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May 1996

FOOD SAFETY

Information on
Foodborne Illnesses

Over the past decade a number of widely reported outbreaks of foodborne illness have captured the public imagination—the most recent being the E. coli outbreak linked to ground beef. Each outbreak has been treated as an isolated case, not as part of a public health problem.

Given the scale of the U.S. food production and distribution system and the lack of control over how consumers handle food after they purchase it, there is little likelihood that foodborne illnesses can be completely eliminated. The most that can be hoped for is that all reasonable steps are taken to reduce the problem to a minimum. In this context, we have prepared this report to provide a factual picture on the extent of foodborne illness in the United States today. Specifically, we obtained the following information on the (1) frequency of foodborne illness, (2) consequences and economic impacts of foodborne illness, and (3) current knowledge about foodborne illness in order to develop effective control strategies.

Data on the extent of foodborne illnesses and related deaths are incomplete and only indicate the extent of the problem because most cases go unreported. However, according to the best available estimates by the Centers for Disease Control and Prevention and other public health and food safety experts, millions of illnesses and thousands of deaths each year in the United States can be traced to contaminated food. Moreover, public health officials believe that the risk of foodborne illness has been increasing over the last 20 years.

Although foodborne illnesses generally cause symptoms such as nausea, vomiting, and diarrhea, they can also lead to more serious complications. While the economic cost of foodborne illnesses is unknown, it is estimated that they cost the U.S. economy more than \$2.2 billion each year. According to the Department of Agriculture estimates, the loss of productivity related to foodborne illness may have been as high as \$1.5 billion during 1994.

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May 8, 1996

Congressional Committees

Over the past decade, a number of widely reported outbreaks of foodborne illnesses caused by microbial contamination—the most commonly identified cause of such outbreaks—have heightened the public's concern about the safety of food. While such outbreaks have brought the issue to the public's attention, public health and food safety officials agree that the largest number of foodborne illnesses occur as isolated cases, not as part of a publicized outbreak.

Given the scale of the U.S. food production and distribution system and the lack of control over how consumers handle food after they purchase it, there is little likelihood that foodborne illnesses can be completely eliminated. The most that can be hoped for is that all reasonable steps are taken to ensure that the problem is minimized. In this context, we have attempted in this report to provide a factual picture on the extent of foodborne illness in the United States today. Specifically, we obtained the best available information on the (1) frequency of foodborne illness, (2) health consequences and economic impacts of foodborne illnesses, and (3) adequacy of knowledge about foodborne illnesses to develop effective control strategies.

Results in Brief

Data on the extent of foodborne illnesses and related deaths are incomplete and may understate the extent of the problem because most cases go unreported. However, according to the best available estimates by the Centers for Disease Control and Prevention and other public health and food safety experts, millions of illnesses and thousands of deaths each year in the United States can be traced to contaminated food. Moreover, public health officials believe that the risk of foodborne illnesses has been increasing over the last 20 years.

Although foodborne illnesses generally cause temporary disorders of the digestive tract, they can also lead to more serious consequences. While the precise cost of foodborne illnesses is unknown, recent estimates range from over \$5 billion to more than \$22 billion annually. According to U.S. Department of Agriculture estimates, the cost of medical treatment and lost productivity related to foodborne illnesses from seven of the most harmful bacteria may have been as much as \$9.4 billion during 1993.

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Public health and food safety officials believe that current data on foodborne illnesses do not provide a complete picture of the risk level and do not depict the sources of contamination and the populations most at risk in sufficient detail. More uniform and comprehensive data on the number and causes of foodborne illnesses could form the basis of more effective control strategies. In 1995, federal and state agencies began steps to collect such data in five areas across the country. Federal officials expressed some concern about whether, in this era of budget constraints, they would be able to continue funding this discretionary effort for the number of years needed to collect meaningful trend data.

Background

The Centers for Disease Control and Prevention (CDC) is the federal agency primarily responsible for monitoring the incidence of foodborne illness in the United States. In collaboration with state and local health departments and other federal agencies, CDC investigates outbreaks of foodborne illnesses and supports disease surveillance, research, prevention efforts, and training related to foodborne illnesses. CDC coordinates its activities concerning the safety of the food supply with the Food and Drug Administration (FDA) in the Department of Health and Human Services and those concerning the safety of meat, poultry, and eggs with the Food Safety and Inspection Service (FSIS) in the U.S. Department of Agriculture (USDA). FDA and FSIS, which are the primary federal agencies responsible for overseeing the safety of the food supply, maintain liaison with CDC in Atlanta, Georgia.

CDC monitors individual cases of illness from harmful bacteria, viruses, chemicals, and parasites (hereafter referred to collectively as pathogens) that are known to be transmitted by foods, as well as foodborne outbreaks,¹ through reports from state and local health departments, FDA, and FSIS. CDC does not have the authority to require states to report data on foodborne illnesses. In practice, each state determines which diseases it will routinely report to CDC. In addition, state laboratories voluntarily report the number of positive test results for several diseases that CDC has chosen to monitor. However, these reports do not identify the source of infection and are not limited to cases of foodborne illness. CDC also investigates a limited number of more severe or unusual outbreaks when state authorities request assistance. (For a description of the data that CDC relies on to monitor foodborne illnesses, see app. I.)

¹For most pathogens, CDC defines an outbreak of foodborne illness as two or more persons experiencing a similar illness for which a common food was implicated.

At least 30 pathogens are associated with foodborne illnesses. For reporting purposes, CDC categorizes the causes of outbreaks of foodborne illnesses as bacterial, chemical, viral, parasitic, or unknown pathogens. (See app. II. for information on these pathogens and the illnesses they cause.) Although many people associate foodborne illnesses primarily with meat, poultry, eggs, and seafood products, many other foods, including milk, cheese, ice cream, orange and apple juices, cantaloupes, and vegetables, have also been involved in outbreaks during the last decade.

Bacterial pathogens are the most commonly identified cause of outbreaks of foodborne illnesses. Bacterial pathogens can be easily transmitted and can multiply rapidly in food, making them difficult to control. CDC has targeted four of them—*E. coli* O157:H7, *Salmonella* Enteritidis, *Listeria monocytogenes*, and *Campylobacter jejuni*—as those of greatest concern. (See app. III.) CDC is also concerned about other bacterial pathogens, such as *Vibrio vulnificus* and *Yersinia enterocolitica*, which can cause serious illnesses, and *Clostridium perfringens* and *Staphylococcus aureus*, which cause less serious illnesses but are very common. The chemical causes of foodborne illnesses are primarily natural toxins that occur in fish or other foods but also include heavy metals, such as copper and cadmium. Viral pathogens are often transmitted by infected food handlers or through contact with sewage. Only a few viral pathogens, such as the Hepatitis A and Norwalk viruses, have been proven to cause foodborne illnesses. Finally, parasitic pathogens, such as *Trichinella*—found in undercooked or raw pork—multiply only in host animals, not in food. CDC officials believe that viral and parasitic pathogens are less likely than bacterial pathogens to be identified as the source of an outbreak of foodborne illness because their presence is more difficult to detect.

Foodborne Illnesses Are Believed to Be a Growing Problem

The existing data on the extent of foodborne illnesses have weaknesses and may not fully depict the extent of the problem. Public health experts believe that the majority of cases of foodborne illness are not reported because the initial symptoms of most foodborne illnesses are not severe enough to warrant medical attention, the medical facility or state does not report such cases, or the illness is not recognized as foodborne. However, according to the best available estimates, based largely on CDC's data, millions of people become sick from contaminated food each year, and several thousand die. In addition, public health and food safety officials believe that the risk of foodborne illnesses is increasing for several reasons. For example, as a result of large-scale food production and broad

distribution of products, those products that may be contaminated can reach a great number of people in many locations. Furthermore, new and more virulent strains of previously identified harmful bacteria have been identified in the past several decades. Also, mishandling or improper preparation can further increase the risk.

Available Estimates Show That Millions Are Affected by Foodborne Illnesses

Between 6.5 million and 81 million cases of foodborne illness and as many as 9,100 related deaths occur each year, according to the estimates provided by several studies conducted over the past 10 years. Table 1 shows the range of estimates from four studies cited by food safety experts as among the best available estimates on the subject. The table also identifies the data on which these estimates are based. While various foods have been implicated as vehicles for pathogens in foodborne illnesses and related deaths, the available data do not allow a precise breakdown by specific foods. In general, animal foods—beef, pork, poultry, seafood, milk, and eggs—are more frequently identified as the source of outbreaks in the United States than non-animal foods. USDA, which regulates meat and poultry products, has estimated that over half of all foodborne illnesses and deaths are caused by contaminated meat and poultry products.

Table 1: Estimates of Foodborne Illnesses and Related Deaths

Study or report/authors (year)	Estimated number of illnesses per year	Estimated number of deaths per year	Basis for estimates
The Incidence and Cost of Foodborne Diarrheal Disease in the United States, Archer and Kvenberg (1985) ^a	24 million to 81 million or more	No estimate provided	National survey of physicians conducted by National Center for Health Statistics (1977-78), supplemented with 1983 data on illnesses from specific pathogens
Closing the Gap: The Burden of Unnecessary Illness, Bennett et. al. (1987) ^b	6.5 million annually	9,100	Published and survey data from National Center for Health Statistics, Center for Infectious Diseases, and the Center for Prevention Services
Preliminary Estimates of Costs of Foodborne Disease in the United States, Todd (1989) ^c	12.6 million	523	Median of four estimates based on (1) CDC outbreak data; (2) 1987 Bennett study data; (3) Salmonella underreporting; and (4) Canadian disease rates extrapolated to U.S. population
Foodborne Pathogens: Risks and Consequences, Council for Agricultural Science and Technology (1994) ^d	6.5 million to 33 million	Up to 9,000	Review of past studies

^aJournal of Food Protection, Vol. 48, No. 10 (Oct. 1985), pp. 887-894.

^bNew York: Oxford University Press.

^cJournal of Food Protection, Vol. 52, No. 8 (Aug. 1989), pp. 586-601.

^dNo. 122, Sept. 1994. Ames, Iowa: Council for Agricultural Science and Technology.

The wide range in the estimated number of foodborne illnesses and related deaths is due primarily to the considerable uncertainty about the number of cases that are never reported to CDC and the methodology used to make the estimate. Public health and food safety officials believe that many of these illnesses are not reported because the episodes are mild and do not require medical treatment. For example, CDC officials believe that many intestinal illnesses that are commonly referred to as the stomach flu are caused by foodborne pathogens. According to these officials, people do not usually associate these illnesses with food because the onset of symptoms occurs 2 or more days after the contaminated food was eaten. In other cases, a foodborne illness may contribute to the death of an already ill person. In these cases, a foodborne illness may not be reported as the cause of death. In the absence of more complete reporting,

researchers can only broadly estimate the number of illnesses and related deaths.

Furthermore, most physicians and health professionals treat patients who have diarrhea without ever identifying the specific cause of the illness. In severe or persistent cases, a laboratory test may be ordered to identify the responsible pathogen. However, some laboratories may not have the ability to identify a given pathogen.

Finally, physicians may not associate the symptoms they observe with a pathogen that they are required to report to the state or local health authorities. For example, a CDC official cited a Nevada outbreak in which no illnesses from *E. coli* O157:H7 had been reported to health officials, despite a requirement that physicians report such cases to the state health department.² Nevertheless, 58 illnesses from this outbreak were identified after public service announcements alerted the public and health professionals that contaminated hamburger had been shipped to restaurants in a specific area of the state.

Experts Believe That the Risk of Foodborne Illnesses Is Increasing

Food safety and public health officials believe that the risk of foodborne illnesses is increasing. Several factors contribute to this increased risk. First, the food supply is changing in ways that can promote foodborne illnesses. For example, as a result of modern animal husbandry techniques, such as crowding a large number of animals together, the pathogens that can cause foodborne illnesses in humans can spread throughout the herd. Because of broad distribution, contaminated products can reach individuals in more locations. Mishandling of food can also lead to contamination. For example, leaving perishable foods at room temperature increases the likelihood of bacterial growth, and improper preparation, such as undercooking, reduces the likelihood that bacteria will be killed and can further increase the risk of illness. There are no comprehensive data to explain at what point pathogens are introduced into foods. Knowledgeable experts believe that although illnesses and deaths often result after improper handling and preparation, the pathogens were, in many cases, already present at the processing stage. Furthermore, the pathogens found on meat and poultry products may have arrived on the live animals.

Second, because of demographic changes, more people are at greater risk of contracting a foodborne illness. Certain populations are at greater risk

²These cases were part of the 1993 outbreak in the western United States.

for these illnesses: people with suppressed immune systems, children, and the elderly. In addition, children are more at risk because group settings, such as day care centers, increase the likelihood of person-to-person transmission of pathogens. The number of children in these settings is increasing, as is the number in other high-risk groups, according to CDC.

Third, three of the four pathogens CDC considers the most important were unrecognized as causes of foodborne illness 20 years ago—Campylobacter, Listeria, and E. coli O157:H7.

Fourth, bacteria already recognized as sources of foodborne illnesses have found new modes of transmission. While many illnesses from E. coli O157:H7 occur from eating insufficiently cooked hamburger, these bacteria have also been found more recently in other foods, such as salami, raw milk, apple cider, and lettuce. Other bacteria associated with contaminated meat and poultry, such as Salmonella, have also been found in foods that the public does not usually consider to be a potential source of illness, such as ice cream, tomatoes, melons, alfalfa sprouts, and orange juice.

Fifth, some pathogens are far more resistant than expected to long-standing food-processing and storage techniques previously believed to provide some protection against the growth of bacteria. For example, some bacterial pathogens, such as Yersinia and Listeria, can continue to grow in food under refrigeration.

Finally, according to CDC officials, virulent strains of well-known bacteria have continued to emerge. For example, one such pathogen, E. coli O104:H21, is another potentially deadly strain of E. coli. In 1994, CDC found this new strain in milk from a Montana dairy.

Foodborne Illnesses Can Be Debilitating and Costly

While foodborne illnesses are often temporary, they can also result in more serious illnesses requiring hospitalization, long-term disability, and death. Although the overall cost of foodborne illnesses is not known, two recent estimates place some of the costs in the range of \$5.6 billion to more than \$22 billion per year. The first estimate, covering only the portion related to the medical costs and productivity losses of seven specific pathogens, places the costs in the range of \$5.6 billion to \$9.4 billion. The second, covering only the value of avoiding deaths from five specific pathogens, places the costs in the range of \$6.6 billion to \$22 billion.

Pathogens Cause Disabling Health Effects in Some People

While foodborne illnesses are often brief and do not require medical treatment, they can also result in more serious illnesses and death. In a small percentage of cases, foodborne infections spread through the bloodstream to other organs, resulting in serious long-term disability or even death. Serious complications can also result when diarrhetic infections resulting from foodborne pathogens act as a triggering mechanism in susceptible individuals, causing an illness such as reactive arthritis to flare up. In other cases, no immediate symptoms may appear, but serious consequences may eventually develop. The likelihood of serious complications is unknown, but some experts estimate that about 2 to 3 percent of all cases of foodborne illness lead to serious consequences. For example:

- *E. coli* O157:H7 can cause kidney failure in young children and infants and is most commonly transmitted to humans through the consumption of undercooked ground beef. The largest reported outbreak in North America occurred in 1993 and affected over 700 people, including many children who ate undercooked hamburgers at a fast food restaurant chain. Fifty-five patients, including four children who died, developed a severe disease, Hemolytic Uremic Syndrome, which is characterized by kidney failure.
- *Salmonella* can lead to reactive arthritis, serious infections, and deaths. In recent years, outbreaks have been caused by the consumption of many different foods of animal origin, including beef, poultry, eggs, milk and dairy products, and pork. The largest outbreak, occurring in the Chicago area in 1985, involved over 16,000 laboratory-confirmed cases and an estimated 200,000 total cases. Some of these cases resulted in reactive arthritis. For example, one institution that treated 565 patients from this outbreak confirmed that 13 patients had developed reactive arthritis after consuming contaminated milk. In addition, 14 deaths may have been associated with this outbreak.
- *Listeria* can cause meningitis and stillbirths and has a fatality rate of 20 to 40 percent.³ All foods may contain these bacteria, particularly poultry and dairy products. Illnesses from this pathogen occur mostly in single cases rather than in outbreaks. The largest outbreak in North America occurred in 1985 in Los Angeles, largely in pregnant women and their fetuses. More than 140 cases of illness were reported, including at least 13 cases of meningitis. At least 48 deaths, including 20 stillbirths or miscarriages, were attributed to the outbreak. Soft cheese produced in a contaminated factory environment was confirmed as the source.

³Fatalities as a percentage of all cases of illness.

- Campylobacter may be the most common precipitating factor for Guillain-Barre syndrome, which is now one of the leading cause of paralysis from disease in the United States. Campylobacter infections occur in all age groups, with the greatest incidence in children under 1 year of age. The vast majority of cases occur individually, primarily from poultry, not during outbreaks. Researchers estimate that 4,250 cases of Guillain-Barre syndrome occur each year and that about 425 to 1,275 of these cases are preceded by Campylobacter infections.

Foodborne Illnesses Can Cost Billions of Dollars in Medical Expenses and Lost Productivity Annually

While the overall annual cost of foodborne illnesses is unknown, the studies we reviewed estimate that it is in the billions of dollars. The range of estimates among the studies is wide, however, principally because of uncertainty about the number of cases of foodborne illness and related deaths. (See app. IV.) Other differences stem from the differences in the analytical approach used to prepare the estimate. Some economists attempt to estimate the costs related to medical treatment and lost wages (the cost-of-illness method); others attempt to estimate the value of reducing the incidence of illness or loss of life (the willingness-to-pay method). Two recent estimates demonstrate these differences in analytical approach.

In the first, USDA's Economic Research Service (ERS) used the cost-of-illness approach to estimate that the 1993 medical costs and losses in productivity resulting from seven major foodborne pathogens ranged between \$5.6 billion and \$9.4 billion.⁴ Of these costs, \$2.3 billion to \$4.3 billion were the estimated medical costs for the treatment of acute and chronic illnesses, and \$3.3 billion to \$5.1 billion were the productivity losses from the long-term effects of foodborne illnesses. Medical expenses ranged from more modest expenses for routine doctors' visits and laboratory tests to more substantial expenses for hospital rooms and kidney transplants. Productivity losses included expenses such as lost wages from long-term disabilities and deaths caused by foodborne illnesses. Table 2 provides information on the costs associated with each of the seven pathogens.

⁴"Pathogen Reduction, Hazard Analysis and Critical Control Point (HACCP) Systems," Federal Register (Feb. 3, 1995).

Table 2: ERS' Estimated Medical Costs and Productivity Losses From Illnesses Caused by Seven Foodborne Pathogens During 1993

Dollars in billions

Pathogens	Medical costs	Productivity losses ^a	Total costs and losses
<i>Campylobacter jejuni</i> or <i>coli</i>	\$0.6-0.8	\$0.0 ^b -0.2	\$0.6-1.0
<i>Clostridium perfringens</i>	0.1 ^c	Not available	0.1
<i>E. coli</i> O157:H7	0.0 ^a -0.1	0.2-0.5	0.2-0.6
<i>Listeria monocytogenes</i>	0.1	0.1-0.2	0.2-0.3
<i>Salmonella</i>	0.4-2.0	0.2-1.5	0.6-3.5
<i>Staphylococcus aureus</i>	1.2 ^c	Not available	1.2
<i>Toxoplasma gondii</i>	0.0 ^b	2.7	2.7
Total	\$2.3^d-4.3	\$3.3^d-5.1	\$5.6-9.4

^aThe productivity losses for *E. coli* O157:H7, *Listeria monocytogenes*, and *Toxoplasma gondii* included costs related to long-term disabilities and deaths. Productivity losses for *Campylobacter* and *Salmonella* were calculated for deaths only.

^bThese amounts are less than \$50 million.

^cBased on average costs and included some productivity losses in addition to medical costs.

^dDoes not add due to rounding.

Source: ERS and FSIS.

CDC, FDA, and ERS economists stated that these estimates may be low for several reasons. First, the cost-of-illness approach generates low values for reducing health risks to children and the elderly because these groups have low earnings and hence low productivity losses. Second, this approach does not recognize the value that individuals may place on (and pay for) feeling healthy, avoiding pain, or using their free time. In addition, not all of the 30 pathogens associated with foodborne illnesses were included.

In the second analysis,⁵ ERS used the willingness-to-pay method⁶ to estimate the value of preventing deaths for five of the seven major pathogens (included in the first analysis) at \$6.6 billion to \$22.0 billion in 1992. The estimate's range reflected the range in the estimated number of deaths, 1,646 to 3,144, and the range in the estimated value of preventing a death, \$4 million to \$7 million. Although these estimated values were higher than those resulting from the first approach, they may have also understated the economic cost of foodborne illnesses because they did not

⁵Aldrich, Lorna. "Food-Safety Policy: Balancing Risk and Costs," *Food Review*. USDA, Economic Research Service, Vol. 17, Issue 2, May-Aug. 1994, pp. 10-11.

⁶ERS also refers to the willingness-to-pay approach as the value of reducing the risk of illness or death.

include an estimate of the value of preventing nonfatal illnesses and included only five of the seven major pathogens included in the first analysis.

Better Data Could Lead to More Effective Control Strategies

While current data indicate that the risk of foodborne illnesses is significant, public health and food safety officials believe that these data do not identify the level of risk, the sources of contamination, and the populations most at risk in sufficient detail. More uniform and comprehensive data on the number and causes of foodborne illnesses could form the basis of more effective control strategies. Beginning in 1995, federal and state agencies took steps to collect such data in five areas across the country. While this effort will provide additional data, CDC officials believe that collecting data at more locations and for other pathogens would provide even more representative data and identify more causes of foodborne illnesses.

Current Data Do Not Provide Sufficient Detail on the Risk Posed by Foodborne Illnesses

According to public health and food safety officials, the current voluntary reporting system does not provide sufficient data on the prevalence and sources of foodborne illnesses. There are no specific national requirements for reporting on foodborne pathogens. According to CDC, states do not (1) report on all pathogens of concern, (2) usually identify whether food was the source of the illness, or (3) identify many of the outbreaks or individual cases of foodborne illness that occur.

Consequently, according to CDC, FDA, and FSIS, public health officials cannot precisely determine the level of risk from known pathogens or be certain that they can detect the existence and spread of new pathogens in a timely manner. They also cannot identify all factors that put the public at risk or all types of food or situations in which microbial contamination is likely to occur. Finally, without better data, regulators cannot assess the effectiveness of their efforts to control the level of pathogens in food.

According to public health and food safety officials, a better system for monitoring the extent of foodborne illnesses would actively seek out specific cases. Such a system would require outreach to physicians and clinical laboratories. CDC demonstrated the effectiveness of such an outreach effort when it conducted a long-term study, initiated in 1986, to determine the number of cases of illness caused by *Listeria*. This study showed that a lower rate of illness caused by *Listeria* occurred between

1989 and 1993 during the implementation of food safety programs designed to reduce the prevalence of Listeria in food.

Efforts to Improve Information on Foodborne Illnesses Are Under Way

In July 1995, CDC, FDA, and FSIS began a comprehensive effort to track the major bacterial pathogens that cause foodborne illnesses. These agencies are collaborating with state health departments in five areas across the country to better determine the incidence of infection with Salmonella and E. coli O157:H7 and other foodborne bacteria and to identify these sources of diarrheal illness from Salmonella and E. coli O157:H7.⁷ Initially, FDA provided \$378,000 and FSIS provided \$500,000 through CDC to the five locations for 6 months. The agencies believe that this effort should be a permanent part of a sound public health system. For fiscal year 1996, FSIS is providing \$1 million and FDA is providing \$300,000. CDC provides overall management and coordination and facilitates the development of technical expertise at the sites through its established relationships with the state health departments.

The project consists of three parts:

- a survey of the local population in the five locations and interviews with local health professionals to estimate the number of diarrheal illnesses and determine the number of illnesses for which medical attention was sought and laboratory samples were taken;
- a survey of laboratories to determine the microbiological testing procedures and processes used to identify foodborne illnesses and an audit of the participating laboratories' test results to determine what proportion of cases were detected; and
- statistical studies to determine, among other things, the risks associated with different foods.

CDC and the five sites will use the information to identify emerging foodborne pathogens and monitor the incidence of foodborne illness. FSIS will use the data to evaluate the effectiveness of new food safety programs and regulations to reduce foodborne pathogens in meat and poultry and assist in future program development. FDA will use the data to evaluate its efforts to reduce foodborne pathogens in seafood, dairy products, fruit, and vegetables.

⁷The areas are (1) the greater metropolitan area of Atlanta, (2) an area comprised by two northern California counties, (3) an area comprised by two Connecticut counties, (4) the state of Minnesota, and (5) the state of Oregon.

According to CDC, FDA, and FSIS officials, such projects must collect data over a number of years to identify national trends and evaluate the effectiveness of strategies to control pathogens in food. Funding was decreased slightly for this project in 1996, and these officials are concerned about the continuing availability of funding, in this era of budget constraints, to conduct this discretionary effort over the longer term.

Agency Comments

We provided copies of a draft of this report to CDC, FSIS, and FDA for their review and comment. We met with the Director, Division of Bacterial and Mycotic Diseases, CDC; the Associate Administrator, FSIS; and other relevant officials from both agencies. These officials generally agreed with the information discussed and provided some clarifying comments that we incorporated into the report. FDA's Office of Legislative Affairs notified us that FDA generally agreed with the contents of the report and provided several technical comments that we incorporated.

Scope and Methodology

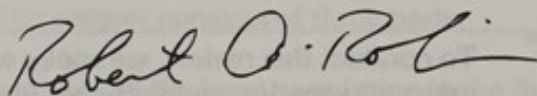
To conduct this review, we spoke with, and obtained studies, data, and other information on foodborne illnesses from, officials at CDC, ERS, FDA, and FSIS. We met with these officials at their headquarters in Atlanta, Georgia, and Washington, D.C. To examine the frequency of foodborne illness, we met with agency officials to identify and discuss the most widely recognized studies on the incidence of foodborne illness in the United States and obtained documentation. To examine the health consequences of foodborne illnesses, we relied primarily on discussions with medical experts at CDC and articles that have appeared in professional journals obtained from CDC officials and our literature review. To examine the economic impacts of foodborne illnesses, we reviewed the analytical approaches used to estimate the costs of foodborne illnesses and recent examples of such estimates and spoke with economists at CDC, ERS, and FDA. To examine the adequacy of knowledge about foodborne illnesses to develop effective control strategies, we spoke with the project managers from CDC, FDA, and FSIS and other agency officials associated with a joint effort with five state health departments recently undertaken to improve their knowledge about foodborne illnesses and collected agency documents.

We reviewed but did not independently verify the accuracy of the data available on the number of reported cases of foodborne illness, the overall estimates of incidence, or the estimates of costs from specific pathogens

because this effort would have required the verification of multiple databases and other information from state and federal agencies and other sources. This verification process would have required a large commitment of additional resources. We did not review data on the incidence of foodborne illness in other countries because comparable data were not readily available and the data that are available have some of the same limitations as the data on U.S. foodborne illnesses.

We conducted our review from June 1995 through April 1996 in accordance with generally accepted government auditing standards.

We are sending this report to you because of your role in overseeing the activities and funding of the agencies responsible for the issues discussed. If you or your staff have any questions about this report, I can be reached at (202) 512-5138. Major contributors to this report are listed in appendix V.



Robert A. Robinson
Director, Food and
Agriculture Issues Area

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Abbreviations

CDC	Centers for Disease Control and Prevention
ERS	Economic Research Service
FDA	Food and Drug Administration
FSIS	Food Safety and Inspection Service
HUS	Hemolytic Uremic Syndrome
USDA	U.S. Department of Agriculture

Sources of Data on Illnesses and Deaths From Foodborne Pathogens

To monitor, control, and prevent foodborne illnesses, the Centers for Disease Control and Prevention (CDC) relies primarily on four types of data from local and state health departments, according to CDC officials. These four types of data are shown in table I.1.

Table I.1: Data CDC Relies on to Monitor, Control, and Prevent Foodborne Illnesses

Type	Description of data	Frequency of collection	Purpose	Limitations
Outbreak data	Reports of foodborne outbreaks from local and state health departments	Reported annually for most outbreaks (more frequently for outbreaks of <u>E. coli O157:H7</u> and <u>Salmonella Enteritidis</u>)	Identify new trends in illnesses and modes and vehicles of transmission of pathogens	Do not include all outbreaks or isolated cases for most pathogens; often, the pathogen and the route of infection are not identified; delay in compiling data
Laboratory data	Computer-based reporting on positive test results for four pathogens from local and state laboratories	Usually weekly, but varies; can be daily or more frequently if needed	Analysis of trends and rapid detection of outbreaks	Can only identify cases for which tests were performed; limited to four pathogens; do not identify source of infection
Outbreak investigations	Data CDC collects when it provides assistance at the request of local and state health authorities	As requested	Provide specific information on the pathogen and source of infection	Only account for a portion of the total number of outbreaks
Active surveillance data from laboratories, physicians, and patients	Comprehensive data collected from a network of representative sites, laboratories, physicians, and patients	Ongoing	Estimate the incidence of illness and determine the source of illness and the populations affected	Until recently, few networks had been established for collecting data on foodborne illnesses because such networks require substantial resources

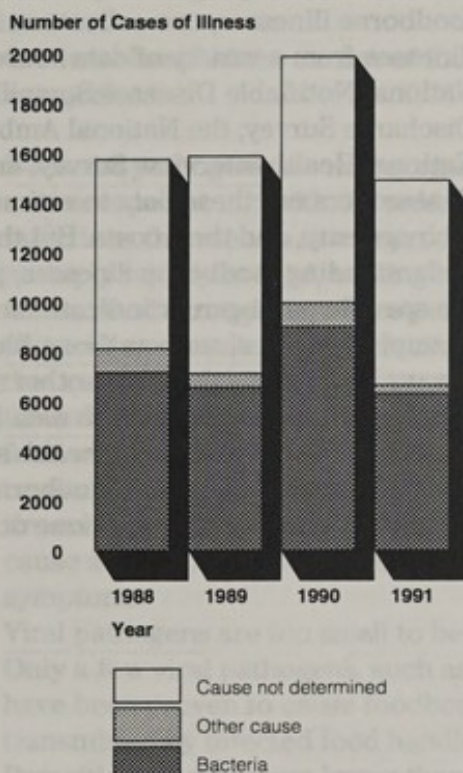
Source: Officials at the National Center for Infectious Diseases, CDC.

As table I.1 notes, each type of data has limitations, particularly the outbreak and laboratory data, which have been CDC's primary monitoring tools. More specifically, in about half of the outbreaks as shown in figure I.1, the data do not identify the agent that caused the outbreak. Furthermore, these data generally do not provide information about the cause of a new trend. One or more factors can account for a new trend: a change in consumption behavior, such as a preference for turkey over red meat; a reporting bias, such as an increase in the number of laboratories testing for the disease; or a change in the nature of the disease, such as the emergence of a new strain. Finally, there is a delay from the time these data are reported to CDC until they are compiled into annual summaries. At

Appendix I Sources of Data on Illnesses and Deaths From Foodborne Pathogens

the time of our review, complete annual summaries of data were only available through 1991.

Figure I.1: Reported Cases of Illness From Foodborne Outbreaks by Cause, 1988-91



Note: Other causes include chemicals, viruses, and parasites.

Source: CDC.

Furthermore, CDC's laboratory data, from its Public Health Laboratory Information System, represent only a fraction of the cases of illnesses that occur from four pathogens that CDC tracks.⁸ For example, only one confirmed case of infection was cited in the laboratory data that the Georgia Health Department reported to CDC during an outbreak caused by contaminated ice cream products in 1994. However, on the basis of a survey of home delivery customers that it conducted, CDC estimated that

⁸The four pathogens are *Salmonella*, *Shigella*, *Campylobacter*, and *E. coli* O157:H7. At least 30 pathogens are associated with foodborne illnesses.

Appendix I Sources of Data on Illnesses and Deaths From Foodborne Pathogens

11,404 cases occurred in Georgia alone (products were distributed in 48 states). Finally, these data do not include information about the source of the illness.

In addition to its program activities to monitor, control, and prevent foodborne illnesses, CDC collects national data on a range of pathogens and illnesses from a variety of data sources. These sources include the National Notifiable Diseases Surveillance System,⁹ the National Hospital Discharge Survey, the National Ambulatory Medical Care Survey, the National Health Interview Survey, and the National Vital Statistics System. Researchers use these data to estimate the number of foodborne illnesses, their severity, and their costs. But these data have major limitations for understanding foodborne illnesses, primarily because they rarely identify the specific pathogen or indicate the method of transmission. For example, illnesses, such as those caused by *E. coli* O157:H7,¹⁰ cannot always be distinguished from other similar illnesses. Researchers may supplement national data with data from health maintenance organizations or community health studies. Such studies provide more detailed information about foodborne illnesses but are limited to small samples and have only been done occasionally.

⁹Data from this system are the basis of CDC's publications on the diseases reported to local and state public health officials each week.

¹⁰*E. coli* O157:H7 is the strain of bacteria responsible for the 1993 outbreak from undercooked hamburgers at a chain of restaurants in the western United States.

Illnesses From Foodborne Pathogens and Chemicals

Major Pathogens

Although foodborne illnesses are often short term and do not require medical treatment, in some cases, these illnesses can involve other organs, resulting in serious complications. In other cases, foodborne illnesses may not result in immediate symptoms but ultimately may produce serious health problems.

CDC has classified the causes of foodborne illnesses into the following four categories:

- **Bacterial pathogens** are microorganisms that can be seen with a microscope but not with the naked eye. Some bacterial pathogens are infectious themselves or can produce toxins. Furthermore, bacteria can multiply rapidly in food, making them difficult to control and can be transmitted through person-to-person contact. Some bacteria, such as *Clostridium botulinum*, which causes botulism, can form spores in food that can resist some food preservation treatments, including boiling.
- **Chemical agents** are primarily naturally occurring toxins that can enter the food supply. Paralytic shellfish poisoning and mushroom poisoning are caused by such chemicals. Heavy metals—such as cadmium, copper, iron, tin, and zinc—are also included in this category. These pathogens can cause a variety of gastrointestinal, neurologic, respiratory, and other symptoms.
- **Viral pathogens** are too small to be seen with a conventional microscope. Only a few viral pathogens, such as the Hepatitis A and Norwalk viruses, have been proven to cause foodborne illnesses. Viral pathogens are often transmitted by infected food handlers or through contact with sewage.
- **Parasitic pathogens** are larger than bacterial pathogens and include protozoa (one-celled microorganisms) and multicelled parasites. They multiply only in host animals, not in food. Protozoa form cysts that are similar to spores but less resistant to heat. Cysts can be transmitted to new hosts through food that has been eaten. Multicelled parasites, such as *Trichinella spiralis*, which causes trichinosis, occur in microscopic forms, such as eggs and larvae. Thorough cooking will destroy larvae.

While the likelihood of serious complications from foodborne illnesses is unknown, some researchers estimate that about 2 to 3 percent of all cases of foodborne illness lead to serious consequences. Although anyone can suffer from foodborne illnesses, certain populations are more at risk from them or their complications than others: pregnant women, children, those with compromised or suppressed immune systems, and the elderly. These groups are more at risk because of altered, underdeveloped, damaged, or weakened immune systems.

Appendix II
Illnesses From Foodborne Pathogens and
Chemicals

Table II.1 provides information on several foodborne pathogens, the serious complications they may result in, and some of the foods in which they have been found.

Table II.1: Some Foodborne Pathogens That Can Cause Serious Illnesses

Foodborne pathogen	Serious illnesses that can result	Foods in which pathogens have been found
Bacteria		
<u>Campylobacter</u>	Arthritis, blood poisoning, Guillain-Barre syndrome (paralysis), chronic diarrhea, meningitis, and inflammation of the heart, gallbladder, colon, and pancreas	Poultry, raw milk, and meat
<u>E. coli O157:H7</u>	HUS, ^a which is associated with kidney failure and neurologic disorders; and other illnesses	Meat, especially ground beef; raw milk; and produce
<u>Listeria</u>	Meningitis, blood poisoning, stillbirths, and other disorders	Soft cheese, other dairy products, meat, poultry, seafood, fruits, and vegetables
<u>Salmonella</u>	Reactive arthritis, blood poisoning, Reiter's disease (inflammation of joints, eye membranes, and urinary tract) and inflammation of the pancreas, spleen, colon, gallbladder, thyroid, and heart	Poultry, meat, eggs, dairy products, seafood, fruits, and vegetables
<u>Shigella</u>	Reiter's disease, HUS, pneumonia, blood poisoning, neurologic disorders, and inflammation of the spleen	Salads, milk and dairy products, and produce
<u>Vibrio vulnificus</u>	Blood poisoning	Seafood
<u>Yersinia enterocolitica</u>	Reiter's disease, pneumonia, and inflammation of vertebrae, lymphatic glands, liver, and spleen	Pork and dairy products
Parasites		
<u>Toxoplasma gondii</u>	Central nervous system disorders	Meat, primarily pork
<u>Trichinella spiralis</u>	Heart and neurologic disorders	Pork

^aHemolytic-uremic syndrome.

Source: CDC, Food and Drug Administration, U.S. Department of Agriculture, and Council for Agricultural Science and Technology.

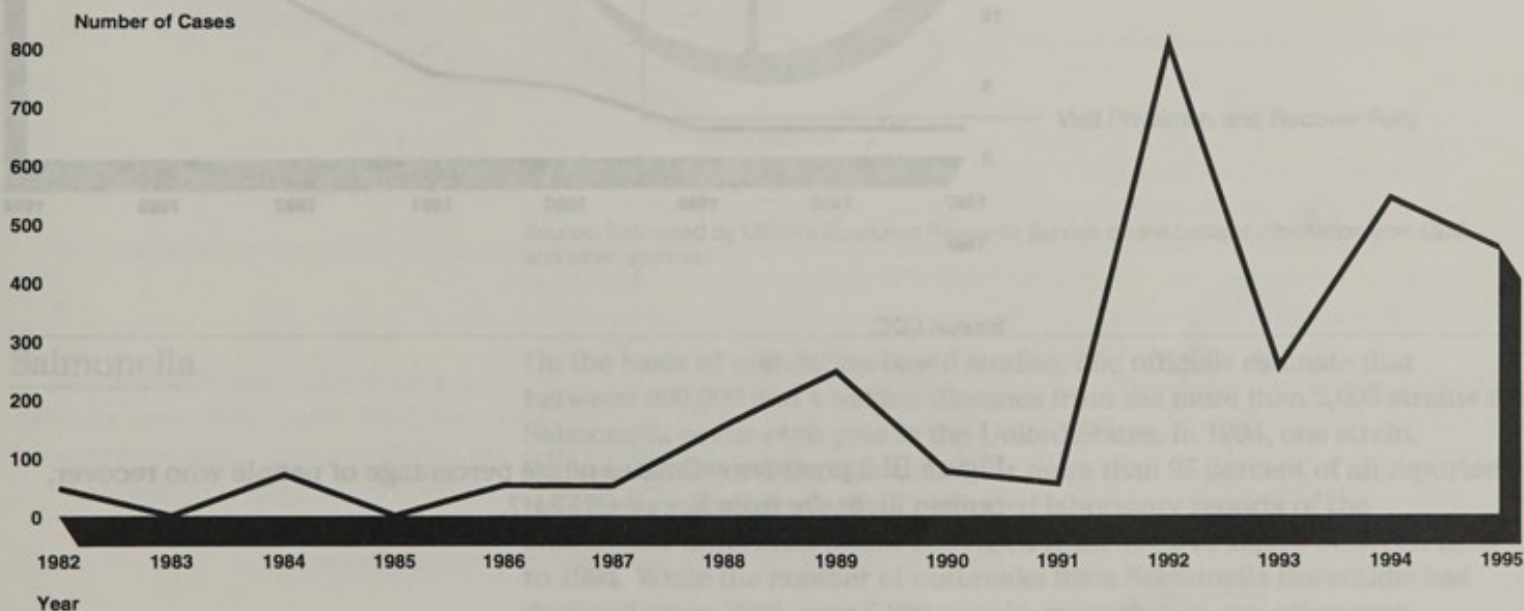
Estimated Number of Illnesses and Deaths From Four Major Pathogens

In 1990, the Public Health Service identified *E. coli* O157:H7, *Salmonella*, *Listeria monocytogenes* and *Campylobacter jejuni* as the four most important foodborne pathogens in the United States because of the severity and the estimated number of illnesses they cause. According to CDC officials, illnesses caused by *E. coli* O157:H7 and *Listeria monocytogenes* are generally more deadly than illnesses caused by other foodborne pathogens. In contrast, illnesses caused by *Salmonella* and *Campylobacter jejuni* are less likely to be deadly but are more common. This appendix discusses the estimated number of cases of foodborne illness caused by these pathogens.

E. coli O157:H7

E. coli O157:H7 has emerged as an important cause of outbreaks of foodborne illness in the United States since 1982. (See fig. III.1).

Figure III.1: Reported Cases of Illness from Outbreaks of *E. coli* O157:H7, 1982-95



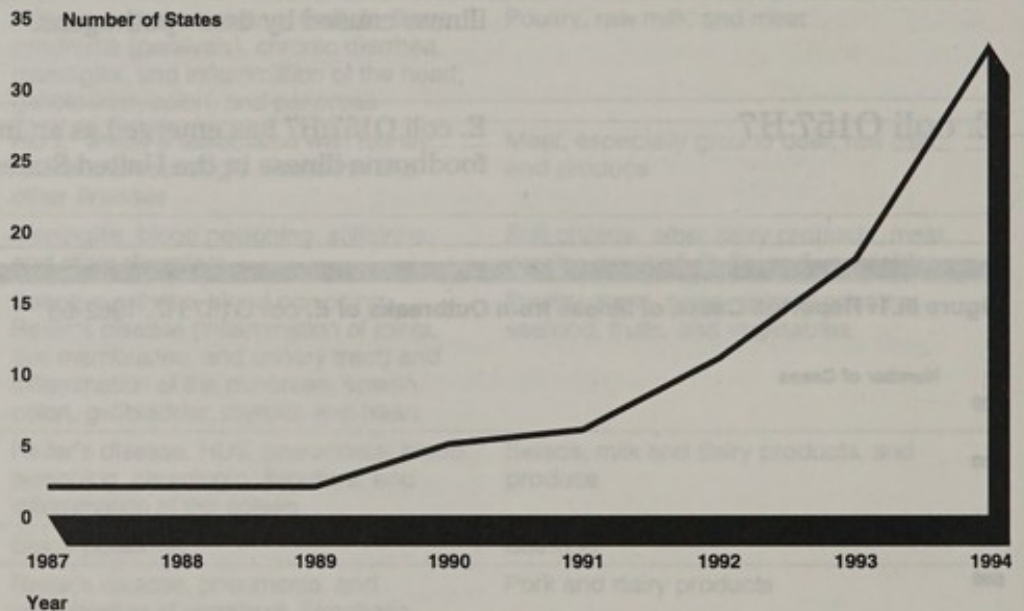
Notes: 1995 data are preliminary. Approximately 66 percent of the outbreaks from 1982-85 were foodborne. The remaining outbreaks include those from other routes of infection, such as person-to-person contact, or were unidentified and may also be related to contaminated food.

Source: CDC.

Appendix III
Estimated Number of Illnesses and Deaths
From Four Major Pathogens

Because few laboratories in the United States routinely test for *E. coli* O157:H7, the actual number of illnesses caused by this pathogen is unknown, but CDC officials estimate that this pathogen causes approximately 21,000 illnesses annually. As shown in figure III.2, only 33 states required reporting of such illnesses through the end of 1994, according to information provided by CDC.

Figure III.2: Number of States
Requiring Reporting of *E. coli* O157:H7,
1987-94

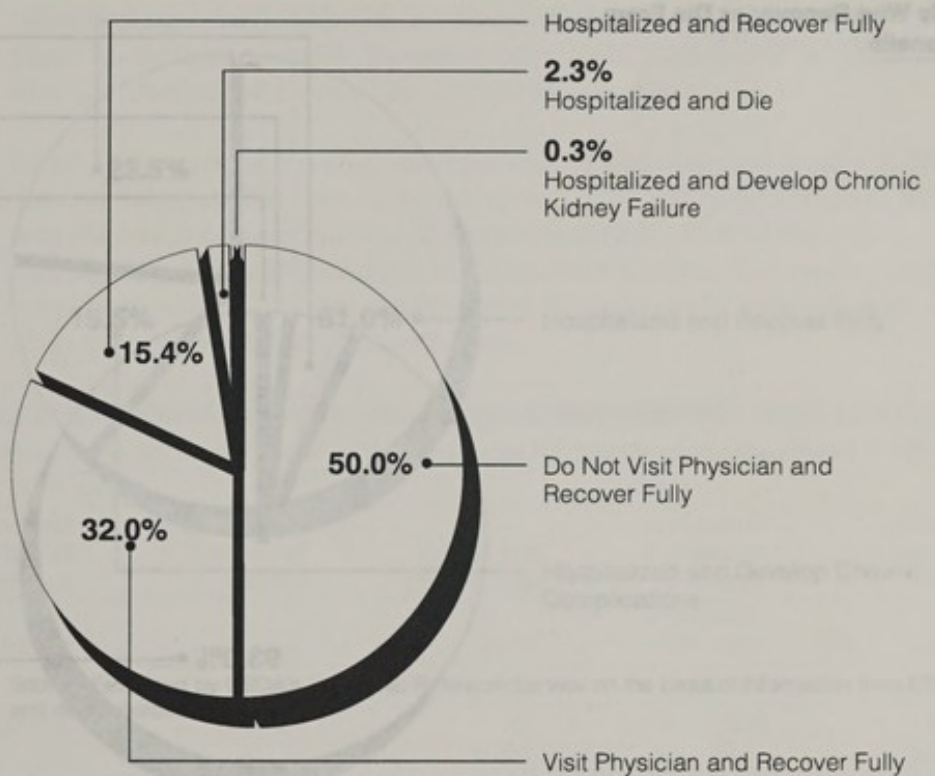


Source: CDC.

Figure III.3 provides estimates of the percentage of people who recover, remain ill, or die from *E. coli* O157:H7.

Appendix III
Estimated Number of Illnesses and Deaths
From Four Major Pathogens

Figure III.3: Estimated Percentage of People Who Recover, Remain Ill, or Die From *E. coli* O157:H7



Source: Estimated by USDA's Economic Research Service on the basis of information from CDC and other sources.

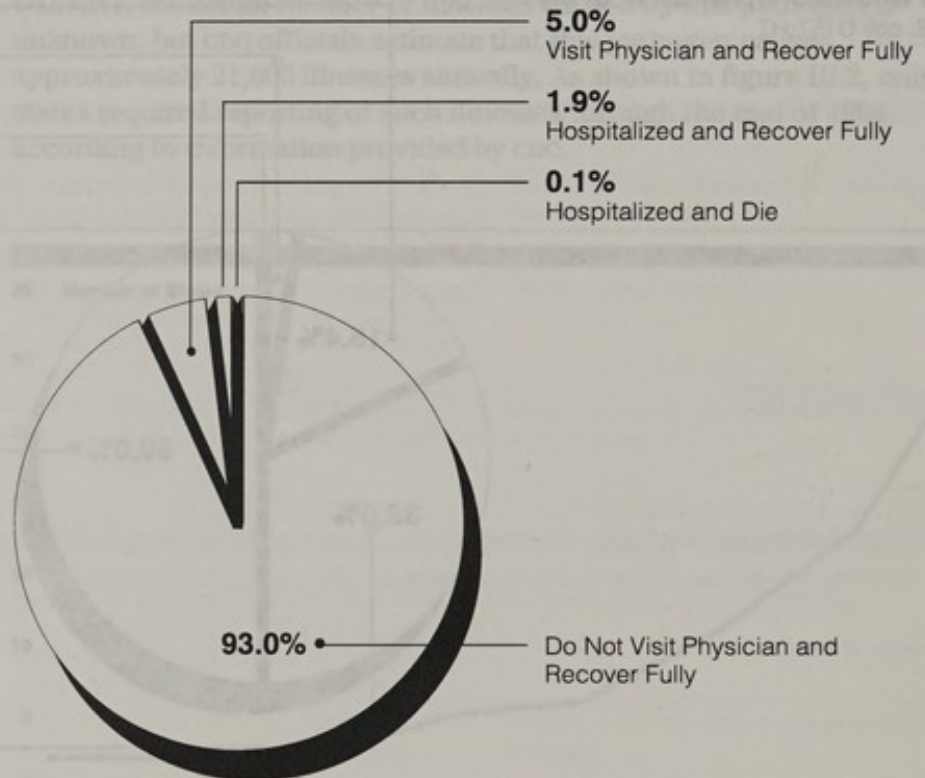
Salmonella

On the basis of population-based studies, CDC officials estimate that between 800,000 and 4 million illnesses from the more than 2,000 strains of *Salmonella* occur each year in the United States. In 1994, one strain, *Salmonella* Enteritidis, accounted for more than 25 percent of all reported infections from *Salmonella*. Confirmed laboratory reports of the *Salmonella* Enteritidis strain increased from 3,322 to 10,009 between 1982 to 1994. While the number of outbreaks from *Salmonella* Enteritidis has declined since 1989, over 5,000 people, more than in any other year, became ill from the 44 outbreaks reported in 1994.

Figure III.4 shows the estimated percentage of people who recover or die from all strains of *Salmonella*.

Appendix III
Estimated Number of Illnesses and Deaths
From Four Major Pathogens

Figure III.4: Estimated Percentage of
People Who Recover or Die From
Salmonella

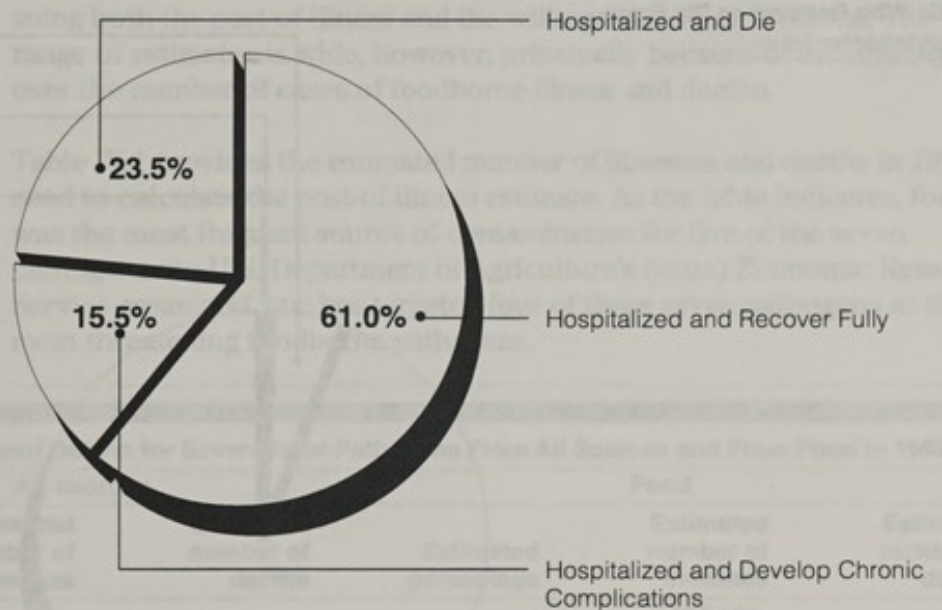


Source: Estimated by USDA's Economic Research Service on the basis of information from CDC and other sources.

Listeria monocytogenes

CDC estimates that the number of illnesses and deaths caused by Listeria monocytogenes declined between 1989 and 1993, from 1,965 cases and 481 deaths to 1,092 cases and 248 deaths. CDC attributes this downward trend to prevention efforts implemented by the food industry and regulatory agencies. Figure III.5 shows the estimated percentages of people who recover, remain ill, or die from Listeria monocytogenes.

Figure III.5: Estimated Percentage of People Who Recover, Remain Ill, or Die From Listeria monocytogenes



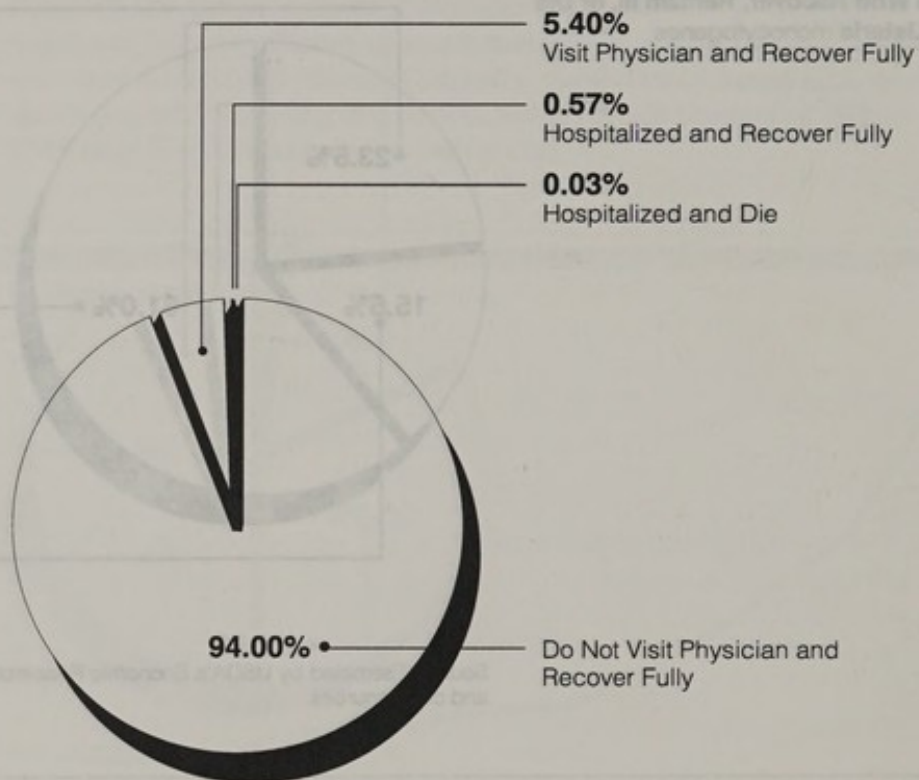
Source: Estimated by USDA's Economic Research Service on the basis of information from CDC and other sources.

Campylobacter jejuni

According to CDC, Campylobacter jejuni is the most common bacterial cause of diarrhea in the industrialized world. An estimated 2 million to 4 million cases occur each year in the United States, according to population-based studies. Although the number of Campylobacter jejuni cases confirmed by laboratory reports represents only a small proportion of the total number of illnesses that are estimated to occur from Campylobacter jejuni, the reported number more than doubled from 3,947 in 1982 to 7,970 in 1989. Most cases of illness occur sporadically and not as part of an outbreak. Illness can occur from contact with raw foods (often poultry) during food preparation. Figure III.6 shows the estimate of the percentage of people who recover or die from Campylobacter jejuni.

Appendix III
Estimated Number of Illnesses and Deaths
From Four Major Pathogens

Figure III.6: Estimated Percentage of
People Who Recover or Die From
Campylobacter jejuni



Source: Estimated by USDA's Economic Research Service on the basis of information from CDC and other sources.

Estimated Costs of Foodborne Illnesses

This appendix provides information on the cost of foodborne illnesses using both the cost-of-illness and the willingness-to-pay methods. The range of estimates is wide, however, principally because of uncertainty over the number of cases of foodborne illness and deaths.

Table IV.1 provides the estimated number of illnesses and deaths in 1993 used to calculate the cost-of-illness estimate. As the table indicates, food was the most frequent source of contamination for five of the seven pathogens the U.S. Department of Agriculture's (USDA) Economic Research Service examined. CDC has targeted four of these seven pathogens as the most threatening foodborne pathogens.

Table IV.1: Estimated Number of Illnesses and Deaths for Seven Major Pathogens From All Sources and From Food in 1993

Pathogens	All sources		Estimated percentage	Food	
	Estimated number of illnesses	Estimated number of deaths		Estimated number of illnesses	Estimated number of deaths
<i>Campylobacter jejuni</i> or <i>coli</i>	2,500,000	200-730	55-70	1,375,000-1,750,000	110-511
<i>Clostridium perfringens</i>	10,000	100	100	10,000	100
<i>E. coli</i> O157:H7	10,000-20,000	200-500	80	8,000-16,000	160-400
<i>Listeria monocytogenes</i>	1,795-1,860	445-510	85-95	1,526-1,767	378-485
<i>Salmonella</i>	800,000-4,000,000	800-4,000	87-96	696,000-3,840,000	696-3,840
<i>Staphylococcus aureus</i>	8,900,000	7,120	17	1,513,000	1,210
<i>Toxoplasma gondii</i>	4,111	82	50	2,056	41
Total	12,225,906-15,435,971	8,947-13,042	Not applicable	3,605,582-7,132,823	2,695-6,587

Source: Economic Research Service, USDA.

Table IV.2 presents cost-of-illness estimates for all foodborne illnesses and illnesses from meat and poultry. Contaminated meat and poultry are believed to be among the most common sources of foodborne illness from these pathogens.

Appendix IV
Estimated Costs of Foodborne Illnesses

Table IV.2: "Cost-Of-Illness" Estimates for Seven Major Pathogens From All Foods and From Meat and Poultry During 1993

Dollars in billions			
Pathogens	All foods Estimated costs	Meat and poultry	
		Estimated percentage	Estimated costs
<i>Campylobacter jejuni</i> or <i>coli</i>	\$0.6-1.0	75	\$0.5-0.8
<i>Clostridium perfringens</i>	0.1	50	0.1
<i>E. coli</i> O157:H7	0.2-0.6	75	0.2-0.5
<i>Listeria monocytogenes</i>	0.2-0.3	50	0.1-0.2
<i>Salmonella</i>	0.6-3.5	50-75	0.3-2.6
<i>Staphylococcus aureus</i>	1.2	50	0.6
<i>Toxoplasma gondii</i>	2.7	100	2.7
Total	\$5.6-9.4	Not applicable	\$4.5-7.5

Source: Economic Research Service and Food Safety and Inspection Service, USDA.

ERS also used the willingness-to-pay method to estimate the value of preventing deaths for five of the seven major pathogens. The results of this analysis are shown in table IV.3.

Table IV.3: "Willingness-To-Pay" Estimate for Five Major Pathogens in 1992

Dollars in billions		
Pathogens	Estimated number of deaths from foodborne sources	Implied value of preventing deaths
<i>Salmonella</i>	960-1,920	\$3.8-13.4
<i>Campylobacter jejuni</i> or <i>coli</i>	120-360	.48-2.5
<i>E. coli</i> O157:H7	146-389	.58-2.7
<i>Listeria monocytogenes</i>	378-433	1.5-3.0
<i>Toxoplasma gondii</i>	42	.17-.29
Total	1,646-3,144	\$6.6-22.0

Source: Economic Research Service, USDA.

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