result in acute toxicity, but far more controversial than poisoning is determining the health effects from chronic exposure to low doses of pesticides. Existing exposure and toxicity data are insufficient to assess these risks in schools.

The California Pesticide Illness Surveillance Program (CAPISP) identifies school exposures in its reporting system, although it does not report the amount of exposure. From 1982 to 1991, student exposures represented 0.6 percent of total pesticide exposures (15,700) and 1.2 percent of total nonagricultural exposures (8,594) reported to CAPISP. During that 10-year period, the program recorded an average of about 10 students exposed a year, although the numbers ranged from zero to 40.

OTA could not find evidence that in-school exposures presented a greater health threat than exposures outside the school environment for school-aged children. Most exposures that did occur in schools were to school staff, who were often untrained in pesticide handling and application. Those cases in which students became ill from pesticide exposures resulted almost entirely from poisonings following inadvertent use, an accidental spill, or intentional or unintentional ingestion. Clearly, inadequate data exist on which to base an assessment of risk from pesticide poisoning.

However, the available data for certain pesticides suggest the potential for adverse health effects and that children may be more susceptible to toxicity with certain pesticides than are adults. Moreover, schools may contribute to the cumulative impact of all the exposures that the student may receive in his or her daily life. Consequently, the steps taken by state and local agencies to promote either pest control strategies that reduce pesticide use or the use of pesticide alternatives in schools seem appropriate (box 1-B).

Other School Materials

In addition to lead and pesticides, other potentially toxic materials can be present in the school environment, in particular, agents used for school maintenance and as teaching aids in the classroom. The Center for Safety in the Arts (CSA), the largest nonprofit clearinghouse on art safety information (19), has identified toxic materials used in arts and industrial art classes, such as lead in ceramic glazes and solvents in paints. They have also presented information on possible exposures to potentially toxic material found in science and other courses in elementary and secondary schools.

Despite many potentially hazardous chemical and biological materials, few data demonstrate that these are making students ill. The sparse data offer random case reports of mishandled materials, but OTA found few case studies of exposures and fewer cases of illness. In fact, CSA claims that most of the reports of illness they receive come from teachers, who are made ill from long exposures in school, as well as from frequent at-home exposures (18).

Ample evidence exists that some of these materials are health hazards: the presence of metals—lead and mercury—and organic solvents—trichloroethylene—all present health risks, especially to school-aged children. These materials cannot be taken lightly or ignored. However, OTA could not find a substantial database demonstrating school exposures, let alone data on illness arising from them. Too little information is available to estimate the likelihood that children become ill following school exposures.

Indoor Air Quality

Indoor air quality considers the thermal environment—temperature, humidity, and air movement—and air contaminants. This report examines the presence of physical, chemical, and biological contaminants in schools. Harmful indoor air hazards include asbestos, which is present in some building materials; radon, a naturally occurring radioactive gas; combustion products; various volatile compounds; and noninfectious biological materials.

Indoor Air Quality in School

Beyond the data on asbestos and radon in schools discussed below, there are no national surveys of indoor air quality (IAQ) in schools. Some state indoor air quality programs exist, however. To provide some information about IAQ problems in schools across the nation, OTA reviewed requests made to the National Institute for Occupational Safety and Health by school teachers and staff for Health Hazard Evaluations (HHEs). OTA analyzed the requests for investigations in 26 schools, to provide a picture of the current nature of school IAQ problems. The health complaints suffered in these schools—neurological

BOX 1-B: Integrated Pest Management in School

Rather than using conventional pesticides to kill pests after they have become a problem, integrated pest management (IPM) approaches the pest problem from a different angle, emphasizing prevention and reduction of the source of the pest problems rather than trying to get rid of all of the pests at once. Comprehensive information regarding the lifecycles of the pests and their interactions with the environment, such as food and habitat, are used instead of relying solely on chemical-based pesticides to eradicate the problem. Through preventative measures, such as education of janitorial staff and improved janitorial practices, landscaping, occupant education, and staff training, IPM creates inhospitable environments for the pests by removing basic needs like food, moisture, and shelter. This use of natural controls can minimize the use of pesticides, therefore reducing possible hazards to people, property, and the environment. The IPM programs do not completely eliminate the use of pesticides, but these measures can help to reduce the amounts used and the exposure to them.

Most school districts do not require that IPM programs be adopted. However, many school districts across the country, including Eugene, Oregon; Conroe, Texas; Dade County, Florida; Montgomery County, Maryland; Cleveland Heights, Ohio; and elsewhere, have voluntarily integrated IPM programs into their pest control management.

Evaluating the costs is almost always a concern when initiating a new program such as an IPM program. IPM programs reduce pesticide use, thereby reducing possible health problems (potential liability) and costs (materials). Long-term reductions in the purchase of pesticides can offset the initial one-time expenses, including structural and grounds modification. Labor costs, however, usually are higher for IPM programs than they are for conventional pest control programs.

Setting up an effective IPM program will take time, money, and the support of all of the participants, including faculty, students, and staff. IPM programs are proving to be a viable alternative to conventional pesticide programs in the California cities of Los Angeles and San Diego.

SOURCES: Dade County Public Schools, Department of Safety, Environment and Hazards Management, *Integrated Pest Management Procedures*, September 12, 1994. Northwest Coalition for Alternatives to Pesticides, "A Better Way: Integrated Pest Management (IPM)," *Getting Pesticides Out of Schools*, 8–13. U.S. Environmental Protection Agency, *Pest Control in the School Environment: Adopting Integrated Pest Management*, EPA 735-F-93-012, August 1993.

effects, headaches, fatigue, dizziness, and throat and eye irritations—reflect the subjective and rather nonspecific nature of the health effects resulting from IAQ problems, including "sick building syndrome" (SBS). SBS is used to describe situations in which adverse, often general and nonspecific, health effects are associated with a building, but the exact cause is unknown.

Specific Indoor Air Contaminants

Although many possible air contaminants may exist in the school environment, OTA considers asbestos, radon, environmental tobacco smoke, volatile organic compounds, combustion byproducts, and biologic organisms as agents worthy of special attention in IAQ issues. These are not the only agents in indoor air associated with health effects, but they are among the best studied and of most concern. Although some information exists about the presence of these agents in schools, there is little direct evidence linking in-school exposures to the diseases discussed. Instead, information is primarily from studies in highly exposed occupational populations—insulation workers for asbestos risks, miners for radon risks, etc.—studies of other nonstudent populations, and animal studies.

Asbestos

About 31,000 primary and secondary schools in the United States have asbestos-containing building materials in some form: insulation and fire protection in heating plants and distribution systems, sprayed-on material for structural fire protection, asbestos-containing tiles, and asbestos-containing plasters, where the asbestos contributes to sound dampening as well as fire resistance (10).

For all of its useful properties, asbestos has a definite downside. Exposures to asbestos are associated with increased occurrence of mesotheliomas (cancers of the lining of the chest or abdomen), but the type of asbestos most commonly used in buildings—chrysotile—is generally considered to present less of a cancer risk than other types. Also most lung cancer cases among asbestos workers occur in smokers; the risks for nonsmokers are much less. Finally, cancer risk decreases with reduced exposures (10).

Following their measurements of asbestos levels in schools, Mossman et al. (20) and Corn et al. (6) calculated the risk of lung cancer and mesotheliomas from measured concentrations of asbestos in schools in the absence of any abatement. The calculated lifetime risks from exposures to asbestos levels of 0.00017 to 0.00024 f/m^3 over a period of five to six years range from 0.3 to 6.5 cancers per million people. This is equivalent to about two to 60 lung cancers per year, out of the entire school population of 46.4 million students.

There is a long lag (usually 20, 30, or more years) between the first recorded occupational exposures to asbestos and increases in asbestos-related cancers. It must be assumed that any cancers that might result from in-school exposures would occur after a similar lag. As sources of asbestos decline nationwide, any in-school exposure might be a child's only contact with the material.

Radon

Radon is a naturally occurring radioactive element that can move from soil and rocks into air and water, and through air and water into homes and other buildings. Radon is concentrated inside buildings because structures retard its dilution into the enormous volume of outside air; thus, "environmental exposures to radon" refers to exposures inside buildings.

The Environmental Protection Agency and the Department of Health and Human Services (44) as well as several independent scientists (17,27) have calculated that environmental exposures to radon are associated with about 13,000 to 15,000 lung cancer deaths annually in the United States. That risk, based on studies of underground miners who were exposed to radon in the course of their work, is the largest cancer risk that the Environmental Protection Agency associates with any environmental exposure (38). If there are any deaths due to exposure as children, these deaths will be decades in the future and mostly among smokers, who are at a much greater risk of getting lung cancer following radon exposure. EPA has established 4 pCi/L as an "action level" (38), and it recommends that actions be taken to reduce any inside radon concentration above that level.

In its *National School Radon Survey: Report to Congress*, EPA made short-term radon "screening measurements" in 927 public schools over seven-day periods during February and March 1991, and long-term radon measurements in 100 schools over the period December 1990 to May 1991. The short-term screening measurements indicate that 2.7 percent (± 0.5 percent, not shown on table) of the tested school rooms had radon at concentrations $\geq$ 4 pCi/L. The percentage of rooms at concentrations $\geq$ 4 pCi/L as determined by the long-term measurements was 1.5 percent (± 1.2 percent).

On average, schools have slightly lower radon concentrations than homes: about 0.8 pCi/L in schools versus 1.25 pCi/L for the average home. Thus, on average, a student faces about equal or slightly lower risk from radon spending the same amount of time in school than at home. By assuming that students will be exposed to the average in-school radon levels for the 12 years of school, it is possible to estimate the numbers of future lung cancer deaths per year due to exposure while in school. This ignores the differences in the distribution of radon among schools in various parts of the country. A one-year exposure to the average in-school level of radon results in 64 cancer deaths, with about half of the total risk borne by high school students that smoke.[19] The risks estimated for in-school exposures are about 10 percent of the risks for school-aged children from residential radon, due to both the slightly lower radon concentration and the considerably lower amount of time spent in school. These deaths are in addition to the 15,000 lung cancer deaths EPA estimates for residential exposures each year in the United States and the 3,000 deaths associated with outdoor exposures.

Only in what appear to be exceptional circumstances do in-school exposures make significant contributions to lifelong radon exposures, which, at certain levels, are unavoidable. In contrast to asbestos, exposure to radon will likely occur throughout a child's lifetime.

Other Air Contaminants

The presence of other air contaminants poses possible hazards in schools. OTA examined the available illness, exposure, and health effects data for environmental tobacco smoke, volatile (and semivolatile) organic compounds, combustion products, and biological contaminants. In each category, ample health effects data suggest that exposure to particular agents can lead to adverse health effects, especially in school-aged children. Nevertheless, little evidence exists to demonstrate that school children are being exposed to dangerous levels of agents. The available data come from case studies of a single school or a few schools with specific problems. Hence, inadequate data are available to conduct a quantitative assessment of the health risks in schools from these indoor air contaminants.

School Location

Parents, teachers, and administrators often express concern about, and even fear of, hazards arising from the location of a school. Environmental hazards associated with location can come from the community, such as polluted air or water, or from placement of the school on or near hazardous waste sites or close to power transmission lines. This report discusses some of the risks associated with those hazards; however, insufficient data exist to assess their risk quantitatively or even qualitatively.

Electromagnetic field (EMF) exposure is among the most uncertain of the environmental risks described in this report. Although concerns have been raised that prolonged, elevated exposures may place individuals at increased risk, there is still no consensus among scientists as to whether power frequency EMF exposure presents a health risk. Those who believe a cancer risk exists are in general agreement that EMF does not cause cancer but instead acts as a promoter—that is, a cancer may be more likely to occur when an individual is exposed. The magnetic field component of power frequency EMF—which is generally unperturbed by buildings and walls, and penetrates the human body—is the typical focus of such concerns.

Electromagnetic fields are ubiquitous in the home and school. Each of these environments is replete with opportunities for exposure. Power frequency EMF exposure may come from sources inside buildings, such as electrical devices and wiring, or outside sources, such as transmission or distribution lines. A child's exposure, whether in the home or the school, varies greatly: it depends on the number of sources, their intensity and configuration, their proximity to the child, and the amount of time he or she spends in their presence. The impact of exposures at school and the school's contribution to a child's overall exposure are almost impossible to predict, even if the sources within both the school and the home are well characterized. Much depends on the child's dose, and no one knows exactly what measure of dose is most

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[19] A Centers for Disease Control and Prevention survey indicates that 70 percent of high school students had tried smoking, even one or two puffs, and 28 percent were considered "current cigarette users," having smoked one or more cigarettes on one or more of the 30 days preceding the survey (40). For these calculations, OTA assumes that 28 percent of the high school population (grades 9–12) smoke; younger students are assumed to be nonsmokers.

informative or how variations in dose might affect the response to the exposure.

Knowledge of power frequency EMF exposure at school comes from a limited number of studies. We do know whether levels at some schools equal or exceed those associated with increased incidence of certain forms of cancer in some residential studies. However, these residential studies of cancer address prolonged exposures (more than 12 hours per day), and their results may or may not be applicable to school exposures of equal magnitude. We also know that transmission lines are just one of many sources of exposure and not necessarily the most important source. So much of the school research has been driven by public concerns about transmission lines that other sources of exposure, particularly sources inside the school, have been neglected. Finally, we know that EMF levels vary from one school to another, vary among locations within a school, and vary over time at any one location. Additional research is needed to better characterize school EMF exposures and exposure sources so that more informed decisions can be made as our knowledge of health effects improves.

Infectious Disease

Infectious diseases are spread mostly by student to student contact in the course of a normal school day, and inadequate ventilation or overcrowding in schools may contribute to the spread of diseases for which the airborne route is a factor. Infectious conditions represent a substantial cause of morbidity and mortality in school-aged children. On top of that, researchers and public health officials are raising additional concerns about infectious diseases as new infectious problems continue to occur, such as human immunodeficiency virus (HIV) infection and streptococcal toxic shock syndrome, and new infectious disease challenges, such as the emergence of drug-resistant bacteria and mycobacteria.

Substantial data are available from a variety of sources on many of the infectious conditions that occur in school-aged children. Sources of data include national surveys, disease-specific surveillance, focused epidemiologic and laboratory research, and national or hospital-based databases. Nevertheless, the source of an infectious disease is typically not known; thus, there are no data on infectious disease from the school environment. This section presents the available data on infectious disease in school-aged children regardless of origin, from the results of a national household survey and cases of notifiable diseases.

The NCHS National Health Interview Survey (NHIS) is a continuing nationwide survey of households. The NHIS data of the incidence and severity of infectious disease in school-aged children are shown in table 1-6. The table shows that over 82 million acute conditions occurred in 1992 for children 5–17 years old, but does not represent all of their diseases. The acute conditions presented here include infective and parasitic diseases, such as common childhood diseases (e.g., measles), respiratory conditions, such as influenza, and acute ear infections. These infectious diseases were responsible for 81 percent of the lost school days from all acute conditions, which include injuries and digestive system complaints.

The NHIS results can give an indication of the health impact of a particular condition. Respiratory diseases account for the greatest number of acute conditions, influenza being the most prevalent. Accordingly, more school days are lost from respiratory conditions; common childhood diseases account for the largest numbers of lost school days per condition.

Data on the reported occurrence of notifiable diseases are collected and compiled by the Centers for Disease Control and Prevention from reports to the National Notifiable Diseases Surveillance System, which has morbidity information for 49 currently notifiable conditions, for which notification to public health authorities by the attending physician is mandatory. Many common diseases do not require reporting. According to the reported cases of infectious disease in the United States for school-aged chil-

TABLE 1-6: Number of Acute Conditions and School-Loss Days in Youths 5–17 Years of Age from the National Health Interview Survey, 1992

Type of Acute Condition	Acute conditions: Number (in thousands)	Acute conditions: Rate (per 100 youths)	School loss days: Number (in thousands)	School loss days: Rate (per 100 youths)	School loss days/ condition
All acute conditions	112,340	239.9	164,797	351.9	1.47
Infective and parasitic diseases	21,155	45.2	40,751	87.0	1.92
Common childhood diseases	2,399	5.1	12,225	26.1	5.12
Intestinal virus, unspecified	5,122	10.9	6,312	13.5	1.23
Viral infections, unspecified	5,826	12.4	7,910	16.9	1.36
Other	7,808	16.7	14,303	30.5	1.83
Respiratory conditions	55,783	119.1	85,509	182.6	1.53
Common cold	16,562	35.4	21,978	46.9	1.32
Other acute upper respiratory infections	8,303	17.7	13,321	28.4	1.60
Influenza	27,653	59.1	43,532	93.0	1.57
Acute bronchitis	1,922	4.1	3,517	*7.5	1.83
Pneumonia	584	*1.2	2,001	*4.3	3.58
Other respiratory conditions	758	*1.6	1,160	*2.5	1.56
Acute ear infections	5,424	11.6	7,149	15.3	1.32

SOURCE: Benson, V. and Marano, M.A. Current estimates from the National Interview Survey, National Center for Health Statistics, *Vital Health Stat*, 10 (189), 1994.

dren, ages 5–19, gonorrhea was the most reported disease in 1992, with over 151,000 cases. This was about four times greater than the second most numerous category, chickenpox, with over 37,000 cases. Hepatitis A had 7,565 cases, and two diseases arising from contaminated food and water are the next most numerous cases: salmonellosis with 5,943 cases and shigellosis with 5,193. Finally, authorities reported 4,060 cases of syphilis and 2,970 cases of aseptic meningitis.

The school environment may put students at a greater risk than other environments for catching many infectious diseases. However, this remains a speculative determination since the school's contribution to disease is rarely determined. Nevertheless, the school environment would appear to be an incubator for many diseases. Respiratory infections, in particular, can spread from student to student during interactions in crowded classrooms. Two of these, pneumonia and influenza, led to the deaths of about 190 school-aged children in 1992.

In that same year, infection with the human immunodeficiency virus (HIV) contributed to the deaths of about 150; while its transmission may occur in schools, the data are inadequate to estimate the importance of school contacts, although about half of fatalities are in the pre-adolescent population (5 to 9), which suggests these deaths are not attributable to school contact.

In box 1-C, OTA presents those disease categories that warrant more attention than others based on their implications for schoolchildren and public health. Based on those categories, OTA examined the available information on illnesses of school-aged children from these specific diseases: meningococcal infections, viral respiratory infections, Group A streptococcal infections, Hepatitis B and human immunodeficiency virus infections, and food poisoning.

Infectious diseases are among the best understood and documented causes of disease in

BOX 1-C: Diseases of Concern to School-Aged Children

Based on interviews with infectious disease experts, the Office of Technology Assessment (OTA) considers the following disease categories as warranting more attention than others based on their implications for schoolchildren and public health.

1. **Diseases with high incidence:** Diseases such as respiratory viral infections, especially influenza, are noteworthy because they occur so commonly. Other diseases of high incidence in schools include common childhood diseases and conditions such as head lice, conjunctivitis, strep throat, otitis media (ear infection), and mononucleosis. These conditions inflict costs not only on the child in terms of lost school days but also indirect costs due to parents' lost time from work.

2. **Diseases of high severity:** Diseases such as pneumonia, AIDS, and meningococcal infections (meningitis and bloodstream infections) that are not common but have a high case fatality rate (CFR) in school-aged children are a significant public health problem. CFRs refer to the deaths attributable to a specific condition in relationship to the reported cases of the condition. Bacterial meningitis used to have a fatality rate of more than 50 percent, but more treatment has reduced the rate to 10 percent.

3. **Diseases with a major impact on the public health systems:** Diseases that occur in outbreaks in schools may deplete public health resources in an affected community. Such impacts may include investigation and intervention in foodborne disease outbreaks or mass immunization campaigns for meningococcal disease clusters.

4. **Diseases that spread from school children to families and the community:** Schools may act as an "incubator" for certain diseases that then spread to families and the community. Influenza and group A streptococcal infections are rarely severe in children but may cause substantial morbidity and mortality in infected family members, especially the elderly. The spread of antibiotic-resistant bacterial infections initially within childcare settings and subsequently into the community is another example of such a problem.

5. **Diseases that are becoming increasingly common ("emerging infections"):** Many microbiological agents can adapt and even mutate in response to their environment. Often these adaptations can result in organisms that can proliferate where they could not before, or previously harmless organisms that can become disease-producing agents. These changes can create new infectious diseases (HIV infection and group A streptococcal toxic-shock syndrome), new problems associated with well-recognized infections (drug resistance in bacteria and tuberculosis), and changes in the epidemiology of infectious disease (clusters of cases of rheumatic fever). Infectious disease in the school environment is an important focus for studying these emerging diseases because it provides an opportunity for surveillance, research, and the development of preventive interventions.

6. **Diseases that offer substantial opportunity for prevention in schools:** This category includes diseases such as meningococcal infections and influenza, for which effective vaccines already exist, and efforts are focused on determining the most cost-effective approach for immunization; respiratory syncytial virus and parainfluenza virus, for which new vaccines are being developed that may offer the opportunity for prevention; foodborne illness, where application of proper food handling practices can eliminate outbreaks; and diseases such as hepatitis B and HIV infection, where schools provide a focus for education on risk factors for illness and on prevention through behavior modification.

SOURCE: Office of Technology Assessment, 1995.

school-aged children. The transmission of disease through social interaction and the often crowded conditions at school suggest that schools are a primary incubator for the growth and spread of infectious organisms; however, OTA could find little national data linking illness specifically to the school environment. Although case studies document the outbreaks of disease and disease clusters emanating from schools, more information is needed on the role of schools as a source for the spread of infectious and foodborne disease.

USING THE DATA

Chapters 3 and 4 of this report are compilations of information about health and safety risks in schools. However, decisions on whether to deal with these risks require more than listing the health and safety data. Decisionmakers likely will want an understanding not only of the hazard but the perceptions of the hazard, why it exists, and what it would take to remove it. When deciding which risks to address first, many people naturally tend to order things by their size or severity, yet simple point estimates of risk often do not convey the spectrum of other important factors. This section briefly reviews several subjective risk attributes that decisionmakers may want to consider in efforts to compare and rank diverse in-school risks. In addition, OTA briefly reviews different types of comparative risk assessment (CRA), that is, a process for using risk estimates, such as those presented in this report, to help set priorities for risk reduction.

Risk Dimensions

Risk attributes, or "dimensions" of risk, can be grouped into three categories: magnitude of the risk; social aspects of the hazard; and feasibility, cost, and other implications of reducing the risk.

Risk magnitude refers to the quantitative estimates of the likelihood of adverse health effects arising from the hazardous conditions. This category reflects the more conventional notions of the number of deaths or cases of injury and illness and their severity. There are several common measures for quantifying risk magnitude. This report used number of incidents and incidence rates as measures of injury or illness in the school population, and lost school days as a measure of severity. There are also measures of the individual probability of risk or the risk to the population. One measure of particular relevance to this report is in the number of years of life lost, rather than the numbers of lives lost. The death of a child is then weighted much more heavily than that for an elderly adult.

Some reasons for wanting to reduce risks extend beyond the benefits to health and safety, but rather relate to the social context of a risk. Some risks are more worth taking—or bearing—than others. This difference is largely governed by the perceived benefits that accompany the risk. Football, for example, is among the most hazardous athletic activities—in terms of the number of injuries—in which high school students participate, yet the perceived benefits of athletic accomplishment and social recognition encourage continued participation in it.

Fear can be one of the most significant dimensions of risk, especially in schools, and one that varies widely across individuals and communities. Contributing to the fear of a hazard is the extent to which individuals can or cannot control the risk through personal action. Parents may fear their child's in-school exposure to asbestos or to a student carrying a weapon because they cannot control it, but they are probably less afraid of the exposures to most infectious pathogens—even though the bacteria and viruses are responsible for more lost school days—because they have more control from antibiotics, vaccines, and rest. The irreversibility of an illness or injury also adds to the fear associated with a hazard; the more irreversible the effect, such as spinal cord injury or HIV infection, the greater the fear.

Another factor is the desire to focus attention on reducing risks where in so doing injustices can also be redressed and blame for the hazard can be affixed. Inadvertent release from a nearby hazardous waste site, or an industry that exposes schoolchildren to toxic material, generates more public interest than the risks from radon—even though the risks of the latter are probably greater—because radon is a natural gas and no one is to blame for children's exposure to it.

An especially important consideration now confronting schools is the cost and feasibility of reducing the risk of a hazard. Small risks that are cheap and easy to eliminate may deserve priority attention, whereas even very large risks may not emerge as priorities from a thorough risk comparison if reducing them would be technically infeasible or prohibitively expensive. Metal detectors, for instance, may provide protection from firearms in schools, but they are expensive and school boards must decide if the risks in their schools justify the costs. The risk of the intervention itself, the dimension of "offsetting or substitution risks," arises whenever reducing one risk would create new risks in so doing. For example, closing the schools to remove asbestos exposes the children to risks of being out of school.

Comparing and Managing Risks

This course of making decisions about which risk reduction measures to undertake leads to suggestions for the use of comparative risk assessment (CRA). CRA remains a controversial and mostly untested process. Nevertheless, efforts at federal, state, and local levels to undertake CRA to establish risk priorities and strategies for reducing them suggest the possible utility for some of CRA's methods and social processes. This section presents some of these processes and the nature of the information needed for them.

Much of the discussion of the process for comparing risks revolves around the distinctions between the so-called "hard" and "soft" versions of risk-based priority setting (7). The "hard" version—also referred to as "expert-judgment"—involves the use of a small group of experts to develop estimates of the magnitude of various risks and a ranking of risk reduction opportunities. The "soft" version uses a societal representative group—composed of citizens as well as experts—that works together to generate a more "impressionistic" ranking of risk based on many factors in addition to quantitative estimates of deaths, illness, and injuries.

The open process that is part of the soft version of CRA helps to inform risk assessors about public values and the relative importance the community places on subjective risk attributes such as fear. By involving the public, a soft CRA can go beyond probability estimates of risk and incorporate ethical and political concerns, which are usually neglected in risk assessments (33). Comparison and ranking inevitably involve incorporating these value judgments as well as the scientific estimates and measurements. The process helps to educate the public on the scientific and technical issues associated with risk assessment, and helps to educate everyone involved—parents, school boards, risk assessors, and others—about the nature of suspected risks.

After ranking risks, the next step involves comparisons of risk-control strategies, where feasible. Setting priorities for risk reduction is more than simply ranking risks. Setting priorities means to guide where *resources* should flow. The *biggest* problems may bear little resemblance to the highest priorities for risk reduction. Decisionmakers are likely to want to incorporate social, political, and technical factors as well as economic costs.

The purpose of comparing the wide range of risks in schools is to help allocate or reallocate resources among the many possible risk-reduction options, including the option of no action on one or more perceived risks. The public may be delighted to have funds spent more efficiently, but probably not at a cost of visibly greater risks to students. To such a combustible, emotional debate, the need for clear, objective analyses and straightforward, understandable information becomes increasingly clear. This report, then, consists of a first step in this process.

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Issues in School Health and Safety 2

Schools, like all buildings and institutions, harbor some risks. Some of the illnesses and injuries in schools stem from preventable or reducible hazards. Nevertheless, compared to other places where children live and play, schools are often safer environments. This finding must be qualified by the paucity and occasional poor quality of data—or even the absence of information about some hazards.

Children daily confront a variety of risks, in or out of school. In 1992, children ages 5 to 17 suffered 13 million injuries and some 55 million respiratory infections, which contributed to their missing about 214 million school days, roughly 460 days for every 100 students. Unknown are the possible long-term health consequences, the impact of the lost learning opportunities, or the care-giving problems faced by families.

Averaged over the year, school-aged children spend about 12 percent of their time in school, and some portion of these injuries and illnesses arise in connection with the school environment. Since government requires school attendance, it ultimately bears responsibility for children's health and safety while they are there. While local, county, and state governments bear most responsibility for the operation of schools, the federal government has taken a role in health and safety issues, as reflected in the 103d Congress considering 66 bills that referenced the "school environment" and 51 that were directed at the goal of "safe schools." Congressional concern led the House Education and Labor and Energy and Commerce Committees of the 103d Congress to request this report, which examines the scientific data on the risks for injury and illness in the school environment.[1]

Important interactions between the student's home life—such as the presence of only a single parent, poor family dynamics, limited supervision, or poor nutrition—and school-connected behavior and health and safety problems are beyond the scope of this report, as are mental health problems of children and adolescents. "Behavioral" risks, such as drugs and pregnancies, are high on the public's list of concerns, but they are not included in this report. Two OTA reports, *Healthy Children: Investing in the Future* (25) and *Adolescent Health (*26), provide broader information about the health of children

[1] In the 104th Congress, the House Education and Labor Committee was renamed the Education and Opportunity Committee and the House Energy and Commerce Committee became the Commerce Committee.

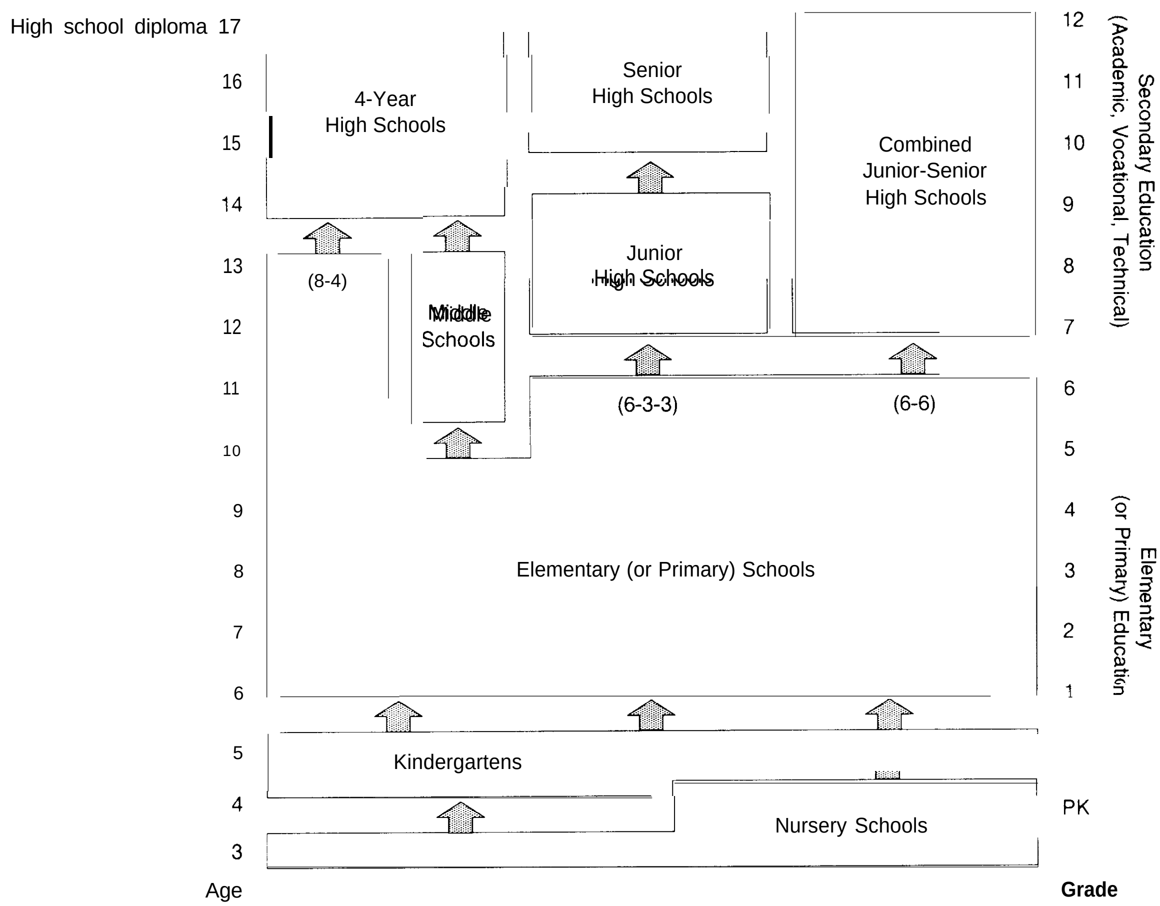
and adolescents through 18 years of age; this report is narrowly centered on health and safety risks to students while in school.

This chapter introduces the issues of school health and safety. It initially describes the student population and the school environment. The rest of the chapter is devoted to introducing concepts concerning health and safety data: the nature of the studies generating them, how the data are collected and interpreted, and the inherent difficulties in obtaining reliable and credible information. It ends by discussing the significance of risk estimates in deciding which risks need to be reduced, strategies for reducing them, and to what levels they should be reduced.

Student Population

The student population covered in this report spans the ages 5 to 18, which correspond to grades kindergarten through the 12th grade (see figure 2-l). According to census figures (31), over 46 million children were enrolled in the 109,000 elementary (kindergarten-8th grades) and secondary (9th–12th grades) schools for the 1990 school year, and a projected 50 million will enroll for the fall of 1995 (see table 2-1A and 1B). Except for the section on lead, the report does not cover nursery schools and students below the age of 5, nor does it cover the provision of health care in schools.

FIGURE 2-1: The Structure of Education in the United States



SOURCE: U.S. Department of Education, National Center for Education Statistics

TABLE 2-1A: Enrollment in Educational Institutions by Level and Control of Institution: Fall 1990 to Fall 1995 (in thousands)

Level of Instruction and Type of Control	Fall 1990	Projected Fall 1995
Elementary and secondary education[a]	46,448	50,709
Public	41,217	45,049
Private	5,232	5,660
Grades K-8[b]	33,973	36,668
Public	29,878	32,275
Private	4,095	4,393
Grades 9-12	12,475	14,041
Public	11,338	12,774
Private	1,137	1,267

[a] Includes enrollments in local public school systems and in most private schools (religiously affiliated and nonsectarian). Excludes subcollegiate departments of institutions of higher education, residential schools for exceptional children, and federal schools. Excludes preprimary pupils in schools that do not offer first grade or above.
[b] Includes kindergarten and some nursery school pupils.

SOURCES: U.S. Department of Education, National Center for Education Statistics, Common Core of Data and "Fall Enrollment in Institutions of Higher Education" surveys; Integrated Postsecondary Education Data System (IPEDS), "Fall Enrollment" surveys; and *Projections of Education Statistics to 2004*.

TABLE 2-1B: Public School Districts and Public and Private Elementary and Secondary Schools: 1990-91

School Year	1990-1991
Public school district	15,358
Public Schools	
Total all schools	84,538
Total all regular schools	81,746
Elementary Schools	
Total	61,340
One-teacher	617
Secondary Schools	22,731
Private Schools	
Total	24,690
Elementary	22,223
Secondary	8,989

SOURCES: U.S. Department of Education, National Center for Education Statistics, Statistics of State School Systems; Statistics of Public Elementary and Secondary School Systems; Statistics of Nonpublic Elementary and Secondary Schools; Private Schools in American Education; and Common Core of Data surveys.

Almost all information concerning school-based risks comes from studies and reports related to public schools. While the data could be applied to the 5 million children in the 24,690 private schools, this report could not find data suggesting one way or the other the appropriateness of that application.

One admitted data shortfall is limited knowledge about the particular susceptibilities of school-aged children, as age is known to be a major determinant of individual risks for particular illnesses and injuries (1,21). In general, compared to adults, children absorb more of any substance in the environment because of the larger ratios of their skin surface and, lung surface area to body weight and their higher metabolic rates. Because of the ongoing growth processes in children, many injuries, for example to the head, can have long-term health implications. These differences have implications for the interpretation of data on school children since most health studies are conducted on adults, and children may not be adequately addressed in the design or analysis of the data.

School Environment

Schools' primary mission is education; their end product can be considered an educated individual. Given the importance of education for an individual's ultimate happiness and satisfaction and the documented benefits to society of an education (34), disruption of the learning process must be considered an adverse effect. Clearly a sick or injured student, even if he or she attends school, is not as prepared to learn as a well student. A student fearful about assault or other violence on the way to and from school or on the playground is not prepared to learn.

Although the impact of sickness or injury on learning is difficult to estimate, one measure of this impact—used in this report—is the number of school days lost from an injury or illness. Injuries and illnesses resulting in absences from school may impede the learning process: a committee of pediatricians reviewed the medical and educational literature and concluded that "children that are frequently or persistently absent from school tend to perform poorly in school and are likely to drop out before graduation" *(*34). Further, they cited a number of social implications, including maladaptive behavior and future unemployment and welfare costs, as ramifications of excessive school absence.

School absences stem from many sources, and injuries and illnesses from the school environment make some unknown contribution to them. Even though the contribution of the school environment to a student's health and education has been discussed for decades *(*6,12,23), our understanding of it remains limited. Complicating our understanding is the lack of knowledge of the environmental, structural, and social hazards found in schools *(*22), which is partly manifested in not knowing which injuries and illnesses originate in schools and which arise elsewhere.

Despite the lack of knowledge of the hazards in them, schools contribute to student safety by protecting them from most hazards and instructing them on how to live safely in an often dangerous world. School prevents exposures to many of the worst risks. A student sitting at a desk, changing classes in an orderly fashion, and playing in supervised sports is likely to be safer than a child in unsupervised play in a neighborhood playground or park. As discussed in Chapter 1, relatively few deaths (less than 1 percent) occur in schools or school buses from the two leading causes of death in school-aged children, motor vehicles and firearms.

Schools also teach the proper use of potentially hazardous equipment, safe conduct on playgrounds and in athletic activities (like swimming), and respect for others and for dangerous situations. These skills carry over to the nonschool environment since many of the same activities occur off the school grounds. In addition, a growing number of organizations offer school-based programs that teach children the importance of health, safety, and the environment. One of the most notable examples is the Enviro-Cops program in the Dade County school system (see box 2-1). Because of this instruction and because of constant supervision by responsible adults, schools are often a safer place for children than most nonschool environments. Despite the concern for school safety, especially school violence, the overwhelming majority of polled school board members responded that they believed schools are still safe places for students and staff *(*33).

HEALTH AND SAFETY DATA

Collecting and analyzing data about illnesses and injuries are the cornerstones of efforts to identify and control health and safety risks. Although data and estimations come from different sources and are collected by different processes, certain generalities describe the data for the four kinds of risks that are considered here: unintentional injury, intentional injury, environmental illness, and infectious disease. The sources of data are considered in detail in the appropriate section; the following briefly discusses the nature of the data collection and interpretation.

■ Nature of Data Collection

Data collection constitutes the first, and in many ways, the most important step in having credible, usable, and understandable information for making decisions. The kinds of data described in this report are usually derived from *surveys* or *reporting systems* that specify what sorts of data to collect. More specific data and, generally, more information important to the interpretation of the data are collected through focused studies.

Despite the obvious desirability of more complete information on the hazards facing children in schools, obstacles to data collection activities exist. Obstacles can be simple, such as the lack of resources—money, expertise, or both—or more complicated, like the fear of being branded a "problem school."

Surveillance: Surveys and Reporting Systems

Surveillance is an active process for collecting, analyzing, and disseminating information on the occurrence of illness or injury *(*4). The meth-

BOX 2-1: Enviro-Cops and Enviro-Mentors

Enviro-Cops/Enviro-Mentors is just one of many successful programs concentrating on making the world safe for children. The Enviro-Cops and Enviro-Mentors program involves students in projects that teach them to save energy, recycle, and eat well, as well as personal, home, auto, and bicycle safety. The Enviro-Cops program starts with second grade students of the Dade County public school system. It teaches them to be eco-smart while developing their self-esteem and personal safety. More than 225,000 elementary school students have become involved with Enviro-Cops. Many of the Enviro-Cops continue their involvement in the program and return to become Enviro-Mentors, which is the second half of the program and consists of high school and college students who volunteer to be role models for the younger students.

Enviro-Cops take on many issues that affect all of the children of the world. The program incorporates safety issues, including personal safety (for example, eating good food, avoiding guns ("see a gun, dial 911"), and saying no to drugs and alcohol), traffic safety (such as wearing bicycle helmets and seat belts and using child seats for younger children), and environmental safety (like confronting issues such as the use of pesticides, the depletion of the world's resources, and destruction of the world). Enviro-Cops actively help reduce waste, recycle, precycle, and reuse. They learn that their actions do make a difference and that they can make the world safe for themselves, their families, their friends, and everyone else.

SOURCE: ARISE Foundation, *Enviro-Cops Guidebook and Lesson Plans*, 1993. ARISE Foundation, *A 10-Year Retrospective*, 1993.

odology for surveillance activities is basically descriptive. Its functions, however, extend beyond data gathering, as the information forms the basis for action by authorities to control or prevent public health hazards.

Surveillance systems were first developed for illnesses from infectious diseases and more recently are becoming established for other causes of disease and injury. Although disease surveillance began in the mid-1800s in England and Wales, in this country the collection of national morbidity data began in 1878, when Congress authorized the Public Health Service to collect reports of the occurrence of quarantined diseases such as cholera, smallpox, plague, and yellow fever (4). In 1893, Congress passed an act stating that weekly health information should be collected from all state and municipal authorities. This developed over time into a weekly bulletin: the *Morbidity and Mortality Weekly Report* (MMWR), issued by the Centers for Disease Control and Prevention (CDC), which was given responsibility for receiving morbidity reports from states and cities in 1960. National disease surveillance programs are maintained by most countries, and the World Health Organization (WHO) maintains a global surveillance system on quarantined and other selected diseases (2).

In establishing its global surveillance system, the WHO (35) identified 10 distinct sources of surveillance information. Sources of surveillance data relevant to this report include mortality and morbidity data, individual case reports for rare diseases or unusual cases, and the reports of epidemics for clusters of cases. Surveys, such as household or population surveys, can provide information on the prevalence and occurrence of a disease. Demographic information, such as age, and environmental information, such as the presence of lead, are also important sources of data.

Surveillance systems are run from central locations with the objective of monitoring a region—local or national—for any changes in the incidence or nature of particular injuries or illnesses. Surveillance data are often reported by health providers to health authorities, such as the state health department. Reporting can be routine or active for specific cases, but both cases require a standardized process whereby comparisons can be made between and across geography or time.

Data collection forms are distributed to the reporting units, and the completed forms are usually collected with similar forms, sometimes analyzed, and sometimes simply stored away.

Some well-established systems, such as the CDC's MMWR, are designed to disseminate the collected information. Other reporting systems may not disseminate the information as widely because the system may be designed for purely local purposes, or because of other reasons, such as fear of bad publicity. For example, school nurses file reports for observed injuries and illnesses, but these reports are often not released to the public. In any case, regardless of the difficulties of establishing and maintaining a survey or reporting system, these activities must be compatible with other sets of data. Surveys and studies must follow accepted or clearly described protocols if the results are to be informative and useful.

Studies

In contrast to the standardization and routine of surveys or reporting systems, studies can be designed to investigate a particular outbreak or situation, and thus require careful attention to design, execution, and analysis. Studies can be especially informative because they allow researchers to account for the complexity of the school environment and activities by incorporating relevant information from the community, such as lead being released from a nearby smelter. That flexibility also increases the complexity of the study. Epidemiological studies provide most of the relevant data in this report. However, toxicological and human exposure studies also provide important information for determining students' risks.

Epidemiological studies

Epidemiology is the study of the distribution of disease in human populations and the factors that influence the distribution of disease. Epidemiological techniques are used to identify causes of disease and determine associations between disease and risks. There are three basic designs for such studies: descriptive, experimental, and observational. This section provides a simple sketch of the field and defines some terms for the reader with no background in epidemiology. For more in-depth discussions, there are many available references, including Hennekens and Buring (13), Lilienfeld (18), Evans (8), and Brachman (4).

Descriptive epidemiology studies examine the patterns of distribution of disease and the extent of disease in populations in relation to characteristics such as age, gender, race, etc. Sources for descriptive studies include census data, vital statistics data, and clinical records from hospitals and private practices. By examining the differences in disease rates over time, descriptive epidemiology provides clues about disease causation. Descriptive studies can also focus on comparisons of geographical regions.

Experimental epidemiology studies involve a deliberate exposure or withholding of a factor and observing any effect that might appear. In these studies the investigator controls exposure to a risk and assigns subjects, usually at random, to either receive the treatment/risk or a placebo. The effects on the two groups are compared and analyzed. Experimental studies are hard to conduct, however, because of the need for a cooperative and eligible group of individuals who will allow intervention in their lives. Also, ethical reasons (either withholding a beneficial treatment from some subjects or introducing subjects to potentially harmful treatments) may make the study difficult to conduct.

Observational epidemiology studies analyze data from observations of individuals or relatively small groups of people in order to determine whether or not a statistical association exists between a factor and disease. Observational studies have two design options: cohort studies or case-control studies. In either design, the risk factor under investigation should define the groups, which otherwise should be comparable.

Cohort studies look forward (prospective), choosing subjects who are free from the disease under study, but who differ in respect to the risk factor under study. The health status of the individuals in the study group is observed over time to determine whether there is an increased risk of a disease associated with that exposure.

Case-control studies, on the other hand, compare individuals with the disease under study (cases) with individuals who do not have the disease under study (controls). Risk factors that are thought to be relevant to the study are compared between the groups. The extent of exposure to the risk in the case group is contrasted with the extent of exposure in the control group. Because of the presence or absence of the risk factor in the past, case-control studies are retrospective studies.

Toxicological Studies

Most often, the information needed to predict adverse health outcomes from exposure to potentially hazardous chemicals comes from testing substances in animals or through *in vitro* tests, that is, in cells or tissues isolated from animals and humans. Such toxicological studies allow scientists to test chemicals and control conditions that cannot be controlled in most epidemiological studies, such as the amount and conditions of exposure and the genetic variability of the subjects. Toxicological studies are the only means available to evaluate the risks of new chemicals.

Biologically, animals, even the rats and mice typically used in toxicity testing, resemble humans in many ways. A substantial body of evidence indicates that results from animal studies can be used to infer hazards to human health (14,15,16). There are exceptions to this generalization, but each must be proved to be able to set aside the assumption that animal tests are predictive.

Toxicological disciplines can be distinguished by the "endpoint" studied, the resulting disease or the organ affected by exposure to a toxic substance. Increasingly, researchers are studying subtle endpoints other than cancer, such as immunotoxicity (27), neurotoxicity (29), reproductive and developmental toxicity, liver and kidney toxicity, and lung toxicity (28). More attention is also being devoted to studying the effects of long-term (chronic) exposures, rather than the effects of large, short-term (acute) exposures.[2]

Toxicological studies, however, have limitations. Cost considerations limit most animal studies to a few hundred test animals, and in most instances, researchers use high levels of exposure to increase the likelihood of observing a statistically significant effect in a relatively small group of animals. It can also be very difficult to verify any quantitative extrapolation of the results of animal studies to human effects. The reader is directed to the many detailed references in toxicology, in particular Klaassen et al. (17).

Human Exposure Studies

Human exposure studies measure the presence of an agent in air, soil, or food. The most accurate information about exposure is based on monitoring the amounts of a substance to which people are exposed (20). Personal monitoring measures the actual concentrations of a hazardous substance to which people are exposed by using devices that individuals wear or by sampling the food, air, and water they eat, breathe, and drink. Biological monitoring measures the toxicant or its metabolite in biological samples such as blood or urine. Ambient monitoring measures hazardous substances in air, water, or soil at fixed locations. That method is often used to provide information about the exposure of large populations, such as people exposed to air pollution in a region. Often, monitoring data are not available. As a result, assessors often estimate exposures to emissions from a distant source like a factory by using exposure models (20). Exposure models simulate the dispersion of substances in the environment.

[2] For excellent reviews and research papers on the various types of toxicological studies on noncancer effects being conducted, see Environmental Health Perspectives, 1993, vol. 100; in particular see Luster and Rosenthal (19); Schwetz and Harris (24); and Fowler (10).

Difficulties with Data Interpretation

Data, however collected, are usually analyzed for their implications and significance at the local level. These analyses use the results of an investigation—"raw data"—and place it in context of the reliability and the strengths, weaknesses, and limitations of the methods used. Analysts and decisionmakers are best able to do their work when they understand the process of measuring adverse events and the numerical estimates of risk; the nature of the data; and the problems inherent in their interpretation. This is particularly true when the data are being used to support legislation or public health action because of the likely scrutiny and the resulting commitments of resources. Besides estimating the likelihood of injuries and illnesses, analysts and decisionmakers must consider the quality, relevance, and predictive value of the available data.

Data are always limited, and generalizations and extrapolations are often necessary to interpret and apply the available data. Most often, gaps in data, knowledge, or both force the use of assumptions and generalizations in drawing conclusions. Even with sufficient data, however, interpretation can be fraught with difficulties. This section describes some of these difficulties in data interpretation.

Completeness and Generalizability of Data

For some hazards, the only information comes from limited studies of specific populations. It is common practice to generalize results from studies of one or a few schools to schools statewide or even nationally. Two types of generalizations are commonly made: *geographic* generalizations use data from one area, such as urban schools, and generalize to another setting, such as suburban schools. Conversely, national databases can be used to infer risks to certain schools or student subpopulations. Similarly, *temporal* generalizations apply results from earlier studies to current circumstances.

All data-reporting systems confront problems of underreporting, self-reporting, and selection bias. School injury data, for example, rely almost entirely on school-based reporting, for which the common methodological concern is underreporting (11). One study designed to measure the extent of underreporting found that for every injury reported, about 4.3 injuries go unreported; however, most of the injuries that are not reported are minor (9). Reporting practices may also vary from school to school. These discrepancies can result in an injury problem being overlooked at a school or the employment of inappropriate remediation measures.

Most of what is known about the risk of intentional injury in schools is derived from voluntary, school-based surveys of particular behaviors, such as physical fighting and willingness to carry a weapon, or particular injuries or illnesses. Frequently, however, response rates are poor, and students do not report honestly. Administrators and school officials from major districts do not always respond to national surveys.

Health questionnaires are often given to patients or family members who must rely on their memory of the illness to describe symptoms. Such self-reporting involves subjective and selective recall about exposures and health effects (18). The National Health Interview Survey relies on parental recall of their children's illnesses. To overcome the problems of faulty recall, they return to the family every other week (3). This requires the careful analyst to look for additional evidence or supporting examples before drawing conclusions.

Even accounting for underreporting and self-reporting, analysts of injury and illness data must determine the extent to which the study can be representative of the larger population or only a narrow segment of it. Even well-designed studies can fall victim to what is termed "selection" bias, where an association is thought to exist but is in reality an artifact of the population being studied. In the case of schools, the finding of illness in certain schools may reflect underlying difficulties of a particular school or small group of schools—not schools at large. For example, a survey of schools with indoor air quality problems is not representative of air quality in schools generally but represents "problem schools," which suffer from actual or perceived elevated indoor air contaminants or other indoor air quality problems.

Uncertainty and Variability

Estimates of the health risks are both uncertain and variable. *Uncertainty* means that we do not yet know the true risk; uncertainty can be reduced through additional data or research. For example, uncertainty exists in estimates of injuries on school playgrounds because of underreporting. *Variability*, in contrast, means that the risk differs considerably from school to school or person to person; variability cannot be reduced, only better understood. Variability appears in estimates of the likelihood that any single smoker will develop lung cancer: some do, and some do not, based on a variety of individual factors that include age and genetics but may include other factors that are not now recognized.

Extrapolation

Extrapolation is most often seen as a problem in environmental health studies. The use of animal data requires extrapolating from animal results to human projections, and from very high exposures to low exposures. When human data are available, they are usually from studies of high levels of exposure, mostly in occupational settings. Analysts then have to extrapolate from the effects of high-level exposures to mostly healthy, working-age men in order to predict effects in young people of varying health characteristics in the school environment. The most prominent occupational-to-school risk extrapolations found in this study are those for lung cancers arising from asbestos or radon exposures. The data come from high-level occupational exposures of populations of men that included many smokers.

Extrapolations are not limited to the environmental health arena. For example, there are no school transportation injury data; thus, injury data reported for school-aged school bus occupants, pedestrians, and bicyclists are assumed to represent students on their way to and from school.

MOTIVATIONS FOR DATA COLLECTION AND ANALYSIS

A fundamental problem for everyone concerned about risks in schools is whether the available information is good enough to help make the decision to accept a risk or expend resources trying to reduce it. It is impossible to collect all the data that might be useful. Instead, analysis of the available data and careful thought about what kinds of data might alter an already-made or pending decision can guide the decision on what additional data to collect.

The surveys and studies that generate health and safety data are usually quite expensive and time-consuming and require considerable expertise to conduct. Decisions to expend those resources can be made for one or more specific reasons, and knowledge of the reasons can help in understanding how the surveys and studies were designed and by whom and the principle objectives of the research. These reasons can include legal requirements (e.g., federal, state, or local reporting laws), litigation, investigations of "rashes" or "outbreaks" of injuries or illnesses, or fear of adverse health effects. These motivations sometimes impugn the credibility of researchers, reducing the usefulness of their results.

Mandates

The most potent motivations for collecting health and safety data are laws that mandate reporting of various kinds. Illnesses and the potential for exposures to environmental toxics are subject to more mandated reporting requirements in schools than are injuries. On the federal level, the Federal Bureau of Investigation (FBI) requires reporting of homicides and suicides, but not in such a way that permits identification of those that occur in schools. Three agencies collect intentional school injury data for national surveys, but there are no mandated nationally reporting systems.

Some federal laws require either the reporting of illnesses and the potential for exposures or the identification of hazards. The Asbestos School

Hazard Abatement Act of 1985 and its 1990 reauthorization (ASHAA) require schools to inspect for asbestos. Both the Superfund Amendments and Reauthorization Act of 1986 and the Indoor Radon Abatement Act of 1988 directed the U.S. Environmental Protection Agency (EPA) to conduct surveys of radon concentrations in schools (as well as other buildings), and the school survey results were reported to Congress in 1993 (32). School are encouraged but not required, under the 1988 Lead Contamination Control Act, to test their drinking water and meet a recommended lead level.

Some states also have reporting requirements. Three—Hawaii, South Carolina, and Utah—have voluntary school injury reporting. Some states require reporting of school crimes, including those involving intentional injuries; the South Carolina legislature was the first to pass such legislation. Other state laws and initiatives trigger investigations or surveillance of environmental illness. California and Washington require the reporting of pesticide illness, including school exposures. South Carolina requires lead testing in day care facilities and foster homes as a condition of licensure. The New York City board of education monitors the physical appearance of all school buildings on an ongoing basis and presents its findings about such hazards as lead paint chips on an annual basis.

Fear and Litigation

Fear and concern can also motivate data collection, resulting in an ebb and flow over time. Urban violence has resulted in increased interest in weapons carrying, not only in big cities but in smaller communities as well. If concern about that wanes, fewer studies of weapons carrying can be expected. The installation of resilient pads covering the ground of some New York City playgrounds dramatically decreased injuries from falls, reducing the motivation for continued surveillance of such injuries. To a major extent, public perceptions of risk provide the motivation for data collection and studies, and that motivation is transmitted through legislation, legal actions, and public pressure.

Data collections and investigations are also performed in anticipation of possible litigation and as a response to pending litigation. Litigation against schools is increasing, particularly negligence cases (11). As a defensive measure, some schools attempt to keep records of injuries occurring on school grounds. However, unless there is an actual suit, these records are rarely tallied and analyzed, and thus are of no value in estimating injury risks. Lawsuits against schools for environmental exposures have led to the gathering of exposure data. A lawsuit filed against the state of Texas required various investigators to assess the presence and concentration of asbestos in the state schools (7). A lawsuit by a teachers' union forced California to investigate EMF exposures (5). Because large sums of money are often involved in litigation, researchers can obtain research funds to conduct studies they otherwise could not afford. However, they must maintain strict independence and follow scientific protocols to avoid perceptions of biased research, which damage the credibility of the results.

Credibility of Researchers, Bias, and Fraud

Researchers and investigators who collect health and safety data and conduct studies about risks can come to their tasks with or without vested interests. People who depend on those data and who disagree with them can accuse the researchers of bias or fraud, even if there is little evidence for the charges. The media can report those charges, giving them credibility, without any independent investigation.

Consider the situation when stakeholders in arguments about risk generate some of the data necessary for decisionmaking. They are tarred with bias no matter how honestly they do their work. On one side of the ideological spectrum, investigators may believe a particular agent or environment, such as a school setting, is responsible for adverse health effects and gather data to show an association between exposure and effect, with the objective of forcing government action or winning a lawsuit. On the other side, studies conducted or supported by manufacturers of a substance under suspicion or those responsible for releasing it into the environment, or by a school district that wants to avoid paying for risk removal, may be viewed skeptically, especially if they fail to show an association between exposure and illness.

Bias or prejudice can be knowing or unknowing, overt or covert, and it can be readily apparent or hidden from all but the most astute observer. Moreover, neither bias nor prejudice may play a role in data collection or study, but either one can be cited as a criticism by participants in a controversy who do not agree with the study results. The conventions of both science, which include publication of results and making data available to other researchers, and democracy, which include discussion, public accountability, and involvement of concerned parties, will not necessarily erase unwarranted charges or validate accurate ones. Nevertheless, they are the most effective tools for ensuring that data are as accurate as possible, that the methods used to collect the data are appropriate, and that the presentation of results is as free from bias as possible.

THE SIGNIFICANCE OF RISKS AND ESTIMATES

This study is intended to inform decisionmakers about the available information and its sources, and to provide some evaluation of the quality of that information. Deciding what to do, if anything, about any of these risks involves consideration of many more factors than are covered here—including fairness, public fears, cost, and feasibility of controlling the risk.

The results of available risk estimates can be compared against certain thresholds or standards as indicators of their significance. In discussions with experts and administrators who contributed data and information to this report, four general kinds of comparisons emerged: baselines, endpoints, school vs. nonschool risks, and risk thresholds.

Baselines

Baseline values are the normal background rates of the injuries or illnesses against which the risk from a particular hazard can be compared. Whether in comparing different risks or evaluating various policy options, baseline values are used as the expected numbers of illnesses and injuries. Officials use baselines to identify hazards by recording increased incidence or monitoring certain trends to see whether the measured rates are above or below the levels expected in a population. There are few established baselines, but the ones that exist are widely applied. Increases in influenza are identified by comparing current reported cases to historical averages; the District of Columbia's 11 percent decrease in homicides in 1994 is based on a comparison of the numbers of killings in 1992 and 1993.

A number of states have established or are attempting to establish a database to track trends in school injuries. More subtle baselines have been established as well. The CDC's Youth Risk Behavior System is creating baselines for behaviors that can forecast risks of intentional injuries in school.

Endpoints

This report uses the incidence of death, injury, or illness as a measure of risk. However, incidence only refers to the number and frequency and not the severity of risk, which—to a large extent—determines the risk's health impact. The impact of risks can be evaluated by considering their endpoints, as measured by the nature of the injury or illness. Endpoints can range from acute effects such as poisonings and broken bones to chronic effects including cancer and debilitating injuries that result in paralysis. Some endpoints—traumatic death, death from cancer, long-term mental or physical impairment—are far worse than others—a scrape or bruise, a 24-hour fever. Beyond such obvious differences, it is difficult to put endpoints on a comparative scale. The endpoints, or impacts, of illnesses and injuries can be distinctly different from each other, and the differences complicate comparisons of risks.

Even with related endpoints, comparisons remain complicated. Most significantly, methods for determining risks of the major risk factors differ: infectious diseases and injuries are counted and measured; illnesses from environmental hazards are estimated for some and counted for others. One endpoint used in this report common to both injury or illness is measuring the number of school days lost.

School and Nonschool Risks

Children and adolescents spend some time in school and a much greater proportion of their time elsewhere. One way to put school risks in perspective is to compare them to nonschool risks. This report, wherever possible, compared injuries and illnesses in school, where students spend about 12 percent of their total time, to injuries and illnesses in the nonschool environment, making allowances for the different times spent in the two environments.

In this report, safety is described in terms of relative risk between in-school and out-of-school. Such comparisons to other environments where children spend time may show that schools and school grounds offer a "safer" environment from certain risks, i.e., relative to out-of-school environments, in-school exposures to a potentially harmful situation for injury or illness may not be as great; conversely, in other situations, the risk is greater and hazards may be more prevalent in schools. Safety is a relative term since it is not a guarantee of a risk-free environment—violence even erupts in "safe cities" and on "safe streets" and in peaceful rural areas. Infections are spread in clean homes and schools and in hospitals despite expert, directed precautions. Nevertheless, comparisons serve to illuminate differences inherent in the various environments in which children learn, play, and reside.

Risk Thresholds for Intervention

Wherever possible, OTA presents baselines or nonschool comparisons and, in a few cases, regulatory exposure limits, all of which can serve as benchmarks to help determine whether interventions are warranted. This information comes from a variety of sources, including federal or state governments and other credible authorities. School-specific benchmarks are most useful, but few are available. More general comparisons, from nonschool situations, are best used with care, but they provide important information for decisionmaking. Federal, state, and local regulations for many environmental hazards specify certain thresholds that trigger actions to reduce or prevent exposure.

Few regulatory thresholds exist for infectious disease or injury hazards. The tolerable level for injuries varies by type of injury and from community to community. Certainly, some levels are unacceptable. They are, equally, undefined. Some injuries are of high incidence and low severity, others are of low incidence and high severity, and reactions to them often differ. For example, proper playground surfacing may not be installed until a large number of children suffer abrasions or broken fingers, but one homicide can trigger installation of metal detectors.

A large number of cases of common childhood diseases may not elicit medical attention, but outbreaks of illness from foodborne pathogens or with high severity, such as meningitis, can trigger further investigation and interventions to prevent disease spread. There are, however, no specified thresholds that require action. Also, reported environmental illnesses—such as complaints about indoor air quality problems—can trigger investigations. In this case, no threshold has to be crossed; a complaint is sufficient.

Asbestos is an example where the presence of a substance, without knowledge of its concentrations, is sufficient to trigger some forms of intervention. EPA, as mandated by Congress, requires visual inspections of schools for the presence of asbestos-containing materials. Airborne asbestos fibers are the hazard in schools, but EPA never established a level of airborne asbestos that was considered sufficiently high to require action or sufficiently low to ignore.

In other cases, numerical thresholds exist. EPA can require remediation actions when lead concentrations in drinking water exceed 20 parts per billion. EPA does not enforce a standard for radon in homes, schools, or other buildings.[3]

ROAD MAP TO THIS REPORT

The remainder of this report presents the data on hazards in the school environment that can adversely affect students' health and a chapter on how these data may be used. OTA separates the hazards based on their health effects, whether injuries or illnesses. Chapter 3 covers injuries to students in schools and the nature, incidence, and causes of injuries. Injury is broken down by intentional and unintentional injuries. Unintentional injuries are injuries from playgrounds, school athletics, and transportation to and from school. Intentional injuries include homicides, suicides, physical fighting, and assaults.

Chapter 4 examines student illnesses. The major school-related causes of illness identified in the report are environmental hazards and infectious diseases. Environmental hazards include toxic materials in the school environment, indoor air quality problems, and hazards arising from the location of the school. Infectious diseases arise from a number of pathogenic organisms and either occur with a high incidence on an endemic or seasonal basis, or they occur less frequently and primarily as outbreaks.

The final chapter discusses how the data presented in the report can be used by decisionmakers—from Congress to individual school boards—in setting priorities for improving school safety. A section of the chapter examines other attributes of risks, beyond the numbers of deaths, injuries, or illnesses, that can play an important role in decisionmaking. A final section explores comparative risk assessment, a process that can be used for comparing and ranking the diverse risks in the school environment.

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[3] EPA has proposed a standard for radon in water (30), but recommends that homeowners undertake mitigation efforts when the radon concentration is equal to or exceeds 4 pCi/L; its report of the survey of radon in schools (23) emphasized that concentration as a level of concern.

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Injury to Students in School 3

Injury is the leading cause of death and disability of children in the United States (54,101). School-aged children ages 17 and younger sustain about 16,614,000 injuries annually (67)[1] which often take a heavy physical, emotional, and financial toll on the children and their families. Children lose over 10 million school days each year due to injuries alone, an average of 22 lost school days per 100 students (8). However, students reduce their exposure to the most serious risks of injury for school-aged children simply by attending school because the leading causes of death and injury to children, such as motor vehicle-related injury, homicide, suicide, falls, and drowning (see figure 3-1), are more frequent outside of school. Nevertheless, a significant number of deaths and disabling injuries occur in the school environment.

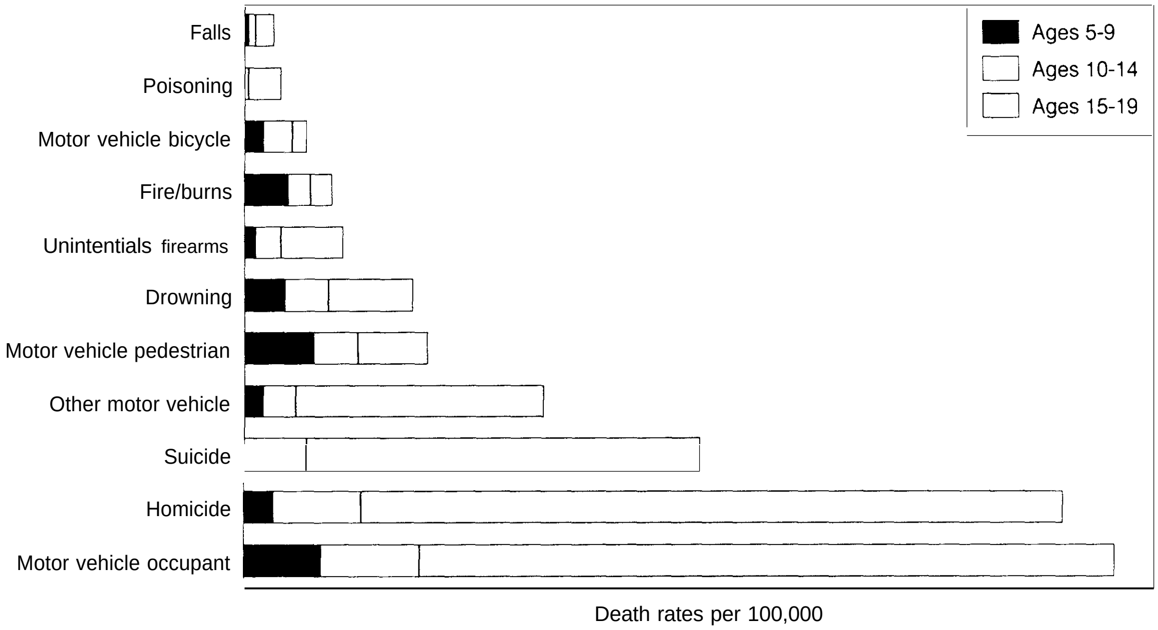
This chapter defines risks to students in schools by number and severity of injuries. An injury occurs from an "acute exposure to energy, such as heat, electricity or kinetic energy of a crash, fall, or bullet. Injury may also be caused by the sudden absence of essentials, such as heat or oxygen, as in the case of drowning" (54).

Risks of unintentional injury to students vary each school day: in their travel to school; in the controlled, supervised classroom environment; in physical activities in gymnasiums and athletic fields; the relatively unsupervised play during recess and lunch periods; and finally, on their return home (63). Demographic factors such as age, sex, race, economics, and geography influence the incidence and severity of injuries (4). The degree of risk to each student is a result of the interaction of many other factors, including the student's developmental stage, staff awareness and supervision, environment, equipment or products used at school (21), and school location.

This chapter presents information on school injuries based on "intent"—unintentional (accidental) and intentional (assaultive or suicidal).

[1] This estimate is based on data from the Child Health Supplement to the 1988 National Health Interview Survey (NHIS). Injury is defined by the NHIS as "a condition of the type that is classified according to the nature-of-injury code numbers (800-999) in the ninth revision of the International Classification of Diseases. In addition to fractures, lacerations, contusions, burns, and so forth, which are commonly thought of as injuries, this group of codes includes poisonings and impairments caused by accidents or nonaccidental violence" (8). "A person may sustain more than one injury in a single accident (for instance, a broken leg and laceration of the scalp), so the number of injury conditions may exceed the number of persons injured. Statistics of acute injury conditions include only injuries that involved medical attendance or at least a half day of restricted activity" (8).

FIGURE 3-1: Injury Death Rates, Children 5–19 years, 1992
(Rates are deaths per 100,000 population)



NOTE: Rates based on fewer than *20* deaths are not reliable,

SOURCE: National Center for Health Statistics, data from the National Vital Statistics System,

For a number of reasons, other reports have chosen to use the term “accidental injury” when reporting unintentional injuries. The term “unintentional injury,” however, is more commonly used by experts in the injury prevention field because it connotes the ability to predict and prevent most of these injuries.[2] Intentional injury means the “threatened or actual use of physical force against oneself or an individual or group that either results, or is likely to result, in injury or death” (88). In this report, intentional injuries include interpersonal violence and suicidal behavior. Unintentional and intentional injuries differ in the type of injury that results, its severity, and the level of response or dread it engenders. Because of these differences, the types and quality of data collected for unintentional and intentional injuries also vary.

OTA surveyed the available injury data and examined three interrelated questions:

1. What school injury data currently exist?
2. What is the quality of the existing data?
3. Given that most estimates are uncertain and variable, what additional data are needed to help decision makers?

To answer these questions, this chapter reviews and comments on the available data concerning injuries occurring in the school environment. As discussed in chapter 2, the types of data

[2] As explained by the Centers for Disease Control and Prevention (CDC), “[injuries are mistakenly referred to as ‘accidents’ because they occur suddenly and are seen as unpredictable and uncontrollable. In particular, parents often believe that ‘accidents’ will not happen to their child because the child is well supervised. Injury prevention in children is much more than a question of supervision; injuries, like disease, occur in highly predictable patterns and are controllable.”

included are: 1) surveillance;[3] 2) survey; 3) epidemiological; and 4) anecdotal. This chapter identifies the data sources of school injury data and assesses their strengths and weaknesses.

Data on unintentional and intentional injuries in schools are widely dispersed. While some national and state estimates of both unintentional and intentional school injuries are available, the databases either do not clearly distinguish between intentional and unintentional injuries or collect information on one or the other. A study based on the Child Health Supplement to the 1988 National Health Interview Survey (NHIS), which provides national estimates of nonfatal childhood injuries, is the one study to analyze national data by school as a location of injury (67). While not limited to the school environment, national databases of playground, athletics, and school bus-related crash injuries provide data used to calculate or estimate the number of school-related unintentional injuries associated with these activities. There are also national estimates of the number of homicides and suicides in the school environment as well as national and local self-report surveys on physical fighting and weapon carrying that provide additional data on nonfatal intentional injuries.

State and epidemiological studies rely on school reports for estimates of school injuries. Epidemiological studies provide a more detailed picture of injury incidence. Because of diverse reporting, underreporting, and inadequate reporting, school injury trends are difficult to characterize. Often within single school districts certain schools report injuries more conscientiously than others. The absence of standardized definitions of reportable injuries among the states and school districts limits comparisons of data. Injury data regularly lack elemental aspects of injuries such as the location, characteristics, causative contributors, socioeconomic, and demographic factors, such as gender and race, particularly for nonfatal events (54). The absence of this information prevents the determination of the circumstances of injury.

Assessment of the available school injury data identifies the need for additional or better quality data to aid decisionmaking. Quality data can turn public attention and possible resources from well-publicized but infrequent occurrences toward more common injuries that represent a greater public health problem. Data collection and analysis can uncover school injury problems or reveal more about a problem already suspected. Implicit in this process is that it can eventually lead to the overall reduction of school injuries.

UNINTENTIONAL INJURY

Unintentional injuries are recognized as a leading cause of childhood mortality and morbidity in the United States. One of the health objectives set forth in *Healthy People 2000: National Health Promotion and Disease Prevention Objectives*[4] is to "provide academic instruction on injury prevention and control, preferably as part of quality school health education, in at least 50 percent of the school systems (grades K through 12)" (87). Compared to unintentional injuries in general, little public attention is given to those occurring in the school environment except in the aftermath of a particularly tragic incident, such as a fatal school bus crash or football injury. Injury deaths, however, are not always representative of injury incidence at school.

Given the time students spend at school and the variety of activities they engage in, the school environment presents many opportunities for injury. For school-aged children, epidemiological studies estimate that 10 to 25 percent of their

[3] Surveillance data has been defined as the "ongoing and systematic collection, analysis, and interpretation of health data in the process of describing and monitoring a health event. This information is used for planning, implementing, and evaluating public health interventions and programs" (42).

[4] Healthy People 2000 is a U.S. Public Health Service plan that developed health objectives designed to reduce preventable death, disease, and disability by the year 2000. Unintentional injury is a priority area targeted for specific reductions in mortality and morbidity.

injuries occur in the school environment (66).[5] Although many of these injuries are minor cuts and bruises that heal quickly, significant numbers are quite serious, resulting in absence from school, restricted activity, hospitalization, disability, and death.

Incidence of injury of students is a function of the type of activities in which they participate and their developmental stage (21). For example, elementary school students are most likely to be injured on the playground, while secondary school students are most likely to be injured playing sports. Their developmental stage also affects their ability to recover from injury. The healing processes of school-aged children are remarkably different from adults because they are still growing (6).

Activities at school differ from those of children and adolescents outside the school. Accordingly, it is essential to recognize patterns of frequency and severity specifically related to school injuries. Students' activities during the day are, for the most part, supervised and restricted to relatively non-risky behavior. The leading causes of childhood unintentional fatal injuries, including motor vehicle crashes, drowning, and fires (see figure 3-1), are more likely to occur outside of school. Thus, the nature of injuries and the focus of prevention efforts directed at school injuries can differ from childhood injuries at other locations. Knowledge of the circumstances involved in such unintentional injuries is important for the development of prevention and control efforts that adequately address the potential risks to students in the school environment.

Due to their frequency and severity, playground and athletic injuries generate considerably more data than other school-related injuries. Accordingly, a separate discussion of playground and athletic injuries follows the general discussion of school-related injuries below. Injuries sustained on the journey to and from school are also discussed separately because they involve different data sources.

Sources and Limitations of School-Related Injury Data

Sources of data on the incidence and prevalence of unintentional injuries in the school environment are:

1) National sources:
- National Center for Health Statistics, U.S. Department of Health and Human Services;
- Centers for Disease Control and Prevention (CDC), U.S. Department of Health and Human Services;
- National Highway Traffic Safety Administration (NHTSA), U.S. Department of Transportation;
- Consumer Products Safety Commission's (CPSC) National Electronic Injury Surveillance System (NEISS);
- National Safety Council (NSC); and
- National Pediatric Trauma Registry (NPTR).

2) State studies and surveys.

3) Epidemiological studies.

National Sources of Data on Unintentional Injuries in Schools

While OTA found no continuous national surveillance system that supplies comprehensive information about school-related unintentional injuries, national databases collect general information relating to childhood injury (54). There are five major national types of unintentional school-related injury data: death certificates, hospital discharge abstracts, hospital emergency room reports, national health survey data, and traffic accident data. These sources have their various advantages and disadvantages, as explained in box 3-1. National data can provide a perspective of injuries and allow for comparisons to local injury data. For the most part, however, the existing national data sources focus on particular problems that include school injuries, but rarely distinguish them from non-school injuries. Even when differentiated, school injuries may include many types of schools, such as colleges and vocational schools.

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[5] The NHIS reports that school-aged children sustained 13 million injuries in 1992.

BOX 3-1: National Sources of Data on Unintentional Injuries in School

Mortality data

The **National Center for Health Statistics** (NCHS) of the U.S. Department of Health and Human Services (DHHS) is the primary source of fatality data; it collects mortality statistics from all 50 states. Fatality data are collected from death certificates, which include information on the cause of death. However, the national report is usually published about three years after the death occurred. The coding of fatal injuries is based on the apparent intent of the persons involved—unintentional, homicide, or suicide (NRC, 1985). Additional coding as to circumstances and location is limited; there is no categorization of the school locale on hospital injury coding forms or death certificates. Also there is no standard system among the states for filling out death certificates, which are often completed without an autopsy or before one can establish the cause of death. Moreover, fatality data may overstate the unintentional fatalities if some intentional injuries, such as suicides, are incorrectly reported. Or conversely, the unintentional fatality data may be understated if some intentional deaths, as a result of child abuse, for example, are reported as unintentional. While these statistics are useful in monitoring national fatality trends, without the reporting of school as a location there is not enough detail to determine fatality trends occurring at schools.

The **National Highway Traffic Safety Administration** (NHTSA) of the U.S. Department of Transportation compiles and analyzes mortality data on school bus-related accidents and on pedestrian and bicyclist mortality for the school-aged population. NHTSA's Fatal Accident Reporting System (FARS) database, established in 1975, compiles information relating to fatal motor vehicle crashes from state agencies. FARS sources include police accident reports, death certificates, and coroner or medical examiner reports. Data include geographic details, roadway and other conditions, information about the driver of the vehicle, and on fatally and nonfatally injured persons involved (including passengers, pedestrians, and others). These data do not distinguish whether travel was school-related.

Morbidity data

DHHS's **National Health Interview Survey** (NHIS) collects data on nonfatal injuries based on household interviews of the civilian noninstitutionalized population. In 1992, 49,401 households containing 128,412 persons were sampled; 96 percent of these households were interviewed.[a] While the NHIS includes "school" as a location for injury, the data are not analyzed regularly or published by school location. Scheidt et al. studied the Child Health Supplement to the 1988 National Health Interview survey to derive national estimates of nonfatal school injuries. The study included a breakdown of the location of injury, including school; the data are not routinely analyzed by school as a location of injury. School as a "place of accident" is defined in the NHIS to include "all accidents occurring in school buildings or on the premises. This classification includes elementary schools, high schools, colleges, and trade and business schools." Thus, the injuries incurred by adults as well as by students K through 12 are included. By limiting the study to persons aged 17 and younger, Scheidt et al. resolved this problem—previous school data were not analyzed by age.

The **U.S. Consumer Product Safety Commission** (CPSC) maintains the National Injury Information Clearinghouse, another source of data on nonfatal injury. Its database includes: death certificate data, the National Electronic Injury Surveillance System (NEISS), accident investigations, consumer complaints, and other injury reports. The NEISS database, the primary CPSC data source for this OTA report, collects injury data from a sample of 91 hospital emergency rooms located throughout the United States. The small sample number precludes determination of regional trends. CPSC data are by definition confined to consumer product-related injuries, thereby limiting the database's usefulness for purposes of this report. For example, the NEISS database does not record all playground and sports-related injuries; it is limited to injuries relating to playground *equipment* and sports *equipment.* Thus, reports from NEISS reflect national estimates of persons with injuries associated with products under CPSC's jurisdiction treated in emergency rooms. CPSC does not have jurisdiction over firearms and motor vehicles.

(continued)

BOX 3-1: National Sources of Data on Unintentional Injuries in School (Cont'd.)

NEISS collects injury data by location categories, including school, but does not analyze data using school as a category. Again, school includes all types—for example, elementary, secondary, vocational, college, and graduate school. Restricting the analysis of injuries to ages 5 to 18 would theoretically restrict the data to elementary and secondary students. CPSC produces such data but does not analyze it. NEISS is capable of discovering national injury trends in a timely fashion, allowing for preventive action. CPSC also publishes safety alerts concerning consumer products, which include equipment used in schools.

Transportation-related nonfatal injury data are from **NHTSA's** General Estimate System (GES), which is a nationally representative probability sample selected from police reports of motor vehicle crashes. NHTSA produces data related to school bus accidents, as well as pedestrian and bicyclist morbidity data. GES data are from a nationally representative probability sample selected from police reports of motor vehicle crashes.

OTA identified two additional national sources of school-related injury data: 1) the **National Safety Council** (NSC) and 2) the **National Pediatric Trauma Registry** (NPTR). NSC collected data on "student accidents" from 7,500 responding school jurisdictions. Accidents were defined as causing the loss of one-half day or more of school time or activity during non-school time and/or any property damage as a result of a school jurisdictional accident. NSC reports the number of injuries in terms of student days rather than student years, which makes it difficult to compare injury rates with other studies, almost all of which are reported in years. Moreover, NSC figures are outdated—the last edition of its *Accident Facts* to include school injuries was published in 1987 and the reported data was collected in academic years 1984–85 and 1985–86.

NPTR data include information from 61 hospitals located in 28 states, Puerto Rico, and Ontario, Canada. From December 1987 to February 1993, 871 cases of school-related injuries of students aged 5 to 19 were recorded in the Registry. In an epidemiological study, Gallagher et al. analyzed 907 school injury cases to assess the causes and consequences of serious injuries occurring among students (Gallagher, 1994). The data evaluated included 19-year-olds, but it was unclear whether "school" was limited to high schools or included college campuses. Since trauma center data are not population-based and catalogue only a few of the most serious cases, conclusions cannot be generalized to the less seriously injured or non-injured school population (NRC, 1985). Moreover, trauma centers receive referrals from other hospitals and many trauma centers specialize in particular types of injuries. Nevertheless, these valuable data illustrate the types and distribution of severe injuries suffered by children and adolescents at school.

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[a] The 1992 questionnaire enabled identification of out-of-school youth (aged 12-21 years) by inquiring whether they were either now going to school or on vacation from school. The results will be used in the Youth Risk Behavior Survey.

SOURCES: Office of Technology Assessment, 1995. National Research Council, Commission on Life Sciences, Committee on Trauma Research & Institute of Medicine, *Injury in America: A Continuing Public Health Problem* (Washington, DC: National Academy Press, 1985); Gallagher, S., Bowdler, M., and Di Scala, C., unpublished data on the cause of severe injuries at school: Results of an Analysis of 907 Severe School Injuries Reported to the National Pediatric Trauma Registry, Newton, MA, 1994.

State Sources of Data on Unintentional Injuries in Schools

No state currently requires mandatory reporting of school-related injuries to the state departments of education or health. OTA identified four states (Arizona, Hawaii, South Carolina, and Utah) that maintain school injury databases, but all four depend on voluntary reporting. These databases are described in box 3-2.

Although few states require reporting at the state level, most schools and school districts keep injury records. For example, Miami, Florida's

BOX 3-2: State Sources of Data on Unintentional Injuries in School

OTA indentified only four states with voluntary state-wide reporting requirements (Arizona, Hawaii, South Carolina, and Utah). In the absence of national reporting, voluntary or otherwise, there is no uniformity in reporting school injuries among states that do compile injury data. Each state uses diferent reporting methods and criteria. Arizona and Utah have computerized forms, which greatly facilitate data collection. Other states have completed studies but currently do not have an ongoing surveillance program (Kansas and Washington) or are just beginning to implement ongoing school injury surveillance systems (Michigan, Minnesota, and Washington). Although Arizona and Michigan have drawn on Utah's experience, for the most part there is little coordination among state departments surveying school injuries; in some cases, states were not aware of other efforts. Some states, such as Massachusetts, have injury surveillance programs from which school injury data can be culled.

Arizona Department of Health Services

In 1991, Arizona instituted the Arizona Injury Surveillance Program. The first reporting year was limited to playground and athletics injuries. The study evaluated 212 elementary schools including 122,056 students in grades K–8, representing 29 percent of the school population. Student health personnel were required to complete a report form when an injured student 1) was sent home, 2) was sent to a physician, 3) was transported or admitted to a hospital, or 4) required restricted activity. The second year's data will be published in early 1995 and the third year data are being analyzed. In 1993, with input from school districts and the main school insurance companies, Arizona officials developed a scannable report form. The front of the form is for recording injury information and the back now includes information for insurance purposes. The program will soon include all school injuries and all grades, starting at preschool and daycare and going through high school. The program will soon include more schools and entire districts. An Early Childhood/School Injury Task Force meets quarterly to determine the direction of the program.

Hawaii Department of Health

In 1984, Taketa attempted a statewide analysis of school injury data collected by the Hawaii Departments of Education and Health. The study evaluated 204 of Hawaii's 224 public schools by collecting Student Accident Report Forms completed by school nurses during the 1981-82 academic year. However, the information varied considerably, impeding efforts to identify particular risks. The Hawaii Department of Education's most recent data are for 1989-90. The data are compromised by the uncertainty of the percentage of the school population included in the report. The data are presented only in terms of location, activity, and nature of injury; not by gender, age, or grade.

Kansas Department of Health

Until 1981, the Kansas Department of Health and Environment biannually published a Student Accident Report. The 1981 report, the 32nd edition, summarized the nonfatal student accidents occurring in Kansas during the 1979–80 and 1980–81 school years. Injuries reported to the department involved those severe enough to cause a student absence of half a day or more from school or to require a doctor's attention. Study authors noted that reporting was incomplete. Significantly, the study was able to track trends over a 25-year period, particularly increases in rates and percentages over the years.

Minnesota Department of Education

In 1989, the Minnesota Department of Education first administered the Minnesota Student Survey with the aim of furthering the understanding of student behaviors and attitudes. The survey was given to students in the 6th, 9th and 12th grades. The only relevant injury questions ask whether an injury occurred at "school not sports" and at "school sports." While the overall injury numbers are useful for comparing the two categories of injuries, the survey provides no insight into the factors causing student injury.

(continued)

BOX 3-2: State Sources of Data on Unintentional Injuries in School (Cont'd.)

South Carolina Department of Health

The South Carolina Department of Health administers the Annual School Health Nursing Survey to compile data about the health status of children in schools. Surveys were distributed to head nurses in 91 school districts; however, not all schools have a nurse. In the two years the report has been completed, school district response rates were 44 and 45 percent. In the 1992–93 school year, this represented about half of the school districts, 69 percent of the 300 school nurses and 60 percent of the students (342,587 students). Data are analyzed to assist those responsible for school health and policy decisions at the state and local level. School nurses in South Carolina have used this survey to identify injury problems and to coordinate and develop injury intervention programs. In fact, in 1992–93 there was a reported decrease in the total number of injuries, despite a fourfold increase in reporting. The 1992-93 report attributes the reduction to data collection efforts that have been translated into local school prevention and intervention efforts.

Utah Department of Health

In 1984, Utah established a voluntary reporting system in which school districts use the Department of Health's student accident report form to report injury information. Since that year, the Department of Health has collected statewide information on injuries sustained by students in schools.[a] Its computerized database is the most comprehensive statewide school injury data source in the United States. Reportable injuries are defined as those severe enough to cause school absence of at least a half day or to warrant medical attention and treatment. To increase the accuracy of description, the form has been revised a number of times in response to problems identified by schools using the form. Participation of the 40 state school districts has progressed to 100 percent since the database's inception. As a result of increased participation and reporting refinements, data collected since the 1988-89 academic year are the most reliable. Nonetheless, as with all school-based injury data, incidents are probably underreported. For example, in 1988–89, the incidence in grades K–6 was 1.7 injuries per 100 students, which increased to 2.1 per 100 students by 1991–92. The Utah Department of Health does not attribute this increase to an overall increase in incidence but to an increase in reporting by school districts. Further analysis of this data by individual grade, if possible, would more accurately define incidence grade peaks and indicate when a student is most at risk from a particular hazard.[b] Similarly, analysis by grade and sex would yield significant insight into the occurrence of school injuries. The Utah data are not contained in a formal report; rather, they were amassed by the Department of Health and presented by category for the two grade divisions, K–6 and 7–12, for each academic year from 1988–89 to 1991–92.

The Utah State Department of Health and Utah State University used the data to identify playgrounds as the leading cause of school injuries at schools and to develop the 1988 publication "Playground Perspectives: A Curriculum Guide for Promoting Playground Safety."

Two additional school injury studies were sponsored by states. These are epidemiological studies; they were limited to specific locations rather than statewide.

(continued)

BOX 3-2: State Sources of Data on Unintentional Injuries in School (Cont'd.)

Massachusetts Statewide Comprehensive Injury Prevention Program

The Massachusetts Department of Public Health established the population-based Massachusetts Statewide Comprehensive Injury Prevention Program (SCIPP), a hospital-based injury surveillance system (Passmore et al., 1989). The advantage of hospital-based over school-based data is that the diagnosis and circumstances relating to the incident are more accurate and reliable. As with all hospital-based data, however, only the most severe cases are seen and selection biases are inevitable. The SCIPP system compiled data on injuries among 86,876 children and adolescents (0–19 years) living in 14 communities from September 1979 to August 1982. Twenty-three participating hospitals accounted for an estimated 93 percent of all pediatric discharges. Since the information is hospital-based, visits to doctor's offices, clinics, health maintenance organizations, or dentist's offices were not included. Passmore and Gallagher analyzed the SCIPP database to determine the incidence of school injuries in a Massachusetts community. This study is particularly important because the authors compare school and out-of-school injury incidence data.

Washington Department of Health

The Washington State Department of Health completed a two school-year study in 1986-87 and 1987–88, *The School Injury Surveillance Project: Results and Recommendations*, of a single school district as a pilot test program. The aim was to test the efficacy of school injury surveillance, with the ultimate goal of identifying potential prevention and investigation priorities. The district studied the Clover Park school district, which had a school-aged population of 12,781 in 1986–87. Injury reports were completed by school nurses and given to district risk managers to pass to the Department of Health. School nurses were to report injuries: 1) that were severe enough for the child to be sent home, including unsuccessful attempts to send the child home; 2) that required a physician's care and/or major first-aid treatment; or 3) that occurred during athletic activities and restricted competitive sports, competition, or practice for two or more days, including all joint injuries, fractures, head and neck injuries, and internal injuries.

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[a] Utah's computerized school injury database was used for the article by Sosin et al. (1993) on surface-specific falls on Utah school playgrounds.

[b] Enrollment data for grades 7–12 were not readily available; therefore, rates could not be determined. The percentages of injuries in grades K–6 can be compared to the those in grades 7–12 to contrast the injury experience of the two groups.

SOURCES: Arizona Department of Health Service, Community and Family Health Services, Office of Women's and Children's Health, *A Study of the Nature, Incidence, and Consequences of Elementary School Playground-related Injuries* (Arizona, 1993); C. Cazier, Project Director for Family Health Services, Utah Department of Health, Salt Lake City, UT, personal communication, 1994; S.S. Gallagher and K. Finison, "The Incidence of Injuries Among 87,000 Massachusetts Children and Adolescents: Results of the 1980–81 Statewide Childhood Injury Prevention Program Surveillance System," *Am J. Public Health* 74:1340–1347, 1984; Kansas Department of Health and Environment, *Athletic Injuries in Kansas Secondary Schools 1990–91*, unpublished report (Topeka, KS: 1992); South Carolina Department of Health & Environmental Control, Division of Children's Health, *Annual School Nurse Survey 1993*, 1994; Utah Department of Health, Division of Family Health Services, Student Injury Report Database 1988–1992; S. Taketa, "Student Accidents in Hawaii's Public Schools," *Journal of School Health* 54:208–209, 1984; Washington State Department of Health, Office of Community Environmental Health Programs, *The School Injury Surveillance Project: Results and Recommendations* (Olympia, WA: 1990).

Dade County Public Schools maintains unintentional injury information annually (23). While some schools maintain records as part of their state's voluntary school injury reporting systems, many maintain injury records for liability purposes (28). The state departments of education or health rarely collect, tally, or analyze injury reports, and often the data on the local level are not computerized, making it difficult to retrieve information. In addition, such reporting is conducted through school districts and, therefore, evaluates only public schools. Injury data collected by private schools are not readily accessible or collected in any systematic manner; thus, comparisons of injury rates in private versus public schools cannot be made.

Epidemiological Studies on Unintentional Injuries in Schools

Epidemiological studies and state surveillance data complement each other. Although state surveillance data are better for identification of particular injury problems, epidemiological studies allow for more detailed analysis of a suspected problem. The five most prominent epidemiological studies found by OTA are presented in table 3-1. Despite the advantages, the available epidemiological studies have numerous drawbacks and methodological problems.

As with most epidemiological data, the available studies are narrowly focused on a small number of school districts, which prevents the determination of regional trends. It is apparent, however, that student populations and injury risks vary widely from school district to school district. Moreover, the focus on injuries occurring at schools does not inform about schools as a source of injury relative to other locations. The lack of standardization of what constitutes a reportable injury and what qualifies as a serious or severe injury across epidemiological studies hinders their comparability. Moreover, four out of the five studies are over 10 years old. The studies used varying reporting categories. For instance, some reported cause of injury by location, others by activity. Most studies define a reportable injury as one that causes the student to restrict school activity for at least half a day, but this criterion may select against late-afternoon injuries. Nevertheless, to the extent that the results of these studies are consistent, they indicate general characteristics of school injury incidence.

These studies draw from school-based, parent-based, and/or hospital-based reports. Of these, school-based reports collected from school districts are the primary source of data used by state surveillance systems and epidemiological studies. Parent-based reports complement school-based reports to assist in determining the accuracy of school-based reporting. Hospital-based reporting provides more comprehensive case information, but only for the most serious injuries.

Most state and epidemiological school-related data differ from national data in that they rely almost entirely on school-based reporting. School-based reporting generally involves completion of an injury report by a teacher, coach, administrator, or other staff member. In most cases, however, the forms are kept at school or a copy is sent to the school district office. Only four states actually collect and tabulate the number of injuries. The primary advantage of school-based data is that it theoretically captures all injuries that occur at school, regardless of the treatment. Moreover, school-based data is local. Decisionmakers at the local level can use the data to verify the actuality of an injury problem before committing scarce resources to a local injury control program.

Methodological concerns common to epidemiological and surveillance data are inherent in school-based reports. Such concerns include underreporting of both minor and serious injuries (13,103), and inconsistent definitions of injury and the school environment. Reporting practices may also vary significantly from school to school. The lack of standardized reporting for school-related injuries compromises the reliability of data. Although underreporting and inconsistent reporting among schools undermine the completeness of the data, school-based data are the most comprehensive and accurate data available.

	Lenaway et al. (1992)	Boyce et al. (1984a)	Sheps & Evans (1987)	Feldman et al. (1983)	Taketa (1984)
Years analyzed	1988–1989	1980–1983	1981–1983	1981–1982	1981–1982
Site	Boulder, CO	Tucson, AZ	Vancouver, BC	Hamilton, Wentworth, Ont.	Hawaii
No. of schools	9	96	108	212	204
Grades	K–12	K–12	K–12	K–12	K–12
Student population	5,518	55,000	53,000	83,692	157,000
Data collection	Prospective	Prospective	Retrospective	Prospective	Retrospective
Definition: reportable injury	Student accident report forms completed by adult administering first aid (i.e., teacher, nurse or coach). Reportable injuries were those: "requiring medical or dental attention, head injuries necessitating student dismissal to home and those with persistent symptoms beyond a two hour observation period, poisoning, suspected fractures, human bites, puncture wounds, and injuries sustained from fighting or equipment failure"	Injury must meet one of the following criteria: (1) required a physician's care and/or major first aid; (2) resulted in an absence from school; or (3) resulted in restricted participation in competitive sports	If a child sustains or requires: "all head injuries, suspected or definite fractures, and ambulance or inhaler, referral to a physician or dentist, sutures or a foreign body in the eye"	Decision as to reportability "made by school principal, consistent with his interpretation of the school board's policy"	"Any accident which happens at school, or at a school sponsored activity, on or off campus, which (1) interrupts the students' normal or expected activity for that period to any significant degree, (2) causes any property damages or losses of more than $5 in estimated replacement cost and/or (3) can generate a litigation on behalf of the injured"
Incidence per 100 student years	9.2	4.9	2.8	5.4	1.7

(continued)

TABLE 3-1: School Injury Epidemiological Studies (Cont'd.)

Definition: severe injury	*	Amputations, third-degree burns, concussions, crush wounds, fractures, multiple injuries	Fractures, loss of consciousness, burns, whiplash, open wounds, foreign body in eye	Fractures, loss of consciousness, dislocations, sprains, torn ligaments and cartilage, chipped/broken teeth, internal injury	"Most severe...foreign bodies in the eye and fractures"
Percentage of injuries that were serious or severe	—	18%	35% elementary 39% secondary	28.6%	—

* no definition of severe or serious

SOURCE: Office of Technology Assessment, 1995, adapted from R.R. Gratz and K. Finison, "School Injuries: What We Know, What We Need," *Pediatric Health Care* 6:256–262, 1992; Lenaway, D.D., et al., "The Epidemiology of School Related Injuries: New Perspectives," *Am J Prev Med* 8(3):193–198, 1992.

A study designed to determine the extent of underreporting (103) of injuries in school-based reporting found about a fourfold difference: 24.0 injuries occurring per 100 students compared to 5.4 injuries reported, indicating that for every injury reported about 3.4 go undetected. Most of the unreported injuries appeared to be minor, while serious injuries were more likely to be routinely reported. Serious injuries were underreported by a factor of two, while minor injuries were underreported by a factor of five (27).

The study also contrasted parent and school reports of injury; parents reported three times as many school-related injuries (15.3 injuries per 100 student years) as schools did.[6] In terms of serious injuries, parents reported close to 30 percent of the total injuries as serious (19.5 percent elementary and 45.5 percent secondary school), in contrast to 13 percent categorized as such by schools (37). While the accuracy of the parental reports is unknown, the study concluded that estimates of the number and severity of injuries by educational authorities should not be relied on as the sole source for accurate injury information.

Hospital-based reporting, an alternative to school-based reporting, is generally more accurate and reliable than school-based reporting because health professionals diagnose the injury. Moreover, hospital records contain more detailed information about the circumstances of the injury and the final disposition of the case (13). In the context of school injuries, however, hospital-based data only represents the most severe injuries and does not include those untreated or treated by a school nurse, at home, or at a doctor's office. Also, hospital admissions may not be reflective of the distribution of injury, because selection biases such as bed supply and social class affect admission for all but the most severe injuries.

Hospital-based data are also problematic in that E-coding, the current system for classifying and coding cause of death and nonfatal injury, does not permit adequate description of activities surrounding the incident. E-coding, which codes for the external cause of injury, is part of the injury classification established by the World Health Organization and used with the International Classification of Disease (ICD) (86). Hospitals and vital statistics recordkeeping sometimes use the ICD, in its ninth revision, to explain how and where an injury occurred. Currently, there is not a national requirement for hospitals to record E-codes on injury records, with one exception (14).[7] In 1994, however, thirteen states had mandated E-coding of hospital records. As more states use E-coding, the data will improve; currently, however, the quality of the morbidity data is uneven. OTA concludes that mandatory use of E-codes for injuries and inclusion of school as a location classification would provide invaluable information for the study of nonfatal school injuries.

Incidence and Distribution of School-Related Injuries

Incidence

Scheidt et al. estimate that 16,614,000[8] injuries are sustained by children ages 17 and under in the United States annually; thus, medically attended injuries occur in at least 25 percent of children each year. Of those, it is estimated that approximately 3 million injuries occurred at school. Authors of the epidemiological studies estimate that 10 to 25 percent of injuries to the school-aged population occur at school (66). Epi-

[6] As part of a random sample, parents of about 200 children attending schools were surveyed over 10 months and asked if the student had sustained any school-related injuries during the previous month and, if so, the numbers, types, and treatment of injuries. Parent survey questionnaires were mailed at the beginning of the each month. If after three weeks the questionnaire was not returned, the parents were contacted by phone when possible. About 53 percent of these surveys were returned by mail and 32 percent were completed over the phone.

[7] E-code recording is required in those cases "where drugs or medicinal and biological substances caused an adverse effect in therapeutic use" (14).

[8] This estimate includes only those injuries involving medical attendance or at least half a day of restricted activity.

demiological studies are likely to include more injuries than national estimates, the excess attributable primarily to minor injuries.

Injury rates from school-related injury studies vary and are likely to underrepresent the number of actual injuries because of underreporting in the routine surveillance and reporting of injuries at schools (35). The variations may also be attributed to one or more of the following: 1) inconsistent case definitions of injury; 2) reporting methods (e.g., school-based as opposed to hospital-based reporting); 3) inconsistent reporting among study schools; 4) natural variability among student populations; and 5) implementation of school-based injury prevention programs.[9] The reporting methods also affect the number of injuries reported. For instance, prospective studies reported higher rates of injuries than retrospective studies (35).

In-School and Out-of-School Incidence

The NHIS reported 28.6 injuries per 100 school-aged children in 1992 (8). Similarly, based on 1988 NHIS data, the Scheidt study revealed an injury rate of 27.0 per 100 children. Population based studies are in close agreement—the Massachusetts Statewide Comprehensive Injury Prevention Program (SCIPP) data show about 24 injuries per 100 children or adolescents ages 6 to 19 (30), and a Puget Sound, Washington HMO population study show about 25 injuries per 100 children, ages 19 and under[10] (66). As shown in table 3-1, the rates of injury in schools found by epidemiological studies range from 1.7 to 9.2 per 100 students.[11] Considering the shorter time spent in school, about 12 percent of a child's year and about 15 to 20 percent of their waking hours annually, the data suggest that the number of school injuries may be about the same or slightly higher than out-of-school injuries. However, the majority of school-related injuries are minor and result in fewer hospitalizations than injuries sustained outside the school environment, and fatal injuries are relatively rare in the school environment (63).

Age-Related and Gender-Related Incidence

Incidence and characteristics of injuries correlate strongly with age and gender. Elementary students incur more injuries than secondary students, but the difference is primarily due to minor injuries. However, Feldman et al. identified a "small but statistically significant" difference between the rate of serious injury among elementary (1.6 injuries/100 students) and secondary (1.3/100) students and concluded that younger students sustained more severe injuries than older ones. Scheidt et al. found that adolescents aged 14 to 17 were at greater risk of injury at school than other students. Epidemiological studies, however, disclose that students aged 10 to 14, or in grades 6 to 8, appear to be at increased risk of injury (10,27,43,69,73). Feldman et al. explained the incidence crest as the effect of increased activities coupled with the onset of puberty. Growth of students in the 6th to 8th grades is characterized by rapid increase in body size, muscle mass, and strength, and consequently termed the "clumsy age" (27).[12] The 10 to 14 age group may also be at greater risk of serious or severe injury. The NPTR study found that 44 percent of hospitalized students were ages 10 to 14.

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[9] Some injury investigators have suggested that injury rates among children may be inflated by a small number of children that suffer a large number of injuries (12). Studies found little evidence to support the accident-prone child notion (12, 27). Although the number of students with recurrent injuries are slightly higher than the rate expected by chance, the overall incidence rates were not greatly influenced.

[10] The study identified injuries of the 8,603 children, ages 0-19, enrolled with an HMO and treated in an HMO clinic, ER, or hospital. It was performed over a one-year period in 1985-86 (66).

[11] Studies of school-related injury outside North America report much lower rates. For example, Pagano et al. (1987) evaluated the student population in Milan, Italy, and found an average annual rate of 1.44 injuries per 100 students (62). Similarly, a study of primary and secondary students in West Lothian, Scotland, disclosed an injury rate of 2.6 per 100 students—3.7/100 for primary students and 1.9/100 for secondary students (11).

[12] However, one population-based study demonstrated injury peaks at ages 14-15, normally associated with 9th grade (63).

While playground and athletics (including both physical education and organized sports) account for the overall highest injury rates in school, distribution of these injuries changes over time due to students' development of physical skill, strength, size, judgment, balance, and experience with hazards (63). The rates of playground injuries decrease as elementary school children mature, while the rates of athletic injuries increase steadily through middle/junior high school to high school.

Across studies and grade levels, injuries occurred nearly twice as often to males than females and the difference was even more pronounced in adolescents (63,67). Minor injuries, rather than severe ones, constituted the difference between the genders (27). In a study designed to determine incidence of underreporting in schools, Woodward et al. found that girls' minor injuries were underreported more routinely (103). Most studies found little difference in gender rates for serious or severe injuries. One exception was the NPTR study of hospitalizations resulting from school injuries—it found a male to female ratio of 2:1. Regardless, the gender gap for overall injuries increases with age. The disproportionate increase in injuries to boys may be accounted for by the greater participation of boys in sports and also the type of sports played by boys.

Predictive Factors

Review of the effects of demographic and social factors, type of school, condition of school buildings, and the availability of health care at schools on injury incidence in schools is meager. With few exceptions, school injury studies have not compiled this type of data, even though such factors may strongly influence students' risk of injury. One non-school-related study in New York City showed that children living in low-income neighborhoods were twice as likely to suffer injuries as children in neighborhoods with few low-income households (24). It follows that students from low-income households are more likely to attend schools in low-income neighborhoods and to confront a broader range of risks in the school and non-school environment than students from more advantaged backgrounds (52). Conditions resulting from inadequate resources due to budgetary constraints, such as poor maintenance of school buildings (78), grounds, and equipment, or higher student-to-faculty ratios resulting in less supervision, are likely to have a significant impact on the potential for injury (52).

Boyce et al. surveyed school principals and nurses with regard to ecological variables that can affect the incidence of injuries at schools.[13] The results indicated that four particular variables were "significantly and independently predictive" of higher injury rate at a particular school: 1) increased length of school day; 2) presence of alternative educational programs; 3) less experienced school nurses; and 4) higher student-to-staff ratio. Significantly, two ecological factors were equally predictive with regard to severity of injury: greater length of school day and higher percentage of minority group students (10). More studies of the association between these factors and school injury rates are essential for understanding the ecological factors that impact the incidence of injury. The connections allow prevention efforts to appropriately target injury problems.

Severity

While overall incidence of school injury is tremendously important in determining the existence of an injury problem, equally important is

[13] The ecologic variables included: demographic characteristics (student enrollment, percentage of minority students, and student-staff ratio), social characteristics (transience rate, absence rate, drug or alcohol problems, family stability in student population, and behavior problems), programmatic characteristics, category of school (elementary, junior high school, high school), alternative educational programs, level of PTA (Parent-Teacher Association) activity, and school hours, physical characteristics (age of school building and playground condition), and health program characteristics (variety of nursing experience, years of nursing experience, nursing education, nurse hours, presence of nurse's aide, presence of safety program) (10).

injury severity. Severe injuries that can result in long-term disability justify attention due to their economic and emotional costs and health implications. Severity, however, is subjective and various terms are used to connote the gravity of an injury, including *severe, serious, significant,* and *major*. The percentage of severe injuries—ranging from 18 to 39 percent across studies—varies because, among other things, severity is defined differently from study to study (see table 3-1). The diversity of definitions inhibits meaningful cross-comparisons. Since most studies do not have medical diagnoses, other indicators are used as indices of severity, including the type of injury, nature of injury, school days lost, and school days in the hospital. Also the number of serious injuries compared to minor injuries is somewhat distorted because student injury report forms are usually completed by the attending adult, whether a teacher, school nurse, coach, or administrator, rather than by medical personnel. The extent of the distortion is unknown.

While most studies define severity by the type of injury (i.e., a fracture), each study uses a different set of criteria to determine if the type of injury is severe (69). According to Sheps and Evans, using the nature or body area of an injury to serve as a proxy for severity is generally unsound because, while they are associated, no specific correlation exists (26). For example, while a head injury is classified as severe, the actual injury may only be a surface abrasion on the head. However, nature of the injury appeared to have a stronger association with severity than body area. Moreover, the inclusion of particular types of injuries can substantially affect total numbers. In one study, for example, severe sports injuries increased from 25 to 56 percent if sprains, strains, and dislocations were classified as severe (69). Nonetheless, the variation of rates for severe injuries was small (0.9 to 1.7 severe / 100) compared to that of overall injury rates (1.7 to 9.2/100) (69).

Regardless of the definition used, playground and sports athletic injuries account not only for the greatest number of injuries, but also for the majority of severe injuries at school (10,43,69). Boyce et al. found that playground and sports equipment related injuries were 1.6 times more likely to be severe when compared to all other causes of injury. National Safety Council (NSC) data, however, indicate that motor vehicle-related injuries occurring on the trip to or from school resulted in the most severe injuries, indicated by the highest average number of school days lost (2.6 days) per injury, followed by interscholastic sports (1.6 days).

Passmore and Gallagher reported that the Massachusetts SCIPP data indicate that school injuries result in slightly lower proportions of hospital admissions and fewer bed-night stays than injuries occurring outside the school environment (63). Some of the more serious injuries incurred in schools are profiled in the NPTR study (29). Of the 907 emergency room cases identified during the NPTR study period December 1987 to February 1993 as being school-related, there were five deaths and nine debilitating injuries that required extensive rehabilitation. The injury rate may be influenced by students with pre-existing conditions, as they contributed disproportionately to the number of injuries. Many of the most serious injuries also resulted from falls: three of the five deaths and four of the nine rehabilitation cases. The most severe injuries for all students were associated with the head and spinal cord. All five deaths resulted from injuries to the head.

Cause

Falls (either from the same surface or from elevation), organized sports or athletics, and unorganized play were the activities most frequently associated with injuries (35,67). Sports activities accounted for a relatively high rate of severe injuries across studies. Comparison of the causes among studies, however, is not feasible because each study categorizes cause differently (69). To compound the problem, many studies approach the characterization of each cause differently. For example, Boyce et al. defined cause as “self, other student intentional, other student accidental, playground or sports equipment, mechanical equipment, and athletics,” whereas Sheps and

Evans included "fall, mechanical or object related, struck by or against another person, sports injury including drowning, and foreign body in eye." The Utah student report form gives cause as a contributing factor, which includes "common falls, fighting, collision, compression, contact with equipment, hit with thrown object, overexertion, and tripped/slipped." These significant methodological variances must be resolved before comparative data can be developed (69).

Locale

Not surprisingly, the most common locales for school injuries were playgrounds, gymnasiums, and athletic fields (10,27,56,73,99). Lenaway et al. found that injuries on the playground, for which data were collected only in elementary grades, occurred close to three times more frequently than those in the gymnasium. Sheps and Evans found that 29 percent of injuries were sustained on the playground. Comparatively, the Boyce study estimate of 65 percent playground injuries is high; however, it includes both playground and gymnasium.

Better supervision of elementary school children, especially on the playground, was a common study recommendation to reduce the risk for falls and other injuries (22,77). Sheps and Evans found an overall relative risk of 6.3 between uncontrolled and controlled areas of the school environment, suggesting that playground and sports activities in school require more attention and targeted prevention.

Injuries in school buildings, which include auditoriums, classrooms, corridors, stairways, and lab and shop facilities, represent a significant portion of all injuries. The NSC reported that they accounted for 24 percent of the injuries. The Utah Department of Health data indicated that students in grades 7-12 sustained 9.7 percent of their injuries in lab activities and 5.4 percent in classroom activities. There is a marked lack of detailed information on exactly which classroom activities caused the injuries. For example, it is not known whether these injuries are occurring in specific types of classes, such as industrial arts, science, or home economics. Moreover, there has been no evaluation of whether certain locations are more frequently reported than others (e.g., sports injuries versus classroom injuries).

Type and Body Area

As found by Boyce et al., the majority of injury types were those normally associated with playgrounds and athletics: swelling, bumps, cuts, bruises, and sprains or strains (see table 3-2). Elementary students sustained more minor injuries (e.g., contusions, abrasions, and swelling), which accounted for the difference in rates between elementary and high school students (27,69) and the decreasing rate of injury in secondary school (27). Types of injuries and body areas affected by injuries were distinct between elementary and secondary students. Elementary

TABLE 3-2: Types of Injuries Among Students

Type of injury	No. (and percent) of injuries to students
Swelling or bump	1,439 (27.1)
Cut	917 (17.3)
Bruise	740 (14.0)
Sprain	588 (11.1)
Scrape/scratch	382 (7.2)
Fracture	298 (5.6)
Chipped or broken teeth	180 (3.4)
Torn cartilage/ligament	83 (1.6)
Dislocation	65 (1.2)
Nosebleed	60 (0.1)
Loss of consciousness	22 (0.4)
Internal injury	13 (0.2)
Other	515 (9.7)

*The numbers and percentages were calculated from the 5,302 reported injuries among the Canadian schoolchildren attending the schools included in the Feldman study. The type of injury was not specified in 32 instances.

SOURCE: W. Feldman et al., "Prospective Study of School Injuries: Incidence, Types, Related Factors and Initial Management," *Canadian Medical Journal* 129:1279–83, 1983.

school students injured the head and face most frequently, while secondary school students were more likely to injure the upper extremities (69). Secondary students suffered twice as many sprains, strains, and dislocations as elementary students; however, the rates of fracture, concussion, whiplash, and foreign body in the eye were comparable (69). As expected, the predominant injuries correlate with types sustained on playgrounds and athletic fields. With few exceptions, studies failed to analyze injuries sustained in classrooms. One study showed that classroom injuries most frequently consisted of cuts and abrasions, punctures, foreign bodies, and poison or burns (43).

Fractures were the most frequent of the more severe injuries. Feldman et al. reported that fractures accounted for 5.6 percent of overall injuries and occurred primarily in the hand (34.2 percent), wrist (18.8 percent), and arm (12.4 percent). Boyce et al. found that 13 percent of all injuries were fractures. In Utah, fractures represented the highest percentage of injuries for grades K-6 (26.4 percent) and the second highest for grades 7-12 (20.9 percent) (99).

Time, Day, and Month

Studies that have attempted to associate the time, day, or month of injury with injury incidence indicate that no one day had significantly more injuries than any other (27,43,73). However, injuries did peak at certain times during the day. Both the Feldman and Lenaway studies reported increased numbers of injuries during recess and lunch hour; similarly, the Utah data revealed an overwhelming majority (62.5 percent) of injuries among students in grades K-6 occurring during recess or lunch. This is not surprising given the Sheps and Evans finding that there were six times as many injuries in uncontrolled areas as compared to controlled areas of the school environment.

Distribution trends of injuries by month were also evident. Rates increased with the return to school and the advent of warm weather that allows more time outdoors. The highest frequency of cases was in September, followed by October. The fall injury rates may be attributable to the excitement of returning to school and to football, the leading cause of sports injuries, which is played during the fall months. Rates rose again in January, as students return to school after the holiday vacation. Of course, to the extent that the pattern varies according to climate, injury rates may rise and fall at different times of the year in different regions of the country (43).

Product and Equipment Involvement

The U.S. Consumer Products Safety Commission (CPSC) maintains the National Electronic Injury Surveillance System (NEISS), which collects injury data from a national sample of hospital emergency departments (see box 3-1). NEISS data is based on injuries that patients say are product-related only; therefore, the injuries are not necessarily caused by the product but only related to the product. Non-product-related injuries are not included. Although collected using school as a location, the data are not analyzed by that criterion. At the request of OTA, the CPSC produced raw data of injuries incurred at school by persons aged 5 to 18. CPSC did not analyze the data; the discussion below presents OTA's limited examination of the data by age, gender, body part injured, and severity. If the CPSC regularly analyzed these data, national estimates of school injuries, albeit only product-related injuries, could be provided. The NEISS data also includes medical diagnoses that provide more accurate information on the types of injuries occurring in schools than reports filed primarily by school staff.

Estimates from the 1993 NEISS data disclose that persons aged 5 to 18 incurred 670,584 injuries requiring treatment in a hospital emergency department. The younger children sustained the fewest injuries, but as the children got older they gradually incurred more injuries, peaking at age 14 or 15 and then gradually decreasing. Thirteen to 17-year-olds combined sustained about 56 percent of the injuries—14- and 15-year-olds alone accounted for nearly a quarter of all injuries.

Finger and ankle injuries were the most prevalent, 113,357 and 90,977 injuries, respectively. For 5- to 9-year-olds, head injuries were the most frequent, followed closely by finger and wrist injuries. Among 10- to 14-year-olds, finger injuries were the most prevalent; ankle and wrist injuries followed at about half the number of finger injuries each. Face, head, and knee injuries were each less than a third of finger injuries. For 15- to 18-year-olds, ankle injuries were the most frequent. Finger and knee injuries were also prominent injuries for this age group.

Ranking severity levels from 1 to 8 (8 meaning fatal), the most frequent severity level for 5- to 9-year-olds was level 3, accounting for almost a third of total injuries (31.7 percent). Severity levels 2 and 4 accounted for another 41 percent. There were zero injuries occurring in this study for severity levels 7 and 8, and only 0.9 percent of 5- to 9- year-olds had injuries of severity 6. For 10- to 14-year-olds, the most frequent severity level was level 1, accounting for 32.5 percent of the total injuries. Levels 2 and 3 accounted for more than half of the total number of injuries. The most frequent severity level for 15- to 18-year-olds was likewise level 1, accounting for 32.9 percent of the total injuries. Levels 2 and 3 accounted for a little less than half of the injuries incurred. While there were no injuries in 7 and 8 for students below age 15, for ages 15 to 18, 0.01 percent and 0.02 percent of the injuries were severity level 7 and 8, respectively.

The CPSC also produces safety alerts concerning consumer products; these include products used in schools. Two 1988 CPSC Safety Alerts involving mobile folding tables and audiovisual carts illustrate equipment hazards in schools. Mobile tables in school cafeterias are commonly 6 feet high when folded and weigh up to 350 pounds. When moved in the folded position, they can tip over and seriously injure a student. CPSC received reports of four deaths and 14 injuries to students who were moving such tables in the period 1980-1988, but the injuries generally occurred during after-school or non-school-sponsored events. Tip-over injuries also occurred with audiovisual carts in classrooms: in 1988, CPSC reported four deaths and nine serious injuries of students aged 7 to 11. All incidents involved slant-top carts, but CPSC noted concern over flat-top carts as well. Like folding tables, the carts characteristically overturned and injured the child pulling rather than the child pushing them.

The Massachusetts SCIPP data considered product involvement and concluded that 35.7 percent of school-related injuries involved products, 58.1 percent of which were structures (e.g., stairs, floors, walls, and fences) and sports or recreation equipment. Table 3-3 lists the types of injury-causing products that present risks to students in schools. Approximately 50 percent of the product-related injuries at school were sustained by 7- to 13-year-olds. Moreover, playground equipment is associated with about one-half of the injuries to 6- to 10-year-olds that involve sports or recreation equipment.

PLAYGROUND-RELATED INJURY DATA

Play is an integral part of each student's school day; it is a natural part of physical and cognitive development. School playgrounds provide elementary and junior high school students with the opportunity to develop motor, cognitive, perceptual, and social skills. The risk-taking part of that activity is inherent in the learning process. In the course of playing, however, children sustain injuries. Indeed, playground injuries are the leading cause of injuries to elementary and junior high students, ages 5 to 14, in the school environment. Relative to other school injury issues, playground safety has attracted much public attention and been the subject of considerable study. Researchers have collected and analyzed data on the nature, distribution, and prevention of injuries sustained on public playgrounds, providing insight into the ability to control such incidents at schools.

Sources and Limitations of Playground Injury Data

Because of the lack of national estimates of school injuries, there are no data available for

TABLE 3-3: Types of Products[a] Involved with Injuries in School

Products	Percent of school injuries involving products[b]
Structures and construction materials (e.g., stairs, floors, walls, fences)	29.2
Sports and recreation equipment	28.9
Furnishings, fixtures, and accessories	15.0
Powered and unpowered tools and workshop equipment (e.g., saws, drills, welding equipment, batteries, hoists)	7.1
Personal use items (e.g., clothing, pencils, pens)	6.1
Housewares (e.g., small kitchen appliances, drinking glasses, tableware, cutlery, cookware)	5.2
Food, alcohol, and medicine	1.9
Packaging and containers (e.g., cans, containers, glass bottles)	1.8
Heating, cooling, and ventilating equipment (e.g., radiators, fans, heating devices)	1.5
Communications, entertainment, and hobby equipment	0.5
Appliances	0.3
Miscellaneous	2.6

[a]These are the products involved with injuries at school to 1,704 children 5 to 19 years old in 14 Massachusetts communities, September 1979–August 1982. Products classified according to codes shown in United States Consumer Product Safety Commission (1987) and aggregated to general reporting levels commonly employed by the Commission (see, e.g., United States Consumer Product Safety Commission). Products are associated with an injury, but are not necessarily the cause of the injury.

[b]Products are involved with 35.7 percent of all school injuries.

SOURCE: From Harvard Injury Prevention Research Center analysis of injuries from SCIPP Injury Surveillance System data.

comparing playground injuries to other school injuries on a national level. It is clear, however, from the state surveys and epidemiological studies focusing on school injuries, that playground injuries are the primary cause of injuries in the school environment for younger students. Definitional issues provided the greatest obstacle for assessing the extent of such injuries. Depending on the study, a playground injury could include minor injuries as well as injuries necessitating a visit to a doctor or to an emergency room. Moreover, some studies of playground injuries have included all injuries sustained on playgrounds, whereas other data, such as the CPSC's NEISS data, may only record injuries involving playground equipment.

OTA reviewed the following data sources: 1) CPSC NEISS data; 2) state survey and study data; 3) epidemiological studies; and 4) the 1994 U.S. Public Interest Research Group (PIRG) and Consumer Federation of America (CFA) *Playing It Safe* survey. Each source, as discussed in box 3-3, has substantial limitations for purposes of this report. In addition, the sources have varying sample populations and distinct methods that do not allow cross-comparisons of conclusions.

Incidence and Distribution of Playground Injuries

Mortality Data (Equipment-Related)

The 1990 CPSC *Playground Equipment-Related Injuries and Deaths* report (the CPSC Report) provides an analysis of data on playground injuries and deaths associated with playground equipment. In the 16-year study period, 276 deaths of children were identified as playground equipment-related, for an average of 17 deaths each year. **Fatalities among school-aged children averaged nine per year**: approximately 50 percent to children under age 6, about 75 percent to children under age 9, and 90 percent to children under age 12. The CPSC Report did not distinguish whether these occurred on public, home, or homemade equipment. OTA could not identify national estimates of the number of total playground non-equipment-related fatalities.

BOX 3-3: Sources of Data on Playground Injuries in School (Cont'd.)

National data

The only national data for playground injuries are derived from CPSC's National Electronic Injury Surveillance System (NEISS) database, which keeps statistics on playground equipment-related deaths and injuries that are recorded in hospital emergency rooms. NEISS records only fatalities that are product-related injuries and, accordingly, excludes those that occur on playgrounds but are not equipment-related. Moreover, NEISS collects only emergency room data, providing only information on the more serious playground equipment-related injuries. NEISS reports on playground equipment that is public, used at home, or homemade.

In April 1990, CPSC published a report entitled Playground Equipment-Related Injuries and Deaths. For the report, CPSC examined 1973–89 NEISS fatality data, CPSC files containing death certificate information, consumer complaints, newspaper clippings, and other sources to obtain fatality data. Nonfatal injury data were obtained from a special study of NEISS data that analyzed information from April to December 1988 (which was extrapolated to a full year). For both mortality and morbidity estimates, the data were limited to children under age 15.

From analyses of playground injury data, CPSC published playground equipment safety guidelines in 1991. The guidelines are intended for those who purchase, install, maintain, and use playground equipment; however, they are not mandatory (see box 3-4). In addition, more technical standards that are voluntarily applicable to manufacturers have been devised by the American Society for Tests and Materials (ASTM).

State data

OTA identified six states that have some data on school playground injuries. These are the best sources of data for school playground injuries because injuries are reported in relation to other school-related injuries and include minor as well as serious injuries. Moreover, the data are not limited to injuries associated with playground equipment but include all injuries sustained on school playgrounds. Hawaii, South Carolina, Utah, and Washington include playground injuries in their surveys and studies of the entire range of school injuries, as reviewed in the previous section (see box 3–2). The data has been used by these states to develop safety programs. The Utah school injury data was used to design a curriculum guide for promoting playground safely in schools. Furthermore, the Utah data were also used for a 1993 study by the Centers for Disease Control and Prevention (CDC) of injury rates from falls for grades K–6 students on Utah playgrounds. The analysis was restricted to injury report forms detailing a fall involving equipment on the playground or athletic field. Arizona and Virginia have completed studies that focus specifically on school playground injuries.

The **Arizona Department of Health Services** completed a comprehensive school playground injury study from 1991 to 1992. However, the study included athletics and sports, so estimates are not restricted purely to playground-related injuries. It evaluated 212 elementary schools including 122,056 students in grades K–8, representing 29 percent of that population. Student health personnel were required to complete a report form when an injured student either 1) was sent home, 2) was sent to a physician, 3) was transported or admitted to a hospital, or 4) required restricted activity. The study was intended to reduce the number of injuries by providing the opportunity to target appropriate interventions.

In 1991, the **Virginia Department of Education** conducted a study on the safety of school playgrounds in that state. However, significant methodological problems with both the survey and the responses limit the reliability of those data. As part of the study, the Department of Education surveyed 75 school districts, of which 65 responded. The districts, representing 348,976 students enrolled in schools that had playgrounds, reported the numbers and types of injuries sustained on school playgrounds; there was no information relating to the grade, age, or sex of the students. One of the major problems of the study was the inconsistent reporting. For example, school districts reported 5,708 total injuries but 12,734 injuries when classified by type, resulting in a more than twofold disparity in the number of injuries.

(continued)

BOX 3-3: Sources of Data on Playground Injuries in School (Cont'd.)

Epidemiological studies

State school injury data and epidemiological studies of the percentages of school playground injuries in relation to other school injuries are remarkably consistent. The epidemiological studies discussed earlier provide valuable insight into the incidence of playground injuries, because many of the epidemiological studies, as discussed in box 3-1, cover the complete school injury experience, allowing playground injuries to be studied relative to other school injuries. The epidemiological study conducted in Tucson, Arizona, by Boyce et al. (1984) evaluated playground injury data separately from other school injuries. There are also a number of studies that concentrate on playground injuries alone, in particular Sosin's study of the surface-specific injury rates on Utah school playgrounds and Bond and Peck's study of injuries on Boston playgrounds.

SOURCES: Office of Technology Assessment, 1995. Bond, M.T., and Peck, M.G., "The Risk of Childhood Injury on Boston's Playground Equipment and Surfaces," *American Journal of Public Health* 83:731–733, 1993. Sosin, D.M., et al., "Surface-Specific Fall Injury Rates on Utah School Playgrounds," *American Journal of Public Health* 83:773–735, 1993.

Strangulation resulting from entanglement and entrapment was the primary cause of fatalities; it was responsible for about 47 percent of the deaths. However, these deaths typically involved children under the age of 5, not school-aged children. Falls were the second highest cause of death (31 percent). The authors noted, however, that the number of falls is probably underreported, since in 1983 the CPSC ceased collecting death certificate information involving accidental falls except for one or two states (75). For fall-related deaths, the associated equipment included swings (52 percent), slides (24 percent), and climbers (17 percent). Equipment tipover or failures were associated with 13.5 percent of the deaths.

Morbidity Data

For each death on playgrounds there were approximately 14,000 emergency room visits for treatment of playground equipment-related injuries. In 1992, public playground equipment injuries were responsible for approximately 241,180 visits to emergency rooms.[14] The American Academy of Orthopedic Surgeons estimated the total cost of playground equipment-related injuries to children under age 15 at $1 billion in 1992.[15] There are no national estimates encompassing the complete extent of school playground injuries since the CPSC estimate is limited to equipment-related injuries and does not include injuries treated at schools, homes, and doctors' offices; however, it provides estimates of injuries by location, age, and time.

For each death on playgrounds there were approximately 10,000 emergency room visits for treatment of playground equipment-related injuries. CPSC projected about 200,000 playground equipment-related injuries in 1988; however, when adjusted by the proportions of verified cases for the CPSC Report, the number was reduced to about 170,000 (75).[16] Public equipment was involved in 70 percent of these injuries; home equipment and homemade equipment accounted for 24 and 4 percent, respectively. Most of the public equipment injury incidents occurred in school playgrounds and public parks,

[14] "Public playground equipment" refers to "equipment intended for the use in the play areas of parks, schools, childcare facilities, institutions, multiple family dwellings, restaurants, resorts and recreational developments and other areas of public use" (83).

[15] Costs include, but are not limited to, medical and travel expenses for initial and follow-up treatment, forgone earnings of the injured child's visitors, and disability costs.

[16] From April to December 1988, CPSC completed an in-depth special study of selected playground injury incidents. The study identified cases involving injuries that were not associated with outdoor playground equipment. Extrapolating the percentage of these cases to the 1988 NEISS, CPSC determined that the estimated 201,400 emergency room-treated playground equipment-related injuries should be reduced to 170,200. The special study was limited to 1988 data.

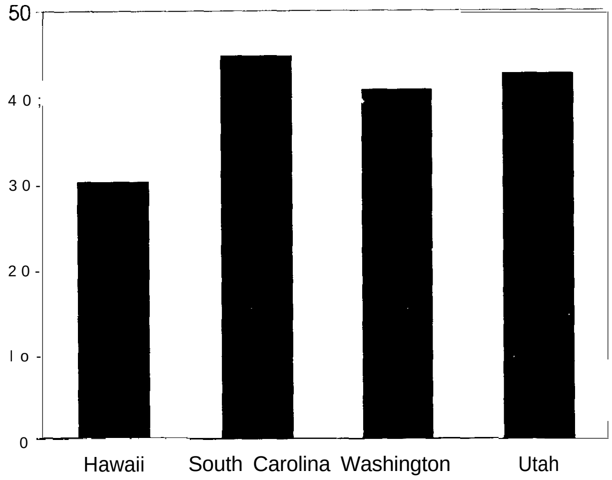
each accounting for approximately 42 percent of the 1988 estimated injuries incurred on public playgrounds. Using this data, OTA calculated that approximately 30 percent of publicly owned playground equipment injuries occurred on school playgrounds. Furthermore, 13,000 playground equipment-related injuries to school-aged children occurred on school playgrounds during school hours, which is about 8 percent of playground equipment-related injuries.

The CPSC's most current estimate of 241,181 playground equipment injuries requiring treatment in hospital emergency rooms in 1992 has not been adjusted in the manner of the 1988 data. The estimate includes 168,827 public playground equipment, 57,883 home playground equipment, and 14,471 homemade playground equipment injuries (84).

Playground injuries were the most prevalent of all injuries sustained by students in school, accounting for 30 to 45 percent of all school-related injuries reported in the available state data (see figure 3-2). This is also true of the epidemiological studies; the percentages of playground injuries ranged from 29 to 43 percent of total school injuries. The percentages are even higher when limited to children in grades K-6. For example, Utah reported that playground injuries accounted for about 65 percent of all school injuries for those grades. Besides being the most prevalent, playground injuries represented some of the most severe injuries (11 ,27). Boyce et al. found that a quarter of the playground injuries were severe, meaning that they resulted in concussions, crush wounds, fractures, and multiple injuries.

Unlike school injuries in general, there was no significant difference between the frequency of injuries suffered by boys and girls (1 1,71 ,75). For all children, the body area most frequently affected by playground equipment-related injuries-was the head and face (47 percent), followed by the arm and hand (34 percent). Children under the age of 6 were significantly more likely to sustain an injury that involved the head or face (60 percent) than the arm or hand (20 percent). Injuries were more equally distributed across body areas for children ages 6 and over (75).

FIGURE 3-2: Percentage of Playground Injuries in Four State Studies



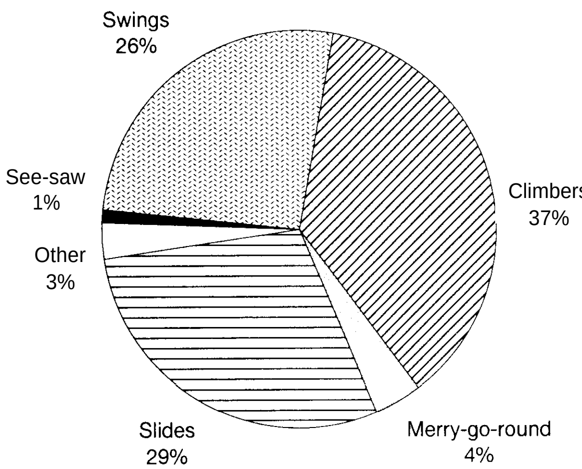
SOURCE Office of Technology Assessment, 1995, based on Hawaii Department of Education, "Summary-School Accident Report, 1989-1990" (Honolulu, HI: 1991), Washington State Department of Health, Office of Community Environmental Health Programs, *The School Injury Surveillance Project" Results and Recornrnendations* (Olympia, WA 1990); South Carolina Department of Health & Environmental Control, Division of Children's Health, *Annual School Nurse Survey 7993* (Columbia, SC 1994), and Utah Department of Health, Division of Family Health Services, Student Injury Report Database, 1988-1992

The types of injuries most frequently sustained on playgrounds were abrasions, contusions, sprains, dislocations, lacerations, and fractures (3,75). The percentages reported by CPSC were as follows: 29 percent lacerations, 28 percent fractures, 22 percent contusion/abrasions, and 13 percent strain/sprains. Lacerations, contusions, and abrasions—relatively minor injuries—were associated with 81 percent of the head injuries; however, 7 percent of the head injuries were potentially more serious, involving fractures, concussions, and internal injuries. Fractures were the most frequent arm and hand injuries, accounting for 65 percent. Strains and sprains accounted for another 22 percent of the arm and hand injuries (75).

The Arizona Department of Health playground study found that 72 percent of the students with reportable injuries were taken to a doctor or the emergency room: 38 percent were taken to the doctor by parents, about 19 percent were taken to the emergency room by parents, and about 15 percent were taken to the doctor or emergency room by school personnel. Of these students, 1 percent were hospitalized with a mean stay of 1.9 days (the longest was 7 days), Moreover, 15 percent of the students taken to a doctor or emergency room required restricted activity for an average of 13.6 days (the longest being 120 days). The study estimated that in Arizona the 10,500 school playground injuries resulted in 6,500 days of absenteeism, 4,300 doctor visits, and 2,000 emergency room visits.

Many of the studies focused on the association between playground equipment and injuries. Boyce et al. found that about 23 percent of the total injuries across all grades in public schools were associated with playground equipment; the rate of playground equipment-related injury at the schools was about 0.9 playground equipment injury per 100 student years (1 1).[17] Lenaway et al. found that playground-related equipment injuries alone accounted for 38 percent of all school injuries, the rate of injury being about 2.4 per 100 students (43). The equipment most often involved in injury-causing events were climbers, swings, and slides (see figure 3-3). Among 5- to 14-year-olds, climbers and swings accounted for 71 percent of injuries (75). Other equipment commonly involved in playground injuries included slides (15,5 percent) and teeter-totters and seesaws (3.4 percent) (75). Across studies, remarkably similar percentages were reported (3,9,43).

FIGURE 3-3: Injuries Associated with Public Playground Equipment, by Type of Equipment (N=10,730)



SOURCE: National Electronic Injury Surveillance System (NEISS) Special Study, Apr,-Dee, 1988, U.S. Consumer Product Safety Commission/EPHA.

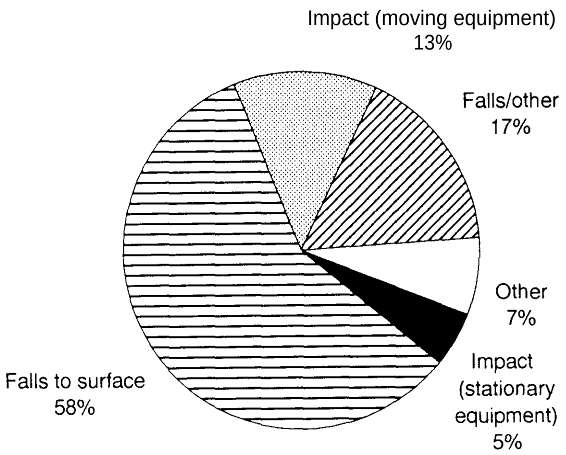
As shown in figure 3-4, falls associated with playground equipment present the greatest risk to students. Falls from climbing equipment accounted for nearly 25 percent of the injuries on public playgrounds (75) and a disproportionate number of severe injuries (11). The body areas most affected by falls to the surface were arm and hand (47 percent) and head or face (36 percent). The overwhelming majority of serious arm and hand injuries resulted in fractures (70 percent).[18] Falls to the surface involved mainly climbers, swings, and slides. In fact, falls to the surface from climbers accounted for 23 percent of all the playground equipment-related injuries; surface falls from swings and slides accounted for approximately 16 and 13 percent, respectively.

Although climbers, slides, and swings accounted for about 87 percent of the overall playground injuries, CPSC found that the proportion of injuries attributed to each type of playground equipment was nearly equivalent to the proportion of each type of equipment used, suggesting that no one type was particularly more risky than any other (75). While no analysis was

[17] The study also found that higher incident rates correlated with two ecologic variables, small student enrollment and 'he Presence ' alternative education programs (e.g., magnet schools). Alternative schools had a mean injury rate of 1.37 per 100 student years compared to 0.71 in other elementary schools (10).

[18] Serious head injuries due to falls from heights of more than 4.5 feet were reported. There did not appear to be a strong correlation between diagnosis and the distance of the fall; however, some fractures, to the wrist and collarbone, occurred at falls from heights of two feet or less (75).

FIGURE 3-4: Incidents Involving Playground Equipment



SOURCE. National Electronic Injury Surveillance System (NEISS) Special Study, Apr.-Dec. 1988. US. Consumer Product Safety Commission/EPHA

completed relating the state of the equipment to the injury rate, three-quarters of the equipment involved in injuries was reported in good condition and only one-tenth of the equipment was reported to be abused, scarred, rusted, or broken. The study, however, did not consider whether there was good protective surfacing, or whether the playground equipment was adequately spaced or at a safe height.

The available studies on the adequacy of surfacing on public playgrounds have, without exception, found that most playground surfacing is unsafe. A study of Boston playgrounds conducted by the Childhood Injury Prevention Program of the Boston Department of Health and Hospitals found that all the surfaces observed were unsafe (9). Sixty-four percent of the surfacing was appropriate (matting, sand, or wood chips) but poorly maintained—making it unsafe. The remaining 36 percent was unsafe due to unsuitable playground surfacing material (asphalt, grass, bare ground). Similarly, a survey of 57 elementary schools around Philadelphia revealed that 99 percent of climbers and slides, equipment associated with many injuries, were placed on inappropriate surfacing of asphalt or packed dirt (65). A 1994 study performed by the PIRG and CFA, *Playing It Safe*, presented the findings from observation of 443 playgrounds in 22 states (102). Consistent with the above findings, 92 percent of the playgrounds lacked "adequate protective surfacing," meaning loose fill material (e.g., hardwood chips) properly maintained at depths of 9 to 12 inches under or around all equipment.[19] Thirteen percent had hard surfaces under and around all equipment, a substantial decrease from the 31 percent found in 1992.

For playground injuries, the problem is not so much lack of data, but rather the lack of the necessary implementation of the safety recommendations and rigorous maintenance of playground equipment. Based on CPSC and other epidemiological studies, voluntary guidelines for safe playgrounds have been devised, and intervention and prevention strategies have been developed (see box 3-4). Short of developing mandatory playground standards, those responsible for the construction and maintenance of playgrounds should be included in efforts to make playgrounds safe and to minimize injuries. Box 3-5 illustrates the impact a successful playground safety program can have on preventing injuries. Physical playground site safety should also be combined with staff supervision of the students. Programs designed to increase supervision have resulted in reductions of injuries (77).

SCHOOL ATHLETIC INJURY DATA

By participating in physical education and interscholastic sports, students benefit from the advantages of regular exercise (33), the opportunity to develop motor and judgment skills, and participation in competitive team sports. Engaging in sports activities entails some risk of being

[19] Of the 443 playgrounds observed for the PIRG and CFA *Playing It Safe* **report, 62 percent had loose fill surfacing but only 3** percent **maintained the loose fill at an adequate depth of at least 9 inches. In addition, 19 percent had loose-filled surfacing under some equipment, but hard surfaces under other equipment. Only 5 percent of the playgrounds had synthetic surfacing, such as premolded rubber tiles, under and around all equipment.**

BOX 3-4: Playground Guidelines and Standards

Public playgrounds cannot exist without injuries. Due to the nature of the playground equipment, potential hazards exist, even when safety standards are met and maintained. The U.S. Consumer Product Safety Commission (CPSC) and the American Society for Testing and Materials (ASTM) have published safety standards for playground equipment to minimize the risk of injuries.

The guidelines recommended by the CPSC are based on a March 1990 report by the COMSIS Corporation. The CPSC handbook, which evaluates the safety of each individual piece of playground equipment along with the entire layout of the playground, is intended for school officials, parents, equipment purchasers, recreation personnel, and anyone else concerned with general playground safety.

ASTM guidelines provide a more technical approach than CPSC standards. Guidelines recommended by the ASTM, published in December 1993, are directed toward equipment manufacturers, designers, and playground planners rather than toward the general public. ASTM standards focus on technical details, including testing information, and are stricter and more extensive than the CPSC standards.

However, these guidelines and standards, which include design, layout, installation, construction, and maintenance, are not mandatory. Schools, child centers, parks, and other public facilities must voluntarily upgrade and maintain the equipment and surrounding areas to help prevent injuries and deaths resulting from incidents related to playground equipment.

Many of the injuries and deaths related to playground equipment can be prevented by providing safer playground equipment. By limiting the height of equipment and providing adequate fall zones and protective surfaces, many injuries and deaths caused by falls would not occur or would be less severe. These injuries could also be prevented by providing adequate protective surfacing. Of 443 playgrounds investigated by the Public Interest Research Group (PIRG) and CFA using CPSC standards, 92 percent did not maintain adequate protective surfacing under and around equipment. Since 1992, fewer playgrounds surveyed had hard surfaces (from 31 percent in 1992 to 13 percent in 1994), such as asphalt and concrete, below the equipment.

According to the guidelines, protective materials should be soft so as to reduce the severity of injuries due to falls. Hard surfaces, such as asphalt, concrete, grass, and packed dirt, do not provide enough protection. Loose-fill materials like sand and hard wood chips, along with unitary synthetic surfaces such as molded rubber tiles, are acceptable when maintained properly. Maintenance of the materials requires keeping proper depths (compressed or uncompressed). Depending on the type of equipment and distance a child might fall, different materials gave different critical heights. For example, compressed double shredded bark mulch at a depth of 9 inches had a critical height of 7 feet, while uncompressed double shredded bark mulch's tested critical height was 10 feet. A difference in critical heights is also seen when comparing wood mulch (10 feet) to fine sand (5 feet) at uncompressed depths of 9 inches.

Adequate fall zones may be often missing. Often protective surfaces did not extend far enough around the equipment, or other structures are built too close. Again, depending on the type of equipment, varying fall zones are recommended. For instance, for a single-axis swing set, CPSC recommends a distance of 6 feet from the perimeter of the supports and a distance that is twice the greatest possible height, both in front of and behind the swings, as a safe fall zone that should have protective surfaces.

Another problem is that in building the structures recommended, height limitations are not always adhered to. Instead, some structures, such as climbers and slides, are built so that if a child falls from them, there is a greater potential for injury than if it was a smaller structure that was equally challenging yet less dangerous. Height limitations depend on the type of equipment, and also on the age of the children using it. For instance, older students have more muscle control and better natural instincts (e.g., to risk an arm to protect the head) than younger children. Therefore, the structures intended for older student use could be built at greater height without a proportionate increase in danger.

SOURCES: U.S. Consumer Product Safety Commission, Handbook for Public Playground Safety, 1991; U.S. Public Interest Research Group and Consumer Federation of America, *Playing it Safe: A Second Nationwide Safety Survey of Public Playgrounds,* May 1994.

BOX 3-5: An Effective Injury Prevention Program

After seeing many children come into the trauma unit with injuries incurred on the playgrounds or indirectly caused by the lack of playgrounds, Barbara Barlow, MD, director of pediatric surgery at the Harlem Hospital Center in New York City, decided to start an injury prevention program. Founded in 1988 and based at the Harlem Hospital Center, the Injury Prevention Program (IPP) has three main targets: playground injury prevention, motor vehicle/pedestrian/bicycle injury prevention, and window guards to prevent falls. Other projects have also grown out of the IPP, such as art and dance programs to keep children off the streets and away from drugs and gunfire.

Working with public schools, state and community agencies, and volunteers from the community, the IPP has contributed to the reduction of the number of children patients at the Harlem Hospital Center. From 1988 to 1993, a reported 38 percent decrease in major trauma and 42 percent decrease in major injury admissions involving children of Central Harlem has occurred (IPP, 1994). Project Oasis and Safety City are two exemplary programs of the IPP that have aided in the dramatic decrease in childhood injuries. These programs implement key parts of the IPP mission: upgrading playgrounds at school, introducing safety features, and teaching the children how to safely encounter traffic situations, such as crossing the street.

Project Oasis focuses on improving the safety of school playgrounds and creating gardens for the schoolchildren. Before the involvement of IPP, school playgrounds often consisted of concrete slabs and rusty monkey bars. While school officials recognized the need to upgrade the playgrounds, monetary and labor resources were not readily available. With the efforts of IPP, the resources were found in grants and contributions of both money and labor. Safety improvements included rubber matting below swings, slides, and jungle gyms; rounded corners on the wooden structures; and railings on elevated structures. These features, among others, have considerably reduced the occurrence of preventable playground injuries, and consequently have reduced the risks of the children at the schools that have reconstructed playgrounds. Since 1988, IPP has completed the reconstruction of four playgrounds and has plans for four more playgrounds at Harlem schools (IPP, 1994).

In addition to rebuilding playgrounds, the IPP has joined forces with the New York City Department of Transportation and the New York public schools to establish **Safety City,** a program that educates students about traffic safety. With few suitable playgrounds available, children often turn to the streets as a place to play; as a result, motor vehicle crashes have been a leading cause of death and injury to New York City children. Safety City teaches third-grade students in the community street safety skills in a full-size yet protected street section built on the school grounds. The children are able to learn street safety in the fenced-in area, which includes real trucks and cars, street signs and signals, and other street paraphernalia. The realistic approach to learning has dramatically reduced the number of preventable deaths and injuries due to traffic accidents involving children. Since the onset of the program, hospital admissions for accidents involving motor vehicles and pedestrians have dropped by 5 percent (IPP, 1994). The IPP has prevented numerous injuries and deaths by successfully teaching the children of Harlem the importance of street safety.

SOURCES: T. Hiss and E. Koren, "Child's Play: New York's Best Places to Play," *The New Yorker* 69(14):80, May 24, 1993; Injury Prevention Program, "Injury Prevention Using Community Coalitions," unpublished article sent by IPP, New York, NY, 1994; R. Mora, "The Creative Playground/Outdoor Learning Center," *Children's Environments Quarterly* 8(1):59–62, 1991; New York City Department of Transportation, "Safety City," New York, NY, June 1992; "An Ounce of Prevention: ED's Outreach Efforts to Reduce Childhood Injuries," *ED Management,* April 1994, pp. 59–61; "Project Oasis: New Playground and Garden Thrive in Harlem," *Columbia Community Affairs,* January 1994, p. 15; A.A. Sgarro, "A Surgeon and Her Community," *Vassar Quarterly,* spring 1993, pp. 10–13; "The Unique Safety Street in Harlem," *Childhood Injury Prevention Quarterly,* fall 1992, p. 5.

injured as all such activities involve some degree of danger. In 1993, approximately 5.6 million students competed in high school athletics (51)—about 43 percent of high school students (85). Student participation in athletic activities is a principal cause of junior high and high school injuries and results in a significant number of debilitating injuries and deaths each school year.

Compared to the number of studies on sports injuries in general, few have been directed specifically at school athletic injuries. Most studies survey all sports injuries, including recreational, community, or school athletic activities. This lack of school specific data makes it difficult to draw conclusions regarding athletic-related injuries occurring only in the school environment. The majority of information focuses on junior high and high school student sports injuries primarily because these students are typically the segment of the school-aged population participating in athletics, and thus sustaining the majority of athletic injuries.

Sources and Limitations of Athletic Injury Data

The major sources of school athletic injury data, as shown in box 3-6, are the National Center for Catastrophic Sports Injury Research, CPSC's NEISS database, the National Athletic Trainers Association, and epidemiological studies. In addition, the American Academy of Pediatrics publication *Sports Medicine: Health Care for Young Athletes* reviews sports injury studies, although they are not limited to schools. Sources providing athletic injury data suffer from the same problems as organizations reporting injury data in general. Limitations of studies typically include: underreporting, inconsistent definitions of athletic injury, inaccurate reporting of injuries, unavailability of athletic exposure times, discrepant criteria for classifying severe or serious injury, and inability to control for certain variables (33).

School sports injuries, or risks, are expressed in a number of ways in different studies, including: 1) total number of injuries, 2) percentage of overall injuries that occur in school, 3) number of injuries per student population, 4) number of injuries per student population participating in a particular sport, 5) number of injuries per athletic season, and 6) number of injuries per duration of athletic exposure (days or hours). Risk is portrayed most accurately by the number of injuries per duration of athletic exposure because it adjusts for differences in the lengths of seasons (64). As typically used, athletic exposure means "one athlete participating in one practice or contest where he or she is exposed to the possibility of an athletic injury" (64). The other measures used and the different indices of severity (for example, missed academic days and missed practices or competition days) inhibit cross-comparison of studies.

Epidemiological studies are directed at determining the distribution or rate of health injuries that result from athletic participation. Most often, the studies focus on a particular problem associated with a single sport. Few studies have examined the range of athletic injuries in the school environment; physical education injury studies are particularly lacking. The major school sports injury studies include those of Garrick and Requa (31), Zaricznyj et al. (104), and Rice (64) (see table 3-4). Both the Garrick and Requa and the Zaricznyj et al. studies are over a decade old, and each was a study in one city. In 1978, Garrick and Requa published their study of student athletes in four high schools in Seattle, Washington, over a two-year period, 1973-75 (31). In 1980, Zaricznyj et al. studied reports of injuries to all school-aged children and adolescents in Springfield, Illinois, from 1974 (104). The Zaricznyj study evaluated all types of injuries sustained during participation in physical education, school team sports, community team sports, and nonorganized sports.

Rice studied sports injuries in 20 high schools in the Seattle and Puget Sound areas of Washington state since 1979. He established a sports injury surveillance system and instructed coaches in record keeping and completing a Daily Injury Report (DIR) to record the participation status and types of injuries at practices

BOX 3-6: National and State Sources of Data on Sports Injuries in Schools

The National Center for Catastrophic Sports Injury (the Center) at the University of North Carolina records catastrophic injuries occurring in all high school and college sports for both men and women. Since 1982, researchers have recorded catastrophic injuries in high school sports nationally. The Center is funded by grants from the National Collegiate Athletic Association, the American Football Coaches Association, and the National Federation of State High School Associations. The Center was founded, in part, to counter the lack of sports injury data, particularly for women. Data are collected from coaches, athletic directors, executive officers of state and national athletic organizations, a national newspaper clipping service, and a team of researchers. When the Center is notified of a possible catastrophic injury, the injured player's coach or athletic director is contacted by telephone, personal letter, and questionnaire. The most current edition of the data reviews information collected from the fall of 1982 to the spring of 1992.

The Center defines catastrophic injury as any severe injury incurred during participation in a sport. Catastrophic includes three degrees of injury: fatal, nonfatal, and serious. Nonfatal injuries are those resulting in permanent severe functional disability, while serious injuries result in severe injury without permanent functional disability (i.e., a fractured cervical vertebra with no paralysis). The Center also categorizes injuries as direct or indirect—direct meaning those injuries that resulted directly from participation in the skills of the sport; indirect meaning those injuries that were caused by systemic failure as a result of exertion while participating in a sport activity or by a complication that was secondary to a nonfatal injury.

The CPSC's **NEISS** database (see box 3-3) contains national estimates of the number of nonfatal injuries incurred by school-aged sports participants; currently the data are not analyzed using school as a location for injury. However, these data can be broken down by age and location to give some sense of sports injuries at school. NEISS data, however, include only those injuries involving consumer products and come from a sample of patients in hospital emergency rooms. Many athletic injuries are never seen in hospital emergency rooms but are tended to by sports trainers or doctors. Moreover, hospital emergency room data inherently contain a selection bias since, except for the most serious injuries, the cost of emergency care affects the decision to seek medical care. CPSC also identifies sports-related deaths from NEISS data and other data sources (death certificates, newspaper clippings, consumer complaints, and medical examiner reports).

The **National Athletics Trainer's Association** (NATA) completed a single-year sports injury surveillance study. The 1986 study was based on medical records of 32,647 of the estimated two million high school athletes participating in football, basketball, and wrestling. NATA extrapolated from the injuries incurred in those three sports to include all other sports. The authors recognized that the study included only those schools that had certified athletic trainers or the equivalent on staff, which only includes 16 to 18 percent of all schools. The fact that these schools have that level care probably indicates that they are more likely to be sensitive to preventing athletic injuries.

In addition, the **Kansas Department of Health and Environment** completed a survey of athletic injuries in secondary schools during the 1990–91 academic year. The survey covered a random sample of 283 schools, with 162 responding. Injuries were reported for grades 7 to 12, but rates were calculated only for grades 9 to 12.

SOURCE: Office of Technology Assessment, 1995.

TABLE 3-4: School Athletic Injury Studies

	Garrick and Requa (1978)	Zaricznyj et al. (1980)	Rice (1992)
Location	Seattle, WA	Springfield, IL	Seattle, WA (Puget Sound area)
Population studied	3,049 high school student sport participants	25,512 school-aged children	6,057 high school athletes
Method of assessment	An athletic trainer was assigned to each of the four high schools studied to collect case and control data on injuries to athletes.	For one year, reports were received from principals and coaches of all 53 public and private schools, supervisors of community sports programs, two hospital emergency rooms, schools' accident insurance company and local physicians.	Coach or student trainer, adult athletic trainer, or manager reported injuries on a "Daily Injury Report," which was completed daily and submitted monthly.
Reportable injury	A medical problem resulting from athletic participation necessitating removal from a practice or competitive event and/or resulting in missing practice or competitive event.	Any traumatic act against the body sufficiently serious to have required first aid, filing of school accident reports, or medical treatment.	A medical problem resulting from athletic participation necessitating removal (or limiting participation) from a practice or competitive event and/or missing a subsequent practice or competitive event. An injury implies a time loss—either missing a practice or game or participating on a limited basis.
Incidence of injury	39 injuries per 100 student participants	About half of all sports injuries sustained by school-aged children in the community occurred in physical education class (15 percent) and organized school sports (38 percent).	32.7 injuries/100 athletes/ season and 7.8 injuries/1,000 athletic exposures. Mean injury time loss (practices and games) was 4.6 days.
Severe/ serious	*Severe injury:* indexes of the severity of injuries sustained include time lost (from practice and /or events), the necessity for special diagnostic tests (e.g., x-ray films) or the need for physician consultation, hospitalization, or operative procedures.	*Serious injuries:* injuries causing disruption of one or more supporting structures of the body or damage to important organs (e.g., brain, liver, kidneys etc.). *Permanent injuries* are those in which body structure was not restorable to its original anatomy or function, such as a broken tooth.	Severity categorized by the amount of time lost from full unrestricted participation. Injuries that kept an athlete from participation are *minor*, those with time loss between one and three weeks are *significant* and those with time loss over three weeks are termed *major*.
Incidence of severe/ serious	About 75% of the injured students returned to practice with fewer than five days of practice or competition missed. 42% were examined by a physician (note: 53% of wrestling injuries were examined by a physician).	20% of the injuries were serious. About half of the serious injuries were related to schools sports, physical education (27%), and organized team sports (25%). Nonorganized sports accounted for about 48% of the serious injuries.	1.8 significant injuries/1,000 athletic exposures. 0.5 major injuries/1,000 athletic exposures.

(continued)

TABLE 3-4: School Athletic Injury Studies (Cont'd.)

Sports with highest injury rates	Highest rates were in: football (81/100) and wrestling (75/100). Overall sport injury rates were lower in the second year of study, primarily due to elimination of trampoline as a competitive event.	Highest injury to participant ratios in school team sports were football (28%), wrestling (16%), and gymnastics (13%).	ALL INJURIES *football:* 70.6 injuries/athlete season; 15.1 injuries/1,000 athletic exposures. *girls' cross-country:* 58.8 injuries/athlete season; 14.7 injuries/1,000 athletic exposures.
		Overall: football (19%), basketball (15%), gym games (11%), baseball (10%), and roller-skating (6%). *PE class*: of 594 injuries, basketball (142), gym activity (164), gymnastics (44), volley ball (45), and football (40). *School sports teams*: of 229 injuries, football (126), basketball (29), wrestling (27), and track and field (23).	*boys' cross-country:* 55.3 injuries/athletic season; 13.1 injuries/1,000 athletic exposures. *girls' soccer:* 41.4 injuries/athlete season; 10.2 injuries/1,000 athletic exposures. *wrestling:* 41.9 injuries/athlete season; 9.5 injuries/1,000 athletic exposures. SIGNIFICANT INJURY RATES *football:* 3.8 injuries/1,000 athletic exposures. *boys' cross-country:* 3.5 injuries/1,000 athletic exposures. *wrestling:* 3.2 injuries/1,000 athletic exposures. *girls' cross-country:* 2.9 injuries/1,000 athletic exposures. *girls soccer:* 2.2 injuries/1,000 athletic exposures. MAJOR INJURY RATES *wrestling:* 1.2 injuries/1,000 athletic exposures. *football:* 1.1 injuries/1,000 athletic exposures. *girls' cross-country:* 1.0 injuries/1,000 athletic exposures.

SOURCE: Office of Technology Assessment, 1995.

and contests. The participation status indicated whether each athlete was present at full participation, present but participating on a limited basis only, unable to participate due to injury, or not at practice (absent or sick).

Incidence and Distribution of Athletic Injuries

Mortality Data

The only national school sports injury mortality figures are compiled by the National Center for Catastrophic Sports Injuries Research (the Center). The Center limits its research to certain high school and college sports and does not include physical education. Over the 10 years of study from the fall of 1982 to the spring of 1992, 200 high school deaths were reported (67 direct and 133 indirect), an average of approximately 20 sports-related deaths annually (49) (see table 3-5). Direct deaths are those resulting directly from an injury sustained from participation in the skills of the sport. Indirect deaths are those resulting from a systemic failure due to exertion while participating in a sport activity or by a complication that was secondary to a nonfatal injury, such as overexertion resulting in cardiac failure or heat exhaustion.

TABLE 3-5: Reported Catastrophic Injuries from High School Sports, 1982 to 1992

	Fatal		Nonfatal			Rate/100,000 participant years	
Sport	Direct	Indirect	Permanent	Serious	Total	Male	Female
Cross-country	0	5	1	0	6	0.6	0.0
Football	48	52	103	113	316	2.4	—
Soccer	2	8	0	4	14	0.5	0.2
Basketball	0	35	2	2	39	0.6	0.1
Gymnastics	1	0	5	3	9	4.8	2.3
Ice hockey	1	1	4	2	8	3.6	—
Swimming	0	3	4	3	10	0.6	0.6
Wrestling	2	10	16	9	37	1.5	—
Baseball	3	5	7	6	21	0.5	—
Lacrosse	1	1	0	0	2	1.0	—
Track	9	12	6	6	33	0.6	0.0
Tennis	0	1	0	0	1	0.1	0.0
Total	**67**	**133**	**148**	**148**	**491**	**16.8**	**3.2**

SOURCE: F.O. Mueller, C.S. Blyth, and R.C. Cantue, *Tenth Annual Report of the National Center for Catastrophic Sports Injury Research,* Fall 1982–Spring 1992, (Chapel Hill, NC: University of North Carolina, 1993).

Football resulted in the greatest number of direct deaths each year among high school athletes, with an average of about five deaths (48,49). Football is associated with about five indirect deaths per year and basketball with three to four. While those three sports account for more than 90 percent of the fatalities, they are not the riskiest when judged by number of deaths per participant in a sport per year. In those terms, the riskiest high school sports for males were: gymnastics (1.75 deaths per 10,000 participants), lacrosse (0.57), ice hockey (0.43), and football (0.35). Basketball (0.63), lacrosse (0.57), ice hockey (0.43), and wrestling (0.41) had the highest rate of indirect deaths per participant. The single female fatality occurred in track.

Morbidity Data

The Scheidt study, based on 1988 NHIS data, disclosed that about 1.3 million sports/recreation injuries occur annually. Of these injuries, schools are the location for 55 percent (715,000 injuries) and the cause of 35 percent (455,000 injuries) (67). Based on a 1986 injury surveillance study, the National Athletics Trainers Association also reported that about 1.3 million injuries occur in high school sports annually (50). About 75 percent of the injuries were categorized as minor, meaning the athlete was sidelined for a week or less.

Sports injuries are reported in differently defined categories in various studies, making cross-comparisons difficult. A review of the state and epidemiological studies illustrates this problem. While the Hawaii Department of Education, Minnesota Department of Education, and Utah Department of Health all reported school sport injury estimates, the reporting categories varied tremendously (36,47,99). The Hawaii Department of Education reported that athletics and physical education represented 9 and 15 percent, respectively, of total school injuries in 1989-90. Injuries were not analyzed according to any demographic considerations. Minnesota's student survey divided school injuries into sport and non-sport categories for the 6th, 9th, and 12th grades and reporting in relation to all injuries both in and out of the school environment. School sports resulted in the following percentages of all injuries to children and adolescents: 6th grade—male 20 percent, female 17 percent; 9th grade—male 30 percent, female 27 percent;

and 12th grade—male 28 percent, female 18 percent. The Utah Department of Health data contain information on 14 different athletic activities, including physical education and organized school sports. Overall, from 1988 to 1992, sport activities accounted for 21.3 percent of the total school injuries for grades K-6 and 44.1 percent for grades 7-12. The different reporting methodologies among states obviously deter efforts to analyze studies beyond total numbers and percentages.

Epidemiological studies estimate that athletic-related injuries, including interscholastic school sports and physical education classes, account for 23 to 53 percent of all reported school injuries. Some epidemiological studies include school injury percentages and comparisons of school sports injuries to other school injuries. Boyce et al. found that athletics were associated with 26 percent of male and 16 percent of female school injuries; athletics were the leading cause of injury for males. Lenaway et al. reported that far more school injuries, 53 percent, were associated with both formally and informally organized school sports.

The few available studies that provide comparisons of in-school and out-of-school sports injuries indicate that they occur at similar rates. Zaricznyj et al. found that about half of all the sports injuries sustained by school-aged youth in Springfield, Illinois, occurred in school.

Lenaway et al. found very high percentages of sports-related injuries that increase as students progressed from elementary (40 percent of school injuries) through junior high (54 percent of school injuries) to high school (69 percent of school injuries); however, the rate of injury was highest in junior high. In contrast, the Kansas Department of Health and Education sports study, which was limited to secondary schools, found that 12th grade sports participants had the highest rate of injury (37.8 per 1,000 participants).

The studies indicate that boys generally sustained approximately twice as many injuries as girls (67 and 33 percent, respectively) (104), the difference being more prominent in high school (43). Garrick and Requa concluded that the difference, at least for organized school sports, was due primarily to participation in different sports. When catastrophic sports injury rates of boys and girls are compared, however, girls' sports actually have higher rates of injury than the same boys' sports (49,64). However, since the passage of Title IX, 20 U.S.C. sections, 1681-1688, as amended by the Civil Rights Act of 1987, Pub. L. No. 100-259, and after many of the sports studies reported here were completed, there has been an increase in female athletic participation and female teams. Moreover, the National Federation of State High School Associations Athletics Participation Survey indicates a steady increase of girls participating in sports over the last 20 years. In 1971, there were 294,015 participants and by 1993-1994 it had increased almost 10-fold to 2,124,755 participants. Accordingly, there may be a corresponding increase in girls sport injuries.

The number, severity, and type of injury depend on the athletic activity. According to the Centers for Disease Control and Prevention's (CDC) 1993 Youth Risk Behavior Survey (YRBS), only 34.3 percent of high school students had attended physical education class daily during the 30 days preceding the survey (91). Physical education classes have been reported in epidemiological studies to account for a greater number of injuries than organized school sports, in which 43 percent of high school students participate.[20] Zaricznyj et al. found that physical education accounted for 38 percent and organized school sports accounted for 15 percent of all community sports injuries. Nonorganized and unsupervised sports (40 percent) and community team sports (7 percent) accounted for the remaining 47 percent of injuries.[21] However, when par-

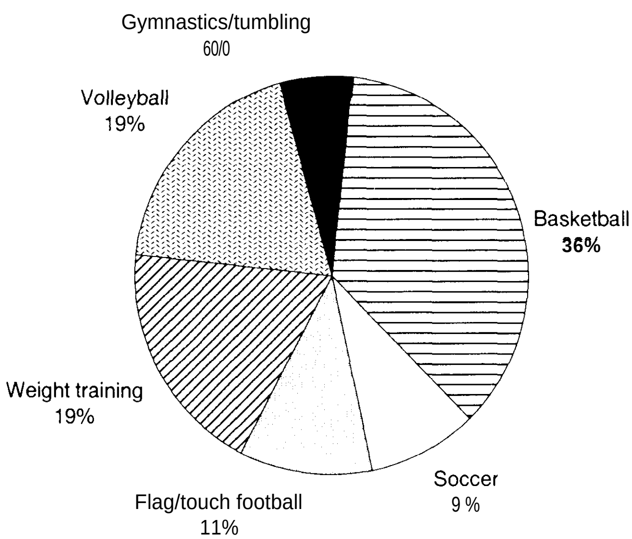
[20] In 1993-94, 3,478,530 male high school students and 2,124,755 female high school students participated in competitive sports (51).

[21] Zaricznyj et al. studied all community sports injuries, including both school sports (physical education class and organized school sports) and non-school sports (nonorganized and unsupervised sports and community sport teams (e.g., Little League)).

ticipation ratios are considered, organized sports (12 injuries/100 student years) were riskier than physical education (2.3/100). Injuries sustained in physical education occurred mainly during gym games (e.g., dodge ball and four square) and basketball, with other sports far behind. In fact, 60 percent of the basketball injuries occurred during physical education (104). In a 1990-91 study of physical education injuries in Kansas secondary schools, basketball was associated with the most injuries as well, followed by volleyball and weight training (see figure 3-5) (41).

The highest number of injuries occurred in some of the most popular sports. Table 3-6 shows the most popular sports for high school boys and girls. The Rice study of high school athletics showed that high-risk sports, in terms of both incidence and severity, are generally those expected to be so: girls' cross country (17.3 injuries per 1,000 athletic exposures), football (12.7), wrestling (1 1.8), girls' soccer (11.6), boys' cross country (10.5), girls' gymnastics (10.0), and boys' soccer (36.4) (64). Lenaway et al. found that the sports resulting in the most injuries by grade level were: 1) in elementary school: football, soccer, and tetherball; 2) in junior high: football, basketball, and soccer; and 3) in high school: football, volleyball, and baseball. Garrick and Requa calculated participation rates for high school sports to find that for boys, football (81 injuries/100 participants) and wrestling (75 injuries) accounted for the highest injury rates, mainly due to the greater force of impact as boys get older. The next most frequent injuries per 100 participants were for boys' track and field (33 injuries), basketball (31 injuries), soccer (30 injuries), and cross country (29 injuries). The sports particularly risky for girls were softball (44 injuries/100 participants) followed by gymnastics (40 injuries), track and field (35 injuries), cross-country (35 injuries), basketball (25 injuries), and volleyball (10 injuries).

FIGURE 3-5: Injuries During Physical Education at Kansas Secondary Schools School Year 1990–91



SOURCE: Kansas State Department of Education, Kansas Secondary Schools Study, 1990-91.

Across studies, football was the sport associated with the greatest number of school sports injuries. In organized school sports, football accounted for four times more injuries than any other sport. Football was the leading cause of all serious injuries, fractures, injuries to the knee, and hospitalization (104), and not surprisingly, more school days were lost due to football injuries than to any other sport (41). However, it is important to note that football has the greatest number of participants.

As of 1993, only two state athletic associations, Michigan and West Virginia, recognized cheerleading as a sport, but many students are being injured while participating in this activity. CPSC estimates that in 1993 there were 15,560 emergency room visits as a result of cheerleading injuries. In the wake of highly visible stories about catastrophic injuries that occurred during cheerleading, a number of high schools across the country have limited the types of stunts that cheerleaders may attempt (49). North Dakota and Minnesota regulations governing high schools, for instance, banned the use of the pyramid after the death of a cheerleader.

Fall sports had a higher rate of injury than spring sports. One study author, Rice, postulated that this was a result of school athletes not main-

TABLE 3-6: Ten Most Popular Sports for High School Boys and Girls

Boy participants		Girl participants	
Football	928,134	Basketball	412,576
Basketball	530,068	Track & field (outdoors)	345,700
Baseball	438,846	Volleyball	327,616
Track & field (outdoors)	419,758	Softball (fast pitch)	257,118
Soccer	255,538	Soccer	166,173
Wrestling	233,433	Tennis	136,239
Cross-country	162,188	Cross-country	124,700
Tennis	135,702	Swimming & diving	102,652
Golf	131,207	Field hockey	53,747
Swimming & diving	81,328	Softball (slow pitch)	41,118

SOURCE: National Federation of State High School Associations, 1993-94 Athletics Participation Survey.

taining their conditioning over the summer months. When the intensive conditioning regimes began in preparation for the fall season, these athletes were susceptible to overuse injuries and strains (64). However, football is a fall sport and probably contributes to this higher fall number.

Comparison of studies rating the severity of sports injuries is difficult because of varying definitions of severe or serious (69). For example, Sheps and Evans recognized that some studies included sprains, strains, and dislocations while others did not. In analyzing their own data they noted that when sprains, strains, and dislocations are classified as severe injuries, approximately 56 percent of sports injuries are severe; when they are excluded, about 25 percent are severe (69). However, most school athletic injuries are not serious.

Zaricznyj et al. found in the study of sports injuries in Springfield, Illinois, that about 80 percent of sports injuries were not serious or severe; these injuries included sprains, contusions, lacerations, and superficial injuries (104). Of the remaining 20 percent of the injuries that were serious or severe injuries, about half occurred in school. Physical education produced 27 percent of serious injuries (one-third of which involved basketball), 25 percent occurred during organized school sports (more than half of which involved football), and 48 percent were accounted for by nonorganized sports. Of the serious or severe injuries (312 injuries), the most frequent included fractures (252 injuries), followed by torn ligaments (20 injuries), concussions (16 injuries), and dislocations (13 injuries). There were 65 hospitalizations, and 1.2 percent of all sports injuries were permanent (18). More than half of the serious injuries were sustained by high school students (51 percent). Junior high and elementary school students accounted for 30 and 19 percent of serious injuries, respectively.

Garrick and Requa, defining severity of injuries in terms of days missed from practice and competition, found in a study of 3,049 participants in 19 sports sustaining 1,197 injuries that nearly three-fourths (73.4 percent) of the injured student participants returned to the sport without missing more than five practice or competition days (31). Of the more serious injuries requiring x-ray examination (360 injuries), 18 percent (65) were fractures. Twenty-five athletes were hospitalized, 21 of whom required surgical procedures. Football players accounted for 16 of the 25 hospitalizations and 12 of the 21 surgical procedures, suggesting that football accounted for the majority of severe injuries. Again, football has the highest number of student participants.

Of the catastrophic injuries (fatal, permanent, and serious injuries), the National Center for Catastrophic Sports Injury Research found that in terms of raw numbers over 10 years (1982-92), football (316), basketball (39), wrestling (37), and track (33) appear to entail the most risk (49).

When these numbers are associated with participation, however, it appears that gymnastics (4.8 injuries per 100,000 participation years), ice hockey (3.6), and football (2.4) result in the most serious injuries per participating high school male athlete. Gymnastics and swimming are most commonly associated with serious injuries in participating high school female athletes.

The athletic injury studies discussed herein provide a description of the magnitude of injuries sustained by children and adolescents who participate in athletic activities. As the injury literature reflects, however, each sport presents different risks, which necessitates sport-specific summaries of the available data and a characterization of the types of injuries typically incurred in each sport (1) (see box 3-7). Most of the studies relating to specific sports injuries depend on medical or clinical reports, and incidence information is incomplete.

TRANSPORTATION INJURY DATA

Every school day, children encounter a variety of risks on their way to and from school, whether they are transported by school bus or car, ride their bicycles, or walk. Data regarding injuries resulting from crashes involving school buses, pedestrians, and bicyclists are described in this section. While there are a number of other modes of transportation to school, particularly parents driving students or older students driving themselves, no data are available to attempt to quantify these injuries.

Estimates from the few studies of injuries incurred on the journey to and from school range from 1 to 3 percent of all school injuries.[22] In general, the journey home is more dangerous than the trip to school (76,95). One study attributed this to more children walking home alone or with other children rather than with an adult (76).

Most of the risks of unintentional injury to students en route to school cannot be controlled by schools except by prevention education. Students, for example, can be taught to behave more safely and cross streets correctly, or to wear helmets when riding their bicycles and seat belts when riding in cars. School buses, however, are subject to state regulation, and school bus safety is evaluated by the U.S. Department of Transportation. Consequently, data specifically relating to school bus safety, including mortality and morbidity statistics, are available.

Sources and Limitations of School Transportation-Related Injury Data

The National Highway Safety Transportation Administration's (NHTSA) Fatal Accidents Reporting System (FARS) and General Estimates System (GES) are the primary databases for fatalities and injuries associated with school bus-related crashes, pedestrians, and bicyclists. Both systems are subject to limitations, discussed in box 3-8. The publications listed below have analyzed FARS and GES data to calculate incidence, prevalence, and trend data. The data were analyzed in the following publications:

1. NHTSA's *Traffic Safety Facts 1992;*
2. NHTSA's *Traffic Safety Facts 1992, School Buses;*
3. NHTSA's *Summary of School Bus Crash Statistics in 1990;* and
4. National Academy of Sciences' (NAS) *Improving School Bus Safety* (NRC, 1989).[23]

[22] These estimates are based on the Hawaii Department of Education and Utah Department of Health state estimates and the NSC national estimates of school injuries. The NSC reported that about 3.1 percent of all school injuries were incurred going to and from school, 1.9 percent were motor vehicle related, and 1.2 percent were non-motor vehicle related. Because these injuries were reported to the NSC by schools, it is likely that a number of transportation injuries occurred but were not reported to the school.

[23] A provision in the federal Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17, 204(a) (April 2, 1987)) required the Department of Transportation to contract with the National Academy of Sciences to perform a "comprehensive study and investigation of the principal causes of fatalities and injuries to school children riding in school buses and the use of seat belts in school buses and other measures that may improve the safety of school bus transportation" (55).

BOX 3-7: Common Sports Injuries in School-Aged Children

Baseball

1. At the high school level, reported injury rates ranged from 14 to 18 percent of participants.
2. Elbow and shoulder overuse injuries were the most frequent.
3. Contact and collision injuries were infrequent.
4. Most Little League (ages 5 to 14) injuries occurred when players were hit by a pitched ball (22 percent), hit by a batted ball (19 percent), while catching (14 percent), hit by a thrown ball (10 percent), or when sliding (10 percent).
5. For Little League participants, the body areas most affected were the head (38 percent) and upper extremities (37 percent), while the common types of injuries were contusions (40 percent), fractures (19 percent), and sprains (18 percent).
6. Deaths have resulted from cardiac damage secondary to non-penetrating chest trauma; 23 deaths were recorded in 5- to 14-year-olds between 1973 and 1981.

Basketball

1. In school-organized teams, the injury rate was 10.2 percent.
2. Among high school players, boys' rates of injury ranged from 6 to 31 percent and girls' from 8 to 25 percent.
3. Girls had a significantly higher rate of injury than boys (76 to 16 percent) and a higher proportion of significant injuries (18 to 8 percent).
4. The ankle, knee, and leg were most often injured. Girls appear to be at greater risk of knee injury and developing significant knee injuries, while boys had a greater chance of injuring their shoulders; there was a high prevalence of ankle sprains for both boys and girls.

Football

1. Injury experience is related to level of competition, which may in turn be related to the intensity of force generated at the time of contact.
2. Injury rates for young players (ages 8 to 14) ranged from 15 to 20 percent.
3. Injury rates for high school players ranged from 25 to 64 percent.
4. At the youth level, significant injuries occurred to 10 percent of the participants. The hand or wrist and knee were the most common injury sites, the upper body accounting for almost 50 percent of the injuries. Fractures, sprains, and contusions were the most common types of injury, and surgery was rarely required. Variables that appeared to be related to risk of injury included larger size in the oldest division, pileups after the play was completed, reinjury of an incompletely resolved prior injury, and impact with helmet.
5. At the high school level, significant injury occurred in 12 to 17 percent of participants. Lower-extremity injuries were most likely; knee and ankle were the most common injury sites. Knee injuries alone accounted for 15 to 20 percent of all injuries annually, approximately 92,000. Sprains and strains were the most common types of injury, and surgery was required for 4 percent of players. Knee injuries accounted for 69 percent of the injuries requiring surgery.
6. A high school football team can expect to average about 32 injuries per season, of which eight will be significant.
7. While more injuries occurred at practice, if corrected to numbers of injuries per exposure, games were associated with eight times the frequency of injury.
8. Tackling and blocking have been associated with the majority of catastrophic football injuries.

(continued)

BOX 3-7: Common Sports Injuries in School-Aged Children (Cont'd.)

Gymnastics

1. Injury rates for club gymnastic programs were between 12 to 22 percent.
2. The lower extremities were most often injured, but head, spine, and upper extremities were also common sites.
3. Floor exercises and tumbling accounted for the greatest number of injuries, followed by the balance beam, uneven parallel bars, and vault.
4. Half the injuries were macro-traumatic and half were due to overuse syndromes.
5. Spondylolysis occurred four times more often than in the general population.

Soccer

1. Youth soccer was associated with a low rate of injury, 2 to 5 percent.
2. Adolescent players had a higher rate of injury, 6 to 9 percent.
3. Most injuries arose from direct contact or collision with a player, the ball, or the ground.
4. Because of the running and kicking demands of soccer, overuse syndromes were also prevalent.
5. The ankle, knee, and forefoot were most often injured.
6. Significant knee sprains were not uncommon.
7. Repeated heading of the soccer ball may cause brain damage.

Track

1. Risk of injury resulted almost entirely from repetitive micro-trauma and acute strains.
2. Youth track and field athletes' (ages 10 to 15) injury rate was 50 percent; two-thirds of the injuries were related to overuse.
3. High school track athletes reported injury rates of 33 percent for males and 35 percent for females.
4. The lower leg was most frequently injured, followed by the knee, ankle, and thigh.
5. Of high school track athletes, sprinting (46 percent), distance running, activities before and after practice, and pole vaulting were most often associated with injuries.

Wrestling

1. High school wrestler injury rates from 23 to 75 percent were reported; the rate of significant injury was 15 percent.
2. Injuries arise from direct blows from an opponent, from friction on hitting the mat, falls particularly during a takedown, and from twisting and leverage forces during controlling maneuvers.
3. High school wrestlers were most likely to sustain knee sprains, back strains, and shoulder injuries; the site of injury was distributed among the upper extremities (29 percent), the lower extremities (33 percent), and the spine and trunk (34 percent).
4. More injuries occurred in competition (43 percent) than in practice (37 percent) or scrimmages (20 percent).
5. "Cauliflower ears" were decreasing in frequency due to use of head gear and improved mat surfaces, and severe neck strains and fractures appeared to be controlled by the strict rule against slams.

[a]Significant injuries are those requiring more than seven days of restriction from participation (Goldberg et al.).

SOURCE: American Academy of Pediatrics, Committee on Sports Medicine and Fitness, *Sports Medicine: Health Care for Youth Athletes*, *2nd ed.,* P.G. Dyment (ed.) (Elk Grove Village, IL, 1993); Goldberg, B., et al., Injuries in Youth Football. Pediatrics, 1988;12:122–132; Mueller, F.O., and Cantu, R.C., *Annual Survey of Catastrophic Football Injuries 1977–1992* (Chapel Hill, NC: 1993).

BOX 3-8: Sources and Limitations of School Transportation-Related Injury Data

Estimating the extent of school-related travel in transportation and deaths is difficult because fatalities and injuries are not reported by purpose of travel. Estimates can be made, however, from the sources of data that are discussed below, remembering that each source has substantial limitations. None of them differentiates whether the injuries were incurred during school-related travel.

The National Highway Traffic Safety Administration's (NHTSA) Fatal Accidents Reporting System (FARS) maintains fatality census data on crashes involving a traveling motor vehicle and resulting in the death of a vehicle occupant or non-motorist within 30 days. FARS is a collection of state-reported data. Since 1975, 50 states, the District of Columbia, and Puerto Rico have submitted qualifying data from police crash reports, state vehicle registration files, state drivers' license files, state highway departments, vital statistics, death certificates, coroner/medical examiner reports, hospital medical reports, and emergency medical service reports, and those data are the primary source for mortality data related to crashes involving school buses, pedestrians, and bicycles. Data, however, vary significantly from state to state. For instance, because the definition of school bus differs among the jurisdictions registering vehicles, there is no accurate number of school buses that transport students and no truly accurate number of school-related crashes.

FARS data are reported for ages 0–20+ at age intervals of 0–4, 5–9, 10–14, 15–19, and 20+. In the discussion below, school-aged children and adolescents in terms of FARS data include ages 5–19. FARS includes data on school bus-related crashes, pedestrians, and bicyclists; however, the information is limited for the purposes of this report as the reason for travel at the time of the crash is not indicated. Thus, it is indeterminable whether the death of a school-aged child was also school related.

In 1988, NHTSA established the General Estimates System (GES), the injury counterpart to FARS. Unlike FARS, however, GES estimates are based on a national probability sample of about 45,000 police crash reports collected each year rather than census data. To qualify for the GES sample, a police accident report must be completed for the crash; the crash must involve at least one traveling motor vehicle and property damage, injury, or death must result. Like FARS, GES includes information on school bus-related crashes, pedestrians, and bicyclists. The actual difference between estimates and true values varies depending on the sample selected. GES pedestrian and bicycle injury data are particularly problematic. The relatively low numbers reported for pedestrian and bicycle injuries result in high standard errors. For example, NHTSA calculated that 1992 GES estimated a generalized standard of error of 400 for 1,000, 1,000 for 5,000, and 1,500 for 10,000.

FARS and GES define school buses by body type as opposed to purpose. Thus, even after a bus is sold by a school to another organization (e.g., a church), it is still classified as a "school bus." NHTSA estimated, however, that approximately 81 percent of bus occupant fatalities from 1977 to 1990 involved school buses providing school-related group transport.

SOURCE: Office of Technology Assessment, based on U.S. Department of Transportation, National Highway Traffic Safety Administration. *Traffic Safety Facts 1992*, September 1993; U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1992: School Buses*, U.S. Department of Transportation, National Highway Traffic Safety Administration, *School Bus Safety Report*, May 1993; U.S. Department of Transportation, National Transportation Safety Board, *Summary of Selected School Bus Crash Statistics in 1990*, 1993

The NAS study *Improving School Bus Safety* reviewed and analyzed school bus-related crash data on fatalities and injuries from 1982 to 1988 (55).

School Bus-Related Crashes Injury Data

School buses transport about 25 million students to and from classes and school-sponsored activities (55). Although most crashes involving school buses are minor, catastrophic crashes resulting in student fatalities and serious injuries do occur every year (98). A comparison of school bus-related crash and passenger car crash fatalities and injuries among school-aged children suggests that school buses are much safer than other forms of transportation used to take students to and from school. NHTSA reports roughly 650,000 fatal traffic crashes in the past 16 years, of which less than 0.4 percent were classified as school bus-related (95). Of these crashes, 90 percent were school bus-type vehicles and 10 percent were other vehicles providing school-related group transportation (95). In fact, NAS estimates that occupant fatalities per mile for school buses are approximately one-fourth those for passenger cars (55).[24] Moreover, given the typical school bus size and weight of more than 10,000 pounds, injuries are more likely to occur to the occupants of a passenger car involved in a crash with a school bus than to the occupants of the school bus (93). Nonetheless, the incidence of school bus-related crash injuries indicates that improvements in school bus safety are essential (55).

While standards passed in 1977 (see box 3-9) have improved the crashworthiness of school buses, national information regarding school bus-related crashes remains sparse. Despite efforts to improve the reporting of school bus crashes, according to the 1989 NAS study on school bus safety, the availability and quality of data have not improved much. The NAS study, the most extensive study of school bus injuries and attendant safety measures, characterized national statistics as inadequate and claimed that its efforts to collect valid national data were seriously hampered by lack of a standard definition among states of school bus crashes or school bus-related crashes. As a result, NAS recommended that "NHTSA work with the states, and other interested organizations to upgrade and standardize school bus crashes data collected by the states" (55). Nevertheless, NAS concluded that the imperfect national and state reports can be used in attempts to understand the magnitude of the problem and where, when, and to whom such crashes occur.

Mortality data

The major studies of fatalities in school bus-related crashes are listed in table 3-7A. The NAS study reports that about 50 school-aged children are fatally injured in school bus-related crashes each year, including school-aged pedestrians and passengers. About 75 percent of the deaths, 37 to 38 children, were pedestrians in loading zones around school buses: of those, approximately 24 were struck by school buses, two were killed by vehicles operated as school buses, and 11 to 12 were killed by other vehicles in the bus loading zone.[25] Approximately 12 school-aged children were killed each year while riding to and from school or school-sponsored activities on school buses or on vehicles used as school buses. Between 1982 and 1986, 60 school bus passengers were killed in 26 separate accidents; of those, 48 were passengers under 20 years old (55). Students aged 10 to 14 were reported to account for 32 percent of all school bus passenger fatalities, followed by students aged 15 to 19 (27 percent) and 5 to 9 (17 percent); the remaining 24 percent were over 20 and most likely drivers of school buses. Fatality rates by age, however, were not presented. It may be that students aged 10 to 14 are more likely to be riding the school bus because more parents drive

[24] According to the NSC's *Accident Facts* (1993), the difference between school bus and passenger car fatality rates was even more pronounced (57). NSC reported that in 1989-91 the average fatality rate per hundred million passenger miles was 0.02 for school buses and 1.05 for passenger cars.

[25] The most recently published FARS estimates of school bus-related crash fatalities and injuries are available in NHTSA's *Traffic Safety Facts* 1992; except for pedestrians, the data are not published by age so the number of school-aged children injured is not known (94). This data indicated that in 1992 an estimated 124 people were killed in school bus-related crashes, of which 83 were occupants of other vehicles, 29 were pedestrians, 9 were school bus passengers, 2 were bicyclists, and 1 was a school bus driver. Of the 29 pedestrians struck by a school bus, 21 were of school age, 50 percent of whom were 5-6 years old.

BOX 3-9: School Bus Safety

In 1977, NHTSA issued regulations that mandated stricter safety for school buses, including requiring seat belts for post-1977 buses of 10,000 pounds or less but not for those of more than 10,000 pounds. The rationale was that buses weighing more than 10,000 pounds are heavy, strong, and well-padded, and their seats are "compartmentalized" to protect passengers in the event of a crash. The NAS report concluded that the 1977 standards greatly improved the crashworthiness of school buses and that the estimated 10 percent of pre-1977 school buses still operating should be replaced by buses manufactured after 1977 as soon as possible.

Additional safety measures and their efficacy, particularly for seat belts, are continually under debate. In recent years, a number of school districts and two states have mandated that all buses ordered after a certain date be fitted with seat belts. New York requires all school buses manufactured after June 30, 1987, and operated within the state to be equipped with seat belts; New Jersey similarly directs that all school buses purchased after September 1, 1992, have seat belts. These laws differ in that New York does not require actual use of the belts whereas New Jersey does. In commenting on the cost and effort of equipping buses with safety belts, NAS concluded that because children are at greater risk of being killed in loading zones (i.e., boarding or leaving a bus) than onboard the bus, a larger share of the total effort should be targeted at improving the safety of school bus loading zones.

The federal government also developed Highway Safety Program Manual #17, *Pupil Transportation*, which provides standards governing school bus driver licensing and training, loading and unloading of students, bus maintenance and inspection, operation, and crash records. The guidelines, which were revised in 1991, are voluntary and, as such, not enforceable; incentive programs or policies are offered to encourage states to adopt the guidelines. Technical assistance is also provided to state transportation officials in reviewing their school bus safety programs.

SOURCE: Office of Technology Assessment, based on U.S. Department of Transportation, National Highway Traffic Safety Administration, *School Bus Safety Report*, May 1993.

younger children to school or more adolescents drive themselves to school. Moreover, children who walk to neighborhood elementary schools may be bussed to larger and more centralized middle schools

The studies also reveal that for the general population (not limited to school-aged children), occupants of other vehicles and nonoccupants, primarily pedestrians, are at greater risk of experiencing a fatality than school bus passengers: 56 percent of the total fatalities involved occupants of other vehicles; 33 percent involved nonoccupants, including pedestrians and bicyclists. School bus passengers represented the remaining 11 percent of the overall fatalities (95).

All studies based on NHTSA's FARS data concluded that school-aged children are at greatest risk of fatal injury while they are getting on or off, as compared to while they are riding, the school bus. It also appears that student pedestrians are at a far greater risk of being struck by their own bus than by another vehicle (98). An average of roughly two-thirds of all pedestrians killed were struck by a school bus (95,98), and 6 percent were struck by vehicles operating as a school bus. In these crashes, "inattention" and "failure to yield" were the contributing factors most often cited by police. Thirty percent of pedestrian fatalities were killed by other vehicles in school bus-related crashes (95). For drivers of other vehicles, the common contributing factors reported by police were "failing to obey signs, safety zones, or warning signs on vehicles," "passing where prohibited," and "driving too fast."

NHTSA further examined the 1983-92 data by time of day. Significantly, more school-aged pedestrians were killed in school bus-related crashes in the afternoon (73 percent) than in the morning (27 percent); 42 percent were killed between 3:00 and 4:00 p.m. alone.

TABLE 3-7A: Annual Passenger, Pedestrian and Bicyclist Fatalities in School Bus-Related Crashes, by Study

Study	Annual total number of fatally injured people in school bus-related crashes	School-aged school bus (or vehicle used as school bus) passengers fatally injured	School-aged pedestrians fatally injured	School-aged bicyclists fatally injured
1992 NHTSA's Traffic Safety Facts (FARS)	124	9	29	2
1983–1992 NHTSA's Traffic Safety Facts (FARS)	157	—	30	—
1977–1990 Summary of Selected School Bus Crash Statistics (FARS) (average)	179	11–12	34	—
1982–1988 NAS Report on Improving School Bus Safety (FARS) (average)	149	12	37–38	3.2
1991–1992 National Safety Council	110	10	25	—

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration (NHTSA); *Traffic Safety Facts 1992,* September 1993; U.S. Department of Transportation, National Transportation Safety Board, *Summary of Selected School Bus Crash Statistics in 1990*, 1993; National Research Council, Transportation Research Board, Committee to Identify Measures that May Improve the Safety of School Bus Transportation, *Improving School Bus Safety* (Washington, DC: National Academy Press, 1989); National Safety Council, *Accident Facts* (Itasca, IL: 1993).

Risk of school bus-related crash pedestrian death appears to be linked to age; younger children are more likely than older children to be fatally injured in school bus-related crashes. NAS determined that 54 percent of the school-aged pedestrians killed in school bus-related crashes were 5- to 6-year-olds and similarly, NHTSA reports that half of all school-aged pedestrians killed by school buses from 1983 to 1992 were between 5 and 6 years of age (55,95). Seven- and 8-year-olds also accounted for a significant proportion of fatalities (23 percent). Fatalities caused by non-school bus vehicles were more equally distributed among all ages; the NAS report concluded that age-specific safety devices for school buses, particularly for young pedestrians, may reduce the occurrence of fatalities.

The NSC also provides annual school bus-related fatality and injury data (57). NSC surveys state departments of education and state traffic authorities each year for information from which it generates national estimates of school bus-related crash injuries. These estimates were generated despite the fact that in 1992, 13 states did not submit data. The NAS study noted that because of the absent information and varying definitions under which state data are collected, the NSC data underestimated the actual numbers (55).

Morbidity data

In a 1977 report to Congress, William Coleman, then Secretary of Transportation, stated that:

> Wholly reliable information on school bus crashes is not readily available on a national basis. This is particularly true for nonfatal injury crashes, and even more so for crashes in which no injury is present. The information deficiency exists with respect to descriptive statistics as well as to accident-injury causation data; and it stems from both inadequate investigation at the accident site and the lack of formal

and systematic data collection and synthesis process to produce aggregated information.

More than 10 years later, the NAS report recognized a similar lack of national data from which to develop a certain number or even an adequate estimate of injuries suffered by children in school bus-related crashes (55). There is tremendous underreporting and inconsistent reporting of school bus-related crash injuries. For example, some states include all school bus passengers when reporting injury statistics, while others report only those involving students (55). The major studies of school bus-related crash injury data are presented in table 3-7B.

To compensate for the lack of reliable data on nonfatal injuries, NAS developed a school bus-related injury estimate using selected state data. School bus-related crash data from 14 states were aggregated and analyzed to develop a national estimate of 19,000 injuries, 9,500 of which were to school bus passengers (see figure 3-6). By using the same data, average characteristics of school bus-related crashes were identified. The report concluded that of the total injuries, 50 percent were sustained by school bus passengers, of which 5 percent were incapacitating.[26] The majority of the school bus-related crashes were minor. A review of a few state crashes and of the National Crashes Sampling System revealed that about half of the injuries suffered in school buses affected the head, face, and neck (55).

About 800 additional injuries suffered by pedestrians in school bus-related crashes were reported. In contrast to fatality estimates, far fewer pedestrians than school bus passengers were injured, but pedestrian injuries were typically more severe. An estimated 20 percent of the pedestrian injuries were incapacitating, compared to 5 percent for passengers. The NAS report stated that research aimed at reducing student transportation injuries should focus on school bus loading zones and additional protections available for students in these zones.[27] Figure 3-6 shows the mortality and morbidity data.

Estimates of injuries on school buses from 1990 GES data were higher than the NAS estimates. The 1990 GES data indicated about 17,500 injuries to school bus passengers; 1,000 (5.9 percent) of these were severe. An additional 4,500 injuries were sustained by occupants of other vehicles; 500 (11.1 percent) of these were severe. Thus, NHTSA's GES data estimates a total of 22,000 injuries as compared to the NAS estimate of 19,000 injuries.

The body locations and types of injuries to students in school bus-related crashes are not reported on a national level. Tables 3-8 and 3-9 provide police reported injury data collected by the New York Department of Motor Vehicles for bus passengers and for pedestrians on the way to and from a stopped school bus (55); they illustrate the type and severity of injuries sustained in these crashes. The figures include all school bus passengers—students and adults. The head, face, and eyes were the predominant sites of injury: about 58 percent of the incapacitating, 65 percent of the non-incapacitating, and 34 percent of the possible injuries were to the head or face. The most frequent types of incapacitating injury were concussion (27.0 percent), fracture/dislocation (24.7 percent), and severe bleeding (14.7 percent). Among those who sustained non-incapacitating injuries, more than half complained of contusion/bruise and 30 percent minor bleeding. Of injuries to pedestrians going to and from stopped school buses in New York (table 3-9), the lower extremities accounted for approxi-

[26] Incapacitating injury is defined as "any injury that prevents the injured person from walking, driving, or normally continuing the activities he was capable of performing before the injury occurred" (NRC, 1989). It includes, but is not limited to, severe lacerations, broken or distorted limbs, skull or chest injuries, abdominal injuries, being unconscious at or when taken from the accident scene, and being unable to leave the accident scene without assistance (55).

[27] Injury data from the Utah Department of Health support the conclusion that students are at greater risk in the loading area than in the school bus. From 1988 to 1992, 102 students were reportedly injured on school buses and 177 in school bus loading zones. Among grades K-6, school bus and bus loading areas injuries accounted for 0.38 and 0.57 percent of total grades K-6 school injuries. The incidence of injury of school bus and bus loading area injuries of students in grades 7-12 was 0.2 and 0.6 percent, respectively.

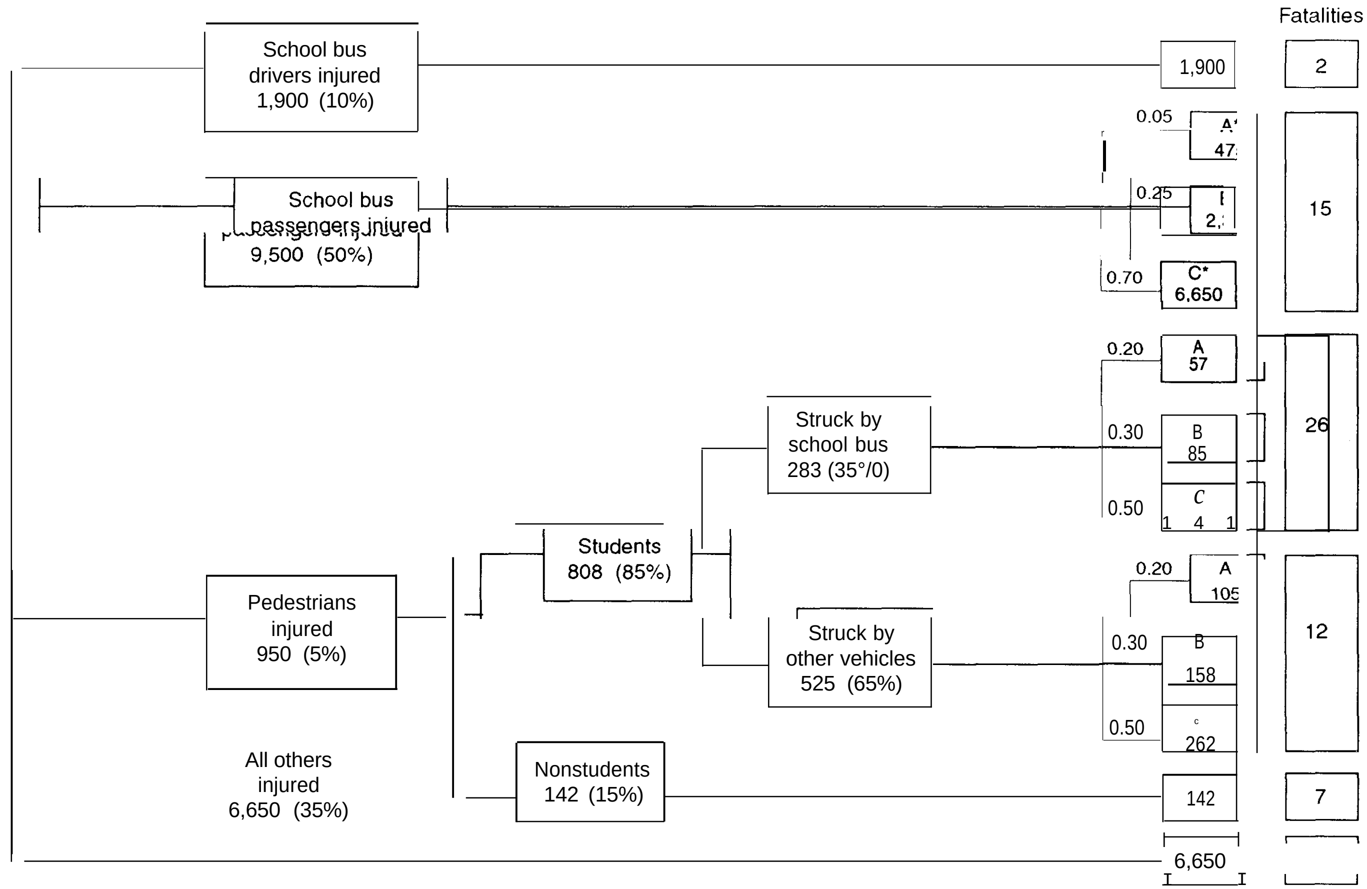
TABLE 3-7B: Annual Passenger and Pedestrian Injuries in School Bus-Related Crashes, By Study

Study	Annual or average annual total school bus-related crash injuries	School bus passenger injuries	Occupant of other vehicle injuries	Pedestrian injuries
NHTSA's Traffic Safety Facts (GES) 1992	23,000	11,000	9,000	1,000
National Safety Council 1991–1992	14,000	8,300 students	—	200
Summary of School Bus Crash Statistics (GES) 1990	17,500 (5.9 percent)[a]	—	4,50 (11.1 percent)[a]	—
NAS Report on Improving School Bus Safety (average) 1982–1988	19,000	9,500 (5 percent)[a]	—	800 (20 percent)[a]

[a]Percentage of severe or incapacitating injury

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Traffic Safety Facts 1992*, September 1993; U.S. Department of Transportation, National Transportation Safety Board, *Summary of Selected School Bus Crash Statistics in 1990*, 1993; National Research Council, Transportation Research Board, Committee to Identify Measures that May Improve the Safety of School Bus Transportation, *Improving School Bus Safety* (Washington, DC. National Academy Press, 1989); National Safety Council, *Accident Facts* (Itasca, IL: 1993).

FIGURE 3-6: Annual Fatalities and Injuries in School Bus Accidents



“Level A: Incapacitating injury. Any injury that prevents the injured person from walking, driving, or normally continuing the activities he was capable of performing before the injury occurred, Inclusions. Severe lacerations, broken or distorted limbs, skull or chest injuries, abdominal injuries, unconscious at or when taken from the accident scene; unable to leave accident scene without assistance; and others. Exclusion: Momentary unconsciousness, and others.

Level B: Non-incapacitating evident injury Any injury, other than a fatal injury or an incapacitating injury, that is evident to observers at the scene of the accident where the injury occurred. Inclusions Lump on head, abrasions, bruises, minor lacerations; and others Exclusion: Limping (the injury cannot be seen); and others

Level C: Possible injury. Any injury reported or claimed that is not a fatal injury, incapacitating injury or non-incapacitating evident injury. Inclusions Momentary unconsciousness Claim of injuries not evident Limping, complaint of pare, nausea, hysteria, and others.

SOURCE. National Research Council, Transportation Research Board, Improving School Bus Safety (Washington, DC: National Academy Press, 1989), mately one-third of all injuries. A significant number of head injuries occurred for both the incapacitating and non-incapacitating injuries, about 30 and 27 percent respectively.

TABLE 3-8: Police-Reported Injuries Sustained by Passengers in School Bus Accidents in New York (1980–1986)

	Injury severity (%)		
	A[a] (N=170)	B[b] (N=971)	C[c] (N=2,619)
Location of most severe physical complaint			
Head	33.4	31.7	27.9
Face	10.0	32.7	6.1
Eye	14.1	1.4	0.0
Neck	5.9	1.1	12.6
Chest	2.4	2.0	3.2
Back	1.8	1.1	9.3
Shoulder/upper arm	4.1	3.1	5.9
Elbow/lower arm/hand	7.1	8.7	4.8
Abdomen/pelvis	4.7	0.5	2.7
Hip/upper leg	5.9	2.9	2.7
Knee/lower leg/foot	6.5	12.8	10.0
Entire body	1.8	0.4	5.9
Unspecified	2.3	1.6	8.9
	100.0	100.0	100.0
Most severe physical complaint			
Amputation	0.6	0.0	0.0
Concussion	27.0	0.0	0.0
Internal	9.4	0.0	0.0
Minor bleeding	6.5	30.9	0.0
Severe bleeding	14.7	0.0	0.0
Minor burn	0.6	0.6	0.0
Moderate burn	0.0	0.0	0.0
Severe burn	0.0	0.0	0.0
Fracture/dislocation	24.7	0.0	0.0
Contusion/bruise	0.6	53.0	0.0
Abrasion	0.6	15.5	0.0
Complaint of pain	12.9	0.0	77.7
None visible	2.4	0.0	16.9
Unspecified	0.0	0.0	5.4
	100.0	100.0	100.0

(continued)

TABLE 3-8: Police-Reported Injuries Sustained by Passengers in School Bus Accidents in New York (1980–1986) (Cont'd.)

Victims' physical and emotional status			
Unconscious	4.7	0.0	0.0
Semiconscious	11.8	0.0	0.0
Incoherent	2.9	0.0	0.0
Shock	3.5	1.1	1.3
Conscious	77.1	98.9	98.7
	100.0	100.0	100.0

[a]Level A injury means an incapacitating injury that "prevents the injured person from walking, driving, or normally continuing the activities he was capable of performing before the injury occurred. Inclusions: severe lacerations, broken or distorted limbs, skull or chest injuries, abdominal injuries, unconscious at or when taken from the accident scene; unable to leave accident scene without assistance; and others. Exclusion: Momentary unconsciousness; and others."
[b]Level B injury means a non-incapacitating evident injury that includes "any injury, other than a fatal injury or an incapacitating injury, that is evident to observers at the scene of the accident where the injury occurred. Inclusions: Lump on head, abrasions, bruises, minor lacerations; and others. Exclusion: Limping (the injury cannot be seen); and others."
[c]Level C injury means a possible injury that includes "any injury reported or claimed that is not a fatal injury, incapacitating injury, or non-incapacitating evident injury. Inclusions: Momentary unconsciousness. Claim of injuries not evident. Limping, complaint of pain, nausea, hysteria; and others."

SOURCE: National Research Council, Transportation Research Board, *Improving School Bus Safety* (Washington, DC: National Academy Press, 1989).

TABLE 3-9: Police-Reported Injuries Sustained by Pedestrians Going to and from Stopped School Buses in New York (1980–1986)

	Injury severity (%)		
	A[a] (N=56)	**B[b] (N=130)**	**C[c] (N=192)**
Location of most severe physical complaint			
Head	30.4	26.9	11.5
Face	0.0	9.2	1.6
Eye	1.8	0.0	0.0
Neck	1.8	0.0	1.0
Chest	0.0	1.5	1.0
Back	0.0	2.3	5.7
Shoulder/upper arm	7.1	4.6	5.2
Elbow/lower arm/hand	5.4	10.0	6.8
Abdomen/pelvis	1.8	0.0	4.2
Hip/upper leg	5.4	13.1	18.2
Knee/lower leg/foot	35.6	30.8	37.0
Entire body	8.9	0.8	5.2
Unspecified	1.8	0.8	2.6
	100.0	100.0	100.0
Most severe physical complaint			
Amputation	5.4	0.0	0.0
Concussion	12.5	0.0	0.0
Internal	3.6	0.0	0.0
Minor bleeding	3.6	19.2	0.0
Severe bleeding	10.7	0.0	0.0

(continued)

TABLE 3-9: Police-Reported Injuries Sustained by Pedestrians Going to and from Stopped School Buses in New York (1980–1986) (Cont'd.)			
Minor burn	0.0	0.0	0.0
Moderate burn	0.0	0.0	0.0
Severe burn	0.0	0.0	0.0
Fracture/dislocation	60.6	0.0	0.0
Contusion/bruise	0.0	53.1	0.0
Abrasion	0.0	27.7	0.0
Complaint of pain	3.6	0.0	82.8
None visible	0.0	0.0	14.6
Unspecified	0.0	0.0	2.6
	100.0	100.0	100.0
Victims' physical and emotional status			
Unconscious	5.4	0.0	0.0
Semiconscious	7.1	0.0	0.0
Incoherent	1.8	0.0	0.0
Shock	10.7	5.4	4.2
Conscious	75.0	94.6	95.8
	100.0	100.0	100.0

[a]Level A injury means an incapacitating injury that "prevents the injured person from walking, driving, or normally continuing the activities he was capable of performing before the injury occurred. Inclusions: severe lacerations, broken or distorted limbs, skull or chest injuries, abdominal injuries, unconscious at or when taken from the accident scene; unable to leave accident scene without assistance; and others. Exclusion: Momentary unconsciousness; and others."

[b]Level B injury means a nonincapacitating evident injury that includes "any injury, other than a fatal injury or an incapacitating injury, that is evident to observers at the scene of the accident where the injury occurred. Inclusions: Lump on head, abrasions, bruises, minor lacerations; and others. Exclusion: Limping (the injury cannot be seen); and others."

[c]Level C injury means a possible injury that includes "any injury reported or claimed that is not a fatal injury, incapacitating injury, or nonincapacitating evident injury. Inclusions: Momentary unconsciousness. Claim of injuries not evident. Limping, complaint of pain, nausea, hysteria; and others."

SOURCE: National Research Council, Transportation Research Board, *Improving School Bus Safety* (Washington, DC: National Academy Press, 1989).

Pedestrian Injury Data

Fatalities and injuries occur to student pedestrians while walking to and from school. NHTSA collects school-aged pedestrian mortality and morbidity data, *but the information does not indicate if travel was school related.* However, databases that record pedestrian injuries by age and time provide some estimates to indicate the scope of the problem. At OTA's request, NHTSA generated time of day data for school-aged pedestrians using 1992 FARS and GES data (96,97). Assuming students typically travel to school between the hours of 6:00 a.m. and 9:00 a.m. and travel home between 2:00 p.m. and 5:00 p.m., some estimates can be made and age and time trends identified. Table 3-10 presents the number of school-aged pedestrians fatally and nonfatally injured during these times students are typically going to and from school. While the data provide an instructive illustration of pedestrian injuries for age groups and time of day, for OTA purposes, the data probably represent overestimates since they include school-aged pedestrians who were not necessarily on the way to or from school.

One hundred and twenty-one school-aged pedestrians were fatally injured during the two school travel time periods; an additional 9,600 suffered nonfatal injuries. Thus, for each death of a school-aged pedestrian during these hours, there were about 79 injuries. Fifty percent of the fatalities were to the 5- to 9-year-olds alone; however, the 10- to 14-year-olds suffered 54 percent of the nonfatal injuries. Of particular note, 60 percent of the injuries suffered by 10- to 14-year-old pedestrians occurred between 2:00 p.m. and 5:00 p.m. Twice as many fatalities and injuries occurred in the afternoon than in the morning.

Bicyclist Injury Data

In 1992, 40 percent of the bicyclists killed in traffic crashes were between the ages of 5 and 15. The fatality rate for this age group was 7.2 per million population—more than 2.5 times the rate for all bicyclists (94). There are about 1 million school-aged children injured on bicycles and skates annually (67). Schools are the reported location for 2.7 percent and the cause of 1.4 percent of these injuries (67). The majority of these injuries occur on the street (42 percent) or at home (32 percent). However, there are no estimates of the number of children and adolescents that ride their bicycles to school. Some children or adolescents injured on the street or at home may have been en route to school. The 1992 FARS and GES data, described above relating to pedestrians, were also used to generate data for bicyclists from 6:00 to 9:00 a.m. and 2:00 to 5:00 p.m. (96,97) (see table 3-11).

Thirty-nine school-aged bicyclists died and 7,000 were injured during these times. More 10- to 14-year-olds were killed or injured than the other age groups; however, they are also the age group more likely to be riding bicycles. Bicycle-related deaths and injuries of school-aged children likewise occurred more often in the afternoon. GES injury data estimates by age for the morning hours were too low to publish due to the large sampling error (95 percent). Nevertheless, GES data estimate a total of 1,200 injuries in the morning, which—when compared to the 5,800 injuries in the afternoon—indicates that school-aged children and adolescents are four to five times more likely to be injured in the afternoon. Increased fatalities and injuries in the afternoon may be attributable to the number of children riding bicycles for recreation as well as for transportation (5). Thus, these data, as they relate to the school environment, are undoubtedly over-inclusive.

TABLE 3-10A: 5- to 18-Year-Old Pedestrians Killed on Monday Through Friday, September 1991–May 1992

Age	6 a.m. to 9 a.m.	2 p.m. to 5 p.m.	All other times	Total
5-9	19	42	90	151
10-14	17	27	68	112
15-18	6	10	87	103
Total	42	79	245	366

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Fatal Accident Reporting System 1992 Data for Pedestrians and Pedalcyclists Ages 5–18* (Washington, DC: 1994).

TABLE 3-10B: 5- to 18-Year-Old Pedestrians Injured Monday Through Friday, September 1991–May 1992

Age	6 a.m. to 9 a.m.	2 p.m. to 5 p.m.	All other times	Total
5–9	900	1,800	3,700	6,400
10–14	1,400	3,800	2,900	8,100
15–18	1,000	700	1,400	3,100
Total	3,300	6,300	8,000	17,600

All estimates subject to large sampling error due to small sample size. 95 percent confidence interval.

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, *General Estimates System 1992 Data for Pedestrians and Pedalcyclists Ages 5–18* (Washington, DC: 1994).

Head injuries sustained when bicycle riding are the foremost cause of fatal injuries. At least 70 to 80 percent of fatally injured bicyclists of all ages had significant head injuries (5). In a study of children less than 16 years old admitted to Maryland hospitals in 1982 for bicycle crash-related injuries, 97 percent were of school age (5 to 15 years). Forty-five percent of the children had head injuries (fractured skull, concussion, or other brain injury). It has been well documented that these injuries could be prevented or ameliorated if the children wore helmets. One case control study estimates that helmets reduce the risk of head injury by 85 percent in emergency room cases (78).

UNINTENTIONAL INJURY CONCLUSION

Unintentional injury is a significant health problem that follows children and adolescents into the school environment. Nonetheless, there is no systematic, organized process for collection of national data on school injuries. Data are collected by many different organizations, public and private, but national data are not available systematically from any identified source. More detailed analysis of existing databases such as NHIS and NEISS by location (school) and age (school-aged persons) could yield some national estimates. OTA identified at least four states that collect school injury data (Arizona, Hawaii, South Carolina, and Utah). Arizona, South Carolina, and Utah have used this data to identify particular injury problems in their respective states and to create specific school injury prevention programs. Epidemiological studies provide a more detailed study of injuries occurring at school; however, caution must be used in generalizing results from local epidemiological studies to national and state school populations. Despite studying different student populations in various geographic locations, most epidemiological studies reached similar conclusions regarding school injuries. Thus, while conclusions about the relative safety of schools are sound, there is a deficiency of reliable school-related unintentional injury data.

In terms of unintentional injury, play at playgrounds and sports are the most risky school activities. While national data provide some estimates on the incidence of these injuries, state and epidemiological studies provide some data on the circumstances of the injuries. Although other injuries that occur in the school building also represent a significant number, little is known about them. Classrooms, laboratories, shop facilities, stairs, and hallways all present some risks of injury to students. While some studies have collected some data on these locations, not much is known about the circumstances of the injuries.

TABLE 3-11A: 5- to 18-Year-Old Bicyclists (Pedalcyclists) Killed on Monday Through Friday, September 1991–May 1992

Age	6 a.m. to 9 a.m.	2 p.m. to 5 p.m.	All other times	Total
5–9	1	9	29	39
10–14	4	15	35	54
15–18	2	8	15	25
Total	7	32	79	118

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, *Fatal Accident Reporting System 1992 Data for Pedestrians and Pedalcyclists Ages 5–18* (Washington, DC: 1994).

TABLE 3-11B: 5- to 18-Year-Old Bicyclists (Pedalcyclists) Injured Monday Through Friday, September 1991–May 1992

Age	6 a.m. to 9 a.m.	2 p.m. to 5 p.m.	All other times	Total
5 to 9	*	1,400	1,900	—
10 to 14	*	3,300	3,900	—
15 to 18	*	1,100	1,000	—
Total	1,200	5,800	6,700	13,800

*Estimates by age for this time period are too small to publish. All estimates subject to large sampling errors due to small sample sizes. For example, the 95 percent confidence interval for an estimate of 1,400 pedalcyclists is 1,400 ± 900.

SOURCE: U.S. Department of Transportation, National Highway Traffic Safety Administration, *General Estimates System 1992 Data for Pedestrians and Pedalcyclists Ages 5–18* (Washington, DC: 1994).

INTENTIONAL INJURY

In recent years, school violence has been a priority for both the executive and the legislative branches (25,79,80,81,82). Support for research at the National School Safety Center (NSSC) (see box 3-10), and the launching in October 1993 of a Division of Violence Prevention at the CDC (see box 3-11) are two initiatives that reflect this interest. In late 1993, Clinton Administration officials also formed a multidisciplinary Interdepartmental Working Group on Violence Prevention with a Subgroup on Schools.

Burgeoning congressional concern and general public inquiry about risks related to intentional injuries have precipitated calls for more accurate measurements of violence and more extensive evaluation of new public health and school security technological interventions in many of the nation's school districts (see box 3-12). By early 1994, the National School Boards Association (NSBA) and the Children's Defense Fund issued reports outlining some risks of school violence in their respective profiles of public and privately supported reduction and prevention strategies (20,58).

Even though the media, parents, students, law enforcement officials, and many other observers have taken it as axiomatic that school violence has increased during the past few years, no comprehensive national surveillance system tracks injuries from intentional violence in the school environment. Nevertheless, authorities are being urged to take action. The 103d Congress submitted 61 bills on school violence. States have spent considerable sums of monies allocated for schools on efforts to decrease violence in school; for example, the New York City Board of Education spent $1,009,000 in the 1992-1993 school year on metal detectors, such as walk-through x-ray equipment, hand-held detectors, and mats (74). Given the costs associated with these policy decisions, it is necessary to evaluate the data that provide the basis for these decisions for accuracy, certainty, and limitations associated with them.

This section considers the following questions related to the information available on intentional injury: What are the data on intentional injuries in school in the United States? How are the data obtained and reported?

National representative samples and surveys of school districts as well as diverse local school records provided the main source of primary data on the risk of interpersonal violence and suicidal behavior in the school environment (61). For the most part, however, these instruments are relatively new. For instance, 1993 is the first year for which data singling out violence-related behaviors and risks on school campuses have been integrated into the Youth Risk Behavior Survey (YRBS). The YRBS is an instrument of the Youth Risk Behavior Surveillance System (YRBSS) developed by the CDC and conducted every two years at the national, state, and local levels. It continues to rank among the most cited sources of information on weapon carrying and physical fighting among the school-aged population.

BOX 3-10: National School Safety Center

Founded by presidential mandate in 1984, the National School Safety Center (NSSC) is the product of a partnership between the U.S. Department of Justice and the U.S. Department of Education. Located near its affiliate—Pepperdine University—in Westlake Village, California, the NSSC's mission has been twofold: to provide education about the problem of school safety and to serve as a clearinghouse for data on trends in violence and innovative programs dealing with school crime prevention. Ronald D. Stephens, the Center's Executive Director, and his staff work very closely with the Centers for Disease Control and Prevention and local school districts. "We're generally working with a different school system somewhere each week around the country with some type of school crime and violence behaviorally related issues," Stephens acknowledges.

In addition to its more active participation in the construction of local programs to tackle school violence and safety concerns, the NSSC issues a set of publications on a regular basis to inform the public, educators, government officials, and law enforcement officials about national and local developments. Two examples of recent publications are *School Safety Update* and *Gangs in School*. The Center's publications have carried articles ranging from "Weapons: A Deadly Role in the Drama of School Violence" to "Dealing with Diversity."

SOURCE: Office of Technology Assessment, 1995.

BOX 3-11: Division of Violence Prevention, National Center for Injury Control and Prevention

Although the Division of Violence Prevention at the Centers for Disease Control and Prevention (CDC) was officially founded in the fall of 1993, the investigation of factors leading to violence-related morbidity and mortality has been a part of CDC's research agenda for more than a decade. The Violence Epidemiology Branch was initially founded at CDC in 1983. With the more widespread acceptance of a public health focus on violence, which stresses the role of prevention as well as the influence of various social, economic, and behavioral factors, a multidisciplinary team of social and behavioral scientists, epidemiologists, and educators has worked to bring visibility to homicide, domestic and spousal abuse, suicide, and other forms of interpersonal violence through the Division of Violence Prevention. Implicitly, this has also entailed greater attention to the improvement of national and local surveillance systems to track the epidemiology of violence-related injury patterns in American society.

In the aftermath of the 1979 Surgeon General's Report "Healthy People" and a Surgeon General's "Workshop on Violence and Public Health" in 1985, both of which helped to lay the groundwork for later goals to reduce rates of intentional injury, interpersonal violence among youth has remained a top priority. It became clear to researchers at the CDC that rising rates of homicide and suicide among youth reflected the need to address pressing social problems through more specific public health interventions at younger ages. For this reason, schools are currently targeted as a site for public health education, and the CDC's Division of Violence Prevention runs such programs throughout the country. The Division for Violence Prevention also collaborates with other centers at the CDC and federal agencies in the design of the Youth Risk Behavior Surveillance System, which measures the incidence of weapon carrying and other violence-related behaviors among youth. Most recently, members of the Division of Violence Prevention collaborated with the National School Safety Center as well as the U.S. Departments of Education and Justice in a retrospective analysis of violence-related deaths on school campuses during the past two years.

SOURCE: Mark L. Rosenburg and Mary Ann Fenley, Editors, *Violence in America: A Public Health Approach*. (New York and Oxford, England: Oxford University Press, 1991); "New Directions in Violence Prediction: The Public Health Approach." *Violence and Victims* 3 (1988): 285–288.

BOX 3-12: Technology and Violence Prevention

Students in urban, suburban, and rural schools across the nation find themselves confronted with a barrage of new technological devices employed to deter the bringing of weapons, such as guns, knives, and razors, into the school environment. Walkie-talkies, video cameras, metal scanners, large airport-size metal detectors, and x-ray machines, as well as the equipment that transports security personnel among and within school campuses, represent a few of the strategies currently implemented in some districts. For instance, one suburban community in Washington state recently purchased bullet-proof vests for its security personnel after several shooting incidents on or near school campuses.

Technologies to deal with the incidence of school violence have recently been adopted in many school districts across the nation. The National School Safety Center reports that the proportion of large school systems employing metal detectors somewhere in their districts increased from 25 percent to 70 percent in two years.

BOX 3-12: Technology and Violence Prevention

Students at one urban school arrive for a daily metal scanning. During the entire process, which takes about a minute and a half per student, pupils place their bookbags on a scanning machine before stepping on a floor metal detector unit. The student then proceeds through a metal detector. If the light turns red on the metal detector unit, he or she is then asked to step aside and is rescanned to detect the source of the problem. Each detector can cost school districts up to $20,000 for a state-of-the-art airport-type unit. Although policy analysts and researchers still do not agree about the effectiveness of metal scanning as a deterrent to weapon carrying, the fact remains that the deployment of technologies to stem violence has changed the character of the school day for many of America's students.

SOURCE: Office of Technology Assessment, 1995.

Sources and Limitations of Intentional Injury Data

OTA has identified three kinds of data bearing on intentional injury in the school environment: incident reports compiled at the school level, crime statistics, and health/vital statistics. The national sources described in box 3-13 were chosen because they were devised as parts of ongoing surveillance efforts.

Definitional inconsistencies, underreporting, and poor baselines characterize each data source. OTA found a number of school crime logs and security reports that failed to identify a police number and official offense in the school district's records, illuminating the problem of definitional inconsistencies. Even when school districts encourage the use of standardized forms to collect information on risks and injuries, parts of the form detailing crucial demographic characteristics, such as age, grade, and race/ethnicity, are often left out of the final product or report. Underreporting results from the failure of many school officials and districts to report criminal acts to police authorities. Finally, researchers have only recently started collecting much of the available data and too little is known from previous years to discern increases or decreases in violence. Together, these handicaps contribute to the poor quality of data that obscures the public's perception and identification of trends in risks of intentional injury in the school environment.

Incidence and Distribution of Intentional Injuries

School-Associated Violent Deaths

Homicide and suicide are ever-present threats for children of school age. Every single killing, especially of children, occurring in school justifiably receives considerable public attention. Currently, the NSSC is the only comprehensive source of information on these incidents, which it compiles from analysis of newspaper clippings (box 3-10). Since July 1992, the NSSC has collected data on "school-associated violent deaths," defined as any homicide, suicide, or weapons-related death in the United States in which the fatal injury occurred either on the school grounds, or on the way to an official school-sponsored event. The NSSC identified 45 school associated violent deaths for the 1993-94 school year and 53 for 1992-1993 (72).

Since the NSSC culls its estimates from news clippings received from various clipping services and other periodicals, it may underreport the exact numbers of cases. Given the limitations of using newspaper clippings as a data source, the CDC's Division of Violence Prevention initiated in 1992 an ongoing collaborative study with the NSSC and the Departments of Justice and Education to collect death certificate data and other school and Justice Department data. Their objective is to verify the number and circumstances around violent deaths at school, on school property, or during school-sponsored events.

BOX 3-13: National Sources of School-Related Intentional Injury

School Data

Incident reports obtained from local school officials constitute the bulk of school-based data. Forms are usually completed indicating that a particular student was involved in an incident where an injury or crime took place, but forms often are not filed. While some school officials keep detailed records for their own purposes, OTA found that many local school authorities failed to report criminal incidents to a district or state-level office. This reluctance or inaction stemmed from fears among principals and teachers of the stigmatization of a particular school or group of students. These problems were illustrated by a crisis at the New York City Board of Education in July 1994, when the Chancellor of Schools rejected a school security report after discovering that 400 schools had failed to report a single incident (Dillon, 1993). A subsequent investigation identified more than 1,300 unreported incidents. Although South Carolina has passed a legislative directive mandating the reporting of school crime to the state's Department of Education, most local school districts have only recently begun to encourage the use of a standardized form to report an incident.

Crime Statistics

The Department of Justice sporadically collects data on school crime in traditional crime surveillance statistics on the federal level. The Bureau of Justice Statistics' annual victimization survey *Criminal Victimization* in the United States provides some pertinent interview information related to school participants 12 years of age and older for: percentage of incidents inside school building or on school property; whether self-protective measures were taken; whether strangers or nonstrangers were involved; whether a weapon was used; race/ethnicity and gender of victim; and the number of offenders. The 1991 victimization survey results stated that 12 percent of violent crimes occurred in school buildings.

The Department of Justice's **School Crime: A National Crime Victimization Report** (1989), an extension of the National Crime Victimization Survey, provides data from a representative sample of 21.6 million students aged 12 to 19 years. According to the survey, 2 percent of respondents indicated that they had been victims of violent crimes at school, such as aggravated assault, robbery, and rape.

Health/Vital Statistical Data

The National Center for Health Statistics estimates the number of intentional injury fatalities that occur to the school-aged population; however, it does not have a systematic mechanism to link injuries in youth aged 5 to 18 in the school environment. The lack of coordination with state-level efforts has handicapped this process. OTA has identified two federal surveillance mechanisms at the CDC that provide some epidemiological information on intentional injury in the school environment on an ongoing basis:

Youth Risk Behavior Surveillance System. The YRBSS is the most comprehensive national initiative to monitor the prevalence of behaviors that result in intentional injuries (such as physical fighting and weapon carrying) among youth. It has of four components: national school-based surveys; state and local school-based surveys; a national household-based survey; and a national college survey. First administered in the spring of 1990, the school-based components of the YRBSS will be implemented biennially during odd-numbered years to national, state, and locally representative samples of 9th to 12th graders.

Two of the YRBSS's principal limitations are that it does not cover students below the 9th grade and relies on student self-reports to characterize trends in physical fighting and weapon carrying. Not all state and local education agencies conduct the YRBSS, and response rates in some states and cities that do participate in the YRBSS have at times been poor.

(continued)

BOX 3-13: National Sources of School-Related Intentional Injury (Cont'd.)

National Adolescent Student Health Survey (NASH). Administered and developed by the American School Health Association in partnership with the Association for the Advancement of Health Education and the Society for Public Health Education, Inc., the NASH provides data on student perceptions of physical fighting, strategies to resolve conflicts, victimization (one of the few studies that covers sexual assault in detail), weapons possession, and participation in violence prevention programs. During the 1987–88 school year, the survey was administered to 3,789 students attending 176 schools in 20 states.

School Health Policies and Programs Study (SHPPS). The SHPPS is a part of the CDC's recent effort to provide a better nationwide profile of public and private school policies in the area of violence. Based on national surveys (voluntary) of 780 schools in 480 school districts that support a comprehensive health program, the SHPPS collects data from state, school district, and school personnel who make or enforce policies related to violence in schools. Data will be used to measure 18 national health objectives and National Education Goal 6 for violence-free schools. The study omits elementary schools, except where they have 7th graders.

Data from the first set of surveys was collected during the first half of 1994. Results will be available late in 1995. When the results are reported individual schools will not be singled out. Instead, the data will be available in aggregate form. Officials at the CDC hope that this new survey instrument will help create better measurements of efforts to reduce and prevent violence in schools with more national data on the influence of particular policies on incidence levels.

Preliminary results from their search of 8,000 newspapers show that 105 violent deaths occurred on school campuses over the two school years (1992-93 and 1993-94): 87 homicides, 18 suicides, and five ruled "unintentional" through the legal process (39). This averages to about 44 homicides and 9 suicides per year or 53 "school-associated violent deaths." Their finding is the most reliable estimate available because they followed up on every report submitted from the NSSC.

Students in school do not appear to be at a great risk for homicide or suicide. The 53 "school-associated violent deaths" constitute a small fraction of the relative mortality of the school-age population, with the 3,889 homicides and 2,151 suicides occurring in children aged 5 to 19.

Suicide, the eighth leading cause of death in the United States, is the third leading cause of death for young people 10 to 19 years old (88). Between 1970 and 1984, suicides in this group rose 55 percent. Though school does not appear to be a prominent site for the commission of suicide, the parents, students, staff, school health officials, and researchers interviewed by OTA stated that depression and general emotional highs and lows are frequently part of the school and adolescent experience at all levels.

Prior to the CDC collaborative study, the most comprehensive national representative sample of risks for suicide in schools has come from the YRBSS and a few surveys of high school behavior (61). Data from several sources indicate that suicide and attempted suicide are problems for some school-age youth, even though schools have not been a common location for commission of these acts (60,88). The 1993 YRBSS noted that 24.1 percent of students surveyed admitted having "thought seriously" about suicide during the 12 months preceding the survey (91).

Furthermore, about 9 percent of students admitted that they attempted suicide during the 12 months that preceded the survey and about 3 percent of students indicated that they needed medical treatment for an injury, poisoning, or overdose as a result of their attempt. Gender differences were noted, as 5 percent of males in the sample had attempted suicide compared to 13 percent of females; however, males are more likely to die in a suicide attempt than females.

Weapon Carrying

After motor-vehicle-related injuries, injury due to firearms is the second leading cause of death in children ages 5 to 19; together they dwarf all other causes of death for which data are available. In 1992, there were 5,260 firearms-related deaths of children ages 5 to 19, which include deaths due to intentional injuries (i.e., firearm-related homicides and suicides) and deaths due to unintentional injuries involving firearms. In 1992, the number of intentional injuries due to firearms in school-aged children (about 3,280 firearm-related homicides, and 1,430 suicides) far exceeded the number of unintentional injuries due to firearms (470 deaths).

However, children are much less likely to die from firearm-related injuries in school than out of school. During two recent school years (1992-93 and 1993-94), researchers identified an average of 53 "school-associated violent deaths"—homicides, suicides, and unintentional weapon fatalities—per year, almost all of which were related to firearms.

Estimates of the number of weapons in school vary widely (see box 3-14). According to the NSBA and the Center to Prevent Handgun Violence, anywhere from 100,000 to 135,000 guns are brought into schools every day (18,58,59). In Cleveland, 22 percent of boys in a sample of 5th, 7th, and 9th graders admitted owning a gun to protect themselves from threats and insults (68). New York City school security officials confiscated 65 guns from students on school grounds barely four months into the 1993-94 academic school year (74). The State of Florida has admitted similar problems, with a 61 percent increase in handguns between the 1986-87 and 1987-88 school years (18). With recent shootings in many urban, rural, and suburban communities, concerns about weapons in schools will probably remain a top priority for local school boards.

In some communities, even young school-aged children have access to weapons. According to the NSBA, 63 percent of gun-related incidents on school grounds occurred among high school students and 24 percent among junior high school students, while elementary school and preschool students constitute 12 percent and 1 percent, respectively, of total incidents (58). These disparities are consistent with other local studies among students on their general access to weapons, as well as with the demographics of where weapons are found by school authorities. One-third of Seattle's 11th graders acknowledge that they have "easy" access to guns (15). Of the 1,249 weapons found in Virginia public schools during the 1991-92 school year, 853 were recovered from middle school students (18).

BOX 3-14: Weapons Confiscated on School Campuses

Weapons possession is tracked very differently among the U.S. school systems that keep such statistics. This area is rife with definitional problems because many school districts report incidents but not necessarily the type of weapon involved. It is often impossible to discern from local school board incident reports whether a gun, knife, club, or other weapon precipitated disciplinary action against a student.

Characterization of the seriousness of weapons in schools, however, varies from location to location. In some areas, such as South Carolina, the Department of Education reported that possession of weapons was the most frequently occurring offense. For other school districts, including New York City, Los Angeles Unified, and most Connecticut districts, weapons offenses—although not the number one offense—ranked high on school crime lists, preceded by vandalism, assault, harassment, larceny, and burglary, many of which involved weapons possession as a secondary offense.

BOX 3-14: Weapons Confiscated on School Campuses

The difficulty in tracking weapons possession in schools stems primarily from the fact that many school districts report the most serious offense as the primary incident. Therefore, weapons are ignored as a secondary offense and consequently are not often reported in school incident data. In South Carolina, for example, from June 1992 through May 1993 there were 626 incidents (21 percent) with weapons possession as the most serious offense. However, the total number of incidents involving weapons was 1,055, 36 percent of all school incidents reported in South Carolina during the 1992–93 school year. Other schools districts, such as Los Angeles Unified School District, further classify weapons incidents to distinguish between assaults and possessions and also to determine at what level such incidents are occurring (whether elementary, junior high school, or senior high school). Still, the newness of mandatory school crime reporting legislation in South Carolina and other areas means that good baselines are in process of being created to measure trends in these offenses and incidents.

Although the diversity in mechanisms and definitions used to collect statistics on weapons possession has made it impossible to generalize trends outside a given school district or state, most school districts reporting to OTA stressed that knives and other sharp objects, such as "box cutters" (instruments used to cut boxes and commonly found on students who have after school jobs where such instruments are used), are the most commonly employed or confiscated weapons. Perhaps this is due to the accessibility and low cost of knives. In the 1992–1993 school year, South Carolina's Department of Education reported that approximately 42 percent of weapons incidents involved knives or sharp objects. Handguns and other firearms are usually the second most popular choice of weapons among students in California, Connecticut, and New York, where more comprehensive statistics have been kept.

SOURCE: Office of Technology Assessment, 1995.

Students carry weapons to school for a variety of reasons (68,92,100). Iowa education officials report that 23 percent of their high school students who carry a weapon to school do so for protection (32). In the 1993 MetLife national sample, 22 percent of boys and 4 percent of girls said that they had brought weapons to school (45). When asked to state a reason for weapon carrying, 66 percent answered that it was to "be accepted" and 49 percent emphasized "self-defense to and from school." Such statistics and statements provide an important social context for rates of weapon carrying across the country.

The motivation for and access to guns outlined in MetLife's results and the recent sample of Seattle's 11th graders are consistent with levels of weapon carrying reported in the most extensive national and regional/local investigations at the CDC. According to the YRBSS, 22 percent of high school students admitted to carrying a weapon (i.e., a gun, knife, or club) to school in the preceding 30 days, and almost one-third of these students (8 percent) admitted to carrying a gun (91). However, due to repeat offenders, there are around 92 weapon-carrying incidents monthly per 100 students (91). Important gender and racial breakdowns accompanied these results. The YRBSS showed that male students were much more likely to carry a weapon to school than females. Black students were much more likely to carry a weapon to school than Hispanic or white students—29 percent of black students carried a weapon to school in the preceding 30 days compared to 24 percent for Hispanics and 21 percent for white students.

A number of shootings have drawn attention to the problem of guns in school, but it is important to note that knives and razors are the weapons most likely to be found on students in most areas sampled by the YRBSS (40). According to MetLife, 55 percent of students bring knives or switchblades to school (45). Suburban Prince George's County, Maryland (near Washington, D.C.), has charted a 94 percent increase in knife possession during the past year. One in five New York City high school students recently reported carrying a weapon anywhere at least once during a 30-day period: 16 percent carried knives or razors, and 7 percent carried handguns (89). Significantly, the same survey also found that weapon carrying of all types was lower inside the building and going to and from school than at other locales outside the school environment. Twelve percent of students admitted carrying a weapon inside the school building, with 10 percent of that group reporting that they carried knives or razors and 4 percent indicating that they carried handguns.

Increasingly, metal detectors and scanners are being employed to prevent weapons from being carried into schools. The NSBA survey in 1993 found that 15 percent of all districts reported using metal detectors (58). In its examination of different localities, the NSBA found that 39 percent of urban districts, 10 percent of suburban, and 6 percent of rural districts reported using metal detectors.

There are some empirical and anecdotal data on the effectiveness of metal detectors in preventing the entrance of guns, knives, and weapons into school buildings, but to date there have been no controlled studies evaluating the effectiveness of metal detectors in reducing weapon-related violence and injuries in schools. In June 1992, researchers from the CDC, the New York City Board of Education, and the New York City Department of Health administered a questionnaire to students as part of an effort to examine violence-related attitudes and behaviors among public high school students (89). The study found that students who attended schools with metal detectors (about 18 percent of all high school students) and students who attended schools without metal detectors were equally as likely to carry weapons anywhere (22 percent versus 21 percent, respectively). There was a difference reported, however, with respect to carrying weapons into the school building: 7.8 percent of students who attended schools without metal detector programs reported that they had carried a weapon inside the school building during the 30 days preceding the survey, while 13.6 percent of those who attended schools with such programs indicated that they had carried weapons into the building.

As the authors of this study point out, these findings do not include data on intentional injury rates in school, and do not have "pre" and "post" measures of weapon-carrying rates in schools that were participating in the metal detector program at the same time of the survey. Nor do the study's results indicate how underreporting by students at schools with metal detector programs may have influenced the findings. The forthcoming 1995 results from CDC's first question related to carrying weapons inside the school building (and not "anywhere" as in previous YRBSS local and national samples) should help to establish important baselines for further school-based research.

Assaults

Assaults present a major problem for investigations of intentional injury among students in the school environment. The lack of a precise definition of "assault" in much of the literature makes it difficult to sort out which behaviors precipitated the labeling of an offense as an assault, particularly among school data (44). This problem primarily reflects the lack of standardization in local and national reporting of school crime in either medical or crime reports. As one observer at an OTA workshop explained, two types of documents about violent incidents often exist within schools: an informal categorization based on a principal's subjective decision and an official police document with a crime report. A principal's report of a physical fight in school, in this context, may not meet the national crime definition for an assault but may be considered such by school authorities.

The characterization of physical—and to a lesser extent, verbal and psychological—assaults has been perceived as a major problem in understanding school violence by most researchers. The NSBA estimates, however, that assaults rank at the top of a list of more than 16,000 violent incidents reported on a daily basis in school buildings (58). Of the more than 2,000 school districts reporting to the NSBA survey about violence, 78 percent noted that they have had problems with student-on-student assaults during the past year. This response came from 91 percent of urban districts, 81 percent of suburban districts, and 69 percent of rural districts.

New York City and Los Angeles, for example, are two cities that keep assault statistics in Divisions of School Security run by administrators who maintain surveillance databases based on official police categories. Yet such databases often suffer from underreporting at the building level. Trends observed for various assault offenses in NYC and Los Angeles and other areas are reported in table 3-12.

Physical fighting

Physical fighting is often cited as an index of how young people in the United States deal with conflict in the school environment (40). It has also been highlighted in the literature as an important correlate of weapon carrying. Data on the prevalence and severity of physical fighting among school-aged youth have emerged from recent national and local surveys. The YRBSS found that 4 percent of all students reported that they had been in at least one physical fight that resulted in an injury requiring medical treatment during the 12 months that preceded the survey (40). Among students who fought, about half indicated that they had fought one time, another quarter of respondents indicated that they had fought two or three times, and about 10 stated that they fought at least four times.

Researchers have also identified differences in incidence rates for physical fighting with regard to gender. The 1993 national YRBSS, for instance, identified a higher rate of physical fighting among males than females (91). A rate of 173 incidents per 100 students occurred among males during the previous 12 months, while females were engaged in 96 incidents per 100 students, or almost twice as many incidents among males as females.

Social attitudes about physical fighting among younger adolescents in the school environment are generally under-researched, but several studies document the extent to which weapon carrying is viewed as a deterrent to physical fighting among older adolescents (46,68,100). A 1992 study of violence-related attitudes and behaviors among a representative sample of 9th- to 12th-grade public high school students in New York City found that students who carried a weapon at school were more likely than others to believe that they could protect themselves from fights if they flashed a weapon, such as a club, knife, or gun (89). When compared with all students, those who brought a weapon to school during the 30 days preceding the survey were more likely to believe that threatening others with a weapon (21 versus 44 percent for all students) and carrying a weapon (20 versus 48 percent) were effective ways to avoid a physical fight. A significant percentage of students who carried weapons to school also reported that their families would support their decision to protect themselves from physical attack even if it meant using a weapon (44 versus 68 percent) (89).

Physical fighting appears to be more prevalent among out-of-school youth than in-school youth. According to a CDC study, there is a difference in the prevalence of certain risk behaviors among adolescents aged 12 to 19 years, based on school enrollment status. The CDC conducted a survey of adolescents aged 12 to 19, between April 1992 and March 1993. The survey found a higher percentage of adolescents “out of school” who indicated that they had participated in a physical fight in comparison to students who stayed in school: 51 percent of out-of-school youth, compared with 44 percent of in-school students. Furthermore, 23 percent of out-of-school youth admitted carrying weapons, 7 percent higher than the number of in-school students admitting such behavior. In New York City, 8 percent of high school students sampled entered into a physical fight inside their school buildings compared to 25 percent of students who reported engaging in fights anywhere (89). Fourteen percent reported being threatened inside the school, as compared with 36 percent who reported that they were threatened anywhere.

TABLE 3-12: Violent Offenses in Selected Areas, July 1992–July 1994

Type of offense	1988–89	1989–90	1990–91	1991–92	1992–93	1993–94
Florida (Dade)						
Homicide		0	0	1	3	2
Sexual battery[a]		34	50	24	23	23
Assault[b]		1,889	1,999	2,125	1,947	2,060
Weapon possession[c]		393	468	558	568	571
Sex offense[d]		128	131	133	159	126
New York City						
Homicide	0	1	2	2	2	
Assault	1,356	1,684	1,260	1,880	2,643	
Weapon possession[e]	1,854	1,891	2,045	2,416	2,444	
Sex offense	78	94	65	121	91	
Gang Fight	1	0	5	1	0	
Los Angeles						
Homicide			1	1	2	0
Assault			68	74	66	107
Assault with a deadly weapon			285	292	236	361
Weapon possession[f]			863	926	845	1,300
Sex offense[g]			53	87	70	119
South Carolina						
Homicide				0	0	2
Aggravated Assault				300	251	410
Weapon offense				540	626	917
Sexual offense[h]				27	44	52

[a]including attempts
[b]including threat of or physical harm
[c]including brass knuckles/firearms, etc.
[d]including lewd behavior/indecent exposure
[e]including weapons that are not illegal, but prohibited by New York City Board of Education
[f]including gun and knife replicas and other weapons
[g]including misdemeanors and felonies
[h]including forcible and non-forcible

SOURCE: Office of Technology Assessment, 1995.

Violence or threatened violence in school is a reflection of violence elsewhere in the community. Officials from the NSSC often stress this point in their reports on school crime and violence, as they also acknowledge that schools exist in the context of a broader community (59,90). Although rates for physical fighting may on some level be reflective of a high degree of interpersonal violence within the school environment, students generally seem to enter conflict to a lesser extent when in school.

Gangs

The preponderance of research about physical fighting has revealed gangs as an important factor in interpersonal violence in some schools (16,38). According to the Northern California-based Center for Safe Schools and Communities, "youth gangs of all races have increased by 200 percent in the last five years and female gangs now represent 10 percent of all gang groups in the nation" (17). Some scholars suggest that gangs can be important places of refuge and identity formation for students in some areas of the country (2,16). Trend data on gangs are sparse, but gang membership in school may begin as early as the 4th grade for many students (34).

Many school districts do not keep consistent statistics on gang activity, which may lead to underreporting. It is also unclear in many instances whether definitions of gang-related problems in the school environment are limited to the building, or its immediate vicinity, or whether they include students going to and from school, as well. The available epidemiological evidence suggests that many of the injuries resulting from gang activity occur away from school (17). Of students sampled in the National Crime Victimization Survey, 79 percent said that no gangs were present in their schools. Of those students reporting the presence of gangs, 35 percent indicated that they feared an attack on school grounds, as compared to 18 percent of students who reported no gang activity (92). A recent analysis of the Los Angeles Police Department, which reports 400 gangs with a total membership of 60,000 in the city, notes that less than 1 percent of injuries stemming from gang rivalry during 1991 took place at public schools or in public parks (38). Approximately 60 percent of urban school districts have also reported gang activity to the NSBA, as suburban and rural districts also find themselves grappling with gang violence (58). Since schools are one of the most important places for socialization of young adults who can wind up in gangs, gang membership rates should continue to be cause for concern.

INTENTIONAL INJURY CONCLUSIONS

OTA has found that for two prominent causes of death—homicide and suicide—students are at less risk in schools than out of schools. An average of 44 homicides occurred annually among students in the school environment during the 1992-1993 and 1993-1994 school years—about 1 percent of all homicides for that age group in 1992. With respect to suicide, an average of 9 occurred in schools annually over these two years, or less than 1 percent of all suicides committed in that age group in 1992.

OTA's investigation of the epidemiological and educational literature as well as school-based records reveals very few intentional injury surveillance mechanisms in local school districts to monitor school violence. The National Research Council's 1993 report, *Understanding and Preventing Violence,* singled out "violent events in schools" as an area in which "high priority be placed on modifying and expanding relevant statistical information systems" (53). OTA has found these shortcomings in most school districts, a fact made clear by the identification of only three states that could supply comprehensive data on school crime and violence covering the past few years. Fortunately, local and national public health officials appear to be moving toward public policies that recognize the value of more systematic data collection efforts on intentional injury as an important basis for prevention.

The poor quality of data on the risk of intentional injury in the school environment makes it impossible to discern the impact and severity of risks from violence, in a national context and in many local districts. Furthermore, the lack of adequate baseline data for particular behaviors in school, such as weapon carrying, is a local and national problem, which results in not being able to determine trends for intentional injury in schools. These problems stem from the reluctance of school authorities to report crimes to the appropriate education officials and crime authorities. OTA identified three states that require reporting of school crime; additional states have voluntary reporting. Most policymakers rely on self-report surveys (often with poor response rates) to characterize trends in school violence.

INJURY IN SCHOOL CONCLUSIONS

With respect to the leading causes of unintentional and intentional injuries among school-aged children, schools are a relatively safe environment. The primary reason for this is that schools are not typically the location of the leading causes of injury deaths to school-aged children—motor vehicle crashes, homicide, and suicide. For fatal injuries such as homicide and suicide, about 1 percent of deaths for persons aged 5 to 19 occur at schools. One study of severe injuries, using data from the National Pediatric Trauma Registry (NPTR), found 3 percent of the injuries admitted to participating trauma units occurred at schools (29). However, for certain types of injuries, such as athletic injuries, the percentage of injuries incurred in schools may be higher than outside the school environment.

TABLE 3-13: Selected Fatalities Occurring in School[a]

Related activity/factor	Approximate number of fatalities per year
Playground	8–9[b]
Sports	20[c]
School bus-related crash (passengers)	12[d]
School bus-related crash (pedestrians)	37–38[e]
School bus-related crash (bicyclists)	3.2[f]
Homicide	44[g]
Suicide	9[g]

[a]These fatalities represent only the most prominent reported fatalities from the sources cited. It is likely that other fatalities occurred in schools from other causes.

[b]CPSC's 1990 *Playground Equipment-Related Injuries and Deaths* reported 276 fatalities over the 16-year study period. About 50 percent of the deaths were of children under the age of six. School-aged fatalities, therefore, averaged eight to nine a year. Importantly, these are equipment-related fatalities only.

[c]F.O. Mueller, C.S. Blyth, and R.C. Cantue, *Tenth Annual Report of the National Center for Catastrophic Sports Injury Research*, fall 1982–spring 1992 (Chapel Hill, NC: University of North Carolina, 1993). This number does not include fatalities which occurred during physical education.

[d]National Research Council, Transportation Research Board, Committee to Identify Measures that May Improve the Safety of School Bus Transportation, *Improving School Bus Safety* (Washington, DC: National Academy Press, 1989).

[e]Ibid.

[f]Ibid.

[g]National School Safety Center and CDC, average of the total numbers of homicides and suicides found in the 1992–93 and 1993–94 school years.

SOURCE: Office of Technology Assessment, 1995.

Table 3-13 presents the approximate number of fatalities due to injury that occur at schools each year. However, fatalities represent only the tip of the injury pyramid, as most students who are injured do not die of their injuries. A population-based study of childhood injuries in Massachusetts showed that for each death of a child (19 years of age or under), there were 45 hospitalizations and 1,300 emergency room visits (30). The number of injuries treated elsewhere or not treated was not known. These ratios are probably greater in relation to school injuries—additional analysis of the data showed that injuries at school resulted in fewer hospitalizations than injuries incurred elsewhere (63). Moreover, leading causes of mortality incidence may not reflect the leading cause of morbidity incidence (70). Thus, to determine the extent of school injury incidence, both quality mortality and morbidity data must be developed and examined.

Currently, mortality data are generally more comprehensive and reliable than morbidity data because death records are maintained by all states; mortality data are compiled annually from death certificates at both the state and national level. Yet these statistics are not detailed enough to analyze unintentional fatalities trends at schools because the location of the death may not be reported. Morbidity data are even less complete, often precluding detailed analysis of the circumstances under which injuries occur. Moreover, data on school injury outcome, rehabilitation, and long-term disability are virtually nonexistent, making the determination of injury severity and impact nearly impossible. The disparity in the quality of national mortality and morbidity data is due in part to the absence of mandatory reporting for the external cause of injury and school as a location category on injury coding forms.

In 1985, the National Research Council report *Injury in America* concluded that "most of the data sources currently available for the study of injury have serious inadequacies" (54). The information has not improved much during the intervening time (70). Although morbidity and mortality estimates are available for injuries incurred by school-aged children, data on school-related injuries are wanting. Definitional inconsistencies, the lack of accurate baselines, underreporting, and the absence of a national—and, in most cases, state-level surveillance system—complicate the characterization of trends in injuries at school and undermine public health intervention efforts to stem the impact and severity of risk factors related to school injuries.

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Using the Data 5

Chapters 3 and 4 of this report are compilations of information about health and safety risks in school. This chapter discusses how these data—along with other types of information—can help set priorities for risk reduction. In the end, surveys and studies of illness, injury, and death can provide only part of the picture. Decisionmakers are still faced with questions of which risks can be remediated and at what cost.

Moreover, even with good health and safety data (uncommon) and good information about the effectiveness and costs of risk reduction measures (even less common), the decision about which risks to focus on first would not be straightforward. These decisions go well beyond counts of illness and injury and costs of improvements, to difficult ethical, social, and emotional choices.

Inevitably, the course of deciding which risks matter the most leads to suggestions for the use of comparative risk assessment (CRA). Following a discussion of the different risk-related concerns, this chapter briefly explains CRA and the opportunities and problems it presents for making risk comparisons and deciding on priorities for risk reduction.

RISK DIMENSIONS

What is presently called "risk comparison" usually compares the number of injuries, illnesses, or deaths each risk may cause, without any other factor distinguishing them. Risk estimates alone do not necessarily relay the entire picture concerning the health effects involved, such as information on the nature of the death, illness, or injury, and the costs involved (13). The challenge for analysts is to present quite varied risks in rich, informative, and nonmanipulative ways. The starting point for broadening the scope consists of a fuller enumeration of the attributes or dimensions of risk.

It is natural for most people to order things by their size or severity, yet simple point estimates of risk often do not convey how risks, even of similar numbers of deaths, illnesses, or injuries, can differ. As an illustration of the importance of risk attributes beyond magnitude, consider the data presented in chapter 3 on deaths to students from school bus crashes and from in-school homicides. In both cases the severity is the same and the number of annual fatalities is roughly equivalent (40 to 50 cases in recent years). Nevertheless, there can be no doubt as to which cause of death is presently of greater public concern: school homicides. One indication of this public concern is the number of bills appearing before Congress on these issues. The 103d Congress introduced 61 bills dealing specifically with school violence and only two on school bus safety—of which one was a resolution for a "school bus safety week." Clearly, setting priorities involves more factors than just the number and severity of injury or illness.

This report discusses those risk attributes that can be considered in efforts to compare and rank diverse in-school risks, which inevitably involves value judgments as well as scientific estimates and measurements. It organizes the relevant risk attributes, or "dimensions," into three categories: magnitude of the risk; fear; and social contexts of the hazard (table 5-1).

The risk magnitude refers to the quantitative estimates of the likelihood of adverse health effects arising from the hazardous conditions. This category reflects the more conventional notions of the number of cases of injury and illness and their severity. There are several common measures for quantifying risk magnitude, some of which measure the individual probability of risk or the risk to the population. This report uses the number of incidents and incidence rates as measures of injury or illness in the school population and lost school days as a measure of severity. One measure of particular relevance in this report is in not treating all fatalities as equal; instead, the death of a child can be weighted more heavily than that of an adult, accounting for the additional years of life lost for the child.

Fear can be one of the most significant dimensions of risk, especially in schools, and one that varies widely across individuals and communities. Contributing to the fear of a hazard is the extent to which individuals can or cannot control the risk through personal action. Parents may fear their child's in-school exposure to asbestos or students carrying weapons because they cannot control these things, but they are probably less afraid of the exposures to infectious pathogens—even though bacteria and viruses are responsible for more lost school days—because they have more control from antibiotics, vaccines, and bedrest. The irreversibility

TABLE 5-1: The Dimensions of Risk

Category I: Magnitude

- Unweighted population-based measures of magnitude.
- Weighted population-based measures.
- Individual-risk measures that are independent of the number of persons at risk.
- Hybrid measures that incorporate characteristics of both population and individual-risk criteria.
- Measures that incorporate the concept of "background."

Category II: Fear

- Degree of fear.
- Degree of irreversibility.
- Degree of individual controllability.
- Degree of deferral to future generations.

Category III: Social Contexts of the Hazard

- Salience of blame.
- Degree of identifiability of those at risk.
- Benefits of the risky activity or exposure.
- Cost and feasibility of reducing risk.
- Risks of the intervention itself.

SOURCE: A. Finkel, "Comparing Risks Thoughtfully," unpublished contractor report prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, September 1994.

of an illness or injury also adds to the fear associated with a hazard; the more irreversible the effect, such as spinal cord injury or HIV infection, the greater the fear.

In contrast to magnitude, much of the social context of different risks cannot be readily quantified. Some risks are more worth taking—or bearing—than others. This difference is largely governed by the perceived benefits that accompany the risk. Football, for example, is among the most hazardous athletic activities—in terms of the number and severity of injuries—in which high school students participate; yet the perceived benefits of athletic accomplishment and social recognition encourage continued participation in it. The risk of a student dying in a car crash on the way to and from school may be high, but the risks are offset by the considerable time saved or the risks averted from having to walk home in the dark.

Analysts and decisionmakers must also consider impacts other than health, such as the disruption of the learning process that occurs from lost school days. One study found that absenteeism can present a social hazard, in terms of maladaptive behavior, difficulties in finding and maintaining employment, and welfare costs (20). Another intangible factor is the desire to focus attention on reducing risks where in so doing injustices can also be redressed and blame for the hazard can be affixed. Toxic releases from nearby hazardous waste sites or industry discharge generate more attention than comparable or even greater risks from radon because, in part, radon, unlike toxic releases, where a culpable polluter can usually be identified, is a natural gas and no one is responsible for its generation or its presence in indoor air.

The last category of risk attributes is an especially important consideration now confronting schools: the cost and feasibility of reducing risks. Small risks that are cheap and easy to eliminate may deserve priority attention, whereas even very large risks may not emerge as priorities from a thorough risk comparison—if reducing them would be technically infeasible or prohibitively expensive. Metal detectors, for instance, may provide added protection from firearms in schools, but they are expensive and school boards must decide if the risks at their schools justify the costs. Not only the cost, but the risk of the intervention itself, the dimension of "offsetting or substitution risks," arises whenever reducing one risk would create new risks in so doing. For example, closing the schools to remove asbestos exposes the children to risks of being out of school.

COMPARING RISKS

Risk comparisons are ubiquitous. Even though the most well-known types of comparisons involve environmental and human health risks, it is important to keep in mind that everyone has experience comparing many other risks as well. People may fear airplane travel and instead opt for travel by car—even though the risks of the latter are far greater. Some may fear bacterial contamination of fish and poultry or pesticides in their salads, yet are unconcerned about smoking cigarettes or drinking alcohol before driving.

To provide a context for the use of the data presented in this report, this section describes different types of comparative risk assessments, ways to conduct those assessments and, finally, factors to consider when setting priorities for risk reduction.

Types of Comparative Risk Assessments

Some analysts distinguish between two different types of comparisons that differ in motivation as well as methodology.[1] These comparisons can be called "small" and "large" CRA paradigms. "Small" CRA involves the quantitative side-by-side comparison of single risks. Ten or 15 years

[1] See A.M. Finkel and D. Golding (eds.), *Worst Things First? The Debate Over Risk-Based National Environmental Priorities* (Washington, DC: Resources for the Future/Johns Hopkins Press, 1994).

ago, the most well-known examples of "small" CRA were the juxtaposition of markedly dissimilar risks, often with one risk of the pair a voluntary risk and the other the result of an involuntary exposure. Such "hang-gliding is riskier than benzene comparisons" were performed and popularized for their supposed value in communication and public education (2). Some, however, viewed this type of analysis as manipulative and grounded in numerical sleight-of-hand rather than a neutral desire to inform and help put risks in perspective (3,14). In any case, the acknowledged intention of these efforts is to provide the perspective on a given risk with a comparison with others risks encountered in everyday life (see box 5-1).

Other types of "small" CRA are entering into current decisionmaking. The U.S. Environmental Protective Agency has recently begun to compare risks closely linked to intended regulatory actions; for example, the comparison of health risks of various automotive fuels and the ongoing assessment of the choice between cancer risks caused by the chlorination of drinking water and pathogenic risks due to the failure to disinfect.

"Large" CRA is a more recent phenomenon. It involves the comparison of categories of risks, and is increasingly being undertaken both for symbolic and practical purposes. The most prominent examples of "large" CRA have come from EPA's 1987 report "Unfinished Business" (18) and its 1990 study "Reducing Risks: Setting Priorities and Strategies for Environmental Protection" (19). Both reports explored whether setting agency priorities using, in part, a risk-based approach would save more lives and provide better protection without increasing the agency's total budget.

Many state and local governments are experimenting with CRA in ranking environmental problems by severity and comparing risk-reduction strategies. As discussed in box 5-1, at least

BOX 5-1: Comparing Risks in the States

At least 30 city, state, and tribal CRA projects are completed, under way, or in the planning stages. These efforts attempt to rank risks and priorities for environmental problems by incorporating qualitative information and value-laden judgments. Various experts in different environmental health fields provide their qualitative estimates of risk, but these estimates are broadened and enriched by public involvement. These studies are part of a nationwide effort by the U.S. EPA to help regulatory agencies in each state identify their most pressing environmental risks. The idea is to help cash-strapped states cope with growing federal environmental legislation and regulations by making it easier to compare the costs and benefits of proposed regulations to existing rules.

Comparative risk analysis deals with the full range of environmental problems and in large areas. It depends heavily on qualitative information and value-laden judgment in addition to the estimates of the magnitude of risk. Comparative risk analysis is a process that can be divided into two phases: risk analysis and risk management. In the analytic phase, participants try to understand how environmental problems affect the things they value, such as health or environmental quality. The first phase ends when participants rank the problems in order of their severity.

In the second phase, participants analyze and compare strategies for better addressing the problems they find are important. Most projects use an open process designed to bring the public into both the analytic design of the projects and the decisionmaking itself.

The ranking process is the key event in the first phase of a comparative risk project because it forces participants to make sense of all they have learned about the causes and consequences of pollution, the distribution of risk, and the quality of data and the uncertainties inherent in risk assessments. Although comparing dissimilar risks is not a technical or scientific process, the framework of comparative risk makes the process systematic, thoughtful, and illuminating.

SOURCES: Office of Technology Assessment, 1995, based on R. Stone, "California Report Sets Standard for Comparing Risks," *Science* 266:214, 1994, and R. Minard, "Comparative Risk Analysis," testimony presented at hearings before the Subcommittee on Technology, Environment, and Aviation. Committee on Public Works and Transportation, House of Representatives, U.S. Congress, Washington, DC, February 3, 1994.

30 city, state, and tribal CRA projects are completed, under way, or in the planning stages (11,16) (figure 5-l). These efforts attempt to rank risks and priorities for environmental problems by incorporating qualitative information and value-laden judgments. Various experts in different environmental health fields provide their qualitative estimates of risk, but these estimates are broadened and enriched by public involvement.

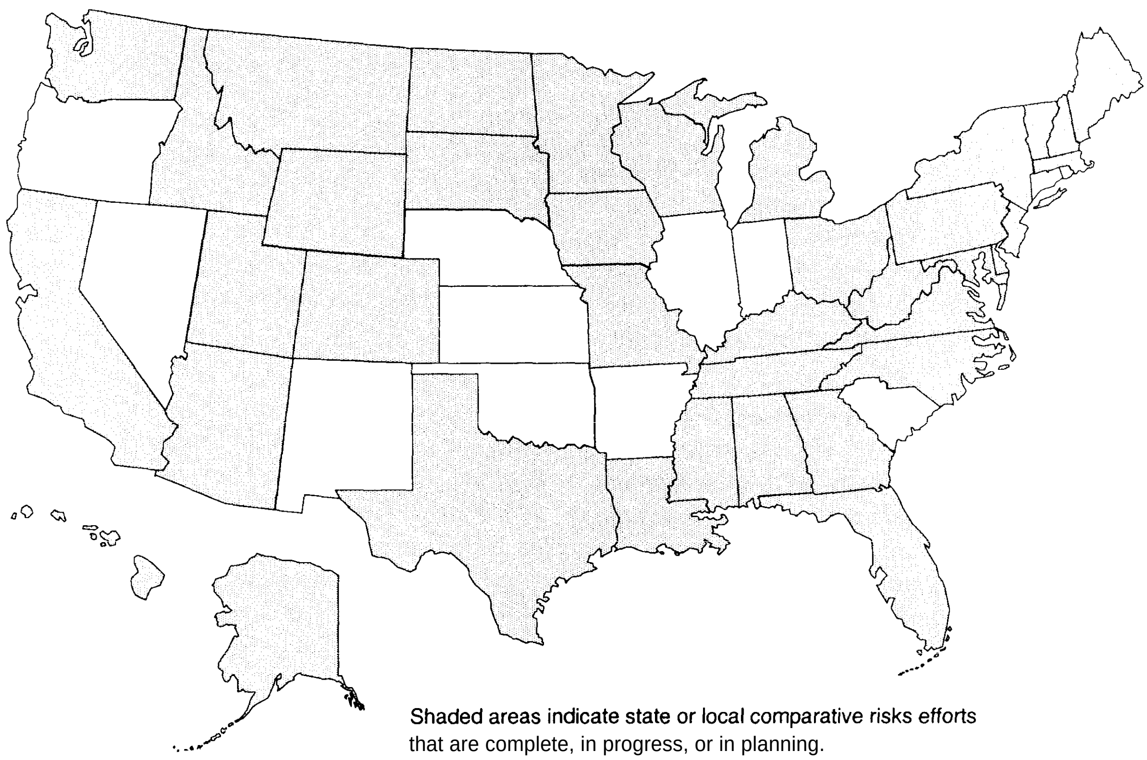
▮ Conducting Risk Assessments

Whatever process society chooses for putting comparative risk assessment into practice, it ought to advance two distinct goals: provide a forum for identifying, and making judgments about, the "important" dimensions of the risks being compared, and provide a framework for asking, and moving towards consensus about, the real underlying question: "What should we do to make our schools safer, given that any intervention we undertake will use up resources from a finite supply?"

Much of the current discussion of the process for comparing risks revolves around the distinctions between the so-called "hard" version of risk-based priority setting and the "soft" version preferred by some other stakeholders (3,4). The design of the "hard" version—also referred to as "expert-judgment"- involves the use of a small group of experts to develop estimates of the magnitude of various risks, as well as a ranking of risk reduction opportunities. This strategy presumes that the experts can estimate the "actual risk" that will be different than the "perceived risk" of the lay public (15).

Some believe that the hard version can do more harm than good. Certainly, confining the ranking process to the experts, and further cir-

FIGURE 5-1: Comparative Risk in the States



Shaded areas indicate state or local comparative risks efforts that are complete, in progress, or in planning.

cumscribing it to deal only in the currency of "risk numbers," may not be productive in advancing social judgments on risks in schools, for two overriding reasons: 1) the conventional ranking tool—using risk estimates—is one-dimensional: many other dimensions may be of equal or greater importance than risk magnitude alone; and 2) even if magnitude is the most important dimension, exclusion from the process to determine the ranking will tend to cause resentment and mistrust among the affected citizens, in this case parents and their children (3,7).

The soft version has its problems too. In this paradigm, a representative group composed of citizens and experts would work together to generate a more impressionistic and less quantitative, magnitude-oriented ranking from a consensual weighting of the various dimensions that distinguish the risks under consideration. In this way the views and values held by those in the community can be incorporated into the risk-ranking activity. The obvious objection to the softening of CRA is that it allows people to make the subjective, soft dimensions, such as fear, as important—if not more so—than the quantitative information on risk estimates. From its critics' point of view, the soft version is just a polite way to describe the emotional, haphazard, inefficient way we currently set priorities. A perhaps less obvious but potentially more damaging criticism points out an irony—that while the soft version serves as a model alternative to the technocratic elitism of the hard approach, it may be no less vulnerable to being dominated by special interests (10).

For all the criticism, supporters of CRA argue that it is a logical extension of the less formal thought process individuals and governments already rely upon to help them make choices in all areas of human endeavor (3). Comparison and ranking inevitably involve value judgments as well as scientific measurements and estimates. One study suggests that qualitative characteristics of perceived risk are important to people in making decisions about new technologies (8). An open process, supporters claim, informs risk assessors about the values of those affected and the importance they place on these subjective risk attributes. Moreover, they claim that even if a CRA fails in establishing priorities, the effort would succeed in both educating and involving the public, engendering more public support for resulting decisions (17). As Fischoff states, "an objective determination of subjective values is needed to protect individuals from being exploited by society and society from being coerced by individuals" (6).

Lessons Learned

Regardless of the nature of the evaluative strategy, hard or soft, certain lessons can be learned from the limited attempts at CRA currently being conducted by local, state, and tribal governments. Few hard and fast conclusions can be drawn until more experience has been gained. Nevertheless, these CRA experiments reveal certain desirable features for CRAs.

The first lesson is to significantly involve the public. Public participation has proven an invaluable aspect of CRAs. By involving the public, a CRA can go beyond probability estimates of risk and incorporate ethical and political concerns, which are usually neglected in risk assessments (6,15). An open process informs risk assessors about the values and importance of subjective risk attributes, such as fear, to the community. Comparison and ranking inevitably involve incorporating these value judgments as well as scientific estimates and measurements.

The process also educates the public on the scientific and technical issues associated with risk assessment. The process should instruct everyone involved—parents, school boards, risk assessors, and others—about the nature of suspected risks. Risk comparisons can alienate people if the comparisons fail to inform them (5).

The next lesson is the need for a strong analysis of the available risk information and clear criteria for comparisons. The methods used by states and EPA (1,11) for risk analysis employ teams of experts to fashion a list of problems, sorted by types of risk—cancer, noncancer, ecological effects, etc. Using a variety of standards for comparison, the experts can first rank the problems within each type of risk and then relative to hazards of other types. The initial information that flows from these analysts to the public should be regarded as the first step. In addition to having a central role to play in evaluating the empirical and narrative information about the various dimensions of the risks being compared, the stakeholders may have much to contribute in structuring the criteria of analysis and supplementing the information itself. Having all participants agree to a common set of criteria and basing the analysis on those criteria make the results more understandable, as well as politically and socially acceptable.

The major obstacles to successful CRA projects come from the resource- and information-intensive nature of the process. Undertaking a CRA in a school district or state requires a large commitment from the school board, possibly the Mayor or Governor, and others involved in city—or statewide decisionmaking. Each project uses the expertise of researchers from a variety of public health fields, as well as substantial public involvement. The staff time and the financial backing necessary to see the project to completion may not be available in many cases. Not only are resources difficult to obtain, but as this report has shown, often inadequate data exist on which to make decisions with anything nearing useful certainty. Risk ranking requires considerable information on the nature of the risk and its potential impact on the community.

MANAGING RISKS

Setting priorities for risk reduction is more than simply ranking risks. As many observers have remarked, to set priorities means to guide where *resources* should flow (9). The biggest problems may bear no resemblance to the highest priorities for risk reduction. Large risks may have no socially, politically, technologically, or economically acceptable means of control or prevention, while small risks may be eliminated through actions that carry a small or even a negative economic price tag. Therefore, even if none of the social dimensions of risk are to be included in the analyst's attempt at risk comparison, decisionmakers and stakeholders need information on the feasibility and costs of *specific interventions* in order to judge where resources should go. These estimates may be as uncertain as the risk estimates and may add further complexity to the social process, but the alternative is either to rank the risks alone and have no guide for policy, or (perhaps worse) for decisionmakers to assume that the risk ranking equals the resource allocation.

Any commitment to a risk-control policy is likely to be supported by a web of beliefs about the magnitude of the risk and the effectiveness of the policy (5). Some of these beliefs will be accurate, and others erroneous. Still others will be half-truths, correct beliefs that ignore parts of the problem—such as the other uses for the resources being spent.

People may also be confused, caught up in the chaotic process by which risks are nominated for consideration. Alarming stories in the media may psychologically commit them to certain safety measures, such as installing school metal detectors or removing asbestos, and they may find it difficult to abandon these strategies. They may feel unbearable pressure to deal with minor risks that the media and others shove into the center of their field of vision.

Regardless of the sizes of the risks or the strength of public perception, limited resources constrain the possible alternatives for risk reduction. The purpose of comparing a wide range of risks in schools is to help allocate or reallocate resources among the many possible risk reduction options, including the option of no action on a certain perceived risk. The result of the process may be to reduce the controls on some risk-producing activities and channel resources elsewhere, into other risk-reducing activities or even activities unrelated to risk reduction.

Some observers criticize these "zero-sum" choices, where governments and school boards declare they can address only one risk or another (12). In fact, parents will likely view funds spent on school safety as nonnegotiable, and they may discount claims of fungibility: they will rarely accept a trade of more books for less safety. The public may accept funds being spent more efficiently, but not at a cost of visibly greater risks to students.

To such a combustible and emotional debate, the need for objective analyses, understandable information, and direct communication becomes increasingly clear. This report, then, consists of a first step in this process.

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