

Guillain-Barré Syndrome Increases Foodborne Disease Costs

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Guillain-Barré syndrome (GBS) is the leading cause of acute paralysis in the United States now that polio has been almost eliminated by vaccination programs. Although the causes of GBS are uncertain, many medical researchers believe that GBS is a reaction by a person's immune system responding to fight off several potential triggers, such as some gastrointestinal or respiratory infections. One trigger of GBS is *Campylobacter jejuni*, which is also the most common cause of foodborne diarrhea in the United States. Sources of *Campylobacter* primarily include raw and undercooked poultry, but raw milk and polluted water have also caused outbreaks.

Medical studies all over the world have confirmed that 20 to 40 percent or more of patients with GBS had become infected with *Campylobacter* in the 1 to 3 weeks prior to the onset of GBS symptoms. Of an estimated 2,658 to 9,575 patients diagnosed with GBS in the United States each year, 532 to 3,830 of the patients had a preceding *Campylobacter* infection.

Last year, USDA's Economic Research Service (ERS) estimated that seven foodborne illnesses in the United States cost society \$6.5 billion to \$34.9 billion (in 1995 dollars) in medical charges and lost productivity. These seven foodborne pathogens—*Campylobacter jejuni*, *Clostridium perfringens*, *E. coli* O157:H7, *Listeria monocytogenes*, *Salmonella*, *Staphylococcus aureus*, and *Toxoplasma gondii* (see box)—caused an estimated 3.3 million to 12.3 million cases of foodborne illness and up to 3,900 deaths in 1995. These seven pathogens were selected because they are primarily found on meat and poultry.

Researchers at the U.S. Food and Drug Administration estimate that 1 to 3 percent of all foodborne-illness cases later develop secondary illnesses or complications that can occur in any part of the body, including the nerves, joints, and heart. These complications may be chronic and may cause premature death. Societal costs have not been estimated for the majority of complications associated with foodborne illnesses. This article updates ERS's 1995 cost estimates to 1996 dollars using 1996 medical cost and wage rate data, and for the first time includes estimated costs of GBS in the *Campylobacter* estimates.

Costs of Foodborne Illness Depend on Severity

The cost-of-illness estimates are calculated from the number of annual foodborne-illness cases and deaths of the seven foodborne illnesses described in this article; the number of cases that develop select secondary complications; and the corresponding medical costs, lost productivity costs, and some other illness-specific costs, such as special education and residential-care costs.

Cases of foodborne illness generally fall into four severity groups: those who did not visit a physician, those who visited a physician, those who were hospitalized, and those who died prematurely because of their illness. A fifth severity group is for patients who develop select secondary complications from the acute illness. For each severity group, medical costs were estimated for physician and hospital services, supplies, medications, and special procedures unique to treating the particular foodborne illnesses. Such costs reflect the number of days/treatments of a medical service, the average cost per service/treatment, and the number of patients receiving such service/treatment.

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For those people with foodborne illnesses who miss only some days of work, lost productivity is approximated by wage rates, published by the Bureau of Labor Statistics. However, some patients die and some develop secondary complications so that they either never return to work, regain only a portion of their pre-illness productivity, or switch to less demanding and lower paying jobs. The total cost of lost productivity is the sum for all individuals affected, primarily the patients and,

in the case of ill children, their parents or costs for paid caretakers.

This update includes two sets of cost-of-illness estimates that use different proxies for the forgone earnings of someone who dies prematurely or who is unable to work because of their foodborne illness. The first set of estimates uses a human capital approach, where estimates of forgone earnings are adjusted by a "risk premium" from life-insurance markets. The second set of estimates uses less conserva-

tive values based on the "risk premium" revealed in labor markets through the higher wages employers must offer to induce workers to take jobs with injury risks. Under the human capital approach, the cost of a premature death is estimated, depending on age, to range from roughly \$15,000 to \$2,037,000 in 1996 dollars. The labor market approach places the value of preventing one premature death at \$5 million, regardless of age.

Study Considers Seven Foodborne Illnesses

Campylobacter jejuni

Campylobacteriosis ranges from a mild illness with diarrhea lasting a day, to severe abdominal pain, and severe diarrhea (sometimes bloody), sometimes accompanied by fever, occasionally lasting for several weeks. The incubation period for most cases is 2 to 5 days, and the illness usually lasts from 2 to 10 days, depending on its severity. Although the illness is generally regarded as a relatively mild disease, death can occur in some cases, especially for the very young, very old, or immunocompromised. A small percentage of cases develop Guillain-Barré Syndrome.

Clostridium perfringens

C. perfringens intoxication typically occurs 6 to 24 hours after ingestion of food that bears large counts of this bacteria. The illness in humans is frequently a mild gastro-intestinal distress, lasting only around a day. Deaths are uncommon.

Escherichia coli 0157:H7

E. coli 0157:H7 disease is usually a mild gastrointestinal illness that occurs 3 to 5 days after eating contaminated food. Severe complications, however, can arise. Hemorrhagic colitis is distinguished by the sudden onset of severe abdominal cramps, little or no fever, and diarrhea that may become grossly

bloody. Although less than 5 percent of *E. coli* 0157:H7 disease cases develop hemolytic uremic syndrome (HUS), it is a severe, life-threatening illness. HUS is a disease characterized by red blood-cell destruction, kidney failure, and neurological complications, such as seizures and strokes. Most HUS cases are children under 5 years old, although the feeble elderly may also be at risk.

Listeria monocytogenes

Listeriosis may be either mild or severe. Milder cases are characterized by a sudden onset of fever, severe headache, vomiting, and other influenza-type symptoms. Listeriosis may appear mild in healthy adults and more severe in fetuses, the elderly, and the immunocompromised. Outbreak data show that the incubation period ranges from 3 to 70 days. Women infected with *Listeria* during pregnancy may transmit the infection to the fetus, possibly leading to stillbirths or babies born with mental retardation.

Salmonella

Salmonellosis usually appears 6 to 74 hours after eating contaminated food and lasts for a day or two. Common symptoms are nausea, diarrhea, stomach pain, and sometimes vomiting. Although the illness is generally regarded as a relatively mild disease, death can occur

in some cases, especially for the very young, very old, or immunocompromised.

Staphylococcus aureus

S. aureus intoxications occur usually within 1 to 6 hours following consumption of the toxins produced by the bacteria, but it may occur within 30 minutes. Illness caused by *S. aureus* enterotoxin is characterized by severe nausea, vomiting, cramps, and diarrhea. Although the illness generally does not last longer than 1 or 2 days, the severity of the illness may indicate the need for hospitalization.

Toxoplasma gondii

Toxoplasmosis can cause mild flu-like symptoms, though most people infected with the parasite do not have any symptoms. People vary in their risk of getting sick from this parasite. People with suppressed immune systems, such as AIDS and cancer patients, face higher risks. One outbreak associated with undercooked meat indicates that the incubation period ranges from 10 to 23 days. Women infected with *T. gondii* during pregnancy may transmit the infection to their fetus, possibly leading to stillbirths or babies born with birth defects ranging from hearing or visual impairments to mental retardation.

Costs of *Campylobacter*-Associated Guillain-Barré Syndrome

Although GBS is a secondary complication in a small percentage of human *Campylobacter* infections, GBS is a severe illness. GBS is characterized by a rapid onset, various degrees of numbness, pain, progressive weakness or paralysis over 1 to 4 weeks, and gradual recovery in the first year or two. Almost all patients are hospitalized and some have relapses. Almost 80 percent of patients recover with only minor deficits and can return to normal life within a year. Others, however, are permanently bedridden, wheelchair-bound, or die prematurely because of the illness. Roughly 20 percent of GBS patients are left significantly disabled, and 2 percent die.

Like polio victims, some patients with GBS require mechanical ventilation to assist breathing. These patients tend to be older and tend to have a poorer prognosis. To capture differences in both the prognoses for younger and older GBS patients and the requirement for mechanical ventilation, we grouped GBS patients into two categories. Based on the average ages found by two physicians, Sunderrajan and Davenport, ventilated GBS patients are repre-

sented by a 47-year-old, and patients who did not require mechanical ventilation are represented by a 30-year-old.

Several neurologists specializing in GBS suggested we lower the overall death rate found by Sunderrajan and Davenport to 2 percent to reflect recent advances in medical care. This adjustment resulted in a total of 10 to 76 deaths each year from *Campylobacter*-associated GBS (fig. 1).

Annual productivity losses totaled across all six patient categories from *Campylobacter*-associated GBS in the United States range from \$0.2 billion to \$1.4 billion for the low and high estimate of the number of annual cases, respectively (table 1). These productivity losses for *Campylobacter*-associated GBS using the human capital approach are roughly three times larger than medical costs. Using the labor market approach, productivity losses are roughly 10 times larger than medical costs.

Annual medical costs include immune-globulin treatments, plasma exchange, regular hospital room fees, and intensive-care unit hospital room fees. Estimated annual medical costs range from \$61 million to \$438 million. Summing all medical and lost productivity costs provides an estimate of total annual

costs for *Campylobacter*-associated GBS ranging from \$0.3 billion to \$1.9 billion.

Roughly 55 to 70 percent of all *Campylobacter* infections are estimated to be foodborne. If 55 percent of all *Campylobacter*-associated GBS have foodborne origins, annual total costs are estimated to range from \$142 million to \$1 billion; if 70 percent are foodborne, total costs range from \$180 million to \$1.3 billion.

Foodborne Illnesses Impose High Costs

In 1996, there were an estimated 3.3 million to 12.4 million cases of the 7 foodborne illnesses in the United States and up to 3,700 associated deaths (table 2), including the *Campylobacter*-associated GBS cases. Total annual costs of the seven foodborne illnesses (in terms of medical costs and costs of lost productivity) in 1996 dollars ranged between \$6.6 billion and \$14.5 billion. These estimates are based on the human capital approach for the cost of a premature death. We use this approach because it is conservative and provides estimates for people of different ages. The \$5 million estimate of the cost of a premature death from the labor market studies increases total annual costs to between \$19.6 billion and \$37.1 billion (table 3). We

Table 1

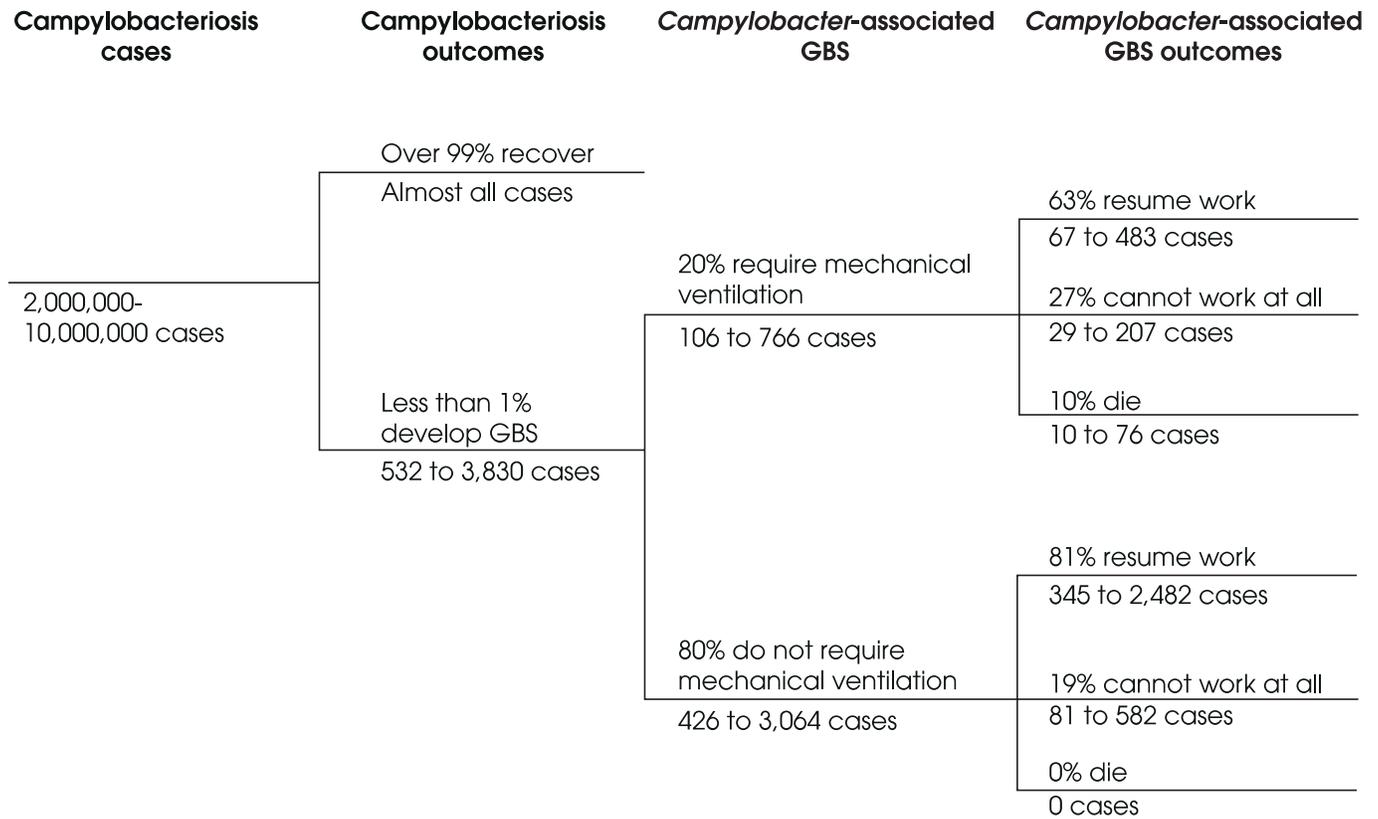
Paralysis Caused by *Campylobacter*-Associated Guillain-Barré Syndrome Imposes High Costs to Society¹

| Source category | Patients | | Deaths | | Medical costs | | Productivity costs | | Total costs | |
|---|-----------|-------|-----------------|-------|-----------------|---------|--------------------|---------|-----------------|------|
| | Low | High | Low | High | Low | High | Low | High | Low | High |
| | Number | | Million dollars | | Million dollars | | Million dollars | | Million dollars | |
| All cases of GBS-associated <i>Campylobacter</i> infections | 532-3,830 | 10-76 | 60.7 | 437.7 | 197.0 | 1,418.7 | 257.7 | 1,856.4 | | |
| If 55 percent are foodborne | 293-2,107 | 6-42 | 33.4 | 240.7 | 108.4 | 780.3 | 141.7 | 1,021.0 | | |
| If 70 percent are foodborne | 372-2,681 | 7-53 | 42.5 | 306.4 | 137.9 | 993.1 | 180.4 | 1,299.5 | | |

Notes: ¹U.S. costs were estimated using the human capital approach and are in 1996 dollars. Figures may not total due to rounding.

Figure 1

Estimated Annual Cases and Disease Outcomes of *Campylobacter*-Associated Guillain-Barré Syndrome (GBS)



provide this second set of estimates because there is no consensus among researchers as to the best type of approach in calculating the cost of illness.

Both sets of estimates undervalue the true costs of foodborne illnesses to society, however, because the analyses covers only 7 of the more than 40 different foodborne pathogens believed to cause human illnesses. Estimated costs would also increase if the costs for all complications linked to foodborne illnesses, such as arthritis and meningitis,

were included. These estimates primarily include medical costs and lost productivity. Total costs would increase if we include other societal costs, such as pain and suffering, travel to medical care, and lost leisure time.

The wide range of costs is largely due to uncertainty about the true number of annual foodborne illness cases and associated deaths. Many people sick with diarrhea do not visit a doctor and even if they do, most will not have a stool culture taken—let alone have the specific test necessary to identify the

pathogen that caused the illness. The lab test may not find the pathogens. Even if a particular pathogen is implicated, not all culture-confirmed foodborne illnesses are reported to the Centers for Disease Control and Prevention (CDC), and these illnesses may not be traced back to a particular food source. Therefore, most foodborne illnesses go unrecorded. Better data could help narrow the ranges of cases and deaths and could provide information to calculate the costs of other foodborne pathogens.

Tracking Food-Related Disease Outbreaks

In July 1995, as part of the Federal Government's campaign to improve the safety of the Nation's food supply, USDA's Food Safety and In-

spection Service and the Food and Drug Administration began a collaborative project with the CDC. The project was originally known as CDC's Sentinel Site Study and more recently as FoodNet.

The project collects improved information on the incidence of foodborne disease in the United States by establishing direct working links with State and local health departments at seven sites nationwide: Minnesota; Oregon; and

Table 2
People Are Exposed to These Seven Pathogens in Food and Nonfood Sources

| Pathogen, acute illness, and complication | Estimated total annual | | Estimated share foodborne |
|---|------------------------------|--------------------|---------------------------|
| | Cases | Deaths | |
| | Number | | Percent |
| Bacteria: | | | |
| <i>Campylobacter jejuni</i> or <i>coli</i> — Campylobacteriosis | 2,000,000-10,000,000 | 200-730 | 55-70 |
| Guillain-Barré Syndrome | 532-3,830 | 10-76 | 55-70 |
| Subtotal | N/A | 210-806 | N/A |
| <i>Clostridium perfringens</i> — <i>C. perfringens</i> intoxications | 10,000 | 100 | 100 |
| <i>Escherichia coli</i> O157:H7— <i>E. coli</i> O157:H7 disease | 20,000-40,000 | 50-100 | 80 |
| Hemolytic uremic syndrome ¹ | 1,000-2,000 | 29-58 | 80 |
| Subtotal | N/A | 79-158 | N/A |
| <i>Listeria monocytogenes</i> ² — Listeriosis | 1,092-1,860 | 270-510 | 85-95 |
| Complications | 26-43 | 0 | 85-95 |
| Subtotal | N/A | 270-510 | N/A |
| <i>Salmonella</i> (non-typhoid)— Salmonellosis | 800,000-4,000,000 | 1,000-2,000 | 87-96 |
| <i>Staphylococcus aureus</i> — <i>S. aureus</i> intoxications | 8,900,000 | 2,670 | 17 |
| Parasite: | | | |
| <i>Toxoplasma gondii</i> ³ — Toxoplasmosis | 520 | 80 | 50 |
| Complications | 3,120 | 0 | 50 |
| Subtotal | N/A ⁴ | 80 | N/A |
| Total | 11,700,000-23,000,000 | 4,400-6,300 | N/A |

Notes: N/A = Not applicable. Subtotal and totals may not add due to rounding. Totals are rounded down to reflect the uncertainty of the estimates. Nonfood sources include drinking or swimming in contaminated water and contact with infected people or animals.

¹Kidney failure. ²Includes only hospitalized patients because of data limitations. ³Includes only toxoplasmosis cases related to fetuses and newborn children who may become blind or mentally retarded. Does not include all other cases of toxoplasmosis. Another high-risk group for this parasite is the immunocompromised, such as patients with AIDS. ⁴Of the 4,000 infections from this parasite each year, 520 develop acute illness and later die prematurely or develop some degree of chronic complication because of the illness, and 2,680 do not have noticeable acute illness at birth but develop complications by age 17. Therefore, a total of 3,200 develop either acute illness, chronic complication, or both.

selected counties in California, Connecticut, Georgia, Maryland, and New York. Laboratories at these sites report weekly to CDC on the number of illnesses caused by certain pathogens.

These sites study foodborne illness outbreaks and explore the relationships between the outbreaks and certain types of food consumed. The major objectives of FoodNet are to:

- Determine the yearly incidence of diarrheal illness due to bacterial foodborne pathogens (such as *Campylobacter*, *E. coli* O157:H7, *Listeria*, *Salmonella*, *Shigella*, *Vibrio*, and *Yersinia*);

Table 3

Complications Were Important Contributors to Costs of Foodborne Illness in 1996¹

| Pathogen, acute illness, and complication | Estimated annual foodborne illness | | Estimated foodborne illness costs, assuming: | |
|--|------------------------------------|--------------------|--|------------------------------------|
| | Cases | Deaths | Human capital approach ² | Labor market approach ³ |
| | Number | | Billion 1996 dollars | |
| Bacteria: | | | | |
| <i>Campylobacter jejuni</i> or <i>coli</i> — | | | | |
| Campylobacteriosis | 1,100,000-7,000,000 | 110-511 | 0.7-4.4 | 1.2-6.7 |
| Guillain-Barré Syndrome | 293-2,681 | 6-53 | .1-1.3 | .4-3.4 |
| Subtotal | N/A | 116-564 | .8-5.7 | 1.6-10.1 |
| <i>Clostridium perfringens</i> — | | | | |
| <i>C. perfringens</i> intoxications | 10,000 | 100 | .1 | .5 |
| <i>Escherichia coli</i> O157:H7— | | | | |
| <i>E. coli</i> O157:H7 disease | 16,000-32,000 | 40-80 | .05-.1 | .1-.2 |
| Hemolytic uremic syndrome ⁴ | 800-1,600 | 23-46 | .1-2 | .2-.4 |
| Subtotal | N/A | 63-126 | .16-.3 | .3-.7 |
| <i>Listeria monocytogenes</i> ⁵ — | | | | |
| Listeriosis | 928-1,767 | 230-485 | .12-.26 | 1.2-2.3 |
| Complications | 22-41 | 0 | .03-.05 | .1-.2 |
| Subtotal | N/A | 230-485 | .1-.3 | 1.3-2.4 |
| <i>Salmonella</i> (non-typhoid)— | | | | |
| Salmonellosis | 696,000-3,840,000 | 870-1,920 | .9-3.6 | 4.8-12.3 |
| <i>Staphylococcus aureus</i> — | | | | |
| <i>S. aureus</i> intoxications | 1,513,000 | 454 | 1.2 | 3.3 |
| Parasite: | | | | |
| <i>Toxoplasma gondii</i> ⁶ — | | | | |
| Toxoplasmosis | 260 | 40 | .04 | .1 |
| Complications | 1,560 | 0 | 3.28 | 7.7 |
| Subtotal | N/A | 40 | 3.3 | 7.8 |
| Total | 3,300,000-12,400,000 | 1,900-3,700 | 6.6-14.5 | 19.6-37.1 |

Notes: ¹Cost estimates are in 1996 dollars. N/A = Not applicable. Subtotal and totals may not add due to rounding. Totals are rounded down to reflect the uncertainty of the estimates. ²The Landefeld and Seskin approach is basically a human capital approach, increased by a willingness to pay multiplier, and estimates the cost of a premature death, depending on age, to range from roughly \$15,000 to \$2,037,000 in 1996 dollars. ³This labor market approach values the cost of a premature death at \$5 million. ⁴Hemolytic uremic syndrome (HUS) is characterized by kidney failure. HUS following foodborne *E. coli* O157:H7 infections causes 44-90 acute illness deaths and 33-62 chronic illness deaths. ⁵Includes only hospitalized patients because of data limitations. ⁶Includes only toxoplasmosis cases related to fetuses and newborn children who may become blind or mentally retarded. Some cases do not have noticeable acute illness at birth but develop complications by age 17. Does not include all other cases of toxoplasmosis. Another high-risk group for this parasite is the immunocompromised, such as patients with AIDS or cancer.

- Develop a network to collaboratively respond to emerging food-borne diseases;
- Determine the proportion of food-borne disease cases attributed to specific foods; and
- Determine whether Federal interventions are having a measurable effect on the incidence of food-borne illness attributable to consumption of meat, poultry, and other foods.

We will update our 1996 cost-of-illness estimates for *Campylobacter*, *E. coli* O157:H7, *Listeria*, and *Salmonella*, with FoodNet data, when available. The FoodNet data on the number of deaths and culture-confirmed cases from the seven sites will first have to be extrapolated to the U.S. population. Another possibility for improving our estimates includes performing cost-of-illness analyses using FoodNet data on *Shigella*, *Vibrio*, and *Yersinia*.

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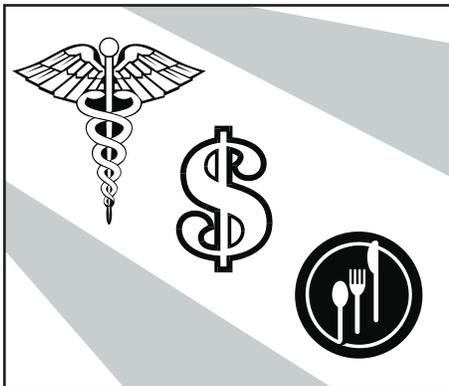
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