An Updated Estimate of the Economic Costs of Human Illness Due to Foodborne \textit{Salmonella} in the United States

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Note: The authors would like to thank T. Lynn Riggs and Thomas Breuer, M.D., of the Centers for Disease Control and Prevention for their significant contributions to the analysis of medical care for salmonellosis reported in this paper.

\section*{Abstract}

The Economic Research Service (ERS) of the U.S. Department of Agriculture updated earlier estimates of the medical costs and productivity losses due to foodborne \textit{Salmonella} infections in the United States. The update is based on a new estimate of annual salmonellosis cases by the Foodborne Diseases Active Surveillance Network (FoodNet) and new data on medical care for salmonellosis from a medical claims database. Using this information, ERS estimated that the annual economic costs of human illness due to foodborne \textit{Salmonella} infections are $2.3 billion (in 1998 dollars). Data on foodborne disease outbreaks suggest that 6-9 percent of foodborne \textit{Salmonella} infections are associated with pork and pork products, so the annual costs of human illness due to \textit{Salmonella}-contaminated pork appear to be approximately $0.1-0.2 billion.

\section*{Data and Methods}

The ERS estimate of the costs of foodborne salmonellosis was updated using information from two sources: (i) a new estimate of the incidence and severity of salmonellosis by the Foodborne Diseases Active Surveillance Network (FoodNet); and (ii) new data on medical care for salmonellosis patients from a medical claims database.

FoodNet is the foodborne disease component of the Emerging Infections Program (EIP) of the Centers for Disease Control and Prevention (CDC). FoodNet monitors illness due to specific foodborne pathogens including \textit{Salmonella} through active laboratory-based surveillance and surveys in the participating EIP sites (3). Based on information gathered during 1996-97, FoodNet estimated that there are 1.4 million annual cases of salmonellosis in the United States, resulting in 113,000 physician visits, 8,500 hospitalizations, and 300 deaths (4,5).

The FoodNet estimate omits salmonellosis-related hospitalizations and deaths that were not confirmed by culture tests and were consequently missed by laboratory-based surveillance (5). Some hospitalizations or deaths due to salmonellosis may occur in circumstances (such as nursing homes) where culture tests are not always ordered. In addition, culture tests for \textit{Salmonella} are not always accurate, and fail to detect some \textit{Salmonella} infections. The actual numbers of salmonelllosis-related hospitalizations and deaths are therefore greater than the FoodNet estimate. For the purpose of the cost estimates, ERS assumed that only 50 percent of salmonellosis-related hospitalizations and deaths are confirmed by culture tests, resulting in an adjusted estimate of 17,000 annual hospitalizations and 600 annual deaths.

New data on medical care for salmonellosis patients were obtained from the MarketScan database maintained by the MEDSTAT Group, a medical information firm (6). The database includes complete medical claims for 4 million persons (nearly 2 percent of the U.S. population) covered by
private health plans offered by large employers. The medical claims for every individual diagnosed with a *Salmonella* infection during 1994-96 were examined to determine the type and amount of medical care provided for salmonellosis patients, classified by severity category. The analysis indicated that salmonellosis outpatients made an average of 1.4 physician visits, 0.1 emergency room visits, and 0.3 outpatient clinic visits per illness. Salmonellosis inpatients spent an average of 4.1 days in the hospital and also made an average of 0.7 physician visits, 0.3 emergency room visits, and 0.2 outpatient clinic visits per illness.

U.S. salmonellosis patients were assumed to receive the same average amount of medical care as MarketScan salmonellosis patients for the purpose of the cost estimates. Total U.S. medical expenses due to *Salmonella* infections were calculated based on the average amount of medical care received by the MarketScan salmonellosis patients in each severity category, the estimated number of U.S. salmonellosis cases in each category, and the 1998 average U.S. cost for each type of medical care. Fatal cases could not be distinguished in the MarketScan database and were therefore 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 not available, so indirect estimates were derived from the National Health Interview Survey (NHIS), a nationally representative annual survey of the U.S. civilian noninstitutional population (7). The 1992, 1993, and 1994 NHIS samples were pooled to obtain more precise estimates. The NHIS estimates of health conditions are based on respondent reports, making it difficult to distinguish salmonellosis from other acute infectious illnesses, so ERS assumed that the time lost from work due to acute infectious illnesses was comparable to the time lost from work due to salmonellosis. The NHIS data indicate that the average time lost from work due to acute infectious illnesses was 0.5 days among cases who did not obtain medical care and 1.6 days among cases who visited a physician. The NHIS did not cover hospitalized individuals, so ERS conservatively assumed that cases who were hospitalized lost an average of 4.5 work days, determined by summing the average time lost by cases who visited a physician (1.6 days) and the average hospital stay for MarketScan salmonellosis patients adjusted for a 5-day weekly work schedule (2.9 days).

Total U.S. productivity losses due to nonfatal *Salmonella* infections were calculated based on the average number of work days lost by employed individuals in each severity category, the U.S. employment rate, and the average daily compensation for U.S. workers in 1998. The productivity losses due to fatal cases were estimated using the "labor market" approach for valuing life reviewed by Viscusi (8). ERS modified this approach by taking the age and sex distribution of salmonellosis 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) was treated as an annuity paid over the average life span for U.S. males and females at an interest rate of 3 percent. Under the modified approach, the value of a life (in 1998 dollars) ranged 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.

ERS assumed that 96 percent of the total medical expenses and productivity losses due to salmonellosis was attributable to the consumption of foods contaminated by *Salmonella*, based on an earlier CDC estimate of the proportion of *Salmonella* infections that are foodborne in origin (9). Other sources of infection include contact with pets and person-to-person transmission.

**Results**

The estimated annual costs of medical care and lost productivity due to foodborne *Salmonella* infections were $2.3 billion (in 1998 dollars), based on the modified labor market approach for valuing life (table 1). The forgone earnings of persons who died prematurely due to salmonellosis accounted for most (93 percent) of these costs. The remaining costs were due to medical expenses, primarily for hospital care. This cost estimate undervalues the societal costs of *Salmonella* infections, omitting medical expenses and productivity losses due to secondary complications such as reactive arthritids, 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 previous ERS estimate of the annual costs of foodborne *Salmonella* infections ranged from $5.0 billion to $12.8 billion (in 1998 dollars), based on the labor market approach for valuing life (1). (ERS formerly reported an alternative cost estimate based on the "human capital" approach for valuing life, but now relies primarily on the labor market approach.) The reduction in the estimated costs of foodborne *Salmonella* infections is due to several factors. Most importantly, ERS adopted the FoodNet estimate of 1.4 million annual salmonellosis cases in place of the previous range of 0.8-4.0 million annual cases, and assumed that salmonellosis is responsible for 600 annual deaths in place of the previous estimate of 1,000-2,000 annual deaths.

The estimated costs of foodborne *Salmonella* infections are sensitive to potential errors in the estimated incidence and severity of salmonellosis. 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 is $3.8 million per fatal case, versus $5,452 per hospitalized case, $316 per case visiting a physician only, and $24 per case recovering without medical care.
Table 1: Estimated Economic Costs of Foodborne *Salmonella* Infections Classified by Severity of Illness and Type of Cost

<table>
<thead>
<tr>
<th>Severity &amp; cost category</th>
<th>Estimated foodborne illness costs (Million 1998 dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severity</td>
<td></td>
</tr>
<tr>
<td>No physician visit</td>
<td>29</td>
</tr>
<tr>
<td>Physician visit only</td>
<td>34</td>
</tr>
<tr>
<td>Hospitalized</td>
<td>89</td>
</tr>
<tr>
<td>Died</td>
<td>2,194</td>
</tr>
<tr>
<td>Total</td>
<td>2,346</td>
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<tr>
<td>Type of costs</td>
<td></td>
</tr>
<tr>
<td>Medical costs</td>
<td>114</td>
</tr>
<tr>
<td>Hospital care</td>
<td>85</td>
</tr>
<tr>
<td>Other medical services</td>
<td>29</td>
</tr>
<tr>
<td>Lost productivity</td>
<td>2,232</td>
</tr>
<tr>
<td>Total</td>
<td>2,346</td>
</tr>
</tbody>
</table>

Note: The estimated costs of *Salmonella* infections include only associated medical expenses and productivity losses. The estimates assume that 96 percent of salmonellosis cases are foodborne. The cost of a premature death was estimated using the modified labor market approach, and ranges between $1.4-$8.3 million for males and $1.6-$8.5 million for females, depending on age at time of death. The values for males and females differ because average life expectancy is greater for females.

Discussion

Information about the share of foodborne *Salmonella* infections caused by different foods in the United States is limited. The most important source of infection is probably undercooked shell eggs, which may be contaminated by hens infected by *Salmonella* serotype Enteritidis. A recent risk assessment of the consumption of *Salmonella* Enteritidis-infected eggs by the USDA Food Safety and Inspection Service (FSIS) estimated that contaminated shell eggs and egg products were responsible for 0.7 million annual salmonellosis cases (5th-95th percentiles=0.1-1.7 million cases) (10). Based on this estimate, the share of foodborne *Salmonella* infections due to contaminated eggs is 47 percent (5th-95th percentiles=7-100 percent), resulting in annual costs of $1.1 billion (5th-95th percentiles=$0.2-$2.3 billion).

Pork and pork products are believed to be an important source of *Salmonella* infections in the United States, although the proportion of infections due to contaminated pork is unknown (11). The role of pork in *Salmonella* infections in Denmark has been investigated by Nielsen and Wegener (12), who estimated that 10-15 percent of infections were associated with pork. However, it is unclear whether the share of salmonellosis cases due to pork in the United States is likely to be higher or lower than in Denmark. The average annual per capita consumption of boneless trimmed pork in Denmark (108.6 pounds) is more than twice as high as in the United States (48.6 pounds) (13). In contrast, the level of *Salmonella* contamination of fresh pork is much higher in the United States. Nearly 9 percent of swine carcasses in large U.S. meatpacking plants were contaminated by *Salmonella* in 1995-96 at the start of the period covered by the FoodNet salmonellosis estimate (14), but only 0.8 percent of fresh pork cuts in Denmark were contaminated during the period examined by Nielsen and Wegener (12). Other factors that might affect the risk of salmonellosis from pork may also differ between the two countries, including the proportion of pork consumed in ground form, consumer food preferences and food handling practices, and the size of the population that is most susceptible to *Salmonella* infections.

In the absence of any other data, a rough estimate of the proportion of salmonellosis cases associated with pork in the United States was obtained by examining recent outbreaks of foodborne salmonellosis. Two separate lists of outbreaks compiled by CDC (15) and the Center for Science in the Public Interest (CSPI) (16) were reviewed in order to identify all salmonellosis outbreaks that involved a single, confirmed food vehicle. The CDC list covered outbreaks reported by public health agencies during 1987-92, and included 140 salmonellosis outbreaks attributed to a single food. The CSPI list covered outbreaks identified by various published sources during 1990-98, and included 60 salmonellosis outbreaks attributed to a single food. Overall, the proportion of salmonellosis cases resulting from these outbreaks that were due to pork was estimated to be 6 percent based on the CDC list and 9 percent based on the CSPI list. (The CDC list did not report the number of cases for individual outbreaks, so salmonellosis outbreaks due to specific foods were weighted by the average number of cases per outbreak associated with each food for all types of pathogens.)

Information about outbreaks is potentially misleading because some outbreaks are never identified or reported, and because the factors responsible for outbreaks may differ from the factors responsible for sporadic cases of foodborne illness. Nevertheless, the CDC and CSPI outbreak lists suggest that 6-9 percent of the foodborne *Salmonella* infections in the United States may be associated with pork. Based on this rough estimate, the annual costs due to the consumption of pork contaminated by *Salmonella* are approximately $0.1-$0.2 billion. The economic costs of human illness due to *Salmonella*-contaminated pork therefore appear to be substantially lower than the estimated $1.1 billion annual cost of illness due to *Salmonella*-contaminated eggs.
References


