

Bacterial Foodborne Disease: Medical Costs and Productivity Losses.
Food and Consumer Economics Division, Economic Research Service, U.S.
Department of Agriculture. Agricultural Economic Report No. 741.

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Abstract

Microbial pathogens in food cause an estimated 6.5-33 million cases of human illness and up to 9,000 deaths in the United States each year. Over 40 different foodborne microbial pathogens, including fungi, viruses, parasites, and bacteria, are believed to cause human illnesses. For six bacterial pathogens, the costs of human illness are estimated to be \$9.3-\$12.9 billion annually. Of these costs, \$2.9-\$6.7 billion are attributed to foodborne bacteria. These estimates were developed to provide analytical support for USDA's Hazard Analysis and Critical Control Point (HACCP) systems rule for meat and poultry. (Note that the parasite *Toxoplasma gondii* is not included in this report.) To estimate medical costs and productivity losses, ERS uses four severity categories for acute illnesses: those who did not visit a physician, visited a physician, were hospitalized, or died prematurely. The lifetime consequences of chronic disease are included in the cost estimates for *E. coli* O157:H7 and fetal listeriosis.

Keywords: cost-of-illness, foodborne pathogens, lost productivity, medical costs.

Acknowledgments

Nedra Williams assisted with the typing and drawing of figures for this manuscript.

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Summary

Foodborne illnesses from six bacterial pathogens are estimated to account for \$2.9-\$6.7 billion in human illness costs in the United States each year. This report provides the first comprehensive, detailed cost-of-illness analyses for the six bacteria in one document, and it puts all cost figures in 1993 dollars. These estimates were developed to provide analytical support for USDA's Hazard Analysis Critical Control Point (HACCP) systems rule for meat and poultry. (The parasite *Toxoplasma gondii* is not included in this report.)

Microbial pathogens in food cause an estimated 6.5 million to 33 million cases of human illness and up to 9,000 deaths annually, according to the Council for Agricultural Science and Technology. Foods most likely to cause human illness are animal products such as red meat, poultry and eggs, seafood, and dairy products.

The six bacterial pathogens studied in this report—all found in animal products—are *Salmonella*, *Campylobacter jejuni*, *Escherichia coli* O157:H7, *Listeria monocytogenes*, *Staphylococcus aureus*, and *Clostridium perfringens*. The U.S. Centers for Disease Control and Prevention (CDC) is the source of most epidemiological information on numbers of foodborne illnesses and deaths used in this report.

The cost of human illness caused by the six bacterial pathogens is between \$9.3 billion and \$12.9 billion annually in the United States. Between \$2.9 billion and \$6.7 billion of these costs are attributed to foodborne causes.

To estimate medical costs and productivity losses, ERS uses four severity categories for acute illnesses—those who: did not visit a physician, visited a physician, were hospitalized, or died prematurely. The lifetime consequences of chronic disease are included in the cost estimates for *E. coli* O157:H7 and fetal listeriosis. The cost estimates can be used to evaluate the economic impact of foodborne diseases, to target pathogen reduction efforts, and to compare benefits and costs of control efforts in order to determine the most cost-effective measures.

Bacteria are one type of microorganism that cause diseases. Others are fungi, parasites, and viruses. More than 40 different foodborne pathogens, including some bacteria, are believed to cause human illnesses. Our estimates of the annual costs to society of foodborne illness would increase considerably if all foodborne pathogens were included in the analysis, all chronic illnesses that are triggered by foodborne disease were considered, and less conservative estimates were used to value premature death.

Some pathogens that cause human illness are carried by animals but do not cause disease in the animals. *E. coli* O157:H7 lives harmlessly in the intestinal tracts of some cattle, but humans who eat undercooked meat from infected animals can develop illness that in some cases leads to kidney failure.

Glossary

Abbreviations

AIDS	Acquired immunodeficiency syndrome
AV	Artificial ventilation
BLS	Bureau of Labor Statistics
CAPD	Continuous ambulatory peritoneal disease
CCPD	Continuous cyclic peritoneal disease
CDC	Centers for Disease Control and Prevention
CFR	Case fatality rate
COI	Cost-of-illness
CPI	Consumer Price Index
ERS	Economic Research Service
ESRD	End-stage renal disease
FSIS	Food Safety and Inspection Service
GAO	Government Accounting Office
GBS	Guillain-Barré syndrome
GPO	Government Printing Office
HC	Hemorrhagic colitis
HCFA	Health Care Finance Administration
HUS	Hemolytic Uremic Syndrome
ICD	International Classification of Diseases
ICU	Intensive care unit
IOM	Institute of Medicine
IVIG	Immunoglobulin treatments
LS	Landefeld and Seskin
NHDS	National Hospital Discharge Survey
PE	Plasma exchange
QUALY	Quality-adjusted life-year
USDA	United States Department of Agriculture
VOSL	Value of a statistical life
WTP	Willingness to pay
LOS	Length of stay

Medical and Economic Terms

The definitions below clarify terms used in this report.

Bacteria. One-celled microorganisms that are either free-living or parasitic, some of which may be pathogenic.

Bacteremia. Presence of viable bacteria in the bloodstream.

Case. An individual who is ill following ingestion of food. Outbreak cases reported by CDC are determined to be contaminated on the basis of laboratory analysis and/or epidemiological evidence. Not all outbreak cases need be confirmed by laboratory analysis if there is sufficient epidemiological evidence linking them to the outbreak.

Campylobacteriosis. An illness in humans caused by *Campylobacter jejuni* or *C. coli*. Symptoms range from general malaise and diarrhea lasting for a day, to severe abdominal pain and bloody diarrhea, which may last several weeks.

Cholecystitis. Inflammation of the gall bladder.

Colonization. “Implantation and growth of a microorganism on a host” (Dorland’s Dictionary 1994).

Colony forming unit (CFU). Unit of measurement for viable bacteria numbers.

Consumer price index (CPI). A measure of the average change in prices over time in a fixed “market basket” of goods and services purchased either by urban wage earners and clerical workers or by all urban consumers.

Contingent valuation method. The use of surveys of individuals to elicit their preferences, measured in monetary terms (willingness to pay, WTP), for a specified improvement in their health outcomes. It circumvents the absence of markets for health outcomes by presenting survey respondents with hypothetical markets in which they are asked their WTP for the improvement in question.

Cost of illness (COI) method. An approach that is used to estimate the societal costs of a particular illness or injury in a given time frame (typically a 1-year period). The approach typically focuses on two main types of societal costs associated with the particular illness or injury: direct medical and non-medical costs and indirect costs of lost productivity due to morbidity or premature mortality.

Diarrhea. Three or more unusually frequent evacuations of loose stools within a 24-hour period. Diarrhea may be caused by microbial, parasitic, or viral infections, or other factors.

Direct costs. Costs associated with resources expended for healthcare (compare with **indirect costs**).^{*} Does not include lost wages—see productivity loss and indirect costs.

Direct medical costs. The costs of resources for medical treatment (*e.g.*, the cost of a physician visit).^{*}

Direct non-medical costs. Costs incurred in connection with a health intervention or illness, but which are not expended for medical care itself (*e.g.*, the transportation costs associated with a physician visit).*

Discounting. A method for adjusting the value of future costs and benefits to an equivalent value today to account for time preference and opportunity cost, *i.e.*, a dollar today is worth more than a dollar a year from now (even if inflation is not considered).*

Discount rate. A rate used in determining a present value equivalent of a future stream of dollars. The lower the discount rate, the higher the present value of a future stream of dollars.

Endocarditis. Infection of the heart.

Gastroenteritis. Inflammation of the intestine and stomach.

Guillain-Barré Syndrome (GBS). An autoimmune reaction of the body that affects the peripheral nerves and causes weakness, paralysis, and occasionally death.

Hedonic wage studies. Statistical analyses that estimate the effect of intrinsic job characteristics, such as health risks, fringe benefits, or autonomy, on pay.

Hemodialysis. Separation of large and small molecules of the blood by use of selective diffusion through a semipermeable membrane. A medical treatment used to treat kidney failure.

Hemolytic Uremic Syndrome (HUS). A disease characterized by kidney failure and neurological failure. HUS especially strikes children under 5 years of age and the immunocompromised elderly.

Hemorrhagic Colitis. A clinical syndrome manifested by bloody inflammation of the colon. This syndrome can be the result of several diseases including *E. coli* O157:H7 disease.

Hospital discharge. The completion of an inpatient's continuous period of stay in a hospital where the stay lasts one night or more.

Human capital approach. A method for estimating the impact of an individual's illness or premature death on society by measuring the discounted value of his/her productivity loss (labor earnings) due to morbidity or premature mortality.

Immunocompromised. Individuals with a weakened immune system, making them susceptible to additional infections.

Incidence. A measure of the magnitude of a disease, usually expressed as the number of new cases of a disease per 100,000 individuals in the U.S. population in a 1-year period.

Incidence-based costs. The total lifetime costs of new cases of a disease or injury that occur during a certain period of time.*

Indirect costs. The resources forgone either to participate in an intervention or as the result of a health condition (*e.g.*, earnings forgone because of loss of time from work).*

Infection. An illness or carrier state arising from colonization of foodborne microbial pathogens in the human gastrointestinal tract or other parts of the human body. Human antibodies that resist these pathogens may cause chronic complications.

Infectious Dose. The number of organisms that make individuals ill or carriers. In reality, there is a probability distribution associated with different pathogen exposure levels.

Isolation rate. In microbiology, the rate at which an organism is identified in a culture.

Labor force participation rate. The percentage of average civilian noninstitutional population in the civilian labor force in a year. The civilian labor force comprises all employed and unemployed civilians in the noninstitutional population 16 years and over.

Life expectancy. The average remaining lifetime in years for an individual of a particular age, given sex-specific and age-specific death rates.

Listeriosis. A gastrointestinal illness in humans caused by *Listeria*. Illness caused by the bacterium, *Listeria monocytogenes*, may be either mild or severe. Milder cases are characterized by a sudden onset of fever, severe headache, vomiting, and other influenza-type symptoms. Severe cases can result in meningitis, chronic illness, and death. Listeriosis may appear mild in healthy adults and more severe in fetuses, the elderly, and the immunocompromised. Pregnant women with *Listeria* infections may have spontaneous abortions and offspring with visual, mental, or other problems. Outbreak data show that the incubation period ranges from 3 to 70 days.

Meningitis. Infection of the brain or spinal tissues.

Neonate. A newborn child.

Net present value (NPV). The sum that results when the discounted value of the costs of a prevention strategy is deducted from the discounted value of the benefits of the strategy.*

Opportunity costs. The monetary value of the resources used in providing a specific set of health-care services valued in terms of forgone alternative uses.*

Outbreak data. CDC data on foodborne disease outbreaks define an outbreak as an incident in which two or more persons experienced a similar illness after ingestion of a common food, and epidemiologic analysis implicated a food as

the source of the illness. There are two exceptions, botulism and chemical poisoning, in which one case constitutes an outbreak.

Pathogen. A disease-causing agent such as a certain bacterium, parasite, virus, or fungus.

Pneumonia. Acute or chronic disease characterized by inflammation of the lungs. The disease is typically caused by bacteria, viruses, or other agents.

Premature mortality. a) Any preventable death. b) Deaths that occur before a specified age, often age 65, or the average life expectancy of a certain population.*

Prevalence. The total number of cases of a given disease at a particular point in time, includes new (*i.e.*, incidence) as well as chronic cases.

Productivity loss. The monetary value of output that would have been produced in the absence of an illness, disability, injury, morbidity, or premature mortality.

Reiter syndrome. Inflammation of the joints and sometimes the eyes and urinary tract. Reiter syndrome (a form of reactive arthritis) typically lasts for 6 weeks and can go on to develop other rheumatoid syndromes, such as rheumatoid arthritis. Reactive arthritis is seen equally in females and males, and sometimes in children. Almost all sexually acquired Reiter syndrome cases are seen in males aged 20-40 years.

Recurrent. “1. Running back, or toward the source, 2. returning after remissions” (Dorland’s Dictionary 1994).

Reservoir of infection. “1. Any person, animal, arthropod, plant, soil, or substance, or a combination of these, in which an infectious agent normally lives and multiplies, on which it depends primarily for survival, and where it reproduces itself in such a manner that it can be transmitted to a susceptible host. 2. The natural habitat of the infectious agent” (Dict. of Epid. 1995, p. 146).

Resistance. “The natural ability of an organism to resist microorganisms or toxins produced in disease” (Dorland’s Dictionary 1994).

Risk premium. The increased wage needed to attract workers to riskier jobs.

Salmonellosis. An illness in humans caused by *Salmonella*. The disease induces fever, nausea, abdominal cramps, diarrhea, and sometimes vomiting. Severity ranges from mild diarrhea to bacteremia and death.

Sepsis. “Presence of disease-causing organisms or their toxins in the blood or tissues” (Webster’s Dictionary 1984). Sepsis is a syndrome of decreased blood pressure and capillary leakage.

Septicemia. “Systemic disease caused by pathogenic organisms and their toxins in the bloodstream” (Webster’s Dictionary 1984).

Sequelae. Abnormal conditions that arise following the acute phase of a disease. For example, kidney failure may follow acute *E. coli* O157:H7 disease.

Serotypes. “A group of related microorganisms distinguished by its composition of antigens” (Webster’s Dictionary 1984). Serotype is sometimes called serovar.

Societal perspective. The perspective of society as a whole. Economic analyses typically take a societal perspective to include all benefits of a program regardless of who receives them and all costs regardless of who pays them.*

Surveillance data. Data on individual cases of foodborne illness that were cultured in a laboratory and reported to the CDC surveillance system.

Virulence. The pathogenic or poisonous potential of bacteria, fungi, or other agents.

Willingness-to-pay (WTP). A measure of the value an individual would place on reducing risk of death or illness. It is the maximum dollar amount the individual would be willing to give up in a given hypothetical risk-reducing situation.

* These terms are from Haddix, A. C., S. M. Teutsch, P. A. Shaffer, and D. O. Duñet (eds.). *Prevention Effectiveness: A Guide to Decision Analysis and Economic Evaluation*. New York: Oxford University Press, 1996 (definitions may have been adapted for this report).

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