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Microbial Foodborne Illness

The Costs of Being Sick and the Benefits of New Prevention Policy

by Jean Buzby and Tanya Roberts

A 1991 survey conducted by the United States Department of Agriculture (USDA) asked 1,925 primary household meal planners or preparers "which food safety issue concerns you the most?" Some 43 percent indicated bacteria and parasites in food. The Council for Agricultural Science and Technology (CAST) estimates that microbial pathogens in food cause 6.5 million to 33 million human-illness cases and up to 9,000 deaths each year in the United States. USDA and the Food and Drug Administration (FDA) have proposed new policy approaches to decrease foodborne illness. What are these new approaches? What are the costs of foodborne illness? And are the benefits of reducing pathogens in food likely to outweigh the costs?

Regulatory background

In general, the USDA's Food Safety and Inspection Service (FSIS) oversees raw meat, poultry, egg, and egg product safety. FDA is in charge of the safety of all other foods (for example, seafood, dairy products, fruits, and vegetables). For meat and poultry, "traditional" USDA/FSIS inspection is based on organoleptic (sight, touch, and smell) properties. However, most microbial hazards cannot be detected in this way.

Food scientists invented the Hazard Analysis and Critical Control Point (HACCP) system to assure safe food for astronauts and avoid some of the high costs and risks of a regulatory system which tests foods for pathogens only at the end of the production line.

Food scientists recommend that government agencies and businesses adopt the HACCP system to improve food safety in the United States. Under HACCP, firms use quantitative risk assessment tools to identify hazards and critical control points in their particular production, processing, and marketing activities. Firms then establish workplans to meet critical limits for pathogen control (table 1). HACCP also includes two steps for monitoring and verification, steps likely to include some microbial testing of products to assure the HACCP system is

Table 1. Public and private sectors share responsibility for food safety under HACCP

	Responsibility Under FSIS Proposal	
Principles of HACCP	Primary	Secondary
(1) Conduct a hazard analysis	Firms	Government agencies
(2) Identify the critical control points (CCP) for each pathogen in the process	Firms	Government agencies
(3) Establish critical limits for preventive measures associated with each identified CCP	Firms	Government agencies
(4) Establish CCP monitoring requirements	Firms	Government agencies
(5) Determine corrective actions and perform them	Firms	Government agencies
(6) Establish recordkeeping systems	Firms	Government agencies
(7) Conduct verification procedures	Government agencies	Firms

Note: Some researchers have suggested the addition of an eighth step incorporating feedback from the HACCP program to adjust critical limits, critical control points, corrective actions, etc.

meeting the target level of safety. Firms and agencies share responsibility for verifying the effectiveness of the HACCP system.

Both USDA and FDA have proposed HACCP systems to improve the scientific foundation for U.S. food inspection. Foodmaker, the supplier of Jack-in-the-Box hamburgers, has instituted an HACCP program for all parts of its food system chain, from carcass suppliers to restaurant servers. Both the probability and the level of pathogen contamination have fallen, without a significant increase in costs.

Public health officials and policy makers have taken other recent actions to reduce the risk of foodborne illness:

- USDA now requires that all raw meat and poultry products destined for household, restaurant, or institutional consumption be labeled with safe handling and cooking instructions.
- Florida, California, and Louisiana require restaurants selling raw shellfish to display warnings to customers.
- Industry has instituted HACCP training programs and is considering supermarket certification.
- FSIS, FDA, and Centers for Disease Control and Prevention (CDC) are collaborating on a six-month pilot project investigating diarrheal disease to improve estimates of the annual incidence of foodborne illnesses and to monitor the effectiveness of reduction efforts.

Pathogen contamination of food can occur at many points in the food chain

People can be exposed to pathogens through inhalation, contaminated drinking water, and contact with infected pets, farm animals, and humans. Yet, food sources account for most human illness caused by some pathogens (for example, *Listeria monocytogenes*, *E. coli* O157:H7, *Salmonella*, and *Campylobacter jejuni*). Foods most likely to cause human illness are high protein, nonacid foods such as meat, poultry, seafood, dairy products, and eggs.

Animal products are the most common sources of foodborne pathogens causing human illness. Either the animal can be the source of contamination or cross-contamination, or, less likely, human food handlers can contaminate the animal product. Pathogen contamination can occur in any part of the food chain, starting with feed and other farm inputs (figure 1).

Parasitic contamination often originates on the farm. Bacterial pathogens may live harmlessly in the gastrointestinal tract of cattle, hogs, and poultry and then contaminate meat and poultry flesh during slaughtering, chilling, and processing. For example, accidental puncturing of the intestinal tract during slaughter can lead to widespread contamination of the packing line. Viruses and some bacteria often originate from human handling. For example, 30 to 50 percent of all healthy people carry the bacterium *Staphylococcus aureus*. Transmission to foods may occur from open sores or from normal skin contacting food during processing, packaging, and preparation. This possibility emphasizes the importance of personal hygiene and the proper use of gloves.

Even if food is contaminated, consumers can reduce their risk by cooking foods thoroughly; using proper temperatures for warming, cooling, and refrigerating foods; practicing sanitary kitchen practices; and avoiding raw eggs, unpasteurized milk, and rare meat, poultry, or seafood. However, consumers cannot protect themselves from all foodborne pathogens. Some pathogens are not easily killed by cooking or by refrigeration. Under some conditions, *Staphylococcus aureus* and *Bacillus cereus* can produce heat-stable toxins which can withstand temperatures as high as 250°F, and *Listeria* can survive and multiply during refrigeration.

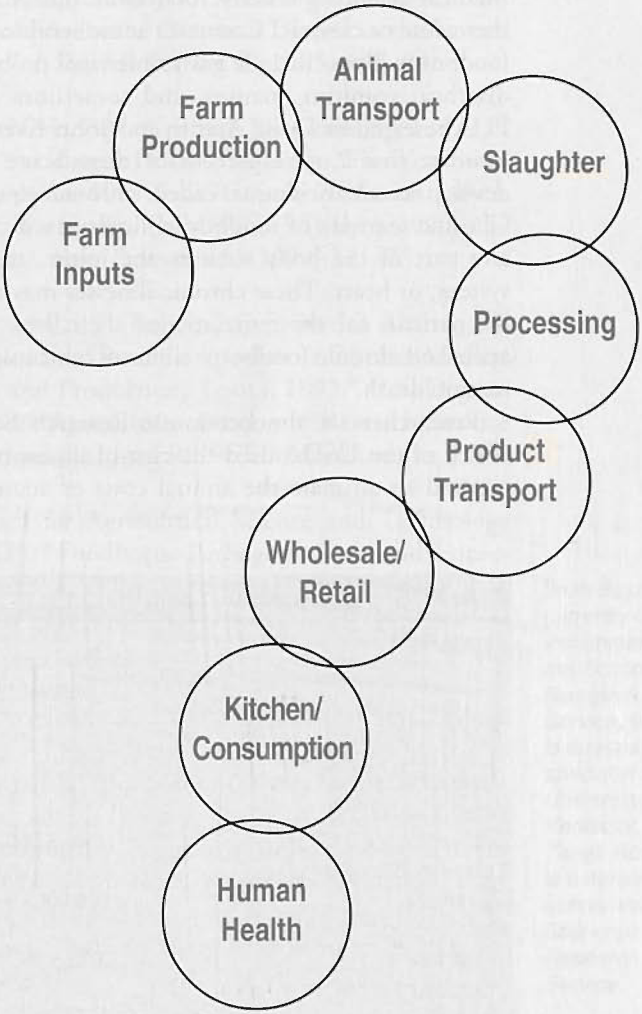

Figure 1. Links in the food chain

Who is most at risk?

People with HIV/AIDS, the immunocompromised elderly, and pregnant women and their offspring face higher risks of acquiring foodborne disease. Women infected with *T. gondii* during pregnancy may transmit the infection to their fetus, possibly leading to stillbirths or babies who are mentally retarded, cross-eyed, or have hearing or visual impairments. Immunocompromised people with suppressed immune systems, especially AIDS patients, are also at higher risk from this parasite. The immunocompromised elderly are more likely to die from a *Salmonella* infection. Children face the highest risk from some foodborne illnesses, such as *E. coli* O157:H7 disease.

The number of people highly susceptible to foodborne illness is increasing because our population is growing and aging, medical technology keeps sick people alive longer, and more people suffer from compromised immune systems. Thus, the demand for food safety regulation may grow.

Estimating the costs of foodborne illness

Medical scientists classify foodborne illness as either acute or chronic. Common acute symptoms of foodborne illness include gastrointestinal problems, diarrhea, vomiting, nausea, and sometimes fever. FDA researchers Doug Archer and John Kvenberg estimate that 2 to 3 percent of these acute cases develop secondary illnesses called "chronic sequelae." Chronic sequelae of foodborne illness can occur in any part of the body such as the joints, nervous system, or heart. These chronic illnesses may afflict the patients for the remainder of their lives. Both acute and chronic foodborne illnesses can cause premature death.

Researchers at the Economic Research Service (ERS) of the USDA used the cost-of-illness (COI) method to estimate the annual costs of acute and chronic human illness caused by foodborne *Salmonella, Campylobacter jejuni, E. coli* O157:H7, *Listeria monocytogenes, Staphylococcus aureus, Clostridium perfringens,* and *Toxoplasma gondii* in the Uiited States. These are the major pathogens found on meat and poultry that cause human illness. Food safety experts at Centers for Disease Control and Prevention (CDC) and elsewhere helped determine the likely annual number of new illnesses attributed to foodborne causes. Ranges were used to reflect the uncertainty of the estimates. ERS estimates that these seven pathogens coming from food sources cause 3.6 million to 7.1 million human illness cases and 2,695 to 6,587 deaths each year (table 2).

The COI analyses (see Buzby et al.) estimated the direct costs of medical care (including special education, physical rehabilitation, and/or residential care costs for some chronic illnesses) and lost productivity (for example, morbidity and mortality costs) of patients and their families.

The cost of foodborne illness

Estimated total annual costs of medical care and lost productivity due to foodborne illness range between $5.6 and $9.4 billion (table 2). These estimates undervalue the true costs of foodborne illness to society because they omit the costs of pain and suffering, use conservative values of statistical life, and do not include all foodborne pathogens and associated chronic complications. (According to CAST, scientists believe over forty different foodborne microbial pathogens cause human illness.)

Estimated costs of foodborne illnesses vary by pathogen because the incidence and severity of disease vary. Salmonellosis and toxoplasmosis cases are the two most costly of the seven foodborne illnesses—largely because of the high number of annual salmonellosis cases and because of the severity of chronic illness caused by *Toxoplasma gondii.*

Table 2. *Toxoplasma gondii* and *Salmonella* ranked as the most costly foodborne pathogens in 1993

Pathogen	Estimated Foodborne		
	Cases	Deaths	Costs
	Number		Billion dollars
Campylobacter jejuni or *coli*	1,375,000–1,750,000	110-511	0.6-1.0
Clostridium perfringens	10,000	100	0.1
Escherichia coli O157:H7	8,000 - 16,000	160-400	0.2-0.6
Listeria monocytogenes	1,526-1,767	378-485	0.2-0.3
Salmonella	696,000 - 3,840,000	696-3,840	0.6-3.5
Staphylococcus aureus	1,513,000	1,210	1.2
Subtotal	3,603,526–7,130,767	2,654-6,546	2.9-6.7
Toxoplasma gondii	2,056	41	2.7
Total	3,605,582 - 7,132,823	2,695-6,587	5.6-9.4

Source: Federal Register 2/3/95, pp. 6781–82 (and p. 6880 for correct number of toxoplasmosis cases).

Costs versus benefits of reducing pathogens

In their Hazard Analysis and Critical Control Point (HACCP) proposal, the Food Safety and Inspection Service (FSIS) used ERS's estimates to calculate that foodborne illness from pathogens in meat and poultry cost $4.5 to $7.5 billion per year in medical costs and lost productivity. The cost-benefit analysis in the proposal looked at implementation and operation costs of HACCP and compared these costs with the benefits of reducing foodborne illness in meat and poultry. Preliminary conclusions of the study found that the implementation of the FSIS HACCP proposal would result in benefits that exceed costs. FSIS is currently responding to comments received on their HACCP proposal. In December 1995, FDA issued their seafood HACCP rule.

Foodborne illness in the next decade

Continuing advances in technology and information in the food marketing chain (that is, refrigerating, pasteurizing, labeling) have improved control techniques. CDC researchers, for example, estimate that the number of listeriosis cases has fallen by 44 percent in the last decade due to educational, industry, and regulatory efforts.

However, the annual number of reported foodborne illnesses may increase. As previously mentioned, a growing number of people in the United States are highly susceptible to microbial foodborne illness. Also, new and cheaper pathogen tests and improved epidemiological methods will allow us to recognize more human illnesses which have foodborne sources. Future advances in science can be expected to discover new links between microbial pathogens and chronic human illnesses. For example, in 1985, *E. coli* O157:H7 was newly identified as a foodborne pathogen causing chronic kidney failure in children.

The short life span of the pathogens encourages improved virulence through quick adaptation to changes in their environment (such as temperature, oxygen, and water levels). Under favorable conditions, some bacteria reproduce every fifteen to thirty minutes, a stark contrast to the seventy-six-year human lifespan. Researchers are concerned about the new *E. coli* O157:H7 strain associated with a recent outbreak from dry salami. This new strain appears to be more acid-tolerant and can survive at higher temperatures than some other *E. coli* strains.

Recent trends in food production and consumption might increase food safety risks. Microwave heating of foods can be uneven, allowing some parasites and bacteria to survive. Diners who eat food away from home (at restaurants, fast food outlets, nursing homes, schools) have less control over food handling and cooking. Also, as the U.S. food supply becomes more centralized and food is shipped to more distant markets, the probability of large foodborne disease outbreaks increases.

Summary

The cost-of-illness estimates reported here can be used to help evaluate the economic impact of foodborne disease, target pathogen reduction efforts toward the most costly diseases, and compare benefits and costs of control efforts to determine the most cost-beneficial public or private interventions. In particular, the estimates show the high social costs of foodborne pathogens, that the benefits from better regulation and from programs like HACCP may well outweigh their costs, and that some pathogens could receive more attention because their health and productivity costs are relatively high. ■

■ For more information

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