Air Quality

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Key Concepts

- Air quality is important because of continuous exposure through normal breathing functions.
- Poor air quality causes possible adverse health effects—from mild to severe, and from temporary to long term—to humans, animals, plants, and ecosystems.
- Community environmental consequences result from poor air quality, e.g., acid rain, smog, and odor problems.
- Six pollutants are measured by the United States Environmental Protection Agency to regulate air quality at the local level.
- Cars, trucks, and other mobile sources are regulated by their tailpipe emissions.
- Many toxic air pollutant releases are regulated at the source (e.g., factory, farm, etc.).
- Regional weather patterns can move air pollution to even remote areas.
- A variety of chemical (e.g., cleaners, smoke, gases) and biological (e.g., molds, fungus spores, dander) pollutants may affect indoor air quality.
- Overall air quality is key to a healthy community, i.e., pollution prevention, technical assistance, community planning.
- Local boards of health aid in state and federal monitoring efforts.
- Local boards of health issue air pollution advisories.
- Local boards of health have input into issuing permits and making site decisions.
- Local boards of health focus programs and policies on prevention and control.
- Local boards of health provide advice to homeowners, schools, and others on indoor air quality.

Introduction

We breathe air every minute of every day. Breathing is a continuous route of exposure to potential health stressors. Compared with other environmental media, such as water and food, individuals have far less control over the quality of the air they breathe. The continuous exposure, lack of control, and possible negative health outcomes from exposure to poor quality air makes air quality an important environmental health concern.

Air quality issues can be regulated, monitored, and enforced at the local, state, and/or federal levels. Local boards of health and health departments may be involved in efforts to achieve federal air quality standards or in the implementation of state plans for meeting

federal requirements, which could include the monitoring, enforcement, and administration of air quality management plans. This level of involvement is often the case for health departments in and around metropolitan areas, where federally targeted air pollution issues are a problem. In addition, boards of health and health departments can proactively identify and address specific concerns within their jurisdictions. Some local agencies are aggressively involved in issues such as radon in the home, odor management, and indoor air quality problems subsequent to flooding.

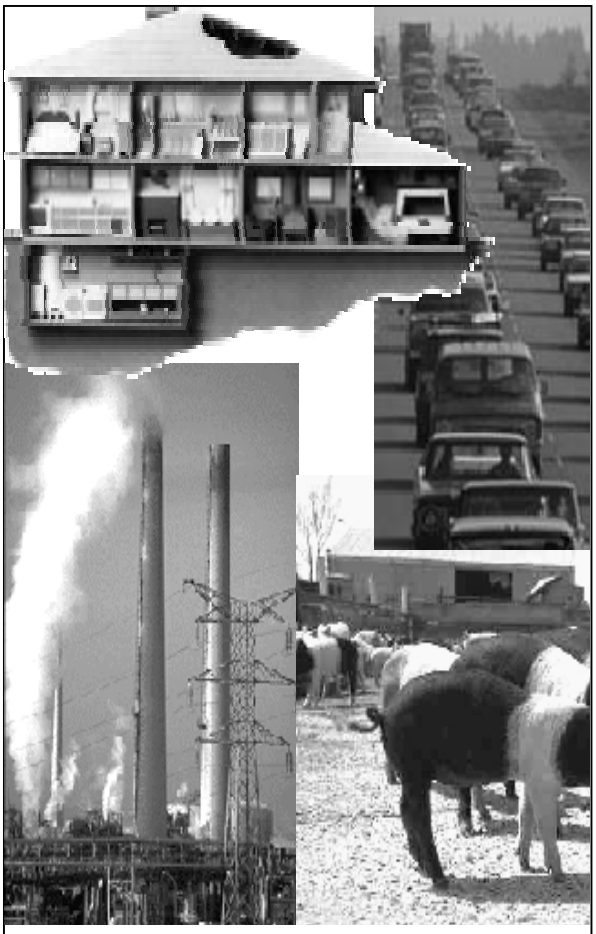

FIGURE 1. A wide range of air pollution issues can face local agencies.

In the past, citizens in rural areas rarely needed to address the air quality issues emphasized by federal or state programs. Today, however, they may have to address a specific source of pollution in their area or address air quality nuisance complaints, such as odor or visibility issues. In addition, the long-range transport of some pollutants and the proliferation of automobiles have brought air pollution from these sources to remote areas. Local agencies everywhere have to face a range of air quality issues, including emissions from factories, vehicles, and agriculture, and air quality in homes (Figure 1).

Air quality is characterized by identifying the pollutants that are present in the air, the levels or concentrations of those pollutants, and the period of time that the concentrations last. Local boards of health need to have a general understanding of how air pollution sources, weather, and mechanisms of dispersion work together to affect air quality. They also need to understand the different approaches to controlling air pollution, technology, and policy efforts. Understanding how these factors interact will enable boards of health to appropriately address air quality issues, whether they are linked to state and federal regulations or arise from unique situations within the jurisdiction of the board.

This chapter looks at two general realms of air quality: outdoor air, sometimes called **ambient air quality** and indoor air quality (IAQ).

Outdoor Air Quality

Figure 2 illustrates the components that interact in determining air quality. Sources emit pollutants into the air. These sources can be **stationary** (e.g., a factory) or **mobile** (e.g., vehicles). Combustion processes, such as steam production, coal fire, electricity generation, and process boilers, are major contributors to stationary sources of air pollution emissions. Mobile sources of air pollution, such as internal combustion engines and fuels used by automobiles and trucks, contribute up to 50% of the pollution that results in **smog** and 90% of the carbon monoxide in urban areas. Although automobiles built today are 60% to 80% less polluting than those made in the 1960s, the increase in the total number of vehicles diminishes the benefit of improved technology.

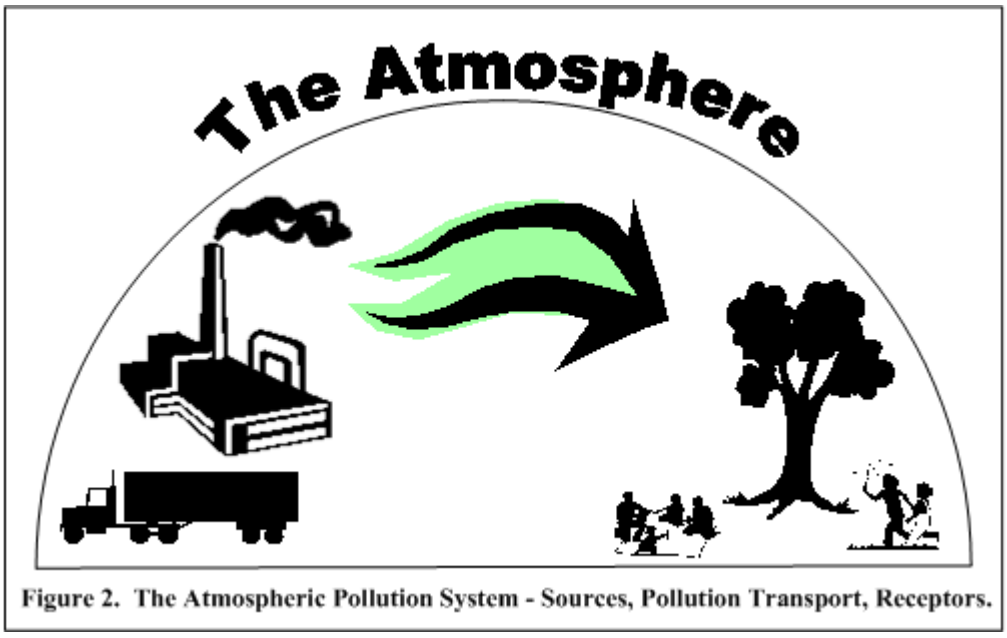

Figure 2. The Atmospheric Pollution System - Sources, Pollution Transport, Receptors.

In addition to being classified as stationary or mobile, sources of pollution can be described as **point sources** or **area sources**. Pollution from a specific location, such as a smoke stack, is called point source because the pollution can be traced to a specific site. Area sources have a less distinct point of release. A refinery is an example of an area source because the combination of many points of pollutant release, some quite small, contributes to the overall emissions from a refinery. Identifying each individual release point would be extremely difficult, so the entire complex is often considered an area source. Waste lagoons at animal production facilities are another example of area sources. The entire surface of a lagoon emits pollution. The amount of pollutants that are emitted over time is the basis for the permits and the characterization of sources. Local agencies may be involved in issuing

permits for sources, allowing a certain level of emissions, and making sure that those permitted levels are not exceeded.

The concentration of pollution is very high close to the point of release. Once emitted into the atmosphere, weather and other factors dilute the pollution and transport it to other regions. The transported air pollution can affect humans, animals, plants, and ecosystems, usually at a lower concentration than the concentration at the source. The reduced level of concentration results from many factors, including how far the person, animal, plant, or ecosystem is from the source; the wind speed and wind direction; the atmospheric stability; and other weather factors. Computer models, which can be used to make policy, help predict exposures based on these varying factors.

Boards of health and health departments are concerned about the local level of air pollution, often called the **ambient concentration**. The United States Environmental Protection Agency (USEPA) has identified concentrations of key pollutants that should not be exceeded. Local agencies may be involved in monitoring outdoor concentrations to determine public health risks and to demonstrate compliance with the federal regulations.

Health Effects

Exposure to air pollution has a number of health effects for humans, animals, plants, and ecosystems. As with any environmental exposure, the effects depend on the concentration, duration, and frequency of the exposure. Local boards of health and health departments are primarily concerned with the effect of air pollution on people; however, they may also be concerned with its impact on vegetation, crops, animals, and bodies of water. This section will focus on human health effects.

Because people breathe in air pollutants through the lungs, many of the resulting health effects are seen in the pulmonary system. Short-term, high-level exposures decrease lung function. Although generally reversible, during a period of increased air pollution decreased lung capacity contributes to increases in hospital admissions and emergency room visits for a variety of diseases (e.g., lung- and heart-related diseases) and can aggravate existing diseases such as asthma. In extreme cases, premature death may result. For example, in December 1952, London, England, experienced a very severe air pollution episode. Hundreds of deaths were attributed to the pollution, many the result of exacerbation of existing conditions.

To help alert the public to short-term air pollution effects, the USEPA published the Air Quality Index (AQI) Reporting Final Rule in August 1999. The AQI is used to report daily air quality conditions to the public. Based on the concentrations of pollutants that produce short-term effects, a value is generated (100 is equivalent to the allowable level) and

is accompanied by an air quality descriptor (Table 1). Reporting of the AQI is required for metropolitan areas with populations greater than 350,000. A useful tool for the AQI is the "Interactive AQI Calculator" program, which is available at no cost from the USEPA AIRNOW Website, <www.epa.gov/airnow>. This program not only calculates the AQI and identifies susceptible groups and health effects but also suggests cautionary language to use in reporting. For example, if the allowable level for ozone is 109, i.e., "Unhealthy for Sensitive Groups" (identified as "children and people with asthma"), the recommended cautionary language is: "Active children and adults and people with respiratory disease, such as asthma, should limit heavy outdoor exertion." Local or regional agencies are often responsible for monitoring and issuing the daily AQI.

TABLE 1
Air Quality Index, Category Index Values and Descriptor

Index	Values	Descriptor color
0 - 50	Good	Green
51 - 100	Moderate	Yellow
101 - 150	Unhealthy for Sensitive Groups	Orange
151 - 200	Unhealthy	Red
201 - 300	Very Unhealthy	Purple
301 - 500	Hazardous	Maroon

Long-term exposure to moderately increased concentrations of pollutants can produce effects, such as increased rates of pulmonary infections and chronic bronchitis. Certain air pollutants have specific systemic toxic effects. For example, exposure to lead has been linked to low IQ in children, nervous system effects, and kidney and liver damage. Lead, however, is a success story for air quality improvement efforts. Lead used to be a significant outdoor air pollutant, but the phase-out of lead from gasoline and the subsequent reduction in levels of airborne lead have been major contributors to the drop in the number of children with elevated blood lead levels (Figure 3).

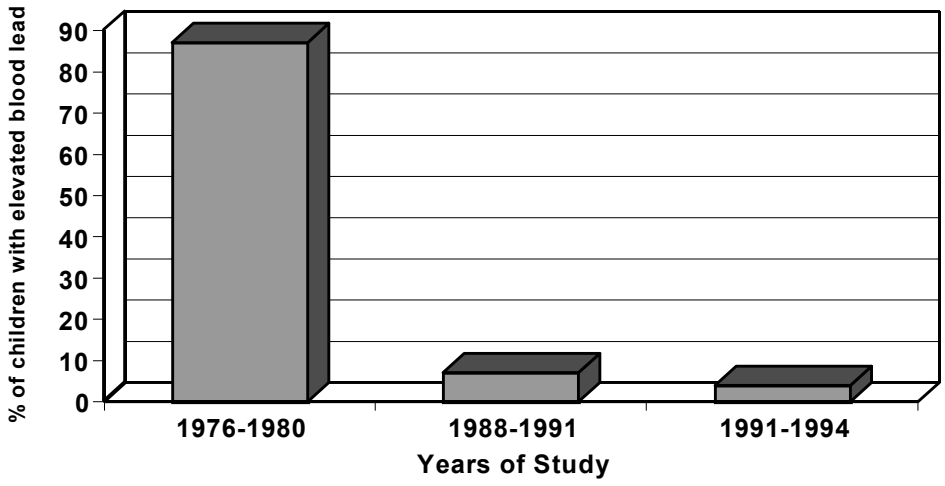

FIGURE 3. Lead is a good example of how policy implementation can improve health.

Other pollutants can cause organ disease, cancer, and reproductive problems. The health effects of specific pollutants can be found in *The Health Effects Notebook for Hazardous Air Pollutants* at the USEPA Unified Air Toxics website, <www.epa.gov/ttn/atw/hapindex.html>.

Regulatory Classes of Air Pollutants

National Ambient Air Quality Standards (**NAAQS**), set by the USEPA, are health-based standards for air pollutants considered harmful to public health and the environment. These standards are divided into two categories: primary and secondary standards. **Primary standards** protect public health, including the health of "susceptible" groups, such as the young, old, and ill. **Secondary standards** preserve public welfare issues, such as maintaining visibility and decreasing plant, animal, and structural damage.

Six common pollutants make up the NAAQS. Also known as **criteria pollutants**, these six air pollutants (Table 2) are used to characterize the air quality of an area. They are measured in parts per million (ppm) by volume, milligrams per cubic meter of air (mg/m^3), and micrograms per cubic meter of air ($\mu g/m^3$).

TABLE 2
The National Ambient Air Quality Standards

Pollutant (abbreviation)	Allowed concentration	Over (averaging time)
Ozone (O_3)	0.12 ppm (235: $\mu g/m^3$)[b]	1 hour [b]
Carbon Monoxide (CO)	9 ppm (10 mg/m^3)[a]	8 hour [a]
	35 ppm (40 mg/m^3)[a]	1 hour [a]
Nitrogen Dioxide (NO_2)	0.053 ppm, (100: $\mu g/m^3$)[b]	Annual [b]
Sulfur Dioxide (SO_2)	0.03 ppm (80: $\mu g/m^3$)[a]	Annual [a]
	0.14 ppm (365: $\mu g/m^3$)[a]	24 hour [a]
	0.50 ppm (1300: $\mu g/m^3$)[c]	3 hour[c]
Particulate matter < 10 microns in size (PM_{10})	50: $\mu g/m^3$ [b]	Annual [b]
	150: $\mu g/m^3$ [b]	24 hour [b]
Lead (Pb)	1.5: $\mu g/m^3$	Quarterly [b]

[a]primary standard, [b]primary and secondary standard, [c]secondary standard.

For areas not in compliance with the NAAQS, the USEPA requires a **state implementation plan** (**SIP**) detailing how the state will return to compliance. While the NAAQS characterize regional patterns of air quality, local patterns from specific sources may be independent of broader geographical air quality issues. For local air quality, the USEPA developed the **Hazardous Air Pollutants** (**HAP**) list of air pollutants that are associated with serious health effects, such as cancer, organ disease, and reproductive effects, and that are regulated at the emission level.

Regional Air Pollution Issues

Some air pollutants are not emitted directly from a source. Rather, they are formed in the atmosphere as a result of chemical reactions. Many of these reactions take time, and as a result, these pollutants, sometimes called **secondary pollutants**, have impacts far downwind of the initial precursor release. Two examples of this are ozone, a main component of smog, and acid particles that contribute to **acid rain**. For example, high ozone levels in the Appalachian Mountains are the result of emissions many miles away. These situations present unique problems to local boards of health since the poor air quality is caused by sources far outside their jurisdiction. Managing air pollution resulting from long-range transport requires regional cooperation.

Another emerging issue in rural areas is the environmental health effects of large-scale animal production, particularly the issue of animal waste. Although often cited as a water quality concern, there are air quality impacts to consider. Animal manure may be a valuable fertilizer, but its management at large animal production facilities is difficult and

leads to a variety of environmental health problems, such as exposure to the gases from the decaying waste either at the job site or in surrounding areas and the strong odors from the facility. Operators are increasingly taking efforts to minimize the environmental impacts of their facilities. The United States Department of Agriculture (USDA), state programs, and other agencies are sponsoring research on management practices and technological controls.

FIGURE 4. Cyclone Filter

Preventing and Controlling Air Pollution

There are two options for controlling air quality: **engineering controls** and **regulatory controls**, and usually both are needed to improve or maintain air quality. Engineering controls use technology to either reduce the amount of pollution created during a process or to reduce the amount of pollution emitted into the air. The first control, changing the amount of pollution made, can be accomplished by changing the way a chemical is used, reducing the amount of a chemical used, or using a different chemical that does not cause pollution. The second engineering control, to reduce the amount of pollution released into the air, requires the use of filters, scrubbers, and other methods that help remove the pollution from the emission. The cyclone filter is an example of this second kind of engineering control (Figure 4). The difference between the two engineering controls is that the first reduces the entire amount of pollution created, and the second reduces only the amount of pollution that is released into the air.

The other way to control air quality is through the use of laws to regulate the allowable levels of emission. The regulations for air pollution are found in the **Clean Air Act** (**CAA**) of 1990. The CAA targeted the key issues of urban air pollution problems, hazardous air pollutants, and acid rain. In addition, the CAA created an Air Pollution Operating Permit Program that significantly changed the way states issue permits for air pollution. The program established minimal federal regulations for air emissions, which means that as long as state and local governments meet these requirements, they have the flexibility to create a permit program that works best for their location. As part of the program, the USEPA continues to improve the program by simplifying the permit application, streamlining permit revisions, and involving citizens in the permit review process.

The CAA lists the regulations for the entire country, but states and local or regional agencies are often responsible for implementing the law.

Indoor Air Quality

The majority of the United States population spends 90% or more of its time indoors. Therefore, indoor air quality (IAQ) has a large potential to affect peoples' health. Just as with outdoor air, the pollution sources and the methods of its transport via indoor air affect humans, plants, and animals. Table 3 lists some of the common contaminants and their sources of indoor air.

TABLE 3
Some Typical Sources of Indoor Air Pollutants

Type	Sources	Example pollutants
Combustion products	• Heating • Cooking • Tobacco smoke	• Carbon monoxide (CO) • Nitrous dioxide (NO_2) • Particles
Biologic contaminants	• Pets • Wet materials • Pests	• Dander/allergens • Mold/fungus spores
Consumer chemicals	• Insecticides • Cleaning products • Adhesives	• Numerous pesticides • Ammonia • Solvents
Furniture and building material	• Pressed wood board • Furniture • Carpet	• Formaldehyde • Volatile organic compounds (found in paints, varnishes, cleaners, solvents, etc.) • Asbestos
Soil gas	• Cracked foundation or basement	• Radon

The ventilation system of a building brings pollution inside. Poor air exchange systems and insufficient amounts of fresh air to a building (or to certain areas in a building) may adversely affect health. If a specific health effect can be related to a specific source, it is called a **building-related illness** (**BRI**). Some examples of BRI are Legionnaires' disease, a form of pneumonia possibly caused by contaminated water in central air conditioning units, and hypersensitivity pneumonitis, a condition with a range of influenza- or pneumonia-like symptoms caused by contaminated home humidifiers and building heating, ventilation, and air conditioning units.

If a building's occupants experience a variety of health effects that are difficult to link to a specific source, it is called **sick building syndrome** (**SBS**). Typical symptoms of SBS

are irritated breathing passages, headaches, fatigue, nasal discomfort, nausea, and general discomfort.

When addressing indoor air quality problems, removing the source of the contamination should be the first choice of action. Changing the ventilation system and introducing air cleaners are additional steps that could be taken to improve indoor air quality.

Two controversial approaches to improving air quality are duct cleaning and using ozone generators in the home. Although cases of extreme biological growth may warrant duct cleaning, studies on the benefits of routine duct cleaning are inconclusive. In addition, there is little evidence that proves that ozone generators improve air quality. In fact, the ozone levels created by the generators can be a harmful pollutant. More information on both of these issues can be found online at the Indoor Air section of the USEPA Office of Air and Radiation website, <www.epa.gov/iaq/>.

Local boards of health can be instrumental in addressing some key IAQ issues, from planning and managing resources during a crisis to working with agencies to improve conditions where poor air quality exists. An example of crisis management would be air quality issues in homes and businesses following flooding or other disasters. Standing water and wet materials (carpets, curtains, etc.) can promote the growth of disease-causing microorganisms, thereby threatening public health. While local boards of health work with local agencies to respond to these public health threats, prior planning before the damage occurs is an important part to maintaining public health. Local board of health members should work with other agencies to establish disaster and emergency plans well before a disaster occurs.

Another local issue for board members to address is the issue of air quality in schools. Many school buildings are old with poor ventilation systems. In addition, schools are home to many of the triggers for environmental asthma, which include cockroaches and other pests, dust mites, molds, and animal dander. In addition, if schools have poor ventilation systems, children and adults are subject to other pollutants, such as perfumes, cleaners, and sprays. These issues increase the call for better management of IAQ in schools and other locations where children may spend a significant amount of time (e.g., daycare centers or homes).

Local boards of health can also improve the health department's capacity to provide IAQ resources for homeowners and renters. Boards can take a leadership role in ensuring that local health agencies create and provide access to information and advice on how to address IAQ concerns. The USEPA Office of Air and Radiation has a variety of publications available from their Indoor Air Quality website, <www.epa.gov/iaq/pubs/>, including *The*

Inside Story: A Guide for Indoor Air Quality, <www.epa.gov/iaq/pubs/insidest.html>, *and Indoor Air Quality Basics for Schools*, <www.epa.gov/iaq/schools/scholkit.html>.

Local boards of health can be instrumental in protecting indoor and outdoor air quality. They should partner with other local, state, and possibly federal agencies to assist in monitoring air quality. In addition, local boards can work with their local health agency to plan responses to events that threaten air quality, such as forest fires, or to provide the necessary warnings or advisory against pollution or high levels of ozone. Finally, local boards can help provide information to homeowners, schools, businesses, and others on indoor air quality.

Resources for Additional Information

American Lung Association. Air Quality. <www.lungusa.org/air>.

Godish, Thad. 1997. *Air Quality*. 3rd ed. Boca Raton, Fla.: CRC/Lewis Publishers.

United States. Environmental Protection Agency. Indoor Air Quality Division. <www.epa.gov/iaq>.

---. Office of Air and Radiation. <www.epa.gov/oar>.

---. Office of Air Quality Planning and Standards. <www.epa.gov/oar/oaqps>.

---. EPA Operating Permits Program. <www.epa.gov/oar/oaqps/permits/index.html>.

---. AIRNOW. <www.epa.gov/airnow>.

---. National Ambient Air Quality Standards. <www.epa.gov/airs/criteria.html>.

---. TTN Web, Unified Air Toxics Website. <www.epa.gov/ttn/atw/hapindex.html>.

Walsh, Phillip, Charles Dudney, and Emily Copenhaver. 1984. *Indoor Air Quality*. Boca Raton, Fla.: CRC Press.

Food Safety

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Key Concepts

- **Foodborne illness** is a serious problem in the United States, causing significant **morbidity** and **mortality** as well as a substantial drain on economic resources.
- Everyone is at risk for contracting a foodborne illness, although the very young, the elderly, and those already ill are most at risk.
- The licensing, monitoring, inspection, investigation of food safety complaints and foodborne illness outbreaks, and enforcement of food service safety regulations in food service facilities are an integral part of any food safety program.
- A major key to solving the food safety problem is a comprehensive approach toward the food safety education of food service managers, food service personnel, and consumers.
- Local health departments play a vital role in protecting the public from foodborne illnesses. Establishing a comprehensive food safety and protection program is essential to the public's health.
- Local boards of health help to make critical contributions to food safety within their communities through the development and oversight of food safety programs within local health departments.

Introduction

The protection of the United States' food supply from the farm to the table is one of the most fundamental responsibilities and activities of public health and environmental health surveillance and monitoring systems. It is a complex network of federal, state, and local agencies, and the food industry itself, which oversees the multifaceted food industry and the delivery of food to consumers. Combating the foodborne disease problem requires the vigilance of many government entities and active participation by the food industry, academia, and the consumer. The three primary federal agencies that are responsible for the overall safety and surveillance of the food supply are the Food and Drug Administration (FDA), the United States Department of Agriculture (USDA), and the Centers for Disease Control and Prevention (CDC). In addition, each of the states and their localities play a vital role in food safety surveillance, monitoring, and control in similar corresponding agencies, organizations, and industries (i.e., state and local health departments). While the FDA assists the 75 state and territorial agencies and the more than 3,000 local boards of health and health departments that are responsible for regulating food service and retail, local boards of health

and health departments are the primary agencies responsible for ensuring the food safety of the public. According to the FDA Food Code, the goal of local and state food protection programs should be to work with the food industry to safeguard the public's health and ensure that food is safe, wholesome, unadulterated, honestly presented and meets customer expectations.

What Is the Public Health Issue?

The food service industry is big business. It represents over 4% of the gross domestic product in the United States. According to the National Restaurant Association, food service has grown eightfold in the past three decades, i.e., from a $42.8 billion industry in 1970 to a $345 billion industry in 1999. From 1972 to 1996, the number of restaurants also increased 66%. Projections suggest the industry will continue to grow over the next 10 years, reaching over $577 billion in sales by 2010. Over 10 million people, or 8% of the workforce in the United States, are employed in the food service industry.

The average American spends roughly 25% of his or her income on food. Of this, 44% of the food budget is spent on meals, snacks, and beverages eaten outside of the home. Approximately 50 billion meals are eaten annually in food service establishments in the United States. Almost half of all adults are food service customers every day.

Although the food safety system in the United States is one of the best in the world, foodborne illnesses continue to be a major, even increasing, problem. Foodborne diseases cause enormous numbers of illnesses and deaths each year, and are a significant drain on financial resources. The Department of Health and Human Services' Public Health Service has listed food safety as a priority with established objectives in both **Healthy People 2000** and **Healthy People 2010**. In addition, in 1997, the federal government launched a Food Safety Initiative and a Food Safety Strategic Plan to strengthen the nation's food safety system.

The Extent of the Foodborne Illness Problem

CDC estimates that foodborne diseases cause an estimated 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths each year from sources known and unknown. They also report that three **pathogens,** *Salmonella, Listeria,* and *Toxoplasma,* are responsible for 75% of reported illnesses and 1,500 deaths. Many foodborne illnesses, however, are never reported to local or state health departments or to the CDC.

Several recent foodborne illness epidemics reported in the news help to further demonstrate the extent of the food safety problem in the United States. The following are

examples of recent foodborne disease outbreaks that have appeared in the media within the last few years:

- In 1998, *Salmonella agona* sickened 209 individuals in 11 states. These infections were associated with the consumption of toasted oat cereal from one U.S. manufacturer.
- Also in 1998, there was an outbreak of *cyclosporiasis* among diners in a Toronto hotel. Illness was associated with eating the berry garnish of a dessert. Twelve other illness clusters of *cyclosporiasis* have been reported that are associated with raspberry consumption.
- The Hepatitis A virus caused several foodborne outbreaks in the late 1980s through the 1990s, sickening thousands of people. These outbreaks were linked to ill food service workers failing to wash their hands frequently while working. Outbreaks are also linked to a lack of washing of fruits and vegetables before service.

USDA's Economic Research Service (ERS) has estimated the economic costs of foodborne illnesses. It suggests that the direct medical costs and productivity loss range from $6.6 billion to $37.1 billion for seven foodborne pathogens. There are other indirect costs that are not included, such as the cost to the food industry.

Despite surveillance techniques and loss estimates, there is a large gap between the actual number of confirmed cases of foodborne disease that are reported to the CDC and the estimated number of cases that actually occur. Closing this gap will require effort from the entire food safety community, which includes both the food industry and consumers.

While licensing, monitoring, inspection, and enforcement of food service safety regulations in food service facilities are necessary at the local level to ensure compliance, the key to food safety is a comprehensive approach toward the food safety education of food service managers, food service personnel, and the general public.

Major Facts About Foodborne Disease

What Is a Foodborne Illness?

An outbreak of foodborne illness is defined as two or more people becoming ill from a common food eaten at the same time and/or place. Cases of illness therefore make up outbreaks of foodborne disease when the agent of disease is microbiological.

Chemical poisonings, whether incidental or accidental, and physical hazards in foods, such as hard foreign objects, are classified as an illness when one case is confirmed. Therefore, for these incidents, one case is an outbreak. The ability to confirm an outbreak of

foodborne disease requires timely and diligent epidemiological investigation by all parties involved in the food safety surveillance system. Such investigations must begin at the local level where outbreaks of illness occur. Local health departments should report **incidence** of foodborne outbreaks to the state level with final reporting to the CDC. This ensures that all actual confirmed cases within the United States are summarized.

Types of Foodborne Illness

Most foodborne illnesses are primarily a function of the gastrointestinal tract (GI); therefore, the symptoms that result are primarily nausea, vomiting, abdominal cramps, diarrhea, and occasionally fever. Some agents of foodborne illness attack other body organs or systems, e.g., *botulism* impacts the central nervous system. The two major types of foodborne illness are food poisonings and food infections. However, illnesses from chemicals in food and injury from physical agents are also grouped as types of illness related to foods.

The three principal types of agents that cause foodborne illness are biological, chemical, and physical in nature. Of these, the biological agents produce the majority of the illnesses, although the importance of chemicals and physical agents cannot be overlooked. Examples of important foodborne disease agents and their likely sources are provided in Table 1.

Table 1
Examples of Important Foodborne Illness Agents

Principal type	Illness or agent	Likely source or cause
Biological		
Bacteria	Salmonellosis	Improper cooking of poultry
	Campylobacteriosis	Improper cooking of poultry
	Shigellosis	Lack of hand washing
	Listeria	Vegetables and contaminated processed foods
	E. coli 0157:H7	Improper cooking of beef
Protozoa	*Cyclospora*	Alfalfa sprouts
Viruses	Hepatitis A	Poor personal hygiene
Chemical		
Natural	Scombroid poisoning	Fish (tuna, mackerel)
Accidental	Cleaning agents	Improper labeling
	Food additives (MSG)	Overuse
Physical		
Hard foreign objects	Metal fragments	Can opener

Who Is at Risk for Foodborne Illness?

While everyone is at risk for contracting a foodborne illness, the severity of illness in healthy human individuals may be less than in certain susceptible populations. Susceptible groups who may experience severe illness and death from disease agents include the very young, the elderly, persons already suffering from an illness, injury, or are immunocompromised (such as those with AIDS), persons on antibiotics, and individuals with nutritional deficiencies. Other groups at risk include chronically ill patients and pregnant women. Educating all segments of the population regarding their risk of illness from food, especially those persons who are most at risk or those persons caring for those most at risk, is especially important. Any comprehensive food safety and protection program must include all facilities that serve food to all segments of the population. These include such institutions as nursing homes, childcare centers, hospitals, jails, and restaurants.

What Are the Major Contributors to Foodborne Outbreaks?

There are many factors that can lead to contamination of foods that then cause a foodborne illness/outbreak. The three most important factors that are found consistently during a foodborne illness investigation are

- Lack of hand washing and poor personal hygiene by food service personnel,
- Inadequate **temperature control**, i.e., refrigeration and/or cooking, and
- Cross-contamination of raw foods with ready-to-eat foods.

Responsibilities of the Local Board of Health and Health Departments

Local health departments and their environmental health units have a variety of tools that may be developed and implemented to address the foodborne illness problem. Any food protection program should be comprehensive in approach. The FDA has proposed that food protection programs contain the following components:

- A solid regulatory foundation,
- Trained regulatory staff,
- Inspection programs based on Hazards Analysis Critical Control Points (**HACCP**) principles,
- Uniform inspection program,
- Foodborne illness response,
- Compliance and enforcement,

- Industry recognition,
- Program resources, and
- Program assessment.

Each of these components is briefly described below. For additional information, see the FDA's Recommended National Retail Food Regulatory Program Standards website <http://vm.cfsan.fda.gov/~dms/ret-toc.html>.

A Regulatory Foundation

Because local health departments and local boards of health have the primary responsibility for regulating and monitoring the food service industry within their jurisdictions, it is imperative that they have the necessary legal foundation to accomplish this task. Local boards of health and health departments should consider adopting the most recent 2001 FDA Food Code as an enforcement tool. The adoption of this model code at the local level (or in many states at the state level) will give the health department the most consistent and effective tool for establishing a legal framework for food protection within the local jurisdiction.

Regulatory codes should

- Incorporate the five public health interventions described in the Food Code,
- Address all known risk factors for foodborne illness,
- Specify sanitation requirements, and
- List compliance and enforcement procedures.

A model code should address the surveillance of all sites where food is prepared or sold. It should include mechanisms for permits, inspections, monitoring, and enforcement for all categories of restaurants, childcare and daycare facilities, hospitals, nursing homes, jails, mobile food service vehicles and vendors, private facilities that serve the public (e.g., church kitchens), and temporary food service facilities (e.g., festivals). Grocery stores and other retail operations (e.g., convenience stores) that prepare food should also be considered for inclusion.

A regulatory framework is an important tool in assuring food safety. Boards of health should also consider collaborating with the food industry, consumer groups, academia, and other government agencies or stakeholders as they develop or adopt codes, rules, and regulations. Boards of health should also encourage health department staff to develop an open relationship with the industry to resolve problems and promote food safety.

Trained Regulatory Staff

The local board of health should ensure that food safety staff have the skills and training needed to implement an effective program. Only qualified and academically prepared personnel should be hired. Because food safety is frequently a responsibility of environmental health departments, boards may establish a policy requiring that the health department only hire persons with training in this area or in the area of food science for food safety programs. Initial in-house field training and continuing education of personnel involved in food safety are also important. Boards should consider establishing a certification program for food safety staff. The FDA (recommended Standard No. 2) outlines that food safety staff should be able to

- Identify risk factors that cause foodborne illness, along with other factors that may contribute to foodborne illness;
- Correctly interpret and apply regulatory requirements;
- Explain public health principles;
- Help develop risk control plans; and
- Enforce regulations and ordinances.

To help agency staff obtain or maintain these skills, the National Environmental Health Association, <www.neha.org>, and/or the FDA, <www.fda.gov>, often offer training or continuing education courses for public health professionals.

Inspection Programs

The purpose of an inspection program is to identify any risk factors for foodborne illness and to take immediate action to correct the hazard in local food service establishments. During inspections, inspectors must also determine that food service managers will actively control risk factors to minimize the possibility of recurring hazards. Ideally, inspectors will work with establishments to develop a program based on Hazard Analysis Critical Control Points (HACCP) for controlling risk. When food service managers fail to control for risk factors, inspectors should take appropriate regulatory action.

Currently, there are two basic approaches to inspection: the "checklist approach" and the newer Hazard Analysis and Critical Control Points (HACCP) or "systems" approach.

Historically the traditional approach has been used in monitoring and inspecting the food service industry. It is based on making routine, unannounced visits to food service establishments for the purpose of comparing observations on-site with checklists drawn from applicable state or local codes. This comparison produces an inspection report that informs

the operator which of these code elements are not in compliance at the time of the inspection. This approach has been very useful in attempting to upgrade physical facilities and has been somewhat helpful in improving food safety practices in food service establishments. This traditional inspection has limitations, however, and is not as effective at describing the kitchen as a system and evaluating the degree of control that an operator has over the contributing factors that have led to past foodborne illness outbreaks. This type of inspection often does not identify the underlying reasons for noncompliance. By failing to deal with these underlying factors, lasting improvements in food safety have been difficult to achieve.

The newer HACCP-based approach is a systems style analysis that better determines the true risks that an operation poses to the public over time. HACCP was developed in the late 1950s as part of the National Aeronautics and Space Administration's (NASA) effort to ensure the safety of the aerospace program's food supply. From their collaboration with NASA, Pillsbury published a comprehensive training manual on HACCP for the FDA in 1973. In 1992, the National Advisory Committee on Microbiological Criteria for Foods endorsed the HACCP principles, which led to their prominence throughout the U.S. The seven basic principles of HACCP are

1. Conduct a hazard analysis to identify potential hazards associated with a particular food;
2. Determine critical control points (CCPs) that can reduce or remove any hazards;
3. Create critical limits that can be used to measure whether the CCPs are properly maintained or enacted;
4. Establish a monitoring procedure involving observation or testing to verify the proper maintenance of CCPs;
5. Establish procedures for correcting any lapses or departures in the maintenance of CCPs;
6. Implement a record keeping system to document the CCPs/HACCP plan; and
7. Establish a system to verify that the HACCP plan is working effectively and is consistently implemented; both regulators and food producers should participate in this evaluation.

Thus, a HACCP system attempts to identify and deal with the root causes of foodborne risks. In a HACCP inspection, the environmental health specialist first maps out the flow of food through a facility to fully describe the system and all of its inputs. The

second step is to determine what is critical about this system in relation to producing a safe outcome. This step includes determining the sources of the food used in the facility. After these critical points in the system have been identified, information is gathered that will help the inspector make judgments about the degree of control this operator may have over these important points (procedures such as cooking, cooling, and personal hygiene, which have all been shown to have been involved in past outbreaks). The final step is to work with the operator to strengthen any weaknesses or lack of control that this system may have.

In both inspection approaches, follow-up to determine if improvements have been made is extremely important to an effective program. Both types of inspection also need to be backed up with effective enforcement abilities and actions to deal with those few operators who do not take their responsibilities seriously and do not exhibit voluntary improvements.

Encouraging voluntary self-inspection programs that are conducted by the food service operators themselves may also be an effective mechanism for achieving voluntary compliance with food safety regulations. Such self-inspection programs focus the attention of food service operators and help to convey their integral role in protecting the public's health.

Local boards of health and health departments may also wish to implement a risk assessment program of food service facilities that allows food safety resources to focus on those facilities that pose the greatest risk to the public. The following criteria, based on both the nature of a food service establishment and the potential hazards present, can be used to determine the amount of risk posed by a food service facility:

- Type of operation (fast food versus hospital kitchen),
- Menu offerings (non-potentially hazardous or minimally hazardous foods versus high **potentially hazardous food** items),
- Level of preparation (reheating of frozen precooked items versus preparation of all fresh ingredients),
- Public served (general public versus high-risk population),
- Number of meals served, and
- Level of food safety as determined by routine inspections.

Under a risk assessment program, health department staff could then conduct more frequent inspections of high-risk facilities, such as hospital kitchens, nursing homes, childcare centers, and hotel restaurants. The majority of facilities, however, may fall within the medium-risk category (e.g., fast food facilities). For high-risk facilities, it is important

that food safety staff communicate this risk to the owners, operators, and managers of the facility so that they are aware of the importance of food safety measures.

Foodborne Illness Response

The FDA recommends that food safety programs create a system for recording all complaints alleging foodborne illness. The agency should use set procedures to investigate all complaints promptly. The FDA's Recommended National Retail Food Regulatory Program Standards Appendix E, <www.cfsan.fda.gov/~dms/ret-ape.html>, contains recommendations for food safety investigation procedures. At the minimum, investigation procedures, or a "memorandum of understanding," should establish an investigation team; delineate the roles, responsibilities, and training of staff; identify laboratory facilities; and appoint a media spokesperson for the agency.

All investigation findings should be noted in the complaint record and be provided to consumers and food service operators as appropriate. Reports of investigations should also be distributed to the state epidemiologist and the Centers for Disease Control and Prevention. Records should be reviewed annually to determine trends and long-term food safety problems.

Compliance and Enforcement

The goal of compliance and enforcement is to reduce known risk factors as well as other factors that may contribute to foodborne illness. Voluntary compliance with food safety regulations should be encouraged. Food safety agencies can determine if voluntary compliance has been achieved through a uniform inspection program. In cases where compliance has not been attained, despite efforts at voluntary compliance, enforcement action should be taken. Enforcement procedures should be outlined in the regulatory framework and implemented accordingly.

Policies and procedures regarding food service inspections and regulation should be implemented uniformly. Health department supervisors should ensure that all food inspection staff are completing inspection reports, correctly interpreting regulatory requirements, and enforcing compliance policies and procedures.

Industry Recognition

Food safety agencies should consider developing a program for recognizing food service establishments that consistently control risk factors for foodborne illness. This program should be based on a written plan with specific selection criteria. These criteria should emphasize the existence of active management control of foodborne illness risk factors. An independent committee consisting of academic, industry, and regulatory

representatives may be charged with evaluating and acknowledging those facilities meeting the program's criteria. Recognition may consist of an award or other appropriate acknowledgment of the facility's exceptional compliance.

Program Resources

Any comprehensive food safety program must have sufficient resources to implement an effective program. All staff involved in the food safety program should be provided with the appropriate equipment to satisfactorily perform inspection, monitoring, and surveillance responsibilities.

Access to a certified microbiological laboratory that can conduct analyses of food samples is also an important part of any food safety program. Although routine sampling of foods is not normally performed, a laboratory is an absolute necessity when conducting investigations of possible foodborne illness outbreaks.

In addition to the budgetary needs to operate an effective food safety program, the support of the political community and citizenry is also important. These groups must be continually made aware of the importance of the food safety program to ensure that the necessary resources will continue to be provided.

Local boards of health should consider a number of options for funding food safety inspection and education programs. These options include license fees for programs, shifting costs to the food service industry through inspection fees, or using public tax revenues.

Program Assessment

Local boards of health and health departments should establish a mechanism for assessing the implementation of the above activities. Ideally, assessments by agency management or the local board of health should occur every two years. In addition, every three years, agencies should undergo an outside evaluation by an FDA-certified evaluation officer using FDA validation procedures.

Agencies may find it helpful to collect baseline data on compliance and foodborne illness incidences. These data can then be used to gauge the success of the program over time and determine areas requiring additional attention.

Additional Program Considerations

Education programs for the local food service industry. Training and education programs for food service workers and food service managers are effective tools to help reduce the **incidence** and prevalence of foodborne illness. Education of personnel who are responsible for the safety of the public's health is an absolutely vital necessity in any comprehensive food safety program.

Local health departments are often the primary providers of training and education for food service workers and food service managers, depending on local code and ordinance requirements. Many areas now require food service managers to be certified in food sanitation if they work in a food service facility. There are several options available to local health departments to implement a certified food manager program. These include using one of the national, state, or academic programs available or developing an in-house program. In many jurisdictions, certified food service managers must be on duty while a facility is open for business. However, the training of food service workers should be considered necessary because this industry has very high employee turnover. Required half-day sessions with food service personnel in which they are instructed about their responsibilities in food safety are an important piece of the comprehensive food safety program.

Local food safety newsletters and websites with links to state, regional, and national food safety sites are also effective tools that a local health department might consider. These could be distributed to the food service industry within the local jurisdiction as well as to the consumer.

Consumer education. Education of the public regarding foodborne illnesses is a vital responsibility of local health agencies. This can be accomplished in several ways, including newsletters, regular newspaper columns, and public service announcements.

Education of the public about the safety of the food service facilities in their region is another consideration. Communication may occur through posting of inspection reports, grading of establishments, and publishing weekly inspection report results. Regardless of the method of communication, all records of inspections of food service facilities are public and available upon request following the procedures under state public records laws.

The Role of the Other Parts of the Food Safety Network

Ensuring that safe, wholesome, unadulterated food is presented to the public is everyone's responsibility. The vast interconnected food safety network must assume varying responsibilities and make every effort to reduce the incidence and prevalence of foodborne disease. Each segment of this network must play a specific role in accomplishing this task. The overall public's health free from foodborne illness is dependent on this coordinated and well-communicated effort.

The Food Industry

All segments of the food industry have a responsibility of producing and processing foods that are safe. This means employing the best available technology based on the most sound food science research that can be used in the production of foods. The industry must also take the lead in using a systems approach in the production, processing, and preparation of foods. An across-the-industry approach employing such scientifically based systems as HACCP will give greater assurances that foods are free of contaminants when they reach the consumer. These methods should be employed at all levels of food production from processing to food service. The food industry, which is involved in quality assurance programs, must continue to conduct its own research to assess risks in the manufacturing processes. The food industry must also be a leader in educating and training its employees. All levels of employees, from upper management to supervisors to food service employees, should be instructed in safe food processing, production, and preparation practices. Education, motivation, and self-monitoring using the latest scientific approaches are key to food safety assurance from the food industry.

The Governmental Sector

All levels of government are involved in the surveillance of the food system (see Figure 1). Each level, while having a specific role, assumes a vital responsibility in the monitoring of the overall safety of the food supply. There are many agencies at the federal level that share responsibility for food safety. The federal government is the leader in the network's coordinated effort to ensure the safety of food. It works with all other segments of the food safety network to

Food and Drug Administration
- Center for Food Safety and Nutrition
- Center for Veterinary Medicine
- Joint Institute for Food Safety
- Centers for Disease Control and Prevention
- Council on Food Safety

Department of Agriculture
- Animal and Plant Health Inspection Service
- Agriculture Research Service
- Food Safety and Inspection Service
- National Academy of Sciences
- National Alliance for Food Safety

FIGURE 1. Federal Food Safety Network

provide guidance, assistance, and enforcement of issues ranging from regulatory approach, research, monitoring and surveillance, and education.

In 1998 the federal government established the Council of Food Safety and the Joint Institute on Food Safety Research. This initiative has established programs aimed at improving food safety, such as **FoodNet** and PulseNet. As a result of this research initiative, several foodborne disease cases implicating the disease agents *Shigella* and *E. coli* 0157:H7 have recently been linked using DNA fingerprinting.

The Professional Society/Academic Sector

There are numerous professional organizations and societies that play a role in educating and communicating information to their professional memberships and the public. The National Environmental Health Association, the American Public Health Association, the Association of Food and Drug Officials, and equivalent state and local organizations represent those professionals who provide the inspection and monitoring activities within the food industry. It is especially important that these individuals are academically prepared, adequately trained, and certified in food safety and foodborne illness surveillance. The National Restaurant Association and the American Hotel and Motel Associations, through their educational foundations, assume a similar responsibility of providing training and education programs for food service industry employees and management; equivalent state and local organizations also share in this role.

Academic institutions should provide state-of-the-art educational opportunities in food safety and sanitation to individuals entering the food industry and the food safety surveillance system. They are also the leaders in food science and safety research. Professional organizations such as the American Society of Microbiology, NSF International, Underwriters Laboratories, Inc., the Institute for Food Technologists, the International Association of Food Protection, and the International Food Information Council in conjunction with the food science and food safety research community are actively involved in the communication and collaboration of the current food safety initiative. This will continue, and academic institutions will play a greater role in the preparation of students entering the food safety field.

The Media

All components of the media network play an important role in informing the public about food safety issues. The majority of the public is informed about food safety issues through the media, usually in headline epidemic stories. The media have the responsibility and opportunity to properly inform the public about food safety in a balanced and unbiased

approach. They should use the food safety experts within their markets to convey to the public the real issues involved in the safety of food. This awareness of food safety has increased over the past 10 years as a result of several major multistate outbreaks of food-related illnesses. The media, the government food safety network, and the food industry should work together to positively convey the food safety message to the public.

The Consumer

While it is the responsibility of the consumer to stay informed about food safety issues, local boards of health should ensure that consumers have access to home food safety information or programs. Consumers must stay informed on the proper preparation and sanitation standards of care involved in preparing their own meals and those of their families. They should also learn to report to the local health department any illness that they or their family members incur that they believe could be food related. Informed food safety consumers are critical for an effective food safety system.

Summary

The local board of health provides guidance and direction to the local health agency on many issues regarding the public's health. This includes providing leadership on food safety. In particular, the function of the local board of health regarding food safety is to ensure that all of the necessary components of a comprehensive food protection program are in place for the protection of the public's health. As described, local boards of health should ensure that food safety programs have a regulatory framework and adequate staffing and funding. Local boards of health may also be responsible for conducting hearings, issuing and revoking licenses, and making certain that staff, food service agencies, and consumers receive regular education and training. Boards should regularly review food protection programs to guarantee that there is a proper mix of education and enforcement activities. Such reviews should also ensure that food protection programs are effective in preventing foodborne illness.

As a politically appointed or elected body, the board of health should ensure that the climate for food safety within its jurisdiction remains favorable, and it needs to persuade policy makers that an effective food safety program can only be accomplished with the necessary resources. History indicates that when disease outbreaks are apparently low within a population, the first programs to be cut are those that are preventive. When that happens, a resurgence of disease usually follows. Because the occurrence of foodborne illness is underreported, it is crucial that prevention-based programs continue to receive the necessary resources.

By staying informed about food safety issues in general and about the food safety surveillance system within their communities, local boards of health will provide support for the local health agency in their efforts to minimize foodborne illness. Local boards of health should stay informed about other efforts provided by other state and local agencies regarding food safety. Food safety should be given a high priority in every community. Communicating this effort to the public, medical societies, and local elected governing bodies will strengthen the local food safety program by adding needed resources to address the foodborne disease issue.

In sum, food safety is a major concern in the United States. The gap between the reported cases and estimated cases of foodborne illness and the cost to the economy are enormous. The food industry is complex and multifaceted. Food safety requires a multidisciplinary approach by the industry, government, professional organizations, the scientific community, the media, and the consumer to adequately address all of the related issues

The local health department historically has played a vital role in the protection of the public's health from foodborne illness in food service facilities. This role will continue and will grow in the future as this important public health issue stays in the forefront of everyone's concern. Local boards of health play a key role in ensuring that the public they represent receive the best protection in food safety by actively overseeing the local public health agency's food safety program.

Resources for Additional Information

Archer, D. L., and J. E. Kvenburg. 1985. Incidence and cost of foodborne diarrheal disease in the United States. *Journal of Food Protection* 48: 887–894.

Bean, N. H., J. S. Goulding, M. T. Daniels, and F. J. Angulo. 1997. Surveillance for foodborne disease outbreaks—United States. *Journal of Food Protection* 60: 1265–1286.

———, and P. M. Griffin. 1990. Food-borne disease outbreaks in the United States, 1973–1987: Pathogens, vehicles, and trends. *Journal of Food Protection* 53: 804–817.

Buzby J. C., C. T. Roberts, J. Lin, and J. M. MacDonald. 1996. *Bacterial food-borne disease: Medical costs and productivity losses*. Washington, D.C.: Food and Consumer Economics Division, Economic Research Service, United States Department of Agriculture. Agricultural Economic Report No. 741.

Centers for Disease Control and Prevention. <www.cdc.gov>.

---. 1990. Food-borne disease outbreaks, 5 year summary, 1983–1987. *Morbidity and Mortality Weekly Report* 39(SS-1): 15–57.

---. 1996. Surveillance of food-borne disease outbreaks, United States, 1988–1992. *Morbidity and Mortality Weekly Report* 45(SS-5): 2–55.

---. 1997. The food-borne diseases active surveillance network, 1996. *Morbidity and Mortality Weekly Report* 46: 258–261.

---. 1998. FoodNet: What we are, where we are and what we're doing in 1998. *The Catchment* 1(Fall): 1–4.

Center for Food Safety & Applied Nutrition. <www.cfsan.fda.gov/list.html>.

Chin, James. 2000. *Control of communicable diseases manual*, 17th ed. Washington, D.C.: American Public Health Association.

Doores, Stephanie. 1999. *Food safety: Current status and future needs*. Prepared for the American Academy of Microbiology.

Food Marketing Institute. 1989. *A program to ensure food safety in the supermarket—The HACCP system*. Washington, D.C.: Author.

Food Safety Teams. <http://vm.cfsan.fda.gov/~lrd/foodteam.html>.

FoodNet Working Group. Food-borne diseases active surveillance network (FoodNet). *Emerging Infectious Diseases* 3: 5813.

Garthright W. E., D. L. Archer, and J. E. Kvenberg. 1988. Estimates of incidence and cost of infectious diseases in the United States. *Public Health Reports* 103:107–115.

Institute of Medicine. 1998. *Ensuring safe food from production to consumption.* Washington, D.C.: National Academy Press.

Latta, Sara L. 1999. *Food poisoning and food-borne diseases.* Berkeley Heights, N.J.: Enslow Publishers.

Levine W., J. Smart, D. Archer, N. Bean, and R. Tauxe. 1991. Food-borne disease outbreaks in nursing homes, 1975 through 1987. *JAMA* 266: 2105–2109.

Marriott, Norman G. 1999. *Principles of food sanitation*. Gaithersburg, Md.: Aspen Publishers.

McSwane, David, Nancy Rue, and Richard Linton. 1998. *Essentials of food safety and sanitation.* Englewood Cliffs, N.J.: Prentice Hall.

Mead P. S., V. Slutsker, et al. 1999. Food-related illness and death in the United States. *Emerging Infectious Diseases* 5(5): 607–625.

National Restaurant Association. 1995. *Serving safe food. ServSafe* c*ertification manual coursebook.* Washington, D.C.: Author.

Partnership for Food Safety Education: <http://fightbac.org>.

Satin, Morton. 1999. *Food alert! The ultimate sourcebook for food safety* New York: Facts on File.

United States Department of Commerce. National Oceanic and Atmospheric Administration. Seafood Inspection Program <http://seafood.nmfs.gov>.

---. Food and Drug Administration. 1999. *Bad bug book: Introduction to food-borne pathogenic microorganisms and natural toxins*. Washington, D.C.: Author. Available at <http://vm.cfsan.fda.gov/~mow/intro.html>.

---. Center for Veterinary Medicine. <www.fda.gov/cvm/default.html>.

---. Cooperative State Research, Education and Extension Service. <www.reeusda.gov>.

---. Food Safety Inspection Service. <www.fsis.usda.gov>.

---. Recommended National Retail Food Regulatory Program Standards, <www.cfsan.fda.gov/~dms/ret-toc.html>.

United States. Environmental Protection Agency. <www.epa.gov>.