

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 risks² 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.

4 | Risks to Students in School

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 chil-

dren'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. Graiz 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

Sport	Fatal		Nonfatal			Rate/100,000 Participant Years	
	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 base-lines 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 YRBS¹⁸ 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 envi-

ronmental 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 pre-schools 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 non-infectious 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/m³ 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 ≥ 4 pCi/L. The percentage of rooms at concentrations ≥ 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

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		School loss days		School loss days/ condition
	Number (in thousands)	Rate (per 100 youths)	Number (in thousands)	Rate (per 100 youths)	
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 com-

mon 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 represen-

tative 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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