Salmonella Cost Estimate Updated Using FoodNet Data

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Salmonella infections due to contaminated food products make many people ill each year and are responsible for substantial economic costs. *Salmonella* infections are potentially serious and may be fatal, particularly for the elderly and people with weak immune systems (see box on *Salmonella* infections). However, most salmonellosis cases do not result in a visit to a medical facility and are never reported to public health agencies. The high proportion of unreported cases makes it difficult to determine the true incidence of salmonellosis, and has resulted in a wide range of estimates of the annual economic costs of foodborne *Salmonella* infections.

Many *Salmonella* infections are caused by undercooked shell eggs, which may be contaminated by hens infected by *Salmonella* serotype Enteritidis, one of the most common

Salmonella strains. Effective August 1999, Federal regulations will require that shell eggs packed for retail sale to consumers be stored and transported at or below 45 degrees Fahrenheit to reduce the risk of *Salmonella* infections. USDA was unable to make a definitive estimate of the potential economic benefits of this rule, partly because of the uncertainty about the economic costs of *Salmonella* infections. USDA shares federal regulatory responsibility for egg safety with the Food and Drug Administration (FDA), which recently proposed requiring safe handling labels on egg cartons to warn consumers about the risk of illness associated with *Salmonella*-contaminated shell eggs.

Previous estimates of the economic costs due to foodborne *Salmo-*

nella infections by USDA's Economic Research Service (ERS) were based on the best available estimates of the annual number of infections and the associated medical expenses and productivity losses. New information about the incidence, severity, and medical consequences of salmonellosis has since become available from the Foodborne Diseases Active Surveillance Network (FoodNet) and other sources, allowing us to refine the previous estimates.

FoodNet Monitors Foodborne Pathogens

The Federal Government and other organizations established FoodNet in 1995 to monitor illness due to certain foodborne pathogens including *Salmonella* in selected

Salmonella Infections May Cause Serious Illness or Death

Many different strains of *Salmonella* bacteria live in the intestinal tracts of domestic and wild animals and may contaminate raw meat, poultry, eggs, dairy products, or other foods. The *Salmonella* cost estimate excludes illnesses due to *Salmonella* serotype Typhi, the strain responsible for typhoid fever. Infections by other, non-typhoidal *Salmonella* strains may cause salmonellosis, an acute gastrointestinal

disease usually lasting 4 to 7 days, with symptoms including diarrhea, fever, or abdominal cramps. Some people develop potentially fatal infections of the bloodstream or other parts of the body, or secondary complications such as reactive arthritis or Reiter's syndrome, a long-term chronic illness characterized by joint pain, eye irritation, and painful urination.

geographic sites (see box on Food-Net). FoodNet's goals include estimating the annual frequency and severity of foodborne diseases, and determining how much foodborne illness is due to the consumption of specific foods such as meat, poultry, and eggs.

Diarrhea is the most common symptom of illness due to the pathogens monitored by FoodNet. Clinical microbiological laboratories can identify the cause of infectious diarrhea if physicians instruct patients with diarrhea to provide stool specimens for bacterial culture tests. Laboratories may then report certain illnesses (including salmonellosis) to public health agencies, depending on local reporting requirements. However, foodborne illnesses tend to be underreported

for several reasons. First, most people with acute diarrhea do not seek medical care. Second, many people who obtain medical care for diarrhea do not provide stool specimens for testing. Third, laboratories do not routinely test stool specimens for every possible foodborne pathogen. Finally, laboratories may not report confirmed cases of foodborne illness to public health agencies, even when required.

FoodNet was designed to determine the number of unreported foodborne illnesses (fig. 1). Estimates of the total number of foodborne illnesses are based on the "culture-confirmed" cases identified by the laboratories in each FoodNet site through stool culture tests. FoodNet investigators regularly contact each laboratory and record all culture-
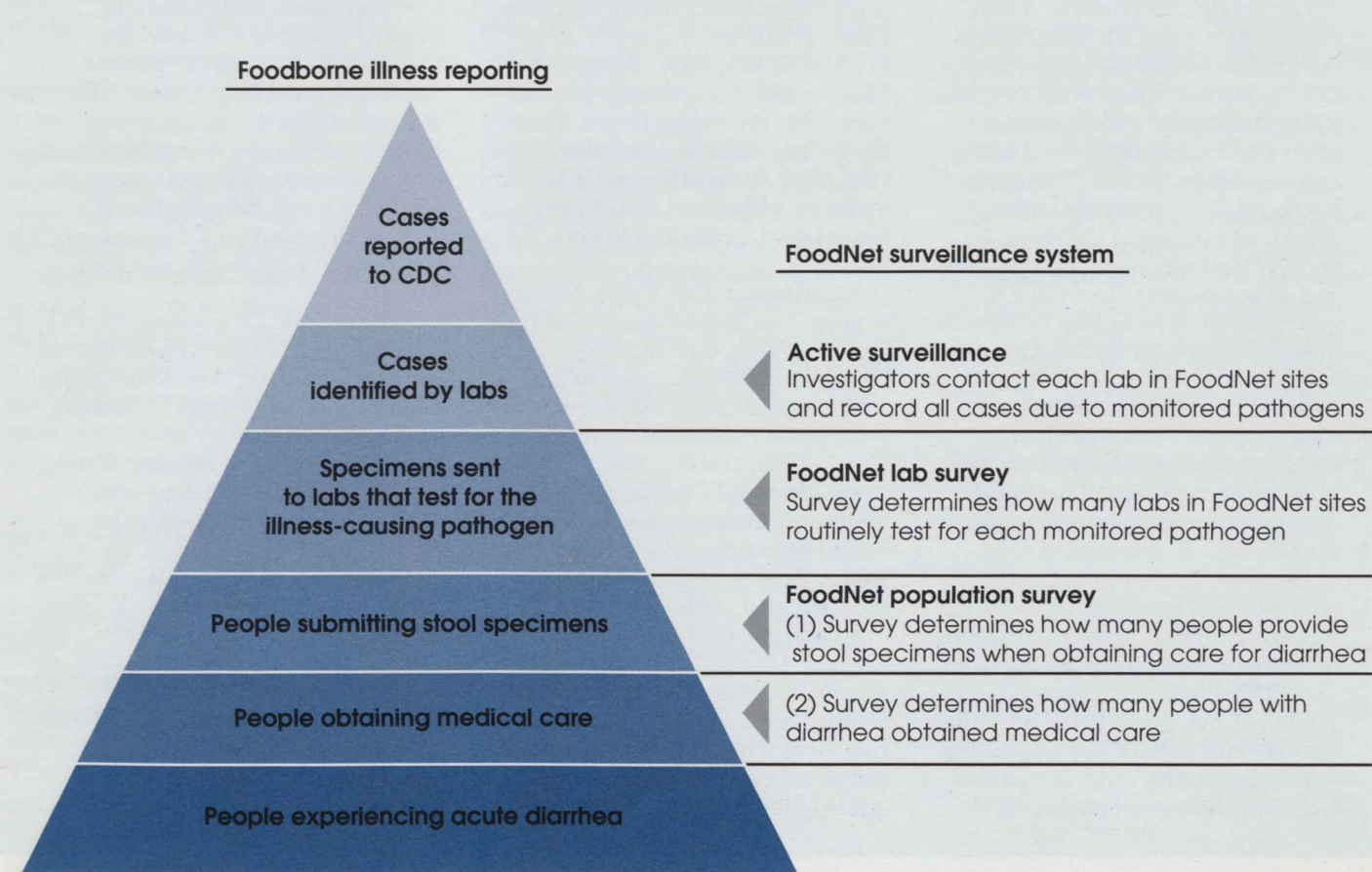
confirmed cases caused by the monitored pathogens, including cases not reported to public health agencies. The number of culture-confirmed cases is then adjusted for the factors that keep most diarrheal illnesses from being identified by laboratory tests, using multiplication factors (or "multipliers") derived from surveys of the population and laboratories in each FoodNet site.

National *Salmonella* Estimate Based on Cases in FoodNet Sites

FoodNet detected an annual average of 2,092 culture-confirmed salmonellosis cases in the FoodNet sites during 1996-97. *Salmonella* was the second most commonly detected

Figure 1

FoodNet Examines Factors Responsible for Underreporting of Foodborne Illness

Foodborne illness reporting

Cases reported to CDC

Cases identified by labs

Specimens sent to labs that test for the illness-causing pathogen

People submitting stool specimens

People obtaining medical care

People experiencing acute diarrhea

FoodNet surveillance system

Active surveillance
Investigators contact each lab in FoodNet sites and record all cases due to monitored pathogens

FoodNet lab survey
Survey determines how many labs in FoodNet sites routinely test for each monitored pathogen

FoodNet population survey
(1) Survey determines how many people provide stool specimens when obtaining care for diarrhea

(2) Survey determines how many people with diarrhea obtained medical care

pathogen, exceeded only by *Campylobacter*. The number of culture-confirmed salmonellosis cases was inflated by the appropriate multipliers, resulting in an estimate of 81,000 annual salmonellosis cases in the FoodNet sites. The multipliers account for the following factors: (1) only 12 percent of the FoodNet site population with nonbloody diarrhea and 15 percent with bloody diarrhea obtained medical care for their condition; (2) 18 percent of those obtaining medical care for nonbloody diarrhea and 100 percent of those obtaining care for bloody diarrhea submitted stool specimens; and (3) all 263 laboratories in the FoodNet sites routinely tested for *Salmonella*, although the tests used by laboratories detect only 70 percent of salmonellosis cases. (The

multipliers are calculated separately for bloody and nonbloody diarrhea cases because people with bloody diarrhea are more likely to obtain medical care and submit stool specimens.)

People in the rest of the country were assumed to fall ill from salmonellosis as often as residents of the FoodNet sites, resulting in an estimate of 1.4 million annual salmonellosis cases for the United States. The average annual number of culture-confirmed salmonellosis cases reported to the Centers for Disease Control and Prevention (CDC) during the same period was 35,621, so the FoodNet estimate of U.S. cases suggests that 97 percent of illnesses due to *Salmonella* went unreported.

CDC has estimated that 95 percent of *Salmonella* infections are

foodborne in origin. The FoodNet estimate of 1.4 million annual salmonellosis cases consequently includes 1.3 million cases due to consumption of foods contaminated by *Salmonella* and 0.1 million cases due to other causes.

CDC also estimated the distribution of U.S. salmonellosis cases among three of the four illness severity categories used in the ERS cost estimates: cases visiting a physician, cases requiring hospitalization, and cases resulting in premature death. An estimated 170,000 cases visited a physician, 16,400 cases required hospitalization, and 600 cases resulted in death. (The CDC estimates are preliminary, and may change when final estimates are released later in 1999.)

FoodNet Monitors Foodborne Illness

The Foodborne Diseases Active Surveillance Network (FoodNet) is the foodborne disease component of CDC's Emerging Infections Program (EIP). FoodNet is a collaborative effort by CDC, USDA's Food Safety and Inspection Service (FSIS), the Food and Drug Administration (FDA), and the eight EIP sites. FoodNet initially included five sites, and now monitors illness due to nine pathogens including *Salmonella* in eight sites (Connecticut, Georgia, Minnesota, Oregon, and selected counties in California, Maryland, New York, and Tennessee). The FoodNet estimate of annual *Salmonella* infections is based on 1996-97 data from five sites covering 6 percent of the U.S. population.

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- **California.** Duc Vugia, Michael Samuel, Ben Werner, Kevin Reilly, Sharon Abbott, Sue Shallow, Gretchen Rothrock, Pam Daily, Alexander McNees, Nandeeni Mukerjee, Joelle Nadle, Mary Ann Davis, Lisa Gelling, and Ben Silk;
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- **Minnesota.** Michael Osterholm, Craig Hedberg, Julie Wicklund, Valerie Deneen, Heidi Kassenborg, Jeff Bender, Kirk Smith, and John Besser;
- **New York.** Dale Morse, Perry Smith, Shelley Zansky, Nellie Dumas, Barbara Damaske, Hwa-Gan Chang, Candace Noonan, Brian Sauders, and Karim Hechemy;
- **Oregon.** David Fleming, Paul Cieslak, Bill Keene, Beletshachew Shiferaw, Maureen Cassidy, Teresa McGivern, Regina Stanton, Steve Mauvais, Stephen Ladd-Wilson, Bob Sokolow, and Vijay Balan;
- **Tennessee.** William Moore, Allen Craig, Timothy Jones, William Schaffner, and Brenda Barnes;
- **FSIS.** Kaye Wachsmuth, Phyllis Sparling, and Ruth Etzel; and
- **FDA.** Ken Falci, Wallace Garthright, and Clifford Purdy.

ERS adjusted the estimated number of physician visits and hospitalizations because CDC included some cases (such as people who saw a physician before being hospitalized) in more than one category. The adjustments were based on information about medical care for culture-confirmed salmonellosis cases in the FoodNet sites. ERS assumed that 36 percent of hospitalized cases did not visit a physician prior to hospitalization because some people first sought medical care in a hospital emergency room. ERS also assumed that 10 percent of fatal cases were not hospitalized prior to death (although all were assumed to have seen a physician) because some people in nursing homes or other settings died outside a hospital. The fourth severity category used in the cost estimates (cases not obtaining medical care) is the residual remaining after the other three categories are subtracted from the estimated total number of cases.

The CDC estimate of annual salmonellosis cases is subject to several potential sources of error, including inaccurate stool tests and the omission of stool specimens shipped to laboratories outside the FoodNet sites. Inaccurate stool tests may be the most likely source of error. Laboratories may not detect *Salmonella* in specimens from salmonellosis patients who previously received antibiotics or waited too long to submit specimens after becoming ill, or in specimens that were improperly transported.

Cost Estimate Uses New Data on Medical Costs

New information about medical care for *Salmonella* infections was extracted from the MarketScan database maintained by the MEDSTAT Group, a medical information firm. The database includes complete medical claims for 4 million persons (nearly 2 percent of the U.S. population) who belong to private health

plans offered by large employers in 45 major metropolitan areas. We examined the medical claims for every individual diagnosed with a *Salmonella* infection during 1994-96.

The health plans tracked by the MarketScan database typically receive volume discounts from health care providers, so the database was used to determine the type of medical care provided for salmonellosis patients rather than the charges paid by health plans. The social costs of medical care for salmonellosis patients were determined based on the average U.S. cost for each type of care, using information from hospital and physician surveys and estimates of annual U.S. health expenditures by the Health Care Financing Administration, U.S. Department of Health and Human Services.

The salmonellosis patients in the MarketScan database were assumed to receive the same average amount of medical care as all U.S. salmonellosis patients for the purpose of the cost estimates. MarketScan patients might require less care than other patients because the MarketScan population includes only workers and their dependents, and is therefore younger and healthier than the U.S. population. Alternatively, MarketScan patients may have used more medical care because they were covered by health insurance and faced only minor financial barriers to care, unlike the 16 percent of the U.S. population without insurance.

The MarketScan salmonellosis patients were divided into those who visited a physician without being hospitalized (outpatients) and those who were hospitalized (inpatients) to match the severity categories used in the ERS cost estimates. Outpatients averaged 1.4 physician visits, 0.1 emergency room visits, and 0.3 outpatient clinic visits. Inpatients averaged 4.1 days

in the hospital, plus 0.7 physician visits (on an outpatient basis), 0.3 emergency room visits, and 0.2 outpatient clinic visits. (The average number of physician visits for inpatients was less than one because some individuals were hospitalized without seeing a physician on an outpatient basis, although all received physician care while hospitalized.) Inpatients were also older on average (32 years) than outpatients (24 years), suggesting that *Salmonella* infections were more severe among older people.

Salmonella Costs Also Include Lost Productivity

The estimated medical costs of *Salmonella* infections were based on the average medical care per case for each severity category, the estimated number of cases, and the 1998 average U.S. cost for each type of medical care. National estimates of the cost of outpatient clinic visits were unavailable, so the average charge for outpatient clinic visits for MarketScan patients was substituted, possibly underestimating the social cost. Fatal cases were assumed to use the same amount of medical care prior to death as hospitalized cases.

Direct estimates of time lost from work due to *Salmonella* infections are unavailable, so indirect estimates were derived from the 1992-94 National Health Interview Survey (NHIS) (see box on survey). The lost productivity costs due to *Salmonella* infections were determined based on the average number of work days lost by employed people in each severity category, the U.S. employment rate, and the average daily compensation for U.S. workers in 1998. All calculations were adjusted for the presumed age distribution of the salmonellosis cases in each severity category, based on age information from FoodNet and the 1992-94 NHIS.

Two separate sets of cost estimates were calculated using alternative proxies for the forgone earnings of persons who died prematurely due to *Salmonella* infections. The first set of estimates is based on the "human capital" approach developed by J. Steven Landefeld and Eugene Seskin of the U.S. Department of Commerce, and uses average wages adjusted by a risk premium derived from life insurance markets. Under this approach, the cost of a premature death ranges from a maximum of $2.2 million at age 22 to a minimum of $17,000 at age 87 or older.

The second set of estimates is based on labor market studies of the higher wages for risky jobs reviewed by W. Kip Viscusi, an economist at Harvard University. ERS modified this "labor market" approach by taking the age and sex distribution of *Salmonella* deaths into account, using information from official death certificates. In effect, the implied monetary value of life for the average worker determined by Viscusi ($5.0 million in 1990 dollars) is treated as an annuity paid over the average life span for U.S. males and females at an interest rate of 3 percent. ERS also updated the value of a life to 1998 dollars. Under the modified approach, the value of a life ranges from $8.3 million for males and $8.5 million for females at birth to $1.4 million for males and $1.6 million for females at age 85 and above. The values for males and females differ because life expect-

ancy is higher for females (79 years) than males (73 years). Nearly two-thirds of those who died from *Salmonella* infections were aged 65 or older, so the average forgone earnings per premature death were $4.1 million for males and $3.5 million for females.

Premature Death Largest Component of *Salmonella* Costs

The estimated annual costs (in 1998 dollars) of medical care and lost productivity due to foodborne *Salmonella* infections were $0.5 billion, based on the human capital approach for calculating forgone earnings (table 1). Using the less conservative labor market approach, the total annual costs were $2.3 billion. Economists have not reached a consensus about the best method for determining the costs of illness. Both approaches undervalue the social costs due to foodborne *Salmonella* infections, omitting medical expenses and the value of lost productivity due to secondary complications such as reactive arthritis and Reiter's syndrome, and other costs due to pain and suffering, travel to obtain medical care, time lost from work caring for sick children, and lost leisure time.

The forgone earnings of persons who died prematurely due to salmonellosis accounted for a large share of the estimated costs of foodborne *Salmonella* infections under both the human capital approach (65 percent) and the labor market approach (93 percent). The estimated medical costs for foodborne *Salmonella* infections were $118 million under both approaches, with two-thirds of these costs due to hospital care.

The previous ERS estimate of the annual costs (in 1998 dollars) of foodborne *Salmonella* infections

Survey Estimates Time Lost From Work

The National Health Interview Survey (NHIS) investigates health conditions and the effects of illness on work and other activities in an annual sample of approximately 49,000 U.S. households. The 1992, 1993, and 1994 NHIS samples were pooled for this study to obtain more precise estimates. The NHIS estimates of health conditions are based on respondent reports rather than medical records and tend to represent symptoms, making it difficult to distinguish salmonellosis from other acute illnesses. The estimate of time lost from work was therefore based on a broad definition of acute illnesses apparently due to infectious agents, including such symptoms as vomiting and abdominal pain typically associated with salmonellosis.

The NHIS found an annual average of 16.4 million acute infectious illnesses in the United States during 1992-94, including 6.4 million illnesses among employed people. Nearly 35 percent of the illnesses among employed people were severe enough to result in a physi-

cian visit. Employed people averaged 1.6 days lost from work for each illness resulting in a physician visit, and 1.0 day for illnesses that were less severe.

Acute health conditions that did not result in medical care or at least one-half day of restricted activity were excluded from the NHIS, suggesting that 1.0 day may be an over-estimate of the time lost from work by employed people with salmonellosis who did not obtain medical attention. Therefore, we conservatively assumed that these people lost an average of 0.5 day from work. Employed people with salmonellosis who visited a physician were assumed to have lost an average of 1.6 days.

The NHIS excludes hospitalized people, so we conservatively assumed that people who were hospitalized due to salmonellosis lost the same number of days from work as those who visited physicians (1.6 days), plus the average number of days spent in the hospital adjusted for a 5-day weekly work schedule (2.9 days), or a total of 4.5 days.

Table 1
Premature Deaths Accounted for Most of the Economic Costs Due to Foodborne *Salmonella* Infections

Severity and cost category	Estimated foodborne illness costs, assuming:	
	Human capital approach[1]	Labor market approach[2]
	Million 1998 dollars	
Severity:		
No medical care	28	28
Physician visit only	48	48
Hospitalized	82	82
Died	307	2,171
Total	464	2,329
Type of costs:		
Medical costs	118	118
Hospital care	79	79
Other medical services	38	38
Lost productivity	347	2,211
Total	464	2,329

Notes: Totals may not add due to rounding. All estimates assume that 95 percent of *Salmonella* cases are foodborne. [1]The human capital approach incorporates a willingness-to-pay multiplier, and estimates the cost of a premature death as $17,000-$2.2 million (in 1998 dollars), depending on age at time of death. [2]The labor market approach values the cost of a premature death as $1.4-$8.3 million for males and $1.6-$8.5 million for females (in 1998 dollars), depending on age at time of death. The values for males and females differ because average life expectancy is higher for females.

ranged from $0.9 billion to $3.7 billion under the human capital approach, and from $5.0 billion to $12.8 billion under the alternative labor market approach. The reduction in the estimated costs is due to several factors. Most importantly, we adopted the CDC estimate of 1.4 million annual salmonellosis cases in place of the previous range of 0.8-4.0 million annual cases, and the CDC estimate of 600 annual deaths in place of the previous range of 1,000-2,000 annual deaths.

The estimated costs of foodborne *Salmonella* infections are sensitive to potential errors in the CDC estimate of salmonellosis cases. Errors in estimating deaths are likely to have the greatest effect on the cost estimates because the average cost is much higher for fatal cases than for other cases. The estimated average cost per fatal case is $0.5 million (under the human capital approach) and

$3.8 million (under the labor market approach). In contrast, the estimated average cost for other outcomes is $5,460 per hospitalized case, $315 per case visiting a physician, and $24 per case recovering without medical care, regardless of the approach for estimating forgone earnings.

The updated estimates of the annual economic costs due to foodborne *Salmonella* infections provide a new basis for assessing the potential economic benefits of measures to improve food safety, particularly those measures intended to reduce risk factors for *Salmonella* infections. Fatal cases will probably continue to account for most of the economic costs due to *Salmonella* infections. Therefore, more precise cost estimates ultimately may depend on a consensus among economists about the best method for determining the monetary value of a life.

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