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Environmental Hazards and the Lives of Children

by Dorothy Noyes Kane and Robert W. Kates

With the exception of the perils of nuclear war, it is safer to be a child in America today than ever before. Today's newborn child has a far greater chance of reaching maturity (98%) than his or her counterpart at the turn of the century (77%). In 1979, of the 1.9 million deaths in the United States, only 1% were children between the ages of 1 and 15 (see Table 1).

THE "NEW MORBIDITY"

It is the virtual conquest of infectious diseases that has so greatly reduced mortality in childhood. But trauma from accidents—often referred to as the "new morbidity"—also has been reduced markedly in the last several decades. In the U.S. in the period from 1923 to 1932, the accident death rate for children under 5 was 75*; for those 5–14, approximately 40. By 1979, the rate had decreased to 25.7 for those under 5 and 15.0 for those 5–14.

Real progress has indeed been made in reducing the acute impact of the new morbidity, but much more needs to be done. For example, the rate of motor vehicle accidents, which account for over 20% of all fatalities and almost 50% of all accidental deaths in the U.S. among children 1–14, has improved little in the last 30 years. In the 1948–52 period, the motor vehicle death rate for those 1–4 was 10.9, and in 1980, 9.1. For the 5–14 age group, it was 9.1 in that same 1948–52 period and 7.9 in 1980. By contrast, the rate of motor vehicle and other transport accidents beteen 1955 and 1971 in all European countries—except for England, Scotland, Wales, Sweden, Switzerland, and Sri Lanka—has been described as "alarming."

The drowning mortality rate in the U.S. presents a sad picture: In the 25-year period from 1955 to 1971, drowning rates *increased* from 6.9 to 8.3 for 1- to 4-year-old boys, the highest increase in some 26 countries. In 1980, the rate was 7.1. On the other hand, since 1950 accidental drowning and submersion rates in 26 countries have decreased "considerably," particularly in Finland, Japan, the Netherlands, Norway, and Sweden. (Increases were recorded for 5- to 9-year-old boys in Chile.)

In the same period, a significant reduction in childhood accidents took place throughout the world, particularly in the Scandinavian countries such as Sweden, which currently holds the world record for the lowest accident mortality rate among 1- to 4-year-olds.

THE "NEWER MORBIDITY"

An even greater threat than the obvious and acute trauma exacted by certain hazards may lie in more subtle and cumulative impacts on children. The impact of these hazards—the "newer morbidity"—consists of the illnesses and developmental problems triggered or aggravated in sensitive children by the release of noxious gases and particulates, metals and fibers, food additives, radiation, and loud noise.

Whereas the newer morbidity may not result in immediate mortality, it may be producing not

*Unless otherwise noted, death and illness rates have the standard denominator "per 100,000."

TABLE 1. Major Causes of Death (1979), Illness (1980), and Accident (1980) Total U.S. Population and U.S. Children[1]

Total U.S. Population	%	U.S. Children	%
DEATHS			
(N=1,913,841)		(N=19,254)	
1. Heart disease	38.3	1. Accidents	46.9
2. Cancer	21.1	2. Cancer	11.1
3. Stroke	8.8	3. Congenital anomalies	8.3
4. Accidents	5.5	4. Homicide	3.7
5. Pulmonary disease	2.6	5. Heart disease	2.8
6. Pneumonia and influenza	2.4	6. Pneumonia and influenza	2.4
7. Diabetes	1.7	7. Meningitis	2.2
8. Cirrhosis of the liver	1.6	8. Anemias	.8
9. Arteriosclerosis	1.5	9. Suicide	.8
10. Suicide	1.4	10. Stroke	.7
11. All other	15.1	11. All others	20.3
INCIDENTS OF ACUTE ILLNESS			
(N=484,159,000)		(N=189,629,000)	
1. Respiratory conditions	52.3	1. Respiratory conditions	52.7
2. Injuries	15.0	2. Infectious and parasitic disease	14.1
3. Infectious and parasitic disease	11.1	3. Injuries	11.8
4. Digestive system	5.1	4. Digestive system	4.6
5. All other	16.5	5. All other	16.5
ACCIDENTS			
(N=68,089,000)[2]		(N=21,693,000)	
1. Home-related	39.2	1. Home-related	46.1
2. Work-related	15.9	2. Moving vehicle	4.2
3. Moving vehicle	6.4	3. Work-related	0.0
4. All other	41.4	4. All other	49.7

[1]Ages 1–14 for deaths based on National Center for Health Statistics data (1982); ages 0–16 for illness and accidents based on National Center for Health Statistics data (1981).
[2]Note that totals in data source[1] are inconsistent; thus, some percentage columns exceed 100%.

only more illnesses but more serious and more chronic illnesses, than injuries caused by accidents. A case in point is the incidence of respiratory diseases among children under 6, which is 6 times higher than disability resulting from accident-related injuries. Polluted air is a major contributor to respiratory diseases. When protracted, these childhood diseases may prove to be antecedents of respiratory disease in adulthood.

Long-term exposure to low-level lead, although not a prime killer of children, is exerting a deleterious impact upon their central nervous and other body systems. Current estimates indicate that approximately 8%, or over 1.5 million American children between the ages of 6 months

and 5 years, show evidence of excessive amounts of lead in their blood. Almost 20,000 children in 1981 were known to be under pediatric care for lead toxicity.

Unfortunately, consideration of the newer morbidity has not yet been accorded high priority in medical circles. It is neither well defined nor well recognized, and it may never be because of the time lag following exposure and the difficulty of obtaining data concerning its unique impact. For example, in 1979, the Surgeon General sought a 20% reduction in the mortality of children 1–14 as one of his goals for the 1980s. Yet, he made no reference to any cause of childhood morbidity other than lead exposure.

ORDERING THE HAZARDS

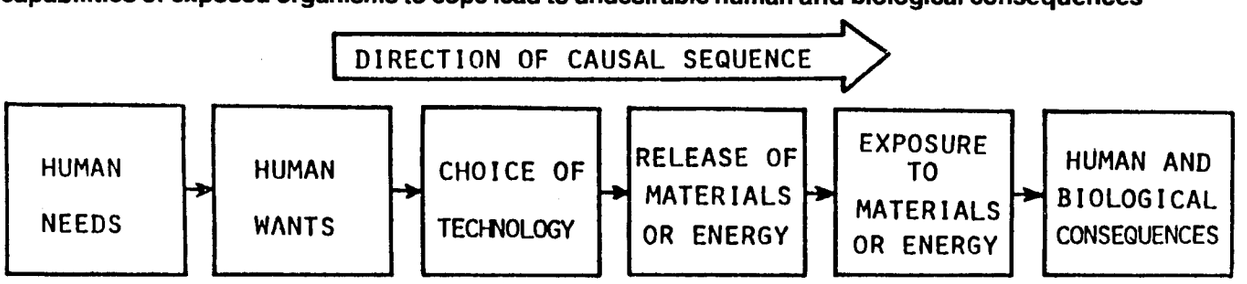
The environmental hazards to children encompass a huge domain, including hazards arising from nature, society, and technology. Ordering this domain is a function of historical or professional antecedents and, increasingly, regulatory decisions. Classification of mortality and morbidity is controlled by the International Classification of Diseases, which serves as the basis for state death certificate data, for the morbidity statistics of the National Center for Health Statistics, and as the prime database for the accident data of the National Safety Council. The system is practical but inconsistent. Deaths are classified by 2 whole-body disease groups (infections, neoplasms); 13 physiological or mental systems disease groups; a catch-all "symptoms" group; and a group of "external causes": accidents, poisoning, and violence. Throughout the system the "cause" of death is in many cases only a symptom or an associated cause.

Accidents are also classified by a locational scheme that distinguishes between transport- and nontransport-related deaths. The latter are classified by home, farm, mine and quarry, industrial workplace, recreational site, public road, building, residential and institutional, or other. The National Safety Council groups these into home, farm, workplace, and public facility sites.

In addition to classification by consequence (e.g., mortality rate), hazards are also classified by their source (e.g., motor vehicles), by their environmental pathways (e.g., air pollution), by their functional threat (e.g., poison), or by their exposed population (e.g., pedestrians). Although any specific classification may possess an internal logic, overall, there is little logic. A specific chemical substance, for example, may fall into several categories—as a consumer product, an air or land pollutant, a poison, or a prescription drug.

In organizing this volume, we have tried to compromise between the familiar, if less logical, categories of the various hazard management professions and a more meaningful and consistent organization. We have taken as a base the newly devised scheme of the Hazard Assessment Group of Clark University's Center for Technology, Environment, and Development (CENTED) for conceptualizing technological hazards. That scheme conceptualizes technological harm as a sequence of causally connected events that lead from *human needs* and *wants,* to *choice of technology,* to possible *releases of materials and energy,* to *human exposure,* and, eventually, to *harmful consequences* (see Figure 1). The focal point of the model is the *release* stage, defined as the unexpected loss of control over flows of energy and materials. Such flows are essential to all living things, and this

FIGURE 1. Causal sequence of hazard evolution. Most technologies originate in an attempt to satisfy human needs and wants, but through the release of materials or energy exceeding the capabilities of exposed organisms to cope lead to undesirable human and biological consequences



model provides the basis for a powerful common language to describe hazards. A release is defined as hazardous to the extent that it exceeds the level at which target organisms can cope with it.

Thus, a basic distinction in this volume has been made between *energy* and *materials* hazard releases. Using a study of 93 technological hazards, the Clark Group has shown that marked differences exist in the characteristics of energy and materials hazards. Readers may recognize these differences as similar to the differences between acute and chronic consequences and between the new and the newer morbidity (Hohenemser, Kates and Kasperson, forthcoming). With few exceptions, energy hazards are distinguished by releases of kinetic energy on a macroscopic scale, whereas materials hazards generally affect organisms on a molecular level. Energy hazards have short persistence times, immediate consequences, and only minor transgenerational effects. Materials hazards persist in the environment, have delayed consequences, and on the average affect at least one future generation.

There is a major difference in the scientific understanding of energy hazards and materials hazards. By and large, the causal structure of energy hazards is well understood. In contrast, the links between exposure and consequences for many materials hazards are at best correlational, and true causal understanding awaits scientific understanding of such important but complex consequences as cancer or arteriosclerosis. These differences between energy and materials hazards are probably fundamental and are related to the levels of biological organization.

Within this basic framework, we revert to more traditional and familiar categories. Five hazards are classified as energy hazards: traffic, burns, falls, noise, and radiation; and 4 as releases of materials hazards: submersion, toxic ingestions, metals and fibers, and gases and particulates. In each category there are certain incongruities: Radiation, an energy release, behaves at low levels as a toxic material; submersion, as a material ingestion, exhibits behavior similar to other accidental energy releases if too protracted. Nonetheless, the overall concept of disjunctive releases of energy and materials to which youthful organisms are not adjusted, as presented in this volume, appears to be more specifically illuminating than the prevailing literature.

Within each hazard type there are further divisions. For example, under traffic accidents we distinguish between injuries in cars, on foot, or while cycling; under metals and fibers we include lead, mercury, cadmium, and asbestos; under radiation we identify ionizing and nonionizing sources and consequences; and under gases and particulates we consider the major pollutants both indoors and out.

CHILDREN'S SUSCEPTIBILITIES

Although children have the advantages of bone resilience and the general capability of repair, they are especially sensitive to environmental hazards because (1) their organs and systems are still developing, and disruption and disturbance, particularly at critical developmental periods, may result in irreparable damage; (2) their immune competence may not be as great as adults'; (3) they frequently inhale and absorb more pollutants per unit of body weight than adults do; and (4) their exposure to certain hazards is frequently greater.

For a few hazards, however, additional special sensitivities are not widely recognized. These include children's unique problems in the traffic environment (their vision and hearing limitations and their misperceptions regarding traffic flow, signals, etc.); their small muscle volume and highly sensitive skin; their difficulties in handling language cues in a noisy environment; their greater susceptibility to blood loss, sepsis, head injuries, and fractures; and the often serious psychological impact of trauma.

All children are thus at particular risk, but 3 other factors put some children at greater risk than others: being *male,* being *poor,* and being a member of a family under *stress.* The risk rates in 1978 for males 1–14 compared with females was 1.88 for accidents, 1.35 for cancer, and 1.16 for birth defects. Poverty is hazardous, particularly in cases of pedestrian deaths, burns, and falls, and sometimes under conditions of high noise and air pollution. Affluence, on the other hand, more seriously affects mortality among automobile passengers and swimming pool users. Familial stress is related to child abuse, which

may result in, among other problems, cigarette-induced burns and scalds, falls, and drownings.

Age is a variable factor. Two-year-old boys are at greatest risk of drowning, 1- to 4-year-olds of suffering burns, and 4- to 5-year-olds of being involved in pedestrian accidents. Falls predominate among preschoolers, and household poisonings among children 2 to 3 years of age. Those under 1 year and particularly under 6 months are at high risk as car passengers, and all those from 1 to 4 are at greater risk than older children. Children from 6 months to 5 years are most susceptible to lead poisoning.

Geographical location is also a factor. Urban areas are most dangerous for pedestrian mishaps, burns, falls, and for exposure to metals and fibers as well as gases and particulates. Table 2 summarizes the special sensitivities of children and related risk for 9 hazards.

THE BURDEN OF HAZARD

Taken together, environmental hazards probably account for 20 million incidents of injury and illness in children under 17 and for perhaps 60% of the 20,000 deaths recorded each year in children aged 1–14. The toll of hazards detailed in Table 3 is relatively accurate for accidental deaths, but the proportion of deaths from cancer, birth defects, and other illnesses associated with environmental hazards can only be guessed at.

Even if cause is debatable, the tragic finality of death makes its counting easy. A central state registration system assures accuracy to within 1% or 2%. Not so with morbidity: Its definition varies by statistical source but generally combines measures of professional medical referral with days lost from normal activity. The major sources for morbidity statistics are the National Center for Health Statistics biennial health surveys of civilian households (41,000 in 1977), supplemented by reports collected from a number of sources by the National Safety Council and special surveys. The 1982 National Health Interviews Survey reports 4 million persons under age 6 injured from all causes (21.47%) and 6 million between 7 and 16 (14.6%).

Estimates of morbidity are subject to considerably more variance. For example, traffic injuries have been found to be underreported by perhaps 100%. This is particularly true among those under 5 years. Poisoning episodes may also be underreported by a like amount, and submersion figures do not include near-drownings.

Taken together and using as a base the overall injury and illness estimates of the National Health Survey, it is estimated that each year at least 30% of the 25 million children under 6 and of the 40 million children aged 6 to 16—a total of approximately 20 million—suffer the effects of injury and illnesses related to environmental hazards.

Within each category of hazards, progress is uneven: Poisons, fires and burns, and falls injure fewer children, traffic, about the same as in the past, and submersion, more than in the past. Submersion includes near-drowning, for which we have no specific data, only estimates. Despite this enormous toll of injury and illness, the death toll is small and decreasing steadily over time. Progress has been greatest in reducing accidental death from the acute energy hazards. The degree to which the newer morbidities of air pollution, toxic ingestion, and radiation may replace these deaths is unknown, but to date it has apparently not risen and has not as yet shown up in measures of cancer or birth defects.

Each chapter from 1 to 5 addresses a different energy hazard, and each chapter from 6 to 9, a different materials hazard. For each hazard current knowledge is reviewed under 5 different themes: (1) consequences, in terms of mortality and morbidity; (2) children's special sensitivities to the hazard, (3) characteristic places, seasons, and times of high exposure; (4) high-risk subgroups of children; and (5) efforts at prevention and protection.

The concluding chapter—which analyzes children's mortality records for the United States and 11 other developed nations—focuses on hazard management for the decade ahead, outlining what might be achieved by wise choices of protection measures. It provides specific recommendations for reducing the risks from each hazard type and suggests the 3 most important priorities.

TABLE 2. Childhood Hazard Susceptibility

HAZARD	CHILDREN SUSCEPTIBILITY	SUBGROUP SUSCEPTIBILITY				TIME		LOCALE
		Age	Sex	SES*	Other	Day	Season	
TRAFFIC	Unaware of dangers and of means of self-protection							
Passengers	Physical fragility	Infants and children under 5	Both	High	Unrestrained; front-seated	Day	Year-round	Near home
Pedestrians	Auditory and visual limitations; "dart-out" behavior; misperceptions of traffic signals	4- to 5-year-olds	Male	Low	Urban	Day	Year-round	Near home
Pedal-cyclists	Auditory and visual limitations; "dart-out" behavior; misperceptions of traffic signals	Older	Male	Both	Physically unadept; unstable equipment	Day	Summer	Near home
BURNS	Excess heat more damaging to infants and toddlers than older children and adults because of thin, soft, and tender skin							
Scalds	Face frequently burned by easily tipped-over appliances; wound sepsis greater by factor of 2.5:1 over adults	1- to 2-year-olds	Both	Low	Neglectful/ abusing parents	Day	Year-round	Home
Heaters/ Matches	Exposure to injury from kerosene and/or space heaters and nonsafety matches may lead to psychic trauma as well	3- to 4-7-year-olds	Both	Low	Neglectful/ abusing parents	Day	Winter	Home

*Socioeconomic status

TABLE 2. Childhood Hazard Susceptibility (continued)

HAZARD	CHILDREN SUSCEPTIBILITY	SUBGROUP SUSCEPTIBILITY				TIME		LOCALE
		Age	Sex	SES	Other	Day	Season	
FALLS	Head injuries and fractures often severe; series symptoms frequently masked	Preschoolers	Male	Low	Urban Neglectful/ abusing parents	Day	Summer	Multistoried dwellings; playgrounds
NOISE								
Transportation	Auditory discrimination and perception of speech (which may affect cognitive development) more difficult under conditions not disturbing to adults	"Young"	Both	Low	Urban	Day	Summer	Near large ariports and heavily trafficked areas
Incubators	Sensitive to high-decibel counts	Newborns	Both	Both	Premature and ill	Day/ night	Year-round	Hospitals
RADIATION								
Ionizing	Sensitivity may be 5–10 times greater through skin absorption, inhalation, and ingestion	Fetuses, infants, and children to age 10	Both	Both	Nuclear power mishaps, Xray exposure	Day/ night	Year-round	Near power plants and hospitals
Nonionizing	May be comparable risk as above	Fetuses, infants, and children to age 10	Both	Both	Careless exposure to microwave ovens, CB radios, etc.	Day/ night	Year-round	Near large airports and/or high-power FM and TV antennas
SUBMERSION								
Pools	Immature behavior; lack of swimming proficiency; may have serious neurologic impact	2- to 4-year-olds	Male	High	Poor adult supervision	Day	Summer	Home; near home
Bathtubs	Unattended baby in water	Infants	Both	Low	Neglectful/ abusing parents	Day	Year-round	Home

TABLE 2. Childhood Hazard Susceptibility (continued)

HAZARD	CHILDREN SUSCEPTIBILITY	SUBGROUP SUSCEPTIBILITY				TIME		LOCALE
		Age	Sex	SES	Other	Day	Season	
TOXIC INGESTIONS								
Household Products	Curiosity, ignorance of dangers, and family conflict	2- to 3-year-olds	Both	Both	Family psycho-pathology, hyperactivity	Day	Year-round	Home
Food additives	Sensitivity to coloring agents and PCBs* in mother's milk	Young	Both	Both	------	Meal-time	Year-round	Home
METALS/ FIBERS	Immature, developing systems and organs particularly vulnerable	Young	Both	Low	Urban	Day/ night	Year-round	Near industrial and heavily trafficked areas
Lead	Impact on CNS**, blood, and kidneys may prove irreversible	Under 5 years old	Both	Low	Blacks	Day/ night	Year-round	Near industrial and heavily trafficked area
Asbestos	Effect on lungs may result in serious pathology, including cancer	Young	Both	Both	Urban Occupationally exposed parents	Day/ night	Year-round	Home, schools, heavily trafficked and industrial areas
GASES/ PARTICU-LATES								
Ambient air	Numerous respiratory tract and other vulnerabilities to both inhaled and absorbed pollutants; greater potential for long-term retention	Infants Young	Both	Low	Urban Asthmatics, occupationally exposed parents	Day/ night	Year-round	Near heavily trafficked and industrial areas
Indoor air	Greater time spent indoors with possibly heavier pollution concentration	Infant Young	Both	Both	Asthmatics, smoking adults, occupationally exposed parents	Day/ night	Year-round	Heavily insulated homes; gas, wood, and other forms of heat

*Polychlorinated biphenyls
**Central nervous system

TABLE 3. Death, Illness, and Injury of Children from Environmental Hazards

	DEATHS			ILLNESS AND INJURY		
	All	Younger	Older	All	Younger	Older
Hazards	3,700	1,200	2,500	180,000	50,000	130,000
Motor Vehicle				121,000	42,000	79,000
Passenger	1,630	640	990	37,000	7,000	30,000
Pedestrian	1,610	540	1,070	22,000	1,000	21,000
Pedalcycle	460	20	440	928,000*	90,000*	838,000*
Fire and Burns	1,324	846	478	571,000*	272,000*	293,000*
Falls	200	111	89	2,496,000*	1,112,000*	1,384,000*
Noise	None			Unknown		
Radiation:						
Ionizing	Unknown			Unknown		
Nonionizing	None Known			None known		
Drowning	1,659	803	856	Unknown		
Toxic Ingestion	257	167	90	100,000–2.5 million		
Household Products	Unknown					
Food Additives	Unknown					
Metals and Fibers						
Asbestos	Unknown			Unknown		
Cadmium	None known			Unknown		
Lead	300–400			20,000		
Mercury	None Known			Unknown		
Gases and Particulates						
Indoors	127	51	76	Unknown		
Outdoors	Unknown			1.25–3.1 million		

Sources: Varied (see text)

*With the exception of the asterisked figures, younger children are defined as those under 5 years; older children, 5–14. The asterisked figures are: for younger children, those 7–16. "All" with an asterisk refers to children under 17; without an asterisk, to those under 15.

REFERENCES

Hohenemser, C.; Kates, R. W.; and Kasperson, J. X. (forthcoming). *Perilous Progress: Technology as Hazard.* Boulder, CO: Westview Press.

National Center for Health Statistics (1981). *Current Estimates from the National Health Interview Survey,* United States, 1980. Department of Health and Human Services (DHHS) Publication DHS 82-1567. Data from the National Survey, Series 10, No. 139. Hyattsville, MD, December.

National Center for Health Statistics (1982). "Advance Report of Final Mortality Statistics, 1979." *Monthly Vital Statistics Report,* 31 No. 6. Supplement, Department of Health and Human Services (DHHS) Publication No. DHS 82-1120. Hyattsville, MD, September 30.

National Center for Health Statistics (1984). Personal communication with Mary White, November 13.

National Safety Council (1984). *Accident Facts.* Chicago.