Children and Microbial Foodborne Illness

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Consumption of food contaminated with microbial pathogens (bacteria, fungi, parasites, viruses, and their toxins) causes an estimated 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths each year in the United States. People who face relatively higher risks from foodborne illness and associated complications, such as kidney failure, include the very young, the very old, and the immunocompromised, such as those with AIDS and cancer.

Children deserve added attention in the study of microbial foodborne illness because the risks of some foodborne illnesses, such as salmonellosis, are relatively higher for children than for other demographic groups. Children's immune systems are not fully developed, placing them at a relatively higher risk for some foodborne illnesses. A child's lower weight means that it takes a smaller quantity of pathogens to make a child sick than it would a healthy adult. Also, children have limited control of food safety risks because their meals are usually prepared by others.

This article focuses on some of the more common or serious foodborne illnesses, namely illnesses from *Campylobacter*, *Salmonella*, *E. coli* O157:H7, *E. coli* non-O157:H7 STEC, *Listeria*, and *Toxoplasma gondii*. Children are usually exposed to these pathogens not only by contaminated food but also by secondary sources of exposure, such as ill family members or ill classmates in a day care center. A pregnant woman who becomes newly infected with *Listeria* or *Toxoplasma gondii* can pass the infection to her fetus.

USDA's Economic Research Service (ERS) estimates that the five foodborne illnesses covered in this article cause $6.9 billion in medical costs, lost productivity, and premature deaths in the United States each year. Using FoodNet data on the proportion of all confirmed and reported illnesses attributed to children for the different pathogens, our preliminary estimate is that about one-third of total costs—$2.3 billion—are the result of illnesses in children under the age of 10.

Children's low body weights and underdeveloped immune systems increase their risk of some foodborne illnesses.

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Foodborne Illnesses Can Develop Chronic Complications

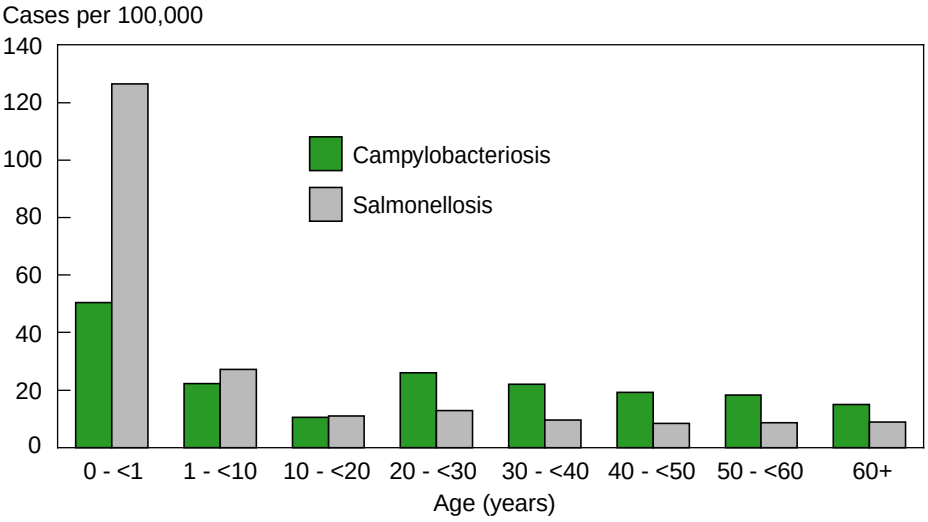
Most cases of foodborne illnesses are classified as "acute." These cases are usually self-limiting and of short duration, although they can range from mild to severe. Gastrointestinal problems and vomiting are common acute symptoms of many foodborne illnesses. Deaths from acute foodborne illnesses are relatively uncommon and more typically occur in the very young, the elderly, or patients with compromised immune systems. However, the U.S. Food and Drug Administration (FDA) estimates that 2-3 percent of all acute cases develop secondary long-term illnesses and complications called chronic sequellae.

Chronic sequellae of foodborne illness can occur in any part of the body, such as the joints, nervous system, kidneys, or heart. Examples of chronic sequellae of foodborne illness include Guillain-Barré Syndrome (GBS) following some *Campylobacter* infections, hemolytic uremic syndrome (HUS) following some *E. coli* O157:H7 infections, and mental retardation following some congenital *Listeria* infections. These chronic illnesses may afflict the patients for the remainder of their lives and may result in premature death.

Infants Have the Highest Reported Incidence of Campylobacteriosis…

Campylobacter is the most commonly reported cause of foodborne illness in the United States. Each year it causes around 2 million cases of foodborne illness, 10,000 hospitalizations, and 100 deaths. In the United States, infants (under 1 year old) have the highest reported incidence of campylobacteriosis; young adults age 20 to 29 are the illness's second highest risk group (fig. 1). According to Dr. Robert Tauxe at the Centers for Disease Control and Prevention (CDC), the peak isolation rate in infants is partly attributed to the increased susceptibility on the first exposure and partly because medical care is quickly sought for infants and incidents are reported.

Figure 1
Infants Have the Highest Reported Incidence Rate of Campylobacteriosis and Salmonellosis



Source: CDC/USDA/FDA Foodborne Diseases Active Surveillance Network, 1998 Annual Report.

Outbreaks of campylobacteriosis in child care facilities are rare, and most children are believed to have acquired their infections from contaminated food. The incubation period is 1 to 10 days with most cases occurring 3 to 5 days after exposure. Campylobacteriosis symptoms can range from diarrhea and lethargy that lasts a day to severe diarrhea and abdominal pain (and occasionally fever) that lasts for several weeks. Diarrhea and abdominal pain are the most common symptoms and most cases are relatively mild.

Some people ill with campylobacteriosis develop secondary complications, such as reactive arthritis and Guillain-Barré Syndrome. GBS is an autoimmune reaction of the body that affects the peripheral nerves and causes weakness, paralysis, and, occasionally, death. About 1,100 GBS cases are caused by *Campylobacter* infections each year. Although paralysis from GBS is generally reversible over time, some patients are bedridden for life and others die prematurely. Patients with GBS have ranged in age from 9 months to 97 years, though most cases are among adults.

…and Salmonellosis

Infants also have the highest risk of contracting salmonellosis; children under 10 years of age are the second highest risk group. Children, as well as the immunocompromised and the elderly, also face a relatively higher risk of death from salmonellosis than other demographic categories. Salmonellosis occurs much more frequently in infants than does campylobacteriosis. Most children who contract salmonellosis are believed to have been infected from contaminated food—outbreaks in child care facilities are rare. Poultry, meat, eggs, and milk are some of the major food vehicles of transmission.

Most salmonellosis cases are relatively mild.

E. coli O157:H7 Disease Can Lead to HUS in Children

E. coli O157:H7 and its link to food became well known to the public as a result of the 1993 *E. coli* O157:H7 disease outbreak caused by contaminated hamburger. Over 700 people became ill from this outbreak (primarily children) and 4 children died. In recent years, an increasing number of *E. coli* O157:H7 outbreaks and sporadic cases have been documented and linked to hamburger, unpasteurized apple cider and apple juice, hot dogs, raw milk, raw potatoes, and salad bar items, such as ranch dressing, pea salad, and cantaloup. In addition to contracting the disease from eating contaminated food, people can become ill from this bacteria through person-to-person contact (for example, at day care centers) and swimming in contaminated water. The incubation period for *E. coli* O157:H7 in humans is typically 3 to 5 days.

E. coli O157:H7 causes human illnesses through the toxins that it produces. Illness from *E. coli* O157:H7 ranges from mild cases of acute diarrhea to premature death. Acute illness from *E. coli* O157:H7 disease is manifested by abdominal cramps, vomiting, diarrhea (often bloody), and sometimes fever. Although most *E. coli* O157:H7 infections are relatively mild and do not require medical care, *E. coli* O157:H7 infections can result in hemorrhagic colitis (bloody inflammation of the colon). A small percentage of cases go on to develop hemolytic uremic syndrome (HUS). HUS is a life-threatening disease characterized by red blood cell destruction, kidney failure, and neurological complications, such as seizures and strokes. People who develop chronic kidney failure may require lifelong dialysis or a kidney transplant.

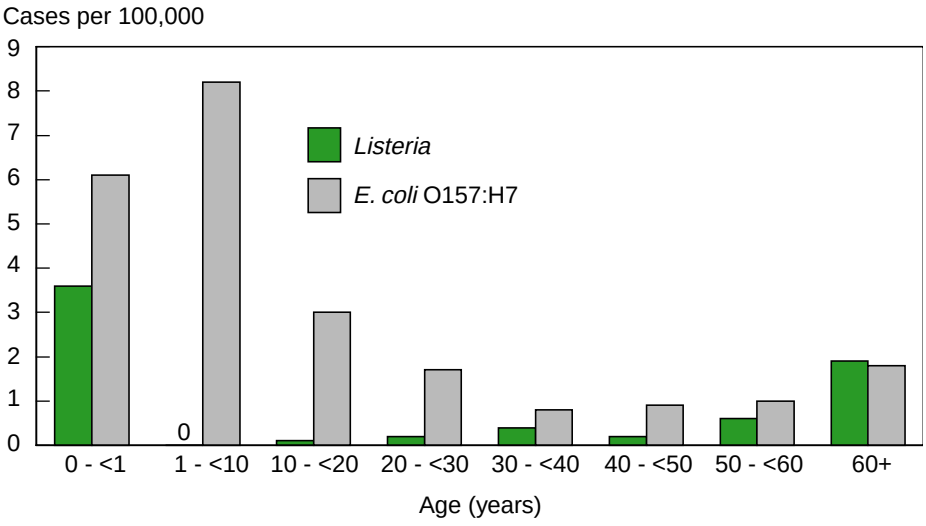
Several studies have identified age less than 4 or 5 years as a risk factor for HUS from *E. coli* O157:H7 disease. *E. coli* O157:H7 disease may be the leading cause of acute kidney failure and HUS in young children and infants. The high incidence of HUS in children could reflect the smaller infective dose by weight, social behavior, immune system development, and other factors affecting the risk of acquiring *E. coli* O157:H7 and HUS infections. According to CDC data, the infection rate for *E. coli* O157:H7 is 6.1 per 100,000 infants and 8.2 per 100,000 children between 1 and 9 years old, the highest infection rate for any age group (fig. 2).

Congenital Listeriosis Can Lead to Lifelong Complications…

Listeriosis is the acute illness caused by an infection from the bacteria *Listeria monocytogenes*. Raw milk products, vegetables, seafood, poultry, red meat, liquid whole egg, and ready-to-eat foods, such as hot dogs and luncheon meats, are foods typically linked to this bacteria. The incubation period for listeriosis is 4 days to several weeks. Milder cases of listeriosis are characterized by a sudden onset of fever, severe headache, vomiting, and other influenza-type symptoms. *Listeria monocytogenes* infection rates are highest for the very young and the very old.

Listeriosis in pregnant women is usually relatively mild and may be manifested as a flu-like syndrome or placental infection. However, listeriosis may cause premature death or cause developmental complications for fetuses and newborns. Babies may be stillborn, develop meningitis (inflammation of the tissue surrounding the brain and/or spinal cord) in the neonatal period, or be born with septicemia (blood poisoning). A portion of babies with meningitis will develop chronic neurological complications.

Figure 2
Children 10 and Under Have Higher Reported Incidence Rates of Listeriosis and *E. coli* O157:H7 Disease Than Other Age Groups[1]



[1]Risk from listeriosis in children under 10 years of age is predominantly for newborns.
Source: CDC/USDA/FDA Foodborne Diseases Active Surveillance Network, 1998 Annual Report.

…As Can Congenital Toxoplasmosis

As with listeriosis, when a pregnant woman becomes newly infected with *Toxoplasma gondii*, she can pass the infection to her unborn fetus. This transmitted illness is known as congenital toxoplasmosis. The pathogens discussed earlier in this article are bacteria; *Toxoplasma gondii* is a parasite. It can cause mental retardation, epilepsy, and blindness in an infected fetus. About 400-4,000 cases of congenital toxoplasmosis occur each year. Toxoplasmosis can also afflict people of other ages, particularly the immunosuppressed, such as people with AIDS.

Pregnant women may become affected if they eat raw or undercooked meat that is contaminated with this parasite or if they inadvertently consume *oocysts*, an environmentally resistant form of the organism that cats pass in their feces. Pregnant women may be exposed to the oocysts when they handle cat litter or soil, such as from unwashed fruits or vegetables or from gardening. According to the CDC, with rare exceptions, women infected with this parasite before conception do not transmit the infection to their fetus.

Economic Costs Accompany Foodborne Illnesses

ERS estimates that, in the United States, annual human illness costs from foodborne *Campylobacter*, *E. coli* O157:H7, *E. coli* non-O157:H7 STEC, *Listeria*, and *Salmonella* total $6.9 billion in August 2000 dollars (table 1). Updated estimates of the costs from *Toxoplasma gondii* are not currently available, though previous estimates of foodborne congenital toxoplasmosis are in the billions of dollars.

The annual ERS cost estimates are calculated from the number of foodborne-illness cases and deaths caused by each pathogen and the

Table 1
Estimated Costs of Foodborne Illness in Children Totaled $2.3 Billion in 2000[1]

Pathogen	Estimated annual foodborne illnesses			Preliminary estimated annual costs	
	Cases[2]	Hospitalizations[2]	Deaths[2]	All cases[3]	Children under 10 years[3]
	Number			*Billion dollars*	
Campylobacter spp.	1,963,141	10,539	99	1.2	.2[4]
Salmonella, nontyphoidal	1,341,873	15,609	553	2.4	.9[5]
E. coli O157:H7	62,458	1,843	52	.7	.3[6]
E. coli non-O157:H7 STEC	31,229	921	26	.3	.1[7]
Listeria monocytogenes	2,493	2,299	499	2.3[8]	.8[9]
Total	3,513,694	33,711	1,604	6.9	2.3

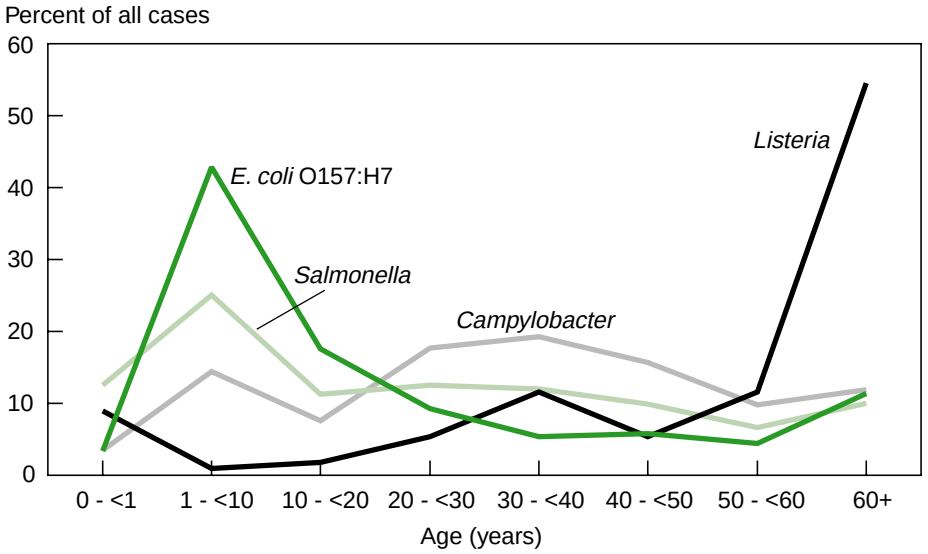
[1]As these new estimates of foodborne illness costs are based on new data and improved methodologies for valuing these costs, the estimates presented here are not directly comparable with earlier ERS estimates of the costs of foodborne disease. Note that estimates for congenital toxoplasmosis have not been included but would raise total costs. Children with foodborne illness are more likely to be cultured than adults with foodborne illness, inflating the share of cases and costs due to children. Also, this preliminary calculation assumes that there is no difference in costs per case by age for *Campylobacter* and *Salmonella*. All costs are in August 2000 dollars.
[2]Data from the U.S. Centers for Disease Control and Prevention Web site (www.cdc.gov/ncidod/eid/vol5no5/mead.htm).
[3]The total estimated costs include specific chronic complications in the case of *Campylobacter* (Guillain-Barré Syndrome), *E. coli* O157 and STEC (hemolytic uremic syndrome), and *Listeria monocytogenes* (congenital and newborn infections resulting in chronic disability or impairment).
[4]The share of *Campylobacter* costs attributed to children under 10 years of age is assumed to be 17.9 percent using 1998 FoodNet data on the age distribution of campylobacteriosis cases (3.5 percent aged 0 - <1 plus 14.4 percent aged 1 - <10).
[5]The share of *Salmonella* costs attributed to children under 10 years of age is assumed to be 37.5 percent using 1998 FoodNet data on the age distribution of salmonellosis cases (12.5 percent aged 0 - <1 plus 25.0 percent aged 1 - <10).
[6]The share of *E. coli* O157:H7 costs attributed to children under 10 years of age is assumed to be 46.2 percent using 1998 FoodNet data on the age distribution of *E. coli* O157:H7 disease cases (3.4 percent aged 0 - <1 plus 42.8 percent aged 1 - <10).
[7]ERS also estimated, for the first time, the costs due to other strains of *E. coli* that produce shiga toxins (STEC). These strains are collectively known as *E. coli* non-O157:H7 STEC. The average costs of medical care and time lost from work due to *E. coli* non-O157:H7 STEC are assumed to be the same as for *E. coli* O157:H7, based on reports in the medical literature. Similarly, the assumption of the share of costs incurred by children under 10 years of age is assumed to be the same as for *E. coli* O157:H7.
[8]The total estimated costs for foodborne *Listeria* are underestimates as they exclude less severe cases not requiring hospitalization. ERS focused its estimates on illnesses in three categories of hospitalized patients: (1) 311 infected pregnant women (all survived), (2) 368 newborns/fetuses who survived and 77 stillbirths and infant deaths, and (3) 1,120 "other adults" who survived and 422 other adults who died.
[9]This $0.8 billion estimate is only for congenitally acquired cases (that is, newborn/fetal cases) and does not cover listeriosis cases acquired by children.

corresponding costs of medical treatment, lost productivity, and premature deaths, and other illness-specific costs, such as special education and residential-care costs. Societal costs have not been estimated for most chronic complications associated with foodborne illnesses. Specific chronic complications covered in our analysis include GBS following *Campylobacter* infections, HUS following *E. coli* infections, and chronic disability or impairment following congenital and newborn infections from *Listeria monocytgenes*.

ERS measures the productivity losses for survivors of a foodborne illness as the value of foregone or lost wages, whether for a few days absent from work or for a lifetime of disability that prevented the individual from returning to work. In 2000, ERS revised the methodology for valuing premature deaths due to foodborne illness. ERS previously assigned all deaths the same value regardless of age at time of death, based on information about the higher wages paid for dangerous jobs. Now, ERS uses information about the age distribution of deaths to adjust this value to account for age at death. The assumed cost of each death ranges from $8.9 million in August 2000 dollars for individuals who died before their first birthday to $1.7 million for individuals who died at age 85 or older. The higher value placed on deaths of children reflects that more years of life are lost.

We estimate that medical costs, productivity losses, and the value of premature deaths due to foodborne illnesses that afflict children under 10 years of age total $2.3 billion in August 2000 dollars. These preliminary calculations are based on specific assumptions about how the cases are distributed by age. For each pathogen, the share of total costs attributed to children under 10 years of age is assumed to be the same as the share of total cases attributed to children under 10 years of age in the 1998 FoodNet age distribution data (fig. 3). Children under 10 years of age account for 33 percent of total costs for all age groups.

Figure 3
Age Distribution of Foodborne Illness Varies by Pathogen



Source: CDC/USDA/FDA Foodborne Diseases Active Surveillance Network, 1998 Annual Report.

Of the pathogens discussed in this article, foodborne *Salmonella* posed the greatest annual cost to society for children under 10 years of age—$0.9 billion. Although campylobacteriosis is more common in the U.S. population, salmonellosis is more common in infants and a higher proportion of all salmonellosis cases require hospitalization. The second most costly foodborne pathogen for children under age 10 is *Listeria* ($0.8 billion). The high ranking of *Listeria* is due to the severity of listeriosis in fetuses and newborns, which causes a relatively high proportion of deaths and lifetime health complications.

More Research Needed To Refine Estimates

The ERS estimates undervalue the true social costs of foodborne illness. Some costs are omitted, notably the human illness costs of certain other chronic complications (such as reactive arthritis in the case of *Salmonella*), as well as the costs of travel to obtain medical care, lost leisure time, and pain and suffering.

The foodborne illness costs for children are preliminary. We used the 1998 FoodNet age distributions for illnesses confirmed by laboratory tests to identify the rough percentage of total estimated costs for each foodborne illness that can be attributed to children under 10 years of age. However, these distributions of culture-confirmed illnesses may not be representative of the distribution of cases across the U.S. population. Children with foodborne illness are more likely to be tested than adults with foodborne illness, inflating the share of cases and costs due to children.

This preliminary calculation assumes that there is no difference in costs per case by age for *Campylobacter* and *Salmonella*. More accurate estimates for each pathogen need to be calculated using the age distribution of each severity category (for example, the number of children under 10 years of age who were hospitalized and died). Additionally, cost of illness estimates for congenital toxoplasmosis would enhance this analysis.

On the positive side, many cases of foodborne illness in children can be prevented. For example, pregnant women can help prevent congenital toxoplasmosis by avoiding changing cat litter. Pregnant women can also help prevent both toxoplasmosis and listeriosis by not eating raw or undercooked meats. Children who go to day care can be kept at home if they are experiencing diarrhea. Child care providers must wash their hands after changing diapers and before preparing food or bottles. These actions, along with good food sanitation and handling practices, can help prevent foodborne illness in children.

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