CHAPTER FIVE

Environmental Aspects of Human Health

Environmental factors play a fundamental role in human health and disease. From polluted air and water to toxic substances in soil and food, environmental pollutants can pose both direct and indirect threats to human health. Their impact on health is often complex and may be influenced by a variety of factors, including exposure patterns, genetic makeup, nutritional habits, and psychological well-being. Correlations between an environmental hazard and an adverse health effect may not, standing alone, establish that the former is the cause of the latter. Nevertheless, reducing exposures to environmental hazards, where causal links are established or likely, is an important component in protecting public health.

Over the past 25 years, federal, state, and local government efforts to ensure safe supplies of food and water, to manage sewage and municipal waste, and to improve air quality have contributed substantially to human health improvements in the United States. The past 25 years also have seen an improvement in the dissemination of information about health risks from environmental degradation. Two primary challenges today are to continue making progress in reducing environmental risks, and to improve the existing regulatory system in order to achieve the greatest public health protection at the lowest cost. A further and related challenge is to improve scientific understanding about the links between environment and health, so that policy decisions can be made with the best information available.

Major new legislation, including the Safe Drinking Water Act Amendments of 1996 and the Food Quality Protection Act of 1996, will improve and streamline the regulatory process while keeping health concerns paramount. New regulations to protect air quality have shown that health standards can be met without sacrificing economic growth and that the health and economic benefits of reducing emissions can be substantial.

The Clinton Administration has been working toward greater transparency in how it evaluates health risks and formulates policy. The reevaluation of dioxin and its effects, for example, was a novel approach in how risk assessments are conducted—incorporating both scientific expertise and broad public input into the process. The Administration has also been actively involved in working toward a greater understanding of the health risks from emerging threats such as endocrine disruptors and global climate change.

This chapter highlights some of these efforts and provides an overview of environmental health hazards, particularly the contamination of drinking water, air, and food. Even so, it only touches on a few environmental risks to human health. Other risks, such as those associated with occupational hazards, accidents, noise, behavioral or lifestyle choices, and infectious diseases, are also important.

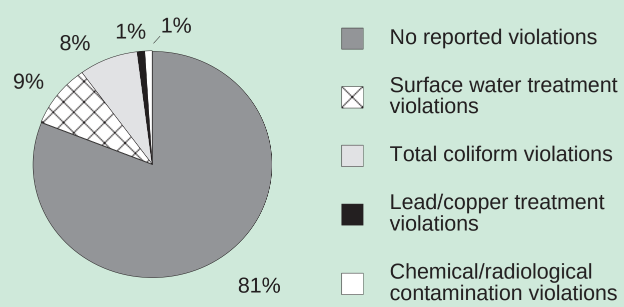
DRINKING WATER QUALITY

Current Trends

EPA and the states are responsible for regulating approximately 200,000 public water systems, including 58,000 community water systems that serve over 240 million people. The concentration of contaminants in drinking water supplies from these systems is controlled by standards established to minimize risk to human health. Contaminants found in drinking water can cause myriad health effects, ranging from stomach upset and diarrhea (as with *Cryptosporidium* or *Giardia*) to chronic health effects such as liver and kidney damage, neurological disorders, and cancer (i.e., from heavy metals and pesticides). When violations of health-based standards occur, water systems are required to take action to remove the contaminants from the drinking water supply and notify the public about the violation.

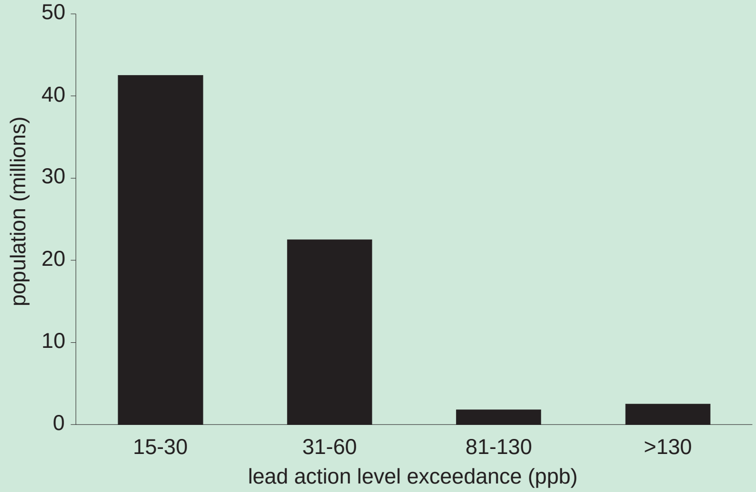
In 1994, more than 80 percent of community water systems serving 240 million people reported no violations of health-based standards. However, over 40 million people received their drinking water from a community water system that did report a violation of health-based standards. The majority of these violations involved microbiological contaminants: either surface water treatment violations (9 percent) or fecal coliform violations (8 percent) (Figure 5.1).

Figure 5.1 Population Served by Community Drinking Water Systems Violating Health-Based Requirements, 1994



Source: U.S. Environmental Protection Agency, Safe Drinking Water Information System, 1994.
Notes: As many as one-fourth of the water systems did not complete required monitoring; compliance status of some of these could not be assessed. 243 million people are served by community systems.

Figure 5.2 Population Served by Drinking Water Systems Exceeding Lead Action Levels, 1995



Source: U.S. Environmental Protection Agency, Safe Drinking Water Information System, 1995.
Note: Data are the results ot lead testing in high-risk households. A water system is found to exceed the action level if more than 10 percent of its high-risk households contain lead levels above 15 ppb.

About 69 million people are served by drinking water systems that have started to institute mitigation measures (such as corrosion control treatment) to reduce potential lead contamination at consumers' taps. These systems are required to act because initial monitoring, required under EPA's lead and copper rule, at high risk consumer taps found lead levels that exceeded the regulatory action level for lead (Figure 5.2). Although exposure to lead can come from many other sources (e.g., from paint, from contaminated soil, and though the air), lead in drinking water remains a significant risk to the public and a large problem for water systems.

In addition to improved regulations, technological innovation can reduce the amount of wastewater generated by developing new water conservation technologies and cleaner industrial technologies. For example, the Department of Energy is supporting research to improve the efficiency of water pipe galvanization. New "hot-dipped" galvanized water pipes emit four orders of magnitude less lead than the conventional technology, which leaves lead on the finished product.

Regulatory Background

The Clean Water Act of 1972 established a body of law and regulations backed by federal financial support to ensure that the nation's surface waters are safe for fishing and swimming and as sources of drinking water. In 1974, Congress enacted the Safe Drinking Water Act, further developing a legislative basis to protect water quality. The Safe Drinking Water Act is intended to ensure that every public water system consistently provides water that is safe to drink. The act, which was substantially amended in 1986, required EPA to establish national drinking water safety standards that incorporate enforceable maximum contaminant levels or treatment techniques, underground injection control regulations to protect underground sources of drinking water, and grant programs for the administration of state wellhead protection area programs. The states were to be delegated responsibility to ensure that safety standards were met.

Despite the progress made in improving drinking water quality in the United States, both natural processes and human activities continue to exert pressures on drinking water quality. For instance, population growth, newly identified and emerging microorganisms, changes in chemical usage, and outdated and deteriorating water systems present significant challenges to the long-term safety of the nation's drinking water supplies. These trends are further exacerbated by shrinking budgets and resources at all levels of government. In 1995, EPA's Science Advisory Board (SAB) released a report, *Safe Drinking Water: Future Trends and Challenges,* which identified significant trends affecting the nation's drinking water, including population growth impacts, public demand for better water, a changing contaminant profile, and changes in drinking water production and treatment. The report recommended improved management of water resources, consolidation of smaller systems, accelerated research in risk assessment methodologies, and establishment of an alert system for emerging pathogens.

Also in 1995, EPA Administrator Carol Browner launched a reassessment of EPA's drinking water program and released EPA's "white paper," *Strengthening the Safety of Our Drinking Water: A Report on Progress and Challenges and an Agenda for Action.* The white paper provided an overview of drinking water safety in the United States and identified five agenda items for improving drinking water protection:

- provide Americans with more information about the nation's drinking water;
- focus standards on the most serious health risks;
- provide technical assistance to protect source water and help small systems;
- reinvent federal/state partnerships to improve drinking water safety; and
- invest in community drinking water facilities to protect human health.

The white paper estimated that substantial health benefits could be achieved if existing standards were fully attained, including reduced exposure to lead for an estimated 50 million people (with protection for 200,000 children against unacceptable blood lead levels); prevention of more than 100,000 cases annually of gastrointestinal and other illnesses attributed to microorganisms; reduced exposure for millions of people to dozens of contaminants that may cause illness, including compromised reproductive capabilities, malfunction of vital organs, "blue baby" syndrome, and nervous system damage; and over 100 excess cancer cases avoided per year.

The Safe Drinking Water Act Amendments of 1996

On August 6, President Clinton signed the Safe Drinking Water Act (SDWA) amendments of 1996. The new law will help achieve many of the goals outlined in both the SAB and the EPA reports. It will: (1) establish a strong new emphasis on preventing contamination problems through source water protection and enhanced water system management; (2) move greater responsibility to the states and expand their role in creating and focusing prevention programs and helping water systems improve operations and avoid contamination problems; and (3) set up a state revolving fund (SRF) system to provide money to communities to improve their drinking water facilities.

The SRF is authorized at $1 billion for each of fiscal years 1995 to 2003. The states may use set-asides from the SRF to pay for programs such as source water assessments; voluntary source water quality protection partnerships with public water systems, local governments, and private companies; and capacity development and implementation efforts. States also will have more flexibility in establishing water quality monitoring requirements.

The 1996 amendments recognize the importance of community right-to-know about potential threats to drinking water quality. Within 2 years of enactment, the law requires EPA to issue regulations requiring all community water systems to prepare at least annually a report with information about the system's source water and the level of contaminants in the drinking water supply. In addition, public water systems must give notice of any violation of a national drinking water standard "that has the potential to have serious adverse effects on human health as a result of short-term exposure" within 24 hours after the violation.

The new law repeals the current requirement that EPA promulgate standards for 25 additional contaminants every 3 years. These requirements, instituted by Congress as part of the 1986 SDWA amendments, have diverted resources from science-based priorities, and have been impossible to meet within the mandated time frames. Efforts to meet all of the statute's remaining standard-setting requirements had detracted from the development of soundly analyzed, well-supported standards for the highest-risk drinking water contaminants, such as microbes. Under the 1996 amendments, the agency's decisions about new standards are informed by a cost-benefit analysis.

Other provisions of the 1996 amendments include the establishment of a priority list of unregulated contaminants and require that EPA promulgate rules on arsenic, enhanced surface water treatment incorporating standards for *Cryptosporidium*, and a new multimedia approach to reducing risks from radon. EPA is also directed to conduct research on sensitive subpopulations that may experience greater adverse health effects from drinking water contaminants than the general population (see also Chapter 6, "Environmental Justice").

Other Programs

In addition to the 1996 SDWA amendments, many other programs are under way to address drinking water quality. In 1993, the Surface Water Treatment Rule (SWTR) went into effect. The SWTR requires water systems using surface water sources to install filters for microbiological contaminants that cause disease, such as *Giardia lamblia*, *Legionella*, and viruses. Compliance with the rule will dramatically reduce the probability of human exposure to harmful levels of microbiological contaminants from surface water sources.

To protect sources of drinking water even before water is withdrawn by a drinking water supplier, EPA has established the Source Water Protection and Wellhead Protection Programs under the SDWA. The Source Water Protection Program emphasizes preventing contamination of drinking water resources and includes wellhead protection and "sole source aquifer" designations. The Wellhead Protection Program protects supplies of groundwater that will provide drinking water in the future from contamination by chemicals and other hazards, including pesticides, nutrients, and other agricultural chemicals. The program is based on the concept that local or state governments that adopt land use plans and other preventive measures can protect groundwater. Currently, 39 states have an EPA-approved wellhead protection program.

The Comprehensive State Ground Water Protection Program (CSGWPP), established by EPA in 1991, coordinates all federal, state, and tribal and local programs that address groundwater quality. States have the primary role in designing and implementing CSGWPPs in accordance with local needs and conditions. EPA has approved programs in 6 states, and plans from an additional 13 states are under review.

The Administration is also working to develop a comprehensive approach to water resource management to address the myriad water quality problems that exist today from nonpoint and point sources as well as from habitat degradation. The Watershed Protection Approach is a management approach for more effectively protecting and restoring aquatic ecosystems and protecting human health. The watershed protection approach recognizes that water quality management must embrace human and ecosystem health and that managing for one without considering the other can be detrimental to both. It has four major features: targeting priority problems, stakeholder involvement, integrated solutions, and measuring success. The watershed protection approach is not a new program that competes with or replaces existing water quality programs; rather, it is a framework within which ongoing programs can be integrated effectively.

AIR QUALITY

Ambient Air Quality

Over the past three or four decades, there have been important advances in the understanding of how air pollutants affect human health. Air pollutants may cause lung cell damage, inflammation, acute changes in lung function and respiratory symptoms, as well as more long-term lung cell changes. Acute and chronic exposure to air pollutants is also associated with increased mortality and morbidity. Yet much remains to be understood, including, for instance, the role of air pollution in observed increases in asthma cases and deaths from lung disease. Table 5.1 summarizes the major health effects of the six pollutants monitored by EPA.

In 1963, the United States took the first step toward healthier air by passing the Clean Air Act. Amended in 1970 and again in 1990, the Clean Air Act requires EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment and to ensure that these air quality standards are met through strategies to control air emissions from sources such as automobiles, power plants, and factories. As a result of these measures, air quality in the United States improved significantly (see Chapter 10, “Air Quality”).

Despite these improvements, in 1994 approximately 62 million people still lived in counties where air quality levels exceeded the national air quality standards for at least one of the six principal pollutants. Ozone is the most commonly violated NAAQS, affecting 50 million people in 1994. According to the current ozone standards established by EPA, ozone levels exceeding 0.12 parts per million can be detrimental to public health. During the high smog season extending from June to early September, those levels are regularly exceeded in major cities across the United States, including New York and Los Angeles. Scientific evidence indicates that ozone affects not only people with impaired respiratory systems, such as asthmatics, but also healthy adults and children. Even exposures to relatively low concentrations of ozone have been found to temporarily reduce lung function and induce respiratory inflammation in normal, healthy people, especially during exercise. EPA is currently reviewing the NAAQS and has agreed to complete its review and issue revised standards by June 28, 1997. EPA may propose more stringent ambient air quality standards for ozone if the data support those changes.

In addition, more than 13 million people live in counties where the current EPA standard for particulate levels is exceeded. On the basis of studies of human populations exposed to high concentrations of particulates and laboratory studies of animals and humans, it has been determined that particulates pose major concerns for human health. These include effects on breathing and respiratory symptoms, aggravation of existing respiratory and cardiovascular disease, alterations in the body’s defense systems against foreign materials, damage to lung tissue, carcinogenesis, and premature death. Two recent epidemiological studies (Douglas Dockery, et.al., and C.

Table 5.1
Air Pollutants and their Impacts on Health

Carbon Monoxide

Sources: Carbon monoxide is a colorless, odorless, poisonous gas formed when carbon in fuels is not burned completely. It is a byproduct of motor vehicle exhaust, which contributes more than two-thirds of all CO emissions nationwide.

NAAQS: 9 ppm (measured over 8 hours)

Health Effects: Carbon monoxide enters the bloodstream and reduces oxygen delivery to the body's organs and tissues. Exposure to elevated CO levels is associated with visual impairment, reduced work capacity, reduced manual dexterity, poor learning ability, and difficulty in performing complex tasks.

Lead

Sources: Smelters and battery plants are the major sources of lead in air. Indoors, lead can be found in old buildings from paint on walls.

NAAQS: 1.5 ug/m3 (measured as a quarterly average)

Health Effects: Lead accumulates in the body in blood, bone and soft tissue. Because it is not readily excreted, lead can also affect the kidneys, liver, nervous system, and other organs. Excessive exposure to lead may cause anemia, kidney disease, reproductive disorders, and neurological impairments such as seizures, mental retardation, and/or behavorial disorders.

Nitrogen Dioxide

Sources: Nitrogen oxides form when fuel is burned at high temperatures, and come principally from motor vehicle exhaust and stationary sources such as electric utilities and industrial boilers.

NAAQS: 0.053 ppm (measured as an annual average)

Health Effects: Nitrogen dioxide can irritate the lungs and lower resistence to respiratory infections such as influenza. The effect of short-term exposure are still unclear, but continued or frequent exposure to concentrations that are typically much higher than those normally found in the ambient air may cause increased incidence of acute respiratory illness in children.

Ozone

Sources: Unlike other pollutants, ozone is not emitted directly into the air but is created by sunlight acting on NOx and VOC emissions in the air. There are literally thousands of sources of these gases, from gasoline vapors to chemical solvents.

NAAQS: 0.12 ppm (measured at the highest hour during the day)

Health Effects: Exposure to ozone significantly reduces lung function and induces respiratory inflammation in normal, healthly people during periods of moderate exercise. It can be accompanied by symptoms such as chest pain, coughing, nausea, and pulmonary congestion.

Sulfur Dioxide (SO2)

Sources: Formed when fuel containing sulfur (mainly coal and oil) is burned, and during metal smelting and other industrial processes.

NAAQS: 0.03 ppm (annual average) .14 ppm (over 24 hours)

Health Effects: SO2 can affect breathing, respiratory illness, alterations in pulmonary defenses, and aggravation of existing cardiovascular disease.

Particulate Matter (PM-10) (PM-10 refers to particles with a diameter of 10 micrometers or less)

Sources: Particulate matter is the term for solid or lliquid particles found in the air. Particles originate from a variety of mobile, stationary, and natural sources (diesel trucks, wood stoves, power plants, dust, etc.), and their chemical and physical compositions vary widely.

NAAQS: 50 ug/m3 (annual average) 150 ug/m3 (daily average)

Health Effects: Major concerns for human health from exposures to PM-10 are: effects on breathing and respiratory systems, damage to lung tissue, cancer, and premature death. The elderly, children, and people with chronic lung disease, influenza, or asthma tend to be especially sensitive to particulate matter.

Source: U.S. Environmental Protection Agency (EPA), *Air Quality Trends* (EPA, Office of Air Quality, Planning & Standards, Research Triangle Park, N.C., September 1995)

Arden Pope III, *et. al.*) have linked particulate pollution to excess morbidity and mortality in U.S. cities, providing striking evidence of the impact of energy-related transportation and industrial emissions upon human health and longevity.

As with ozone, EPA is considering the revision of its particulate standards. Ambient air standards for total suspended particulate matter were first set in 1971. Since 1987, however, EPA has used the indicator PM-10, which includes only those particles with aerodynamic diameter of 10 micrometers or less. These smaller particles are likely responsible for most of the adverse health effects of particulate matter because of their ability to reach the thoracic or lower regions of the respiratory tract. Further investigations by EPA may develop standards down to the PM-2.5 scale.

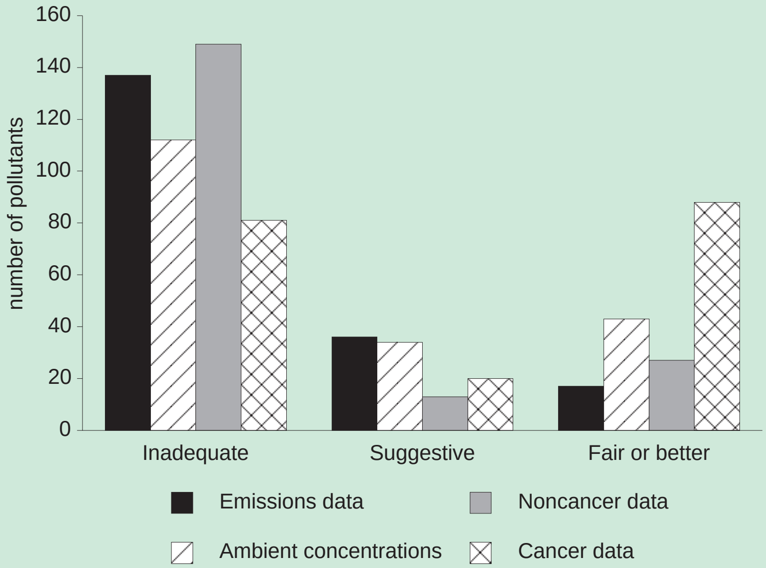
Most of the smaller particles under 2.5 microns in diameter are from fossil-fuel based energy-related emissions such as those from power plants, vehicles (especially diesel), and industry. Fortunately, initiatives intended to address other energy-related air pollution problems, such as ozone, acid rain, air toxics, and global climate change, can also yield substantial reductions in fine particle pollution while increasing energy efficiency and decreasing costs.

In addition to evaluating standards, the Administration has been working with federal agencies, the states, and industry to develop innovative and cost-effective programs to reduce emissions under the Clean Air Act. Market-based programs such as emissions trading provide incentives for industry to develop new pollution control technologies or pollution prevention approaches. In May 1996, EPA completed a draft study on benefits and costs of the Clean Air Act during the 1970–90 period. The analysis, which must still undergo review and possible revision by the EPA Science Advisory Board, found that spending for Clean Air Act programs had yielded benefits that far outweigh the costs due to the impact of lead and particulate matter controls (see Chapter 1, “America and the Environment: A 25-Year Retrospective” and Chapter 10, “Air Quality”).

There have also been government-wide efforts to find innovative solutions to air pollution problems. For example, the Department of Energy (DOE) has made much progress both in research and in deployment of technologies to mitigate the urban heat islands that can negatively affect air quality. DOE is working to help develop and identify the best roofing and paving materials, to use computer models to determine the optimal approach to cooling a city, and to disseminate information around the nation. DOE estimates that over a 20-year period, trees can be planted cheaply and roads, roofs, and parking lots replaced with cooler surfaces, with considerable savings in energy and environmental costs.

In many cities and regions, local efforts to reduce air pollution are also bearing fruit. In Los Angeles, the combination of cars, industries, weather, and natural topography contributes to the worst air pollution problems in the United States. To meet federal health standards by 2010, a regional air pollution control board has devised an elaborate

Figure 5.3 Adequacy of Available U.S. Data on 189 Hazardous Air Pollutants



Source: K. Sexton, "Science and Policy in Regulatory Decision Making: Getting the Facts Right about Hazardous Air Pollutants," *Environmental Health Perspectives*, Vol. 103, Supplement 6 (1995), pp. 213-222.

local air quality management plan that targets industry, transportation, and consumers and relies on both current technologies and some that are just now being developed. The estimated health benefits would be substantial. In Chattanooga, Tennessee, a collaborative effort among the city's political, business, and environmental leaders managed to end the severe air pollution problems that plagued the city only two decades ago. When confronted with federal standards in the Clean Air Act requiring local industries to install air pollution equipment, the city translated these requirements into economic growth, generating nearly $40 million in locally manufactured air pollution control equipment.

Hazardous Air Pollutants

In addition to the six criteria pollutants monitored under NAAQS, EPA also monitors hazardous air pollutants such as benzene, chlorine, and heavy metals, from stationary and urban area sources. Hazardous air pollutants are believed to pose a significant threat to human health. Estimates by EPA suggest that as many as 2,500 cancer cases per year may result from outdoor exposure to 45 of the 189 hazardous air pollutants listed under the Clean Air Act Amendments of 1990. However, the scientific basis for estimating risks from outdoor exposure to hazardous air pollutants is currently fragmented and sparse (Figure 5.3). EPA is in the process of using its research capabilities and testing authorities to respond to this gap in scientific knowledge. In June 1996, EPA proposed a test rule under the Toxic Substances Control Act to acquire needed inhalation toxicity data on 21 hazardous air pollutants.

The Administration has also taken a steady and aggressive stance on increasing the amount of information available to the public about toxics in their communities, their homes and their workplaces. The Federal Right-to-Know Program, for example, assures that communities have easy access to critical environmental information about the releases of toxic chemicals within their communities. In 1995, the number of chemicals covered by the Right-to-Know Program of Toxics Release Inventory increased from 300 to over 600. In 1996, EPA proposed to require the mining industry, utilities, hazardous waste handlers and other industrial sectors to also disclose basic toxic emissions data. Reporting from these industries would begin in 1997.

In addition, the 1990 Clean Air Act amendments introduced important innovations for controlling air toxics. Prior to passage of the 1990 amendments, EPA had regulated directly only seven of the hundreds of toxic air pollutants emitted from industries. Under the 1990 amendments, EPA must identify categories of "major" sources that emit any of the 189 hazardous air pollutants listed specifically under the act. This modification will allow EPA to better protect human health from hazardous air pollutants. These major sources of toxic air pollutants also will provide a roadmap for DOE pollution prevention efforts, which are targeted at the responsible industrial sectors.

Indoor Air Quality

Modern indoor environments contain an array of chemical and biological sources of air pollution, including synthetic building materials, consumer products, and dust. Common indoor pollutants include lead, radon, tobacco smoke, volatile organic compounds, combustion gases, particles, and mold. This section highlights three indoor air problems: lead, radon, and environmental tobacco smoke.

Lead. In the United States, children's mean blood lead levels have decreased more than 75 percent since the 1970s. This reduction is primarily the result of the phaseout of lead in gasoline and reductions in other sources and pathways of exposure, such as lead in soldered cans and paint (see Chapter 6, "Environmental Justice"). With the reduction of lead in gasoline and foods, the remaining major sources of lead are lead-based paint, dust and soil, drinking water, and occupational exposures.

While lead is not solely an "indoor air" issue, lead-based paint is currently the largest source of high-dose lead exposure for children. Approximately 1.7 million children still have blood lead levels above 10 micrograms per deciliter, the accepted level set by the Centers for Disease Control and Prevention, with the highest rates of blood lead levels found among poor, urban, African American, and Hispanic children. Although lead was banned from residential paint in 1978, it is estimated that 83 percent of all housing units built before 1980 contain some lead-based paint. Older, deteriorating buildings with peeling paint pose the greatest lead risk. The Department of Housing and Urban Development (HUD) estimates that about two out of three homes occupied by young children have lead paint and dust hazards, potentially affecting their mental and neural development. In adults, lead in the blood can interfere with hearing, increase blood pressure, and, at high levels, cause kidney damage and anemia.

In response to this environmental health threat, several U.S. agencies have made reducing lead exposure to children a top priority. Under the Toxic Substances Control Act and the Residential Lead-Based Paint Hazard Reduction Act of 1992, many new rules have been or will be developed to help reduce lead exposures. These rules incorporate lead hazard identification programs, lead disclosure and consumer education, and renovation and remodeling procedures to reduce lead hazards. Since 1992, HUD has awarded a total of $279 million in grants to reduce lead hazards in low-income housing. The grant program supports activities such as public education (using local media and community-based organizations to ensure widespread dissemination in the neighborhoods where lead poisoning is most prevalent), paint inspection and risk assessments, low-cost interim controls, and lead abatement. EPA and the National Institute of Environmental Health Sciences (NIEHS) also have programs researching the health risks from lead exposures as well as reducing lead exposures.

Radon. Radon is a cancer-causing, radioactive gas that comes from the natural breakdown of uranium in soil, rock, and water. Odorless and colorless, radon is believed to be a leading cause of lung cancer in the United States today. Radon is estimated to cause about 14,000 deaths per year. However, this number could range from 7,000 to 30,000 deaths per year. The links between radon and cancer are based largely on high-level dose-risk relationships developed from early studies of uranium miners, but the degree to which residential exposure to radon represents an actual risk of lung cancer is not known. Despite the uncertainty about the exact toll on human health, all major health organizations (e.g., the Centers for Disease Control and Prevention, the American Lung Association, and the American Medical Association) agree with estimates that radon causes thousands of preventable lung cancer deaths every year.

Radon gets into buildings from the soil, moving up through the ground into buildings through cracks in floors and walls, construction joints, gaps around service pipes, and well water. Nearly 1 out of every 15 homes in the United States is estimated to have indoor radon levels at or above EPA's current action level of 4 picocuries per liter. Typically, mitigation systems to lower radon levels cost less than $2,000. With these systems, radon levels can be lowered in virtually all homes to below 4 picocuries per liter, and in 70 percent of those homes the levels will be below 2 picocuries per liter.

EPA has taken action on many fronts to address this hazard to human health. For example, EPA has developed a program that evaluates the proficiency of contractors who conduct radon testing and those who install mitigation systems for homes and buildings. The names of proficient contractors are available through states, and 20 states have added their own certification programs for these contractors. EPA's Office of Air and Radiation has been educating the public about the dangers of radon and about ways to address it. This outreach program informs communities about how simple measures such as sealing cracks in floors and walls can help to reduce radon. With the assistance of EPA and other collaborative groups, state agencies are also coming up with innovative outreach programs. For example, in Kentucky, the state's medical history forms were amended to include a question about whether patients had tested their homes for radon. If not, a public health nurse would then explain radon risks and present a brochure on how to test a home cheaply and quickly for radon. With one simple change in a form, some 70,000 Kentucky citizens are now being reached every year.

In the 6 years of the program, EPA estimates that more than 9 million homes have been tested for radon and mitigation systems have been installed in 300,000 homes. In addition, on the basis of EPA's national school survey and discussions with states, it is estimated that about 20 percent of U.S. schools have been tested for radon.

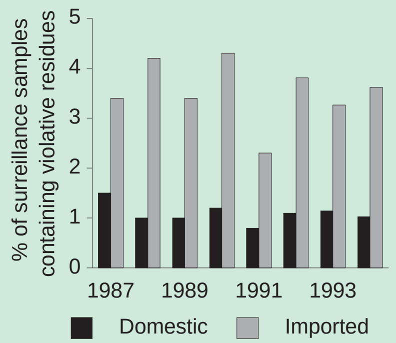
On the research front, DOE is sponsoring research at the Lawrence Berkeley Laboratory's Center for Building Science that has found ways to prevent radon from entering homes. In addition, Lawrence Berkeley Laboratory is working with the U.S. Geological Survey to develop radon concentration maps.

Environmental Tobacco Smoke. Smoking is the number one cause of lung cancer in the United States, and one of the greatest public health threats. Many government agencies are actively pursuing policies, from education campaigns to regulatory instruments, to educate the public about the health hazards of smoking and to get people to put down their cigarettes.

Tobacco smoke can also be hazardous to the health of the nonsmoker. Environmental tobacco smoke, also known as secondhand smoke, includes mainstream smoke, which is exhaled by the smoker, and sidestream smoke, which is the smoke that comes from the end of a burning cigarette, pipe, or cigar.

EPA estimates that environmental tobacco smoke is responsible for approximately 3,000 lung cancer deaths each year. EPA warns that environmental tobacco smoke can be especially harmful to children and estimates that on an annual basis it is responsible for 150,000 to 300,000 cases of lower respiratory tract infection, such as pneumonia and bronchitis, in infants and children under 18 months of age and a worsening of the condition of 200,000 to 1 million asthmatic children.

Figure 5.4 Pesticide Violations in Food Samples, 1987-1994



Source: See Part III, Table 76.

Many new laws, regulations, and ordinances restrict or ban public smoking. On the federal level, the General Services Administration imposed regulations restricting smoking to designated areas in federal office buildings. By law, smoking is prohibited on almost all domestic airline flights and, by regulation, on all interstate bus travel. In 1995, the United States entered into an international agreement banning smoking on all nonstop flights between the United States, Canada, and Australia. Currently, nearly every state has some form of legislation to protect nonsmokers; some states require private employers to enact policies that protect employees who do not smoke. In addition to state legislation, more than 560 local jurisdictions have enacted ordinances addressing nonsmokers' rights, and most are more restrictive than their state counterparts.

On August 23, 1996, President Clinton established the nation's first-ever comprehensive program to protect children from the dangers of tobacco and a lifetime of nicotine addiction with the publication of the Food and Drug Administration's final rule on tobacco and children, and with FDA's initiation of a process to require tobacco companies to educate children and adolescents — using a national multimedia campaign — about the dangers of cigarettes and smokeless tobacco.

The plan is intended to reduce tobacco use by children and adolescents by 50 percent in seven years. It builds on previous actions taken by Congress and others such as the ban on television advertising and state laws to prohibit the sale or use of tobacco by children. It follows recommendations by the American Medical Association and the National Academy of Science's Institute of Medicine. Experts have consistently recommended that the keys to achieving the goal are reducing access and limiting the appeal to children. This initiative accomplishes that objective while preserving the availability of tobacco products for adults.

CONTAMINATED FOOD AND FISH

Pesticide Residues in Food

Pesticides are used widely in agriculture in the United States. The use of pesticides has contributed to dramatic increases in yields for most major fruit and vegetable crops by controlling harmful pests. Their use has led to substantial improvements over the past 40 years in the quantity and variety of the U.S. diet and thus in the health of the public. The use of pesticides can also reduce spoilage and health risks from biological contaminants. In general, pesticide residues in food have remained at low levels for many years. In 1994, only about 1 percent of domestic food samples (55 out of 5,366 samples) contained illegal pesticide residues that exceeded established tolerance levels. In imported food samples, the frequency was 3.6 percent (197 out of 5,488 samples). In 1987, 1.5 percent of domestic samples and 3.4 percent of imported samples exceeded tolerance levels (Figure 5.4).

However, many pesticides are harmful to the environment and may negatively affect human health. Historically, EPA has regulated pesticides under two major federal statutes: the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and the Federal Food, Drug, and Cosmetic Act (FFDCA). FIFRA prohibits the sale or use of pesticides not registered by EPA for use in the United States and prescribes labeling and other regulatory requirements to prevent unreasonable adverse effects on health or the environment. Under FFDCA, EPA establishes tolerances (maximum legally permissible levels) for pesticide residues in food. Tolerances are enforced by the Department of Health and Human Services' Food and Drug Administration for most foods and by the U.S. Department of Agriculture's Food Safety and Inspection Service for meat, poultry, and some egg products.

For over two decades, there have been efforts to update and resolve inconsistencies in the two major pesticide statutes, but consensus on necessary reforms has been elusive. In 1993, the Administration published a "Pesticide Reform Agenda" with proposals for reform. In August 1996, Congress unanimously passed and President Clinton signed a landmark pesticide food safety bill, the Food Quality Protection Act of 1996, which incorporated these proposals, to better protect people from food contamination. The act represents a major breakthrough, amending both FIFRA and FFDCA to establish a more consistent, protective regulatory scheme, grounded in sound science. It mandates a single, health-based standard for all pesticides in all foods; provides special protection for infants and children; expedites approval of safer pesticides; creates incentives for the development and maintenance of effective crop protection tools for American farmers; and requires periodic reevaluation of pesticide registrations and tolerances to ensure that the scientific data supporting pesticide registrations will remain up to date.

A significant provision of the Food Quality Protection Act is that it substitutes a single strong health-based limitation on risks presented by pesticides in food for the inconsistent standards in the Delaney clause. The Delaney clause, contained in the section on food additives of the FFDCA, states that no additive will "be deemed safe if it is found to induce cancer when ingested by man or animal" and directs EPA not to approve such food additives. Its language was interpreted to mean a "zero risk" standard for any cancer-causing food additive, including residues from pesticides found in processed foods. However, on raw foods the law requires that EPA use a negligible risk standard, in the belief that if the cancer risk is outweighed by several factors such as the ability of the pesticide to help in the production of an adequate, wholesome, and economical food supply, the safe use of the pesticide is warranted. Thus, the Delaney clause presented regulators with the problem of conflicting standards for pesticides in raw versus processed foods. The application of the Delaney clause criteria limited the introduction of lower-risk pesticides that could replace older and potentially more hazardous compounds. Furthermore, the Delaney clause approach was unduly narrow, because it singled out one health endpoint—cancer—and did not cover substances causing birth defects, nerve damage, or immune system failures.

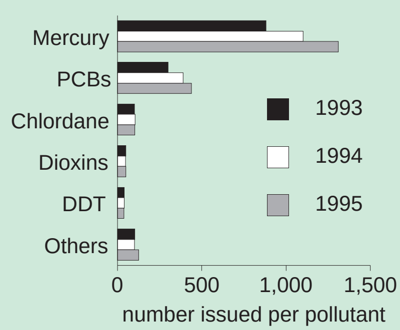
These "paradoxes" now no longer exist for pesticides in food. A new standard that requires that all tolerances be safe, in both raw and processed foods, is now used. Safety is defined as "a reasonable certainty that no harm will result from aggregate exposure," and the requirement applies to both raw and processed food, not just for cancer risks, but for all risks. This revision will allow EPA and others to address any risks presented by food as it is consumed as well as to devote resources that had been consumed by Delaney-related activities to higher- priority public health and environmental protection activities, including mandates secured in the Food Quality Protection Act of 1996: protecting children and other sensitive subpopulations, implementing Consumer Right-to-Know provisions regarding pesticide risks, and evaluating and reducing risks from pesticides that may be endocrine disruptors.

Contaminated Fish

Last year, 46 contaminants, from dioxin to chlordane, were found in fish. The number of lakes, rivers, and other U.S. waterways where consumers have been advised to avoid or limit consumption of trout, salmon, or other species because of chemical contamination rose from 1,278 in 1993 to 1,740 in 1995 (Figure 5.5).

While EPA provides guidance on levels of contamination, primary responsibility for protecting residents from the health risks of consuming noncommercial contaminated fish and wildlife lies with the states, the District of Columbia, and the four U.S. territories. They issue consumption advisories to the public when high concentrations of chemical contaminants have been found in local wildlife and freshwater fish. A complete database of these advisories—the Nation-

Figure 5.5 Contaminated Fish Advisories, 1993-1995



Source: U.S. Environmental Protection Agency (EPA), *Update: National Listing of Fish and Wildlife Consumption Advisories* (EPA, Office of Water, 1996).

al Listing of Fish and Wildlife Consumption Advisories—is maintained by EPA's Office of Water to help water quality officials and the public identify where fish contamination is a concern. The database contains information on the types of advisories and bans in effect (e.g., whether the advisory applies to the population in general or only to sensitive subpopulations such as pregnant women and children), the species and size range of piscivorous (fish-eating) fish in the wild, the chemical contaminant identified in the advisory (e.g., mercury, PCBs, chlordane, dioxins, or DDT), the geographic location and area covered by each advisory, and the date the advisory was issued.

The database is designed primarily to help federal, state, and local government agencies and Native American tribes assess the potential for human health risks associated with the consumption of chemical contaminants in noncommercial fish and wildlife. The increase in advisories issued between 1993 and 1995 reflects an increase in the number of assessments of the levels of chemical contaminants in fish and wildlife tissues. These additional assessments were conducted as a result of increased awareness of health risks associated with the consumption of chemically contaminated wildlife and freshwater fish. The number of advisories decreases if states determine that the monitored concentrations of chemical contaminants in wildlife or freshwater fish tissues have decreased and no longer pose a risk to human health.

Mercury, PCBs, chlordane, dioxins, and DDT were responsible for almost 95 percent of all fish consumption advisories in effect in 1995. In 463 cases, the advisories recommended that everyone avoid eating a certain species of fish; in 1,393 instances, children, pregnant women, or other vulnerable groups were warned to restrict or eliminate their freshwater fish consumption.

For commercial fish, EPA and FDA also set limits for levels of chemical contamination to protect human health.

Case Study: The Dioxin Reassessment

Since the early 1970s, dioxins have often been referred to as one of the most toxic groups of chemical compounds known. Dioxins are inadvertently created through a number of activities, including combustion, certain types of chemical manufacture, chlorine bleaching of pulp and paper, and other industrial processes. The main pathway for exposure to humans is via airborne emissions of dioxin that settle on plants and are passed on and accumulated through the food chain. While dioxin is produced in very small quantities in comparison with other pollutants (equivalent to around 30 pounds of the most toxic member of the class annually), its high toxicity and properties of bioaccumulation and persistence in the environment have led EPA to treat dioxin as a major public health threat. EPA first took action against dioxin regarding the herbicide 2,4,5-T in 1979 and since then has expanded its dioxin control efforts to each of its major programs.

In 1985, EPA published a scientific review of the health effects of 2,3,7,8-

TCDD, the most toxic of the dioxin family of compounds. In the 1985 assessment, EPA concluded that dioxin is a proven animal carcinogen and a probable human carcinogen and began using that assessment as the scientific basis for dioxin risk estimates for all EPA programs. In 1988, EPA prepared a draft reassessment, as well as a draft exposure document that presented procedures for conducting site-specific exposure assessments. However, questions about the scientific methodology, dioxin's toxicity, and possible health effects remained.

In 1991, EPA announced that it would conduct a scientific reassessment of the health risks of exposure to dioxin and dioxinlike compounds, drawing on significant advances in the scientific understanding of mechanisms of dioxin toxicity, new studies of dioxin's carcinogenic potential in humans, and increased evidence of other adverse health effects. In September 1994, EPA released its final "public review draft" of the dioxin reassessment. The dioxin reassessment breaks new ground—not only by providing policymakers with the most comprehensive assessment of dioxin to date, but also by establishing a new, participatory model of how a risk assessment should be conducted.

The dioxin reassessment process is noteworthy for several reasons. First, EPA has worked to make each phase of the dioxin reassessment an open and participatory process. More than 100 scientists from academia, government, and industry have collaborated throughout the reassessment process by providing data, writing chapters, and reviewing drafts. In addition, EPA has held several public meetings to gather comments on progress, and it published earlier drafts for public comment and review. Second, unlike the 1985 report, which considered only the compound 2,3,7,8-TCDD, the 1994 draft report also investigates the health impacts of dioxin-related compounds. Thus, other chemicals that behave like dioxins (i.e., chemicals that have a similar structure to dioxin and bind to a cellular protein called the "Ah receptor") were also considered in the 1994 report.

Third, the 1994 draft report is also unique in that it attempted to provide a comprehensive inventory of emission sources. It found that waste combustion accounts for a large percentage of all known emissions, yet acknowledged the likelihood that there are a number of unidentified sources of dioxin in the United States. The sources of dioxin are still under review, and EPA is still in the process of collecting additional information and data about sources and emission levels.

Finally, unlike the 1985 report, which focused exclusively on cancer risks, the 1994 draft report evaluates dioxin's noncancer effects as well. These effects may include developmental and reproductive effects, immune suppression, and disruption of hormones that regulate normal biological functions. In addition, the reassessment reaffirmed with greater confidence that dioxin is a proven animal carcinogen and a probable human carcinogen.

Until the final report is released in 1997, EPA's efforts to control dioxin risks will not change. Indeed, during the reassessment process, efforts to implement dioxin control programs have continued. In December 1995, EPA Administrator Carol Browner announced promulgation of air standards for new and existing municipal waste combustors. The rule specifies technology-based performance standards, which would reduce dioxin and other organic chemical emissions by 95 to 99 percent from a number of existing municipal waste combustors and all new plants. In addition, EPA has proposed similar regulations for medical waste incinerators. EPA has continued to administer programs to limit dioxin contamination of U.S. waters by developing technology-based effluent limitation guidelines for pulp and paper mills, by developing ambient water quality criteria guidance, and by prohibiting the discharge of dredged material that is contaminated with dioxin in violation of state water quality standards. The Safe Drinking Water Program, the Superfund Program, and the Pesticides and Toxic Chemicals Program also all have active pollution prevention and control programs for dioxins and furans. Once the final report is released, EPA will begin an extensive review of policies developed to manage dioxin risks, again relying heavily on early public input into the policy evaluation process.

EMERGING CHALLENGES

The Endocrine Disruptor Debate

There have been many reports that domestic animals and wildlife have suffered adverse reproductive and other health effects from exposure to environmental chemicals that interact with the endocrine system, often called endocrine disruptors or environmental hormones. These problems have primarily been identified in animals and humans exposed to relatively high levels of certain organic chemicals. Whether similar effects are occurring in the general human or wildlife populations from ambient environmental levels is currently unknown.

While many uncertainties exist regarding the effects that environmental hormones have on humans and animals, the issue must be taken seriously. Hormones play a major role in the functioning of all organ systems, and small disturbances in endocrine function in laboratory animals, at critical stages of development, have been shown to produce profound and lasting effects. In addition, people are exposed to a complex mixture of many natural and synthetic compounds, which may have synergistic effects. Further, some chemicals that have been identified as endocrine disruptors, such as PCBs, persist in the environment for a long time.

Most of the effects associated with exposure to endocrine-disrupting chemicals, such as reproductive dysfunction and sexual abnormalities, have been observed in wildlife populations receiving relatively high levels of exposure consisting mainly of persistent chlorinated compounds, such as DDT. Examples include reproductive problems in wood ducks from Bayou Meto, Arkansas; embryonic deformities in Great Lakes fish-eating birds; feminization and demasculinization in gulls; developmental effects in Great Lakes snapping turtles; and developmental dysfunction in lake trout in the Great Lakes. In each case, detectable concentrations of chemicals with known endocrine-disrupting effects have been reported in the animals or their environment, but a cause-and-effect link has been established for only a few of these observations.

For human populations, some studies have suggested that endocrine-disrupting chemicals may be responsible for reported increases in certain cancers and adverse reproductive effects. The hypothesis that endocrine disruptors can cause cancer in humans is based largely on the clear association between exposure of pregnant women to diethylstilbestrol (DES), a drug taken to avoid miscarriage, and reproductive organ cancers in their daughters. In addition, cancer trend data for the 1973–91 period show increases in the incidence of some cancers associated with hormones (female breast, 24 percent; testicular, 41 percent; prostate, 126 percent). So far, because there are insufficient supporting data, the linkage between the incidence of human cancers and an endocrine (hormonal) disruption mechanism remains a working hypothesis. Most of these increases in incidence may be attributed to improvements in detection and early diagnosis, or other factors. In the case of breast cancer, for example, epidemiological studies have determined a variety of risk factors, such as oral contraceptives, estrogen replacement therapy, family history, smoking, and alcohol use.

There have been documented cases of reproductive problems in humans exposed accidentally to high doses of endocrine-disrupting chemicals as well as reports of declines in the quality and quantity of sperm production in humans over the last four decades. Several studies, such as a 1992 study by Carlsen *et al.* and a 1995 study by Auger *et al.*, have provided evidence that there have been declines in sperm count in their selected populations. However, other studies, such Suominen and Vierula's review of several studies published between 1958 and 1992, and clinical studies by Fisch *et al.* and Paulsen *et al.*, have concluded that there were no decreases in sperm count or semen volume. Thus, while there may be reductions in some specific locations, more research is needed concerning potential reductions in sperm production in the general population.

While there is much scientific uncertainty and debate about this issue, there is resounding agreement that additional data and research are needed. The public and private sectors have recognized this need and have established research programs. Several federal agencies are currently engaged in a wide range of research activities relating to endocrine disruptors, which include studies of exposure and effects, as well as the mechanisms of endocrine-disrupting chemicals. The National Science and Technology Council's Committee on Environmental and Natural Resources identified this issue as an initiative in November 1995, and has established an interagency working group of scientists to identify research needs related to the health and ecological effects of endocrine-disrupting chemicals and to develop an interagency research plan. The National Academy of Sciences is also conducting an assessment. The Environmental Protection Agency has recently completed an agencywide draft on the state of the science entitled "Environmental Endocrine Disruption: An Effects Assessment and Analysis Document," which has been submitted to the Risk Assessment Forum and the Science Policy Council for approval. EPA is also forming a committee (the Endocrine Disruptor Screening and Testing Advisory Committee) to advise the agency on the development of a strategy for screening and testing chemicals and pesticides for their potential to disrupt the endocrine system. These efforts, and others, will lead the way to a better understanding of endocrine disruptors and their potential impacts and ultimately will provide the tools needed to make informed policy decisions about this issue.

Ozone and Climate Change

Ozone. In 1994, the World Meteorological Organization (WMO) in collaboration with the National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA), and the United Nations Environment Programme (UNEP) released its scientific assessment of ozone depletion. The report, *Scientific Assessment of Ozone Depletion: 1994*, includes a review of potential health impacts from stratospheric ozone depletion.

The assessment reports that the accumulation of certain human-made gases in the upper atmosphere or stratosphere—from the widespread use of various halocarbons for refrigeration, insulated packaging, and in industry and agriculture—has resulted in a sustained decline in stratospheric ozone concentrations. The major consequence of this stratospheric ozone depletion is reduced shielding of Earth's surface against incoming solar ultraviolet radiation; thus, a continuing depletion of stratospheric ozone would increase the amount of ultraviolet radiation that reaches Earth's surface. These increases would be experienced, mostly, in the middle and high latitudes, where the majority of the global population is concentrated. Indeed, United Nations projections indicate that as ozone depletion reaches its peak before the year 2000, mid-latitudes in the Northern Hemisphere may experience a 15 percent increase in UV-B exposure during winter and spring. The assessment found that UV-B radiation increased by 2 percent for every 1 percent decrease in the ozone layer.

Although the amount of UV-B striking Earth's surface can vary routinely by as much as 20 percent, scientists have warned that if the current trend were to continue, radiation would reach levels high enough to increase the incidence of skin cancer and cataracts in humans. The assessment, assuming no change in exposure patterns in the general population, projected that a sustained 10 to 15 percent depletion of stratospheric ozone over several decades could result in an estimated 15 to 20 percent increase in the incidence of skin cancer in fair-skinned populations. Solar ultraviolet light is an important cause of squamous-cell carcinoma of the eye. Increased UV-B radiation can also interfere with the body's immune system; this constitutes one of the most potentially dangerous effects of UV-B because of the possibility that immunity to infectious diseases may be compromised.

Climate Change. As discussed in Chapter 12, "Climate Change," the international scientific community, represented by the 2,500 scientists of the Intergovernmental Panel on Climate Change (IPCC), reported in its latest assessment in 1995 that human activities are having a discernible influence on global climate. The models used by the IPCC predict an increase in average global temperature of about 1^{o} to 3.5^{o} C (1.4^{o} to 6.3^{o} F) by 2100. A change of this magnitude will likely produce alterations both in physical systems (e.g., higher temperatures, heavier rainfall, and rising sea level) and in ecosystems (e.g., forests, agriculture, marine ecologies, and the habitats of various insects and animals), with profound implications for human health.

In its chapter on human health, the IPCC reports that climate change, by altering local weather patterns and by disturbing life-supporting natural systems and processes, may affect the health of human populations and that adverse effects are likely to outweigh beneficial effects. The range of health effects would be diverse, often unpredictable in magnitude, and sometimes slow to emerge. Researchers believe that both direct risks (e.g., death in heat waves or floods) and indirect risks (e.g., changes in food production or the distribution and incidence of vector-borne diseases) to human health will emerge.

Estimating health impacts of climate change is still a relatively new field of scientific study, and it remains controversial. There are inevitable, multiple uncertainties involved in trying to project potential health impacts in relation to future scenarios of climate change. In addition, actual health impacts will vary dramatically by region depending on environmental circumstances, the existing health infrastructure, social and economic resources, and the baseline health status of the population. Many of the anticipated adverse health impacts of climate change are expected in the world's less-developed regions; in many of those countries, there already exists a high prevalence of undernutrition, chronic exposure to infectious disease agents, and inadequate access to social and physical infrastructure. Nevertheless, human health in the United States may be adversely affected in several ways: by an increase in heat-related mortality, especially in urban areas; by an increase in the frequency and severity of extreme weather events such as flooding; and by an increase in the potential for the spread of diseases such as malaria, dengue, cholera, and salmonellosis. In addition, demographic trends including population aging and increasing levels of disability, chronic illness, and coastal retirement may increase the vulnerability of the U.S. population to adverse health impacts related to climate change.

Table 5.2

Total Summer Heat-related Deaths in Selected Cities: Current Mortality and Estimates of Future Mortality Under the GFDL89 Climate Change Scenario

		GFDL89 climate change scenario			
		Year 2020		Year 2050	
City	Present mortality[1]	No acclimatization	Acclimatized population	No acclimatization	Acclimatized population
	average number of summer-season heat-related deaths				
United States					
Atlanta	78	191	96	293	147
Dallas	19	35	28	782	618
Detroit	118	264	131	419	209
Los Angeles	84	205	102	350	174
New York	320	356	190	879	494
Philadelphia	145	190	142	474	354
San Francisco	27	49	40	104	85
Canada					
Montreal	69	121	61	245	124
Toronto	19	36	0	86	1
China					
Shanghai	418	1,104	833	2,950	1,033
Egypt					
Cairo	281	476	na	830	na

Source: A.H. McMichael, A.Haines, R.Sloof and S, Kovats, eds. *Climate Change and Human Health*, p. 57 (World Health Organization and United Nations Environment Program, Geneva, 1996).

Notes: [1]raw mortality data. na=not applicable.

Cases of heat-stress mortality, particularly in vulnerable individuals such as the very young and the very old, could increase because of climate change. Recent analyses of concurrent meteorological and mortality data in cities in the United States, Canada, the Netherlands, China, and the Middle East show that overall death rates rise during heat waves, particularly when the temperature and humidity rise above the local population's threshold value. One model suggests that the annual number of heat-related deaths would approximately double by 2020 and would increase severalfold by 2050. For a city like Atlanta, Georgia, that could increase the number of heat-related deaths from the current average of about 80 each summer to nearly 200 in 2020 and closer to 300 in 2050 (see Table 5.2). These estimates are based on myriad assumptions and involve a large amount of uncertainty. Nevertheless, in very large cities with populations sensitive to heat stress, climate change could cause significant increases in extra heat-related deaths annually.

Climate change will also likely increase the frequency and severity of some extreme weather events such as flooding. Flash flooding is currently a leading cause of weather-related mortality in the United States. In addition to direct deaths from drowning and other accidents, flooding could also facilitate the spread of infectious diseases by damaging homes and displacing residents, as well as contaminating water sources with fecal material or toxic chemicals. Weather-related disasters often overwhelm local public health facilities and water and sanitation infrastructure, further affecting human health.

A third area in which climate change can affect human health in the United States is by changing the distribution of disease vectors. Infectious agents and their vector organisms are sensitive to factors such as temperature, surface water, humidity, wind, soil moisture, and changes in forest distribution. Net climate-change-related increases in the geographic distribution (altitude and latitude) of the vector organisms of infectious diseases (e.g., malarial mosquitos, schistosome-spreading snails) and changes in the life-cycle dynamics of both vector and infective parasites would, in aggregate, increase the potential transmission of many vector-borne diseases. Malaria, a mosquito-borne disease that currently afflicts an estimated 1 in 20 people in the world, provides an apt example. Models reported on by the IPCC suggest that with the predicted climate change, the proportion of the world's population living within the potential malaria transmission zone could increase from around 45 to around 60 percent by the latter half of the next century. Although this predicted increase in potential transmission encroaches mostly into temperate regions, actual climate-related increases in malaria incidence would occur primarily in tropical, subtropical, and less well protected temperate zone populations currently at the margins of endemically infected areas.

Addressing the Issues. The United States has been an active participant in both the Montreal Protocol and the Climate Convention. On December 31, 1995, the industrialized nations of the world officially ended their production of ozone-depleting chlorofluorocarbons (CFCs), except for a few essential uses. The U.S. role in this effort and the Administration's continued work toward reducing greenhouse gas emissions are discussed in detail in Chapter 11, "Stratospheric Ozone" and Chapter 12, "Climate Change."

On the health side, the Administration is working closely with the scientific community to further investigate the links between ozone depletion and climate change and human health. The development of advanced remote sensing and GIS technologies will help in facilitating large-scale data collection and analysis.

REFERENCES

Auger, J., *et al*., "Decline in Semen Quality Among Fertile Men in Paris During the Past 20 Years," *New England Journal of Medicine*, Vol. 332 (1995), pp. 281–285.

Browner, Carol M., "Environmental Tobacco Smoke: EPA's Report," EPA 175-N-93-027, *EPA Journal* (Fall 1993).

Carlsen, E., et al., "Evidence for Decreasing Quality of Semen During Past Fifty Years," *British Medical Journal*, Vol. 304 (1992), pp. 609–613.

Center for the Study of Environmental Endocrine Effects, "Environmental Endocrine Effects: An Overview of the State of Scientific Knowledge and Uncertainties," discussion draft (Center for the Study of Environmental Endocrine Effects, Washington, DC, September 1995).

Colburn, Theo, Dianne Dumanoski, and John Peterson Myers, *Our Stolen Future: Are We Threatening Our Fertility, Intelligence, and Survival - A Scientific Detective Story* (Dutton, New York, 1996).

Cushman, John, Jr., "E.P.A. Plans Radical Change in Calculation of Cancer Risk," *The New York Times*, April 16, 1996, pp. A1, A18.

"Dioxins and Dioxin-like Chemicals," *Environmental Health Monthly*, Vol. 7, No. 6 (March 1995).

Dockery, Douglas W., *et al.*, "An Association Between Air Pollution and Mortality in Six U.S. Cities," *The New England Journal of Medicine*, Vol. 329, No. 24 (December 1993), pp. 1753–1759.

Farland, William H., "EPA's Scientific Reassessment of Dioxin," *Health and Environment Digest*, Vol. 5, No. 12 (March 1992).

Fisch, H., *et al*., "Semen Analyses in 1,238 Men from the United States over a 25-Year Period: No Decline in Fertility," *Fertility and Sterility*, Vol. 65 (1996), pp. 1009–1014.

Folinsbee, Lawrence J., "Human Health Effects of Air Pollution," *Environmental Health Perspectives*, Vol. 100 (1992), pp. 45–56.

Food and Drug Administration (FDA), *Pesticide Program Residue Monitoring 1994* (FDA, Washington, DC, 1994).

Hileman, Bette, "Health Effects of Electromagnetic Fields Remain Unresolved," *Chemical and Engineering News* (November 8, 1993).

Institute of Medicine, *Emerging Infections: Microbial Threats to Health in the United States* (National Academy Press, Washington, DC, 1992).

Intergovernmental Panel on Climate Change, *Climate Change 1995: Impacts, Adaptations, and Mitigation Summary for Policy Makers, Contribution of Working Group II to the Second Assessment Report* (Intergovernmental Panel on Climate Change, Washington, DC, 1995).

Kavlock, R.J., et al., "Research Needs for the Risk Assessment of Health and Environmental Effects of Endocrine Disruptors: A Report of the U.S. EPA-sponsored Workshop," *Environmental Health Perspectives*, Vol. 104, Supplement 4 (1996).

Lee, Gary, "Clean Air Regulations Are Paying Off, EPA Says," *The Washington Post* (June 10, 1996), p. A17.

Lee, Gary, "Hospitalizations Tied to Ozone Pollution," *The Washington Post* (June 21, 1996), p. A3.

McMichael, A.J., A. Hains, R. Sloof, and S. Kovats, eds., *Climate Change and Human Health* (World Health Organization, World Meteorological Organization, and United Nations Environment Programme, Geneva, 1996).

National Research Council, *The Epidemiological Transition: Policy and Planning Implications for Developing Countries* (National Academy Press, Washington, DC, 1993).

National Research Council, *Measuring Lead Exposure in Infants, Children, and Other Sensitive Populations* (National Academy Press, Washington, DC, 1993).

National Research Council, *Pesticides in the Diets of Infants and Children* (National Academy Press, Washington, DC, 1993).

National Science and Technology Council and Institute of Medicine, *Conference on Human Health and Global Climate Change: Summary of the Proceedings* (National Academy Press, Washington, DC, 1996).

Natural Resources Defense Council, *Breathtaking: Premature Mortality due to Particulate Air Pollution in 239 American Cities* (Natural Resources Defense Council, New York, May 1996).

Nichols, Mary, "Lessons from Radon," EPA 175-N-93-027, *EPA Journal* (Fall 1993).

Office of Technology Assessment, *Identifying and Controlling Immunotoxic Substances: Background Paper* (Office of Technology Assessment, Washington, DC, 1991).

Office of Technology Assessment, *Researching Health Risks* (Office of Technology Assessment, Washington, DC, 1993).

Ozone ACTION, "Human Health Effects: Ozone Depletion and Climate Change," Fact Sheet (Ozone ACTION, Washington, DC, 1996).

Patz, Jonathan A., *et al*., "Global Climate Change and Emerging Infectious Diseases," *Journal of the American Medical Association*, Vol. 275, No. 3 (January 17, 1996), pp. 217–223.

Paulsen, C.A., N.G. Berman, and C. Wang, "Data from Men in Greater Seattle Area Reveals No Downward Trend in Semen Quality: Further Evidence That Deterioration of Semen Quality Is Not Geographically Uniform," *Fertility and Sterility*, Vol. 65 (1996), pp. 1015–1020.

Physicians for Social Responsibility and Environmental Defense Fund, *Putting the Lid on Dioxins: Protecting Human Health and the Environment* (PSR and EDF, Washington, DC, 1994).

Pope, Andrew, "Indoor Allergens: A Report," EPA 175-N-93-027, *EPA Journal* (Fall 1993).

Pope, C. Arden, III, et al., "Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults," *American Journal of Respiratory Critical Care Medicine*, Vol. 151 (1995), pp. 669–674.

The President's Council on Sustainable Development, *Sustainable America: A New Consensus for Prosperity, Opportunity, and a Healthy Environment for the Future* (Government Printing Office, Washington, DC, 1996).

Sexton, Ken, "An Inside Look at Air Pollution," EPA 175-N-93-027 EPA *Journal* (Fall 1993).

Sexton, Ken, "Science and Policy in Regulatory Decision Making: Getting the Facts Right About Hazardous Air Pollutants," *Environmental Health Perspectives*, Vol. 103, Supplement 6 (1995), pp. 213–222.

Suominen, J., and M. Vierula, "Semen Quality of Finnish Men," *British Medical Journal*, Vol. 306 (1993), p. 1579.

U.S. Department of Agriculture (USDA), *Water Quality*, NRCS/RCA Issue Brief 9 (USDA, Natural Resources Conservation Service, Washington, DC, March 1996).

U.S. Department of Commerce, "We Asked . . . You Told Us: Source of Water and Sewage Disposal," Census Questionnaire Content, 1990 CQC–28 (Department of Commerce, Washington, DC, February 1995).

U.S. Department of Health and Human Services, *Healthy People 2000 Review* (Department of Health and Human Services, Washington, DC, 1994).

U.S. Environmental Protection Agency (EPA), *Air Quality Trends*, EPA-454/F-95-003 (EPA, Washington, DC, September 1995).

U.S. Environmental Protection Agency (EPA), *Environmental Indicators of Water Quality in the United States*, EPA 841-R-96-002 (EPA, Office of Water Washington, DC, June 1996).

U.S. Environmental Protection Agency (EPA), "EPA's On-Going Regulatory Program," Dioxin Facts (EPA, Office of Communications, Education, and Public Affairs, Washington, DC, September 1994).

U.S. Environmental Protection Agency (EPA), "For Your Information: Major Issues in the Food Quality Protection Act of 1996," FYI Brief (EPA, Office of Prevention, Pesticides, and Toxic Substances, Washington, DC, August 1996).

U.S. Environmental Protection Agency (EPA), "For Your Information: The Food Quality Protection Act of 1996," FYI Brief (EPA, Office of Prevention, Pesticides, and Toxic Substances, Washington, DC, August 1996).

U.S. Environmental Protection Agency (EPA), *National Drinking Water Program Redirection Strategy* (EPA, Washington, DC, June 1996).

U.S. Environmental Protection Agency (EPA), "The Reassessment Process," Dioxin Facts (EPA, Office of Communications, Education, and Public Affairs, Washington, DC, September 1994).

U.S. Environmental Protection Agency (EPA), "The Safe Drinking Water Act Amendments of 1996: Strengthening Protection for America's Drinking Water," draft paper (EPA, Office of Water, Washington, DC, August 1996).

U.S. Environmental Protection Agency (EPA), *Science Advisory Board Report: Safe Drinking Water, Future Trends and Challenges*, EPASAB-DWC-95002 (EPA, Washington, DC, 1995).

U.S. Environmental Protection Agency (EPA), "Scientific Highlights from Draft Reassessment," Dioxin Facts (EPA, Office of Communications, Education, and Public Affairs, Washington, DC, September 1994).

U.S. Environmental Protection Agency (EPA), "Statement of Lynn Goldman, M.D., Assistant Administrator for Prevention, Pesticides, and Toxics: September 13, 1994," press release (EPA, Office of Communications, Education, and Public Affairs, Washington, DC, September 1994).

U.S. Environmental Protection Agency (EPA), *Update: National Listing of Fish and Wildlife Consumption Advisories*, Fact Sheet, EPA-823-F-96-006 (EPA, Office of Water, Washington, DC, June 1996).

U.S. Environmental Protection Agency (EPA), *Watershed Protection: A Statewide Approach* (EPA, Office of Water, Washington, DC, March 1996).

U.S. Environmental Protection Agency (EPA), "White Paper," *Strengthening the Safety of Our Drinking Water: A Report on Progress and Challenges and an Agenda for Action* (EPA, Washington, DC, March 1995).

Vogt, Donna U., *The Delaney Clause Effects on Pesticide Policy*, Congressional Research Service Report for Congress 95-514 SPR (Congressional Research Service, Washington, DC, 1995).

The World Commission on Environment and Development (The Brundtland Commission), *Our Common Future* (Oxford University Press, Oxford, 1987).

World Meteorological Organization (WMO) in collaboration with the National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA), and the United Nations Environment Programme (UNEP), *Scientifc Assessment of Ozone Depletion: 1994,* Global Ozone Research and Monitoring Project - Report No. 37 (WMO, NOAA, NASA, UNEP, Geneva, 1995).

World Resources Institute in collaboration with the United Nations Environment Programme, the United Nations Development Programme, and the World Bank, *World Resources 1996–97* (Oxford University Press, New York, 1996).