Consumption patterns affect the risks of foodborne illnesses. Poultry consumption increased 35 percent during the 10-year period between 1982 and 1992, as consumers substituted chicken for other meats (Lin *et al.* 1993, p. 38). This increase is partly because of concerns over dietary fat content, and partly because chicken has become cheaper than other meats. A recent consumer survey showed that 95 percent of the chicken bought for home consumption consisted of fresh products, such as fresh chicken parts (Lin *et al.* 1993, p. 38). The prevalence of *Campylobacter jejuni* and *Salmonella* in raw poultry means that this new consumption trend may lead to increasing numbers of foodborne illness cases.

COI Estimates of *Escherichia Coli* O157:H7 Disease

E. coli O157:H7 was first isolated by CDC in 1975 (FDA Consumer 1994, p. 9) but was not identified as a cause of human illnesses until 1982 when two outbreaks of gastrointestinal illness in Michigan and Oregon were investigated and linked to consumption of contaminated hamburgers (Riley *et al.* 1983)(fig. 7). There has been worldwide detection of *E. coli* O157:H7 and its associated illnesses. Bovine isolates or human cases of *E. coli* O157:H7 have been documented in over 16 countries and on 6 continents (USDA:APHIS:VS 1994, p. 2). Benenson (1990, p. 137) states that infections from enterohemorrhagic strains of *E. coli* (mainly O157:H7) are recognized as important health problems in Europe, southern South America, and North America. The following analysis updates the 1992 COI estimates found in Roberts and Marks (1995) to 1993 dollars.

E. coli O157:H7 and its link to an associated life-threatening illness called hemolytic uremic syndrome (HUS) became well known to the public as a result of the 1993 *E. coli* O157:H7 disease outbreak caused by contaminated hamburger in Washington, California, Idaho, and Nevada. The American Gastroenterological Association's (AGA) Consensus Conference Statement on *E. coli* O157:H7 Infections (1995, p. 1923) indicated that this outbreak led to over 700 illness cases (primarily children) and of these cases, 195 were hospitalized (28 percent), 4 died (0.57 percent), and 55 developed HUS (7.86 percent). In recent years, an increasing number of *E. coli* O157:H7 outbreaks and sporadic cases have been documented (AGA 1995, p. 1923).

E. coli O157:H7 is a hardy organism. Although bile acids can help kill some microorganisms such as *Clostridium botulinum*, *Escherichia is* resistant to these acids (CAST 1994, p. 25). *E. coli* O157:H7 can also survive some acid environments in food such as that found in apple cider (FDA Consumer 1994, p. 8). *E. coli* O157:H7 can grow and multiply slowly at temperatures as low as 44°F and can even survive freezing (FDA Consumer 1994, p. 9). *E. coli* O157:H7 can also survive in water for extended periods (USDA:APHIS:VS 1994, p. 1). However, *E. coli* O157:H7 is easily killed by heat used in pasteurization and cooking (USDA:APHIS:VS 1994, p. 1). The 1993 outbreak of *E. coli* O157:H7 infections indicated that the infectious dose is less than 1,000 organisms (AGA 1995, p. 1925). The CAST report estimates that the infectious illness dose is in the range of 10 to 1,000 colony-forming units (1994, p. 12).

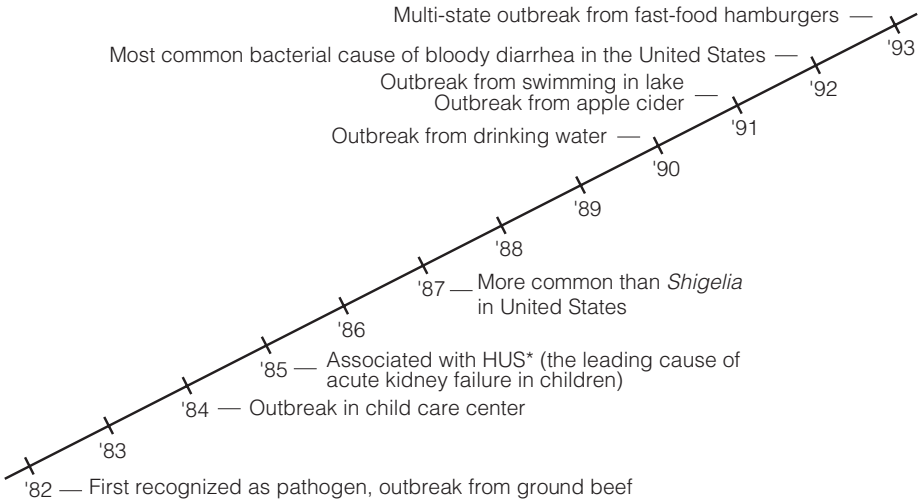
E. coli O157:H7 is a toxicoinfective microorganism because it causes human illnesses through the toxins that it produces (CAST 1994, p. 19). *E. coli* O157:H7 toxins cause human illnesses by adhering to receptors in the kidney, intestine, and central nervous system where it prevents protein synthesis and kills cells (CAST 1994, p. 19). The bloody diarrhea and abdominal cramping typically found in symptomatic cases of *E. coli* O157:H7 disease are caused by the toxins that *E. coli* O157:H7 produces and by the partial destruction of the colon's mucosal lining (USDA:APHIS:VS 1994, p. 1). In the United States, *E. coli* O157:H7 is a major cause of bloody diarrhea (AGA 1995, p. 1924).

E. coli O157:H7 causes a wide range of illness severities in humans 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. Ostroff *et al.* (1989, p. 355) found that 95 percent of the 93 reported sporadic cases of *E. coli* O157:H7 disease in Washington State in 1987 had bloody diarrhea. Griffin and Tauxe (1991, p. 64), in reviewing the literature, speculated that bloody diarrhea is the most commonly reported symptom, because persons with bloody diarrhea are more likely to seek medical care and because physicians are more likely to culture stools if patients report bloody stools.

The incubation period for *E. coli* O157:H7 in humans is typically 3 to 5 days (AGA 1995, p. 1925).

Figure 7

Emergence of *Escherichia coli* 0157:H7



*Hemolytic Uremic Syndrome

Source: Centers for Disease Control and Prevention. Addressing Emerging Infectious Disease Threats: A Prevention Strategy for the United States. Atlanta, Georgia: U.S. Dept. of Health and Human Services, Public Health Service. p. 11., 1994.

Benenson (1990, p. 137) states that the incubation period may be as short as 12 hours but the median is 48 hours. On average, the acute illness ends 6 to 8 days after onset (CDC April 16, 1993, p. 262).

Although most *E. coli* O157:H7 infections are mild and do not require medical care, *E. coli* O157:H7 infections can result in hemorrhagic colitis (bloody inflammation of the colon).[43] Symptoms of hemorrhagic colitis may include the sudden onset of severe abdominal cramps, little or no fever, and watery diarrhea (Riley *et al.* 1983; Pai *et al.* 1984; Ostroff *et al.* 1989) that may become so grossly bloody that it has been described as "all blood and no stool." Vomiting occurs in roughly half of the affected individuals (Griffin and Tauxe 1991, p. 64).

Most cases of hemorrhagic colitis fully recover 6 to 8 days after onset (Griffin and Tauxe 1991, p. 64). Patients with more severe symptoms are hospitalized. Physicians may misdiagnose hemorrhagic colitis as appendicitis, inflammatory bowel disease, or various forms of colitis, and these misdiagnoses could lead to unnecessary and/or inappropriate surgery, antibiotic therapy, and therapeutic procedures. Although most patients with *E. coli* O157:H7-induced hemorrhagic colitis recover without developing sequelae, others develop HUS (Griffin and Tauxe 1991, p. 65).[44]

Although less than 5 percent of *E. coli* O157:H7 disease cases develop HUS, outcomes from HUS are severe. HUS is a life-threatening disease characterized by red blood cell destruction, kidney failure, and neurological complications, such as seizures and strokes (McCarthy 1993, p. 10A; AGA 1995, p. 1923). Those who develop chronic kidney failure may require lifelong dialysis or a kidney transplant.[45] Other neurological complications such as central nervous system deterioration, blindness, or partial paralysis may also result (Merck 1992). Many HUS patients die.

[43]Hemorrhagic colitis can be the result of several different diseases.

[44]Another condition that may follow *E. coli* O157:H7 infection is thrombotic thrombocytopenic purpura (TTP), which is similar to HUS but Griffin and Tauxe suggest that TTP may have more prominent abnormalities in the central nervous system and may be relatively more common in *E. coli* O157:H7 disease patients who are adults (1991, pp. 84-85). Remuzzi (1987, p. 294) believes "that none of the proposed differentiating features can clearly separate these two clinical syndromes." The current study focused on HUS in children because of the preponderance of *E. coli* O157:H7 infections among the very young.

[45]During dialysis such as hemodialysis, the blood is removed from the patient, sent through a machine that balances its water and mineral content while removing toxic waste products, and then is returned to the patient.

HUS especially strikes children under 5 years of age and the immunocompromised elderly (Griffin *et al.* 1988; Griffin and Tauxe 1991; Martin *et al.* 1990). *E. coli* O157:H7 disease may be the leading cause of acute kidney failure and HUS in young children and infants. Tarr *et al*. (1989, p. 585) found that *E. coli* O157:H7 disease is the leading cause of HUS in the Pacific Northwest. Siegler *et al.*'s (1994) results from a 20-year population-based study of HUS in children in Utah were consistent with Tarr *et al.*

Other risk factors for *E. coli* O157:H7 disease include a previous gastrectomy, recent antimicrobial use, and occupational exposure to ground beef, cattle, or clinical stool specimens (Griffin and Tauxe 1991, p. 65). Spika *et al.* (1986, p. 290) and Martin *et al.* (1990, p. 1161) found that attendance at day care may be a risk factor.[46] In 1991, a swimming-associated outbreak of hemorrhagic colitis and HUS was traced to *E. coli* O157:H7-contaminated lake water (Keene *et al.* 1994, p. 579).

Over 67 percent of sporadic *E. coli* O157:H7 cases have occurred between May and September, while 88 percent of all outbreak cases have occurred between May and November (USDA:APHIS:VS 1994, p. 2). This seasonality may be related to the summer barbecue season.

A 2-year study of stool samples showed that a significantly lower percentage of stool samples tested positive for *E. coli* O157:H7 in the South than in the Western and Northern United States (USDA:APHIS:VS 1994, p. 2). Yet, there is no strong evidence suggesting a geographical pattern for *E. coli* O157:H7 disease. The documentation of the incidence of *E. coli* O157:H7 infections in humans is hindered by the variation in State reporting requirements to the CDC. As of the summer of 1993, 17 States had reporting requirements for *E. coli* O157:H7, 20 States were amending their public health regulations to require such reporting, 10 States and the District of Columbia were seriously considering this requirement, and the remaining three States were not addressing the issue (Vogt 1994, p. CRS-7).

As with *Salmonella* and *Campylobacter*, *E. coli* O157:H7 can live harmlessly in the gastrointestinal tracts of farm animals and poultry and later contaminate meat and poultry products during slaughter.

[46]Belongia *et al.* (1993, p. 883) found that "person-to-person transmission of *E. coli* O157:H7 is common when infected preschool children attend day care while symptomatic."

Most outbreak cases associated with food in the United States are linked to bovine products (USDA:APHIS:VS 1994; Griffin and Tauxe 1991, p. 71). Some outbreaks are suspected or have been confirmed as originating in the cross contamination of other foods such as mayonnaise, apple cider, and vegetables by meat products or manure (USDA: APHIS:VS 1994, p. 1).[47] Other foods associated with human *E. coli* O157:H7 disease outbreaks and sporadic cases include hot dogs, raw milk, raw potatoes, turkey roll, and salad bar items such as ranch dressing, pea salad, and cantaloupe (Griffin and Tauxe 1991; USDA:APHIS:VS 1994; AGA 1995, p. 1923).

Sporadic cases of *E. coli* O157:H7 disease have also been attributed to person-to-person transmission and to contaminated water (Griffin and Tauxe 1991, p. 73). Outbreaks from contaminated water have also occurred. Swerdlow *et al.* (1992) examined a large outbreak of *E. coli* O157:H7 infections traced to contaminated water in a Missouri municipal water system. Keene *et al.* (1994) investigated a 1991 swimming-associated outbreak of hemorrhagic colitis caused by *E. coli* O157:H7 contaminated water.

Bennett *et al.* (1987, p. 109) found that in 1985 potentially 5 percent of *E. coli* O157:H7 infections were attributed to attendance at day care centers. Because *E. coli* O157:H7 is not spontaneously generated, it is possible that many of these person-to-person cases originated with consumption of food contaminated with *E. coli* O157:H7. Several other studies also report or suggest that *E. coli* O157:H7 disease can be caused by person-to-person transmission (Ratnam *et al*. 1986; Spika *et al.* 1986). In the 1993 outbreak in the Northwest, more than 50 of the 500-plus cases were attributed to person-to-person contact, especially taking place among infants in child care facilities (FDA Consumer 1994, p. 8). In addition to food, water, and human sources of transmission of *E. coli* O157:H7, Renwick *et al.* (1993) report transmission from calves to a child, presumably through oral contact with feces.

Estimates of Cases

Laboratory screening for *E. coli* O157:H7 is relatively straightforward (Griffin *et al.* 1988, p. 711) and pro-

[47]Apple cider contaminated with *E. coli* O157:H7 is believed to result from making cider with apples that have fallen from orchard trees and that are contaminated with manure fertilizer or feces from farm animals or deer.

vides the opportunity to compare the frequency of isolation of this pathogen to frequencies of other pathogens causing diarrheal illnesses in humans. Gransden *et al.* (1986, p. 523) found that *E. coli* O157:H7 was the second leading bacterial cause of diarrhea (following *Campylobacter*) in 1,425 school children in British Columbia who had stool cultures taken. MacDonald *et al.* (1988, p. 3567) report that out of 6,485 stool specimens from a health maintenance organization in Washington State, researchers isolated *E. coli* O157:H7 less frequently than *Salmonella* or *Campylobacter*, but more frequently than *Shigella*.[48]

We updated Roberts and Marks' (1995) COI estimates for *E. coli* O157:H7. As with the other foodborne pathogens studied here, this analysis considers four main patient categories, those who: do not visit a physician, visit a physician, are hospitalized, and die. However, the COI analysis for *E. coli* O157:H7 infections is more complicated than for salmonellosis and campylobacteriosis, because hospitalized acute illness cases and deaths are subdivided into those who have hemorrhagic colitis and those with HUS. The COI analysis for *E. coli* O157:H7 is further complicated in that some HUS cases develop chronic illnesses and some of these chronic illness cases die prematurely. For simplicity, our analysis will first discuss medical costs, subdivided into acute and chronic cases, followed by a discussion of the costs of lost productivity, also subdivided into acute and chronic cases. Table 10 presents the estimated acute and chronic *E. coli* O157:H7 disease cases in the United States, broken down by the four disease severity categories used throughout this report. Figure 8 presents the distribution of estimated annual cases of *E. coli* O157:H7 disease and disease outcomes. Table 11 presents the assumptions used here to estimate annual costs of *E. coli* O157:H7 disease.

To simplify the analysis, all cases are assumed to be 4 years of age at death or at the onset of the illness. This was roughly the average age (3.8 years) in Martin *et al.* (1990), which is the largest U.S. study of children with HUS. They studied 117 children under age 18 with HUS in Minnesota. This is also the average age in Siegler *et al.'s* (1994, p. 36) 20-year population-based study. Several studies also identified age less than 4 or 5 years as a risk factor for HUS from *E. coli* O157:H7 disease (Pai *et al.* 1984, p. 590; Griffin

[48]Isolation rates were as follows: 7/100,000 persons for *Shigella*; 8/100,000 persons for *E. coli* O157:H7; 21/100,000 persons for *Salmonella*; and 50/100,000 persons for *Campylobacter*.

Table 10—Estimated U.S. *Escherichia coli* O157:H7 disease cases, 1993[1]

Severity of illness	Cases	
	Low	High
	Number	
Acute:		
No physician visit[2]	5,000	10,000
Visited physician[2]	3,200	6,400
Hospitalized and survived[3]	1,600	3,100
Hemorrhagic colitis	1,340	2,630
HUS	260	470
Deaths (during hospitalization)[4]	200	500
Hemorrhagic colitis deaths	100	250
HUS deaths	100	250
Total acute cases[5]	10,000	20,000
Chronic:		
No physician visit	0	0
Visited physician	0	0
Hospitalized and survived (all are HUS)[6]	11	25
Deaths (all are HUS)[7]	19	37
Total chronic cases	30	62

[1] We assumed no chronic conditions resulted from hemorrhagic colitis (HC) and assumed both chronic and acute conditions resulted from hemolytic uremic syndrome (HUS). For both acute and chronic *E. coli* O157:H7 illness, we estimate there is a total of 219-537 deaths each year (see below).

[2] Of the 82% of all *E. coli* O157:H7 acute illness cases that are not hospitalized, we assume that 50% of all cases do not seek any medical attention and the remaining 32% visit a physician.

[3] Griffin and Tauxe (1991) found that 18% (p. 69) of all acute illness cases are hospitalized (1,800 to 3,600 cases) and 20% (calculated from Table 2 on p. 70) of the hospitalized cases (360-720) develop HUS. After subtracting the 100-250 HUS acute illness deaths, there were 260-470 hospitalized HUS cases who survived. We categorize the remainder of the hospitalized cases (80%) as those that develop HC (1,440-2,880). After subtracting the 100-250 HC acute illness deaths, there were 1,340-2,630 hospitalized HC cases who survived.

[4] The American Gastroenterological Association's (AGA) 1994 Consensus Conference on *E. coli* O157:H7 Infections estimate the annual number of *E. coli* O157:H7 acute illness deaths as ranging between 200 and 500. We assume that 50% of all *E. coli* O157:H7 acute illness deaths were HC patients and 50% were HUS patients.

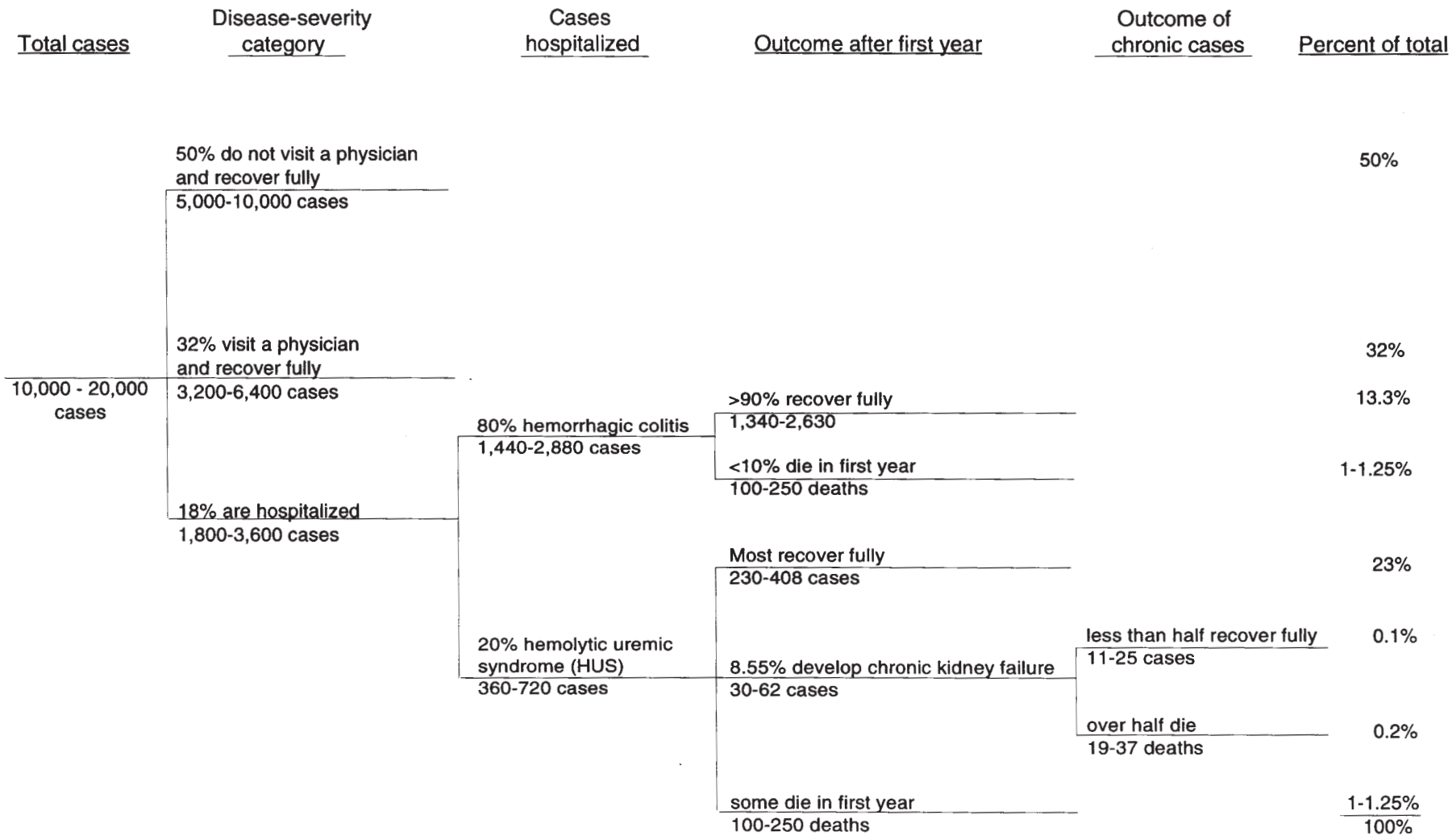
[5] The AGA's 1994 Consensus Conference on *E. coli* O157:H7 Infections (p. 7) estimate the annual number of *E. coli* O157:H7 disease cases as ranging between 10,000 and 20,000 cases.

[6] In Martin *et al.* (1990), 8.55 percent of HUS patients had kidney failure and we use this percentage to represent the proportion of acute illness HUS cases that developed chronic complications. Out of the 360-720 HUS cases, we estimate that 30-62 developed chronic complications.

[7] Using the HCFA's data on the rates of kidney transplantation, survival after the operation, and survival on dialysis for pediatric patients, life tables for the 30-62 chronic illness cases were estimated (Eggers, personal communication with Marks). We estimate that 19-37 die prematurely from chronic illness due to HUS.

Figure 8

Distribution of estimated annual U.S. *Escherichia coli* O157:H7 disease cases and outcomes[1]



[1]Percentages and cases may be rounded.

Prepared by Economic Research Service, USDA.

Table 11—Assumptions used to estimate annual costs of illness for *E. coli* O157:H7 disease, 1993

Cost category & severity	Costs during acute illness	Costs during chronic illness
Overview: Incremental costs due to foodborne disease	Estimates of new cases annually are divided into severity level categories to estimate costs. Acute illness costs are not discounted, except for productivity losses for deaths occurring during the acute illness.	Some survivors develop chronic conditions. All lifetime costs are discounted at 3% per year to calculate the 1993 present value.
Medical costs		
No physician visit	No medical costs estimated. (Although some may self-medicate.)	Not relevant.
Visited physician	Physician visit cost calculated by dividing the updated Health Care Financing Administration annual national expenditures on physician services by the National Center for Health Statistics annual number of physician visits. Laboratory expenses are computed separately.	Not relevant.
Hospitalized	Hospital room cost is the American Hospital Association's average cost per day. An intensive care room is assumed to be double the cost of a regular room. Total fees for physician care, laboratory tests, and medications during hospitalization are assumed to be equal to hospital room costs. Costs of dialysis are computed separately.	For known chronic conditions associated with the foodborne illness, chronic costs are computed the same as acute costs, except that they are computed for the remaining life of an individual and discounted back to 1993 using a 3% discount rate. Discounted costs of kidney transplants and drug therapy were also included.
Productivity losses	If ill person is a child under age 16, productivity loss is calculated for one parent/caretaker.	For children, the productivity loss is calculated for one parent/caretaker's time estimated for care of chronically ill child until age 16. After the age of 16, the ill individual's productivity loss is estimated.
No physician visit	Productivity loss uses the BLS average weekly earnings for all nonagricultural workers (pre-tax, no fringe benefits) multiplied by 39% to account for fringe benefits, divided by 5 to get a daily rate, and multiplied by the estimated days lost from work.	The average weekly earnings are multiplied by 52 weeks, adjusted by the labor force participation rate for the age of the patent, and multiplied by the percentage of productive capacity lost. Or, an estimate of the proportion of productivity lost because of the disability is multiplied by Landefeld and Seskin's (1982) value of life according to the age of the patient to get the marginal lifetime productivity lost.
Visited physician	Time away from work was estimated either by assuming the average duration of illness or by using estimates from survey data. The cost per day is estimated by adjusting BLS average weekly earnings as above.	
Hospitalized	Time away from work is assumed to be 3 times the days in the hospital, adjusted for weekends. The cost per day is estimated by adjusting BLS average weekly earnings as above.	
Death	The present value of a statistical life lost is computed as the average of male and female values given by Landefeld and Seskin (1982) for each age, updated to 1993 values using the change in average weekly earnings.	The value of a statistical life lost to chronic illness is Landefeld and Seskin (1982) value for the age of the person in the year he/she dies, discounted back to 1993.
Other costs: education, nursing home, lost leisure, pain & suffering, transportation to medical care	Not estimated.	Not estimated

et al. 1988, p. 706; Ostroff *et al.* 1989, p. 355; Pavia *et al.* 1990, p. 549; Cimolai *et al.* 1990, p. 590). Figure 9 presents the age-specific rates of infection with *E. coli* O157:H7 for 93 surveillance cases in Washington State in 1987. Note that the highest infection rate is for children less than 5 years old.

The annual estimated incidence of *E. coli* O157:H7 disease is between 2.1 and 8 cases per 100,000 persons (Ostroff *et al.* 1989, p. 355; and MacDonald *et al.* 1988, p. 3567, respectively). Participants of the AGA's 1994 Consensus Conference on *E. coli* O157:H7 infections (1995, p. 1924) believed that the best estimate of *E. coli* O157:H7 disease cases was between 10,000 and 20,000 cases per year (a rate of approximately 4 to 8 cases per 100,000 persons in 1993). We use these consensus estimates for this analysis.

Using data on 12 U.S. outbreaks of *E. coli* O157:H7 disease between 1982 and 1990, Griffin and Tauxe (1991, p. 69) found that 18 percent of all cases are hospitalized and 20 percent of the hospitalized cases develop HUS (calculated from table 2 on p. 70).[49]

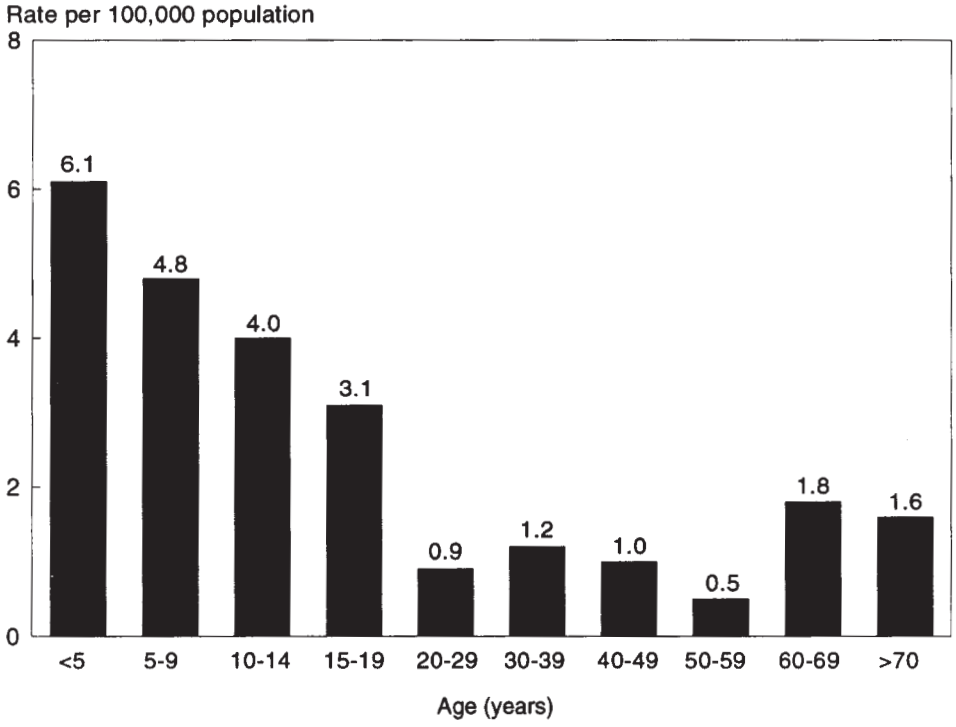
These percentages are used in this analysis. The remainder of the hospitalized cases (80 percent) are categorized as those who develop hemorrhagic colitis. Using these percentages along with the estimated range of 10,000-20,000 E. coli O157:H7 disease cases, an estimated 1,800-3,600 cases are hospitalized. This includes hospitalized patients who survive and those who die prematurely because of acute *E. coli* O157:H7 disease. Of these 1,800 to 3,600 cases, 360 to 720 (or 20 percent) develop HUS, and 1,440 to 2,880 (or 80 percent) develop hemorrhagic colitis.

In Martin *et al.*'s (1990, p. 1164) study of 117 children who had HUS, 9 children had renal failure and survived, and one child required a kidney transplant.[50] Here, we assumed that these 10 renal failure and transplant cases (or 10/117=8.55 percent) constitute those HUS patients who remain chronically ill with kidney failure. Using this percentage (8.55 percent), we estimated that of the 360 to 720 cases who contract HUS in our analysis, approximately 30 to 62 remain chronically ill.

[49]This translates into 3.6 percent of all *E. coli* O157:H7 cases develop HUS. Our estimate is conservative when compared with Karmali *et al.* (1985, p. 778) who found that roughly 10 percent of all *E. coli* O157:H7 infections develop HUS.

[50]Martin *et al.'s* (1990, p. 1164) table 3 indicates 10 cases of renal failure, but one of these is linked to the sepsis death which would have first had renal failure.

Figure 9
E. coli O157:H7 infection rates by age, 1987



Prepared by Economic Research Service, USDA, based on personal communication with Stephen Ostroff from the Centers for Disease Control and Prevention on February 7, 1996. Data for 93 *E. coli.* O157:H7 cases in Washington State.

We assumed that all of the 30 to 62 chronic illness cases required dialysis and some had kidney transplants, and that there were premature deaths resulting from both of these procedures. Because kidney failure is the major chronic complication of HUS in children, end-stage renal disease (ESRD) data were used in the cost estimation. We used data on the percentage of ESRD children receiving kidney transplants (Eggers, personal communication with Marks (ERS) 1993) and HCFA's Medicare data on survival rates after kidney transplantation and survival rates on dialysis for pediatric patients (HCFA 1992, tables 35-37) to develop life tables for kidney transplant and dialysis survivors, and to estimate the number of premature deaths due to chronic illness from HUS. Table 12 shows the breakdown of the estimated 19 to 37 premature deaths from chronic *E. coli* O157:H7 illness, by age at death. The estimated number of chronic illness deaths is the sum of the estimate of premature deaths from complications during kidney transplantation and the estimate of premature deaths from complications during dialysis. None of these deaths occurred during the first year of illness but were spread out over subsequent years.[51] Age at death and number of deaths depend upon both kidney transplant survival rates and dialysis survival rates.

Not all kidney transplants take place within the first few years following the onset of the chronic illness. A variety of reasons, such as the patient's health and the availability of a suitable kidney, may delay kidney transplants or remove this procedure as an option for patients. Paul Eggers of HCFA provided data on the cumulative percentage of children receiving transplants within the first 6 months of ESRD and the percentage receiving transplants for each of the following 5 years after ESRD was diagnosed (personal communication between Eggers and Marks (ERS), 1993). This cumulative rate of receiving a transplant increases over time as more kidney transplants are performed. From these data, the cumulative percentage receiving transplants for the remaining years in the average life span of 77 years was estimated, as was the annual percentage receiving transplants (decreasing) for each of the years in this timeframe. Using these annual percentages, out of the 30 to 62 chronic illness cases, an estimated 26 to 53 cases had kidney transplants. Table 12 also shows the breakdown of the estimated range of 26 to 53 transplant recipients by year.[52]

Survivability after a transplant depends on the type of kidney received, with higher survival rates for transplant recipients of a kidney from a "living-related" donor versus a kidney from a cadaver. For the representative age used in this study, an estimated 56 percent of the kidney transplant patients had cadaver donors and 44 percent had living-related donors (personal communication between Eggers and Marks (ERS), 1993).

Two groups of deaths from *E. coli* O157:H7 disease were considered: acute illness deaths and chronic illness deaths. In the literature, human deaths attributed to *E. coli* O157:H7 disease generally refer to acute illness deaths and do not include chronic illness deaths. Griffin and Tauxe (1991, p. 69) found a 1.9-percent death rate (op. cit.). However, participants of the Consensus Conference on *E. coli* O157:H7 generally agreed that an estimated 200 to 500 deaths occur from *E. coli* O157:H7 disease each year (Notes by Roberts for this conference), which in our study translates into a death rate of 2 to 2.5 percent.[53] This death rate is high compared with other microbial infections.

We were unable to find published data that specified what percentage of the estimated 200 to 500 *E. coli* O157:H7 acute illness deaths were from hemorrhagic colitis cases and what percentage were from HUS. Therefore, we assumed that 50 percent of all acute *E. coli* O157:H7 disease deaths were hemorrhagic colitis patients and 50 percent were HUS patients. Of the estimated 1,440 to 2,880 cases of hemorrhagic colitis, an estimated 100 to 250 cases died prematurely from the acute illness. The remaining 1,340 to 2,630 patients hospitalized with hemorrhagic colitis achieved a complete recovery. And of the estimated 360 to 720 cases that contract HUS, an estimated 100 to 250 cases died prematurely from their acute illness. These proportions of the percentage of acute illness deaths from HUS and hemorrhagic colitis reflect the greater severity of HUS.

To estimate the number of HUS deaths attributed to chronic complications from kidney transplants, HCFA data on cadaver-donor transplant patient survival

[51]This "first year" is really only 6 months, because it was assumed that the patients became ill in the middle of the year, on average.

[52]All kidney transplants were performed within the 6 full years following the originating illness at age 4, because, over time, the proportion that received a transplant each year declines sharply.

[53]This range of deaths was agreed upon during the conference yet does not appear in the written statement.

Table 12—Chronic illness: Deaths, dialysis recipients, and transplant survivors

Age	Chronic deaths[1]		Dialysis recipients		Transplant recipients		Transplant survivors	
	Low	High	Low	High	Low	High	Low	High
				Numbers				
4 in 1993	0	0	30	62	0	0	0	0
5	2	4	15	31	15	31	14	29
6	1	3	8	17	6	12	19	39
7	2	0	5	11	3	5	21	44
8	1	3	3	8	1	3	21	44
9	1	2	2	7	1	1	21	44
10	1	1	2	5	0	1	20	44
11	0	2	2	5	0	0	20	42
12	0	0	2	5	0	0	20	42
13	1	1	2	5	0	0	19	41
14	0	0	2	5	0	0	19	41
15	0	0	2	5	0	0	19	41
16	0	0	2	5	0	0	19	41
17	1	0	2	5	0	0	18	41
18	0	1	2	5	0	0	18	40
19	0	0	2	5	0	0	18	40
20	0	1	2	5	0	0	18	40
21	0	0	2	4	0	0	18	40
22	0	1	2	4	0	0	18	39
23	0	3	2	4	0	0	18	36
24	1	0	2	4	0	0	17	36
25	1	0	2	4	0	0	16	36
26	0	0	2	4	0	0	16	36
27	0	0	2	4	0	0	16	36
28	0	0	2	4	0	0	16	36
29	0	1	2	4	0	0	16	35
30	0	0	2	4	0	0	16	35
31	0	0	2	4	0	0	16	35
32	0	0	2	4	0	0	16	35
33	0	0	2	4	0	0	16	35
34	0	0	2	4	0	0	16	35
35	0	1	2	4	0	0	16	34
36	1	0	2	4	0	0	15	34
37	0	0	2	4	0	0	15	34
38	0	1	2	4	0	0	15	33
39	0	1	2	4	0	0	15	32
40	1	2	2	4	0	0	15	31
41	0	0	1	3	0	0	15	31
42	0	1	1	3	0	0	15	30
43	0	0	1	3	0	0	15	30
44	0	0	1	3	0	0	15	30
45	0	0	1	3	0	0	15	30
46	0	0	1	3	0	0	15	30
47	0	0	1	3	0	0	15	30
48	0	0	1	3	0	0	15	30
49	1	0	1	3	0	0	14	30
50	0	1	1	3	0	0	14	29
51	0	0	1	3	0	0	14	29
52	1	0	1	3	0	0	13	29
53	0	0	1	3	0	0	13	29
54	0	0	1	3	0	0	13	29
55	0	0	1	3	0	0	13	29
56	0	0	1	3	0	0	13	29
57	0	0	1	3	0	0	13	29

See notes at end of table.

--Continued

Table 12—Chronic illness: Deaths, dialysis recipients, and transplant survivors--Continued

Age	Chronic deaths[1]		Dialysis recipients		Transplant recipients		Transplant survivors	
	Low	High	Low	High	Low	High	Low	High
				Numbers				
58	0	0	1	3	0	0	13	29
59	0	2	1	3	0	0	13	27
60	0	1	1	3	0	0	13	26
61	0	0	1	3	0	0	13	26
62	0	0	1	3	0	0	13	26
63	1	0	1	3	0	0	12	26
64	0	0	1	3	0	0	12	26
65	0	1	1	3	0	0	12	25
66	0	0	1	3	0	0	12	25
67	0	0	1	3	0	0	12	25
68	0	0	1	3	0	0	12	25
69	0	2	1	3	0	0	12	23
70	0	0	1	3	0	0	12	23
71	0	0	1	3	0	0	12	23
72	0	0	1	3	0	0	12	23
73	1	0	1	3	0	0	11	23
74	0	0	1	3	0	0	11	23
75	1	0	1	3	0	0	10	23
76	0	1	1	3	0	0	10	22
77	0	0	1	3	0	0	10	22
Total	19	37	*	*	26	53	*	*

*=These could not be totaled as they would overcount the numbers of recipients or survivors over time.

[1] Of the estimated 19 to 37 chronic illness deaths, 3 to 6 occur from complications from dialysis and 16 to 31 occur from complications arising from the kidney transplants.

(1992, table 36, p. 41) and HCFA data on living-related donor transplant patient survival were used (1992, table 37, p. 42). For both types of kidney transplants, these HCFA cumulative survival rates show that transplant patient survival rate decreases over time as more kidney transplant patients die. These data on the survivability following the two types of kidney transplants were available only for the first full 5 years after the kidney transplant. From these 5 years of data, the survival rates were estimated as well as the number of transplant survivors for both types of kidney transplants for each year in the average life-span of 77 years. Table 12 provides estimates of the total number of transplant survivors from operations using both cadaver and living-related donor kidneys. Given the estimated 26 to 53 kidney transplants and the number of transplant survivors, an estimated 16 to 31 premature deaths occur as a result of complications from the kidney transplants.

To estimate the number of HUS deaths attributed to complications from dialysis, HCFA data on ESRD were used (1992, table 35, p. 40). As with the kidney transplant survival data, the HCFA cumulative estimates of dialysis patient survival declined over time as more patients died prematurely. These data only provided for the first full 5 years after the initiation of dialysis and were used to estimate the cumulative dialysis survival rate for each of the remaining years in the average life span of 77 years. Once all cumulative dialysis survival rates were determined, they were used to develop the percentage of dialysis patients that die each year over the 77-year life span. These annual death rates for dialysis patients were used to estimate that three to six patients with chronic illness due to HUS die prematurely from complications during dialysis.

Out of the 30 to 62 chronic illness cases, an estimated 19 to 37 died prematurely (table 12) from chronic complications over their lifetime (3 to 6 from dialysis and 16 to 31 from transplants). Adding these estimated chronic illness deaths to the estimated 200 to 500 acute illness deaths provides an annual estimate of 219 to 537 deaths caused by *E. coli* O157:H7 disease.

Of the 82 percent of all *E. coli* 1057:H7 disease cases that are not hospitalized, we assumed that 50 percent of all cases do not seek any medical attention (5,000

to 10,000 cases) and that the remaining 32 percent of all cases visit a physician (3,200 to 6,400 cases). This is a higher rate of physician visits than for salmonellosis and campylobacteriosis, but *E. coli* O157:H7's bloody diarrhea is likely to scare people into seeing a physician.

Costs of *E. Coli* O157:H7 Disease

As previously mentioned, the COI analysis for *E. coli* O157:H7 disease differs from those for salmonellosis and campylobacteriosis. *E. coli* O157:H7 disease cases were divided into acute and chronic cases, and *E. coli* O157:H7 disease had two categories of illness that required hospitalization, hemorrhagic colitis and HUS.

Medical Costs for Acute E. Coli O157:H7 Disease

Acute illness medical costs consisted of the costs of hemodialysis, hospital room charges, and physician fees. Hospital room charges include regular hospital rooms and intensive care unit (ICU) rooms. Several nationwide data bases were used. For example, the American Hospital Association's Hospital Statistics provided data on daily costs of hospitalization. The National Hospital Discharge Survey (NHDS) implemented by HCFA's National Center for Health Statistics was used to provide estimates for hospital length of stay. The study also used HCFA's estimates of per capita expenditures on physician services and HCFA's medicare reimbursement rates for the annual costs of ESRD and the costs of kidney transplants.[54] Table 13 presents the estimated annual medical costs of acute illness from *E. coli* O157:H7 disease by severity category.

- No physician visited. For the estimated 5,000 to 10,000 *E. coli* O157:H7 disease cases who do not seek medical care, the study assumed that they have abdominal discomfort and non-bloody diarrhea (often lasting several days) yet do not purchase over-the-counter medications and do not miss work because of their illnesses. For the cases in this category, no medical costs were computed.

- Physician visited. For the estimated 3,200 to 6,400 cases who visited a physician for *E. coli* O157:H7 disease but were not hospitalized, it was assumed that these cases had diarrhea (often bloody and lasting several days) and that they visited a physician once or twice and had one or two laboratory tests. Prescribed medications and medication costs were not included in the estimated costs.

  The costs of physician visits was estimated at $109.57 per visit.[55] This number reflects the per-visit cost of a doctor visit for all reasons, not specifically for the foodborne illness, and includes the portion paid by insurance. Laboratory tests were estimated at $50 per case. Medical costs for those *E. coli* O157:H7 disease cases who visited a physician for their illness but did not require hospitalization are estimated at between $0.5 million and $2.0 million annually.

- Hospitalized for Hemorrhagic Colitis. For the estimated 1,440 to 2,880 cases of hemorrhagic colitis, we assumed that these cases were hospitalized for their bloody diarrhea, dehydration, and severe abdominal cramps. The estimated length of stay (LOS) in a hospital for patients with hemorrhagic colitis is 6.5 days (the average from the NHDS range of 5 to 8 days, Steahr 1993). To compute hospitalization costs, the average cost to community hospitals per patient per day in 1993 dollars was used ($887.20).[56]

- Fees for laboratory tests, supplies, medications, and physician visits while hospitalized are assumed to equal the costs of hospitalization (following Roberts and Pinner 1990) but were updated using the physician services CPI, for a total cost of $843.74 per

[54]Medicare billing records provide a major source of information on the medical costs of specific diseases. However, such information is specific to the Medicare population and may understate the treatment costs of diseases affecting the non-Medicare population.

[55]In 1990, the average number of physician and dental contacts per person per year was 4.7 for males and 6.4 for females (*Statistical Abstract of the United States 1993*: table 174), for an average of 5.55 visits per person. The average cost of a physician visit was estimated by dividing per capita annual natjioal expenditures on physicians' services, $542 in 1991 (*Statistical Abstract of the United States 1993*: table 151), by the average number of annual physician visit (5.55), and updating the resulting number to 1993 dollars (using the 1991 physician services CPI from the *Statistical Abstract of the United States 1993*: table 163, and the 1993 physician services CPI from personal correspondence with BLS on June 16, 1994).

[56]In 1991, the daily hospitalization cost per person was estimated at $752 per patient (American Hospital Association in *Statistical Abstract of the United States 1993*: table 182. This estimate was updated to 1993 dollars using the change in the hospital room CPI (1991 CPI from the *Statistical Abstract of the United States 1993*: table 163, and the 1993 CPI from personal correspondence with BLS in June 1994).

Table 13—Estimated medical costs of acute *E. coli* O157:H7 disease, 1993

Severity of illness	Unit cost[8]	Service/ case	Cost/ case[8]	Cases		Total costs[8]	
				Low	High	Low	High
	Dollars	*Number*	*Dollars*	*Number*		*Million Dollars*	
No physician visit	0	0	0	5,000	10,000	0	0
Visited physician:							
Physician visits[2]	110/visit	1-2	110-219				
Laboratory tests	50/case	1-2	50-100				
Subtotal			160-319	3,200	6,400	0.5	2.0
Hospitalized with hemorrhagic colitis:							
Hospital room3	887/day	6.5	5,767				
Physician fees, lab tests, etc.[4]	844/day	6.5	5,484				
Subtotal			11,251	1,440	2,880	16.2	32.4
Hospitalized with HUS:[1]							
Hospital room[5]	1,183/day	15	17,744	360	720	6.4	12.8
Physician fees, lab tests, etc.[6]	1,125/day	15	16,875	360	720	6.1	12.1
Dialysis and medication[7]	130/day	12	1,566	169	338	0.3	0.5
Subtotal			36,185			12.7	25.5
Total	N/A	N/A	N/A	10,000	20,000	29.4	59.9

N/A = Not applicable.

[1] Medical costs are for those who survive and those who die (after hospitalization) from the acute illness.

[2] The average cost of a physician visit was estimated by dividing per capita annual national expenditures on physician services, $542 in 1991 (*Statistical Abstract of the United States 1993*: table 151), by the average number of annual physician visits (table 174, averaged across gender), and updating the resulting number to 1993 dollars using the physician services CPI (table 163 and personal correspondence with BLS on June 16, 1994). We estimate these cases visit a physician one to two times for their illness.

[3] In 1991, the daily hospitalization cost per person was estimated at $752 per patient (American Hospital Association in *Statistical Abstract of the United States 1993*: (table 182). This estimate was updated to 1993 dollars using the change in the hospital room CPI (Table 163 and personal correspondence with BLS in June 1994). The average hospital length of stay is 6.5 days (average from NHDS data, Steahr 1993).

[4] Fees for laboratory tests, supplies, medications, and physician visits while hospitalized are assumed to equal the costs of hospitalization (following Roberts and Pinner 1990) but were updated using the physician services CPI (as above). Medical costs exclude costs of neurological procedures and gastrointestinal procedures.

[5] Martin *et al.* (1990) found that HUS patients stay on average 15.4 days in a hospital, which we round down to 15 days. We assume the patient stays in a regular hospital room 10 days at the same daily room rate as above, and stays in an intensive care unit (ICU) 5 days at double the regular room rate.

[6] Fees calculated in the same fashion for ICU days as for days in a regular hospital room.

[7] Daily rate of medicare reimbursements for dialysis (Eggers 1994, table 48), updated to 1993 dollars using the general medical care CPI (table 163 and personal correspondence with BLS in June 1994).

[8] Some costs have been rounded for this table.

patient per day.[57] The total costs of hospitalization and fees are estimated at $1,730.94 per patient per day. For the estimated 1,440 to 2,880 cases of hemorrhagic colitis, total costs for this medical category ranged from $16.2 million to $32.4 million. We assumed that these cases recovered fully.

- Hospitalized for acute HUS. Of the estimated 360 to 720 *E. coli* O157:H7 disease cases hospitalized for HUS (which included the 100 to 250 who died prematurely from the acute illness), 30 to 62 of these patients later developed chronic illnesses (which includes 19 to 37 who die from chronic illness due to HUS). The acute and chronic medical costs are not mutually exclusive, because those who develop chronic illnesses first bear the costs incurred during HUS. Additional medical costs incurred by the 32 to 60 patients who develop chronic illness due to HUS illness are discussed in the next section.

In Martin *et al.*'s (1990, p. 1163) study of 117 HUS cases in Minnesota, the average hospital length of stay for HUS patients was 15.4 days. Following Martin *et al.*, we assumed an average patient stay of 15 days (after rounding) in the hospital. We also assumed that 5 of these days would be spent in an ICU. We used an estimate for ICU room costs of $1,774/ICU day, or twice the normal hospital room charge of $887/day. Thus the average cost equals $1,183 per day for the duration of hospitalization. Total annual costs of the regular and ICU hospital rooms for the 360 to 720 acute HUS cases range from $6.4 million to $12.8 million.

We also assumed that the physician fees, laboratory tests, and other charges during hospitalization would be similar to the hospital room and ICU room fees, but were updated using the physician services CPI (updated as described under physician visits) to get an average cost of $1,125 per day. Estimated total annual costs of physician fees, laboratory tests, etc. for the 360 to 720 acute HUS cases range from $6.1 million to $12.1 million.

Martin *et al.*'s (1990, p. 1163) found that 47 percent of HUS cases required dialysis for an average of 12 days. For the current analysis, this translates into 169 to 338 acute HUS cases requiring dialysis. The annual medicare reimbursement rate for kidney dialysis for children in 1993 dollars was $130.50 per day.[58] For the estimated 169 to 338 children who required dialysis, estimated total annual costs of dialysis ranged from $0.3-$0.5 million.

Estimated medical costs for the 360 to 720 hospitalized acute HUS cases ranged from $12.7-$25.5 million annually. This includes the costs of hospitalization, dialysis, physician fees, laboratory tests, and other charges during hospitalization.

- Deaths. We assumed that the estimated 200 to 500 patients who died prematurely from acute *E. coli* O157:H7 disease incurred hospitalization costs prior to their deaths. As previously mentioned, these deaths were divided among those hospitalized for hemorrhagic colitis (50 percent of deaths) and those hospitalized for HUS (50 percent of deaths).[59] The acute illness medical costs associated with these deaths are included in the two hospitalization categories above.

- Subtotal. Acute illness medical costs for the four disease severity categories were estimated to total between $29.4 million and $59.9 million annually.

Medical Costs for Chronic Illness Due to HUS

As previously mentioned, HUS may lead to chronic kidney failure, requiring lifelong dialysis or a kidney transplant. We estimated costs for chronic kidney-related disease, but did not estimate costs for the chronic neurological complications or intestinal operations (laparotomies or colostomies).

[57]As before, we use the 1991 hospital cost of $752 per day, but we updated this cost with the physician services CPI (1991 CPI from *Statistical Abstract of the United States 1993*: table 163 and the 1993 CPI from personal communication with BLS in June 1994).

[58]In 1990, the average Medicare End Stage Renal Disease Program expenditures per dialysis patient were $38,502 per year (Eggers 1993, table 48). This cost estimate was updated to 1993 dollars using the general medical care CPI (1990 CPI from *Statistical Abstract of the United States 1993*: table 163; 1993 CPI from personal communication with BLS in June 1994) to get 1993 annual costs of $47,630.85 per patient or $130.50 per patient per day.

Peritoneal dialysis such as Continuous Ambulatory Peritoneal Dialysis (CAPD) and Continuous Cyclic Peritoneal Dialysis (CCPD) results in one infection every 9 months, on average. Consequently, the infection may be treated with antibiotics in the hospital for 2 days or at home, depending on the severity of the infection. In addition, the children must visit a physician once a month for a checkup. We assumed that the HCFA costs of dialysis for pediatric patients include some, if not all, of these costs.

[59]Patricia Griffin, personal communication July 1993, estimates that 5 percent of deaths occur in nonhospitalized cases which would mean that our assumptions used here overestimated hospitalization costs by 5 percent.

Estimated annual medical costs for chronic illness due to HUS were calculated by adding the costs of three separate medical services for these cases: dialysis, kidney transplants, and drug therapy. For each of these three categories, costs for each year of service were determined by multiplying the average cost per service by the number of patients receiving that service. A total cost for each type of service was then computed by summing annual costs of the service. After the total costs for each of these three subcategories were estimated and combined, total medical costs for chronic illness due to HUS cases were discounted at a rate of 3 percent.

Once chronic kidney failure occurred, our representative 4-year-old patient either continued hemodialysis at the hospital on an outpatient basis, received a transplant, or switched to peritoneal dialysis (performed within the abdominal cavity). In practice, the child has the option to continue hemodialysis at the hospital as an outpatient, yet most receive a kidney transplant or eventually switch to some form of peritoneal dialysis because it can be carried on a person while going about normal activities. If there is no medical reason for choosing one form over another, the decision is generally left up to the parents. Some patients with skin infections or perforations in their peritoneum (*i.e.*, from an operation or other medical condition) have no choice but to continue hemodialysis. HCFA's statistics (1986-89) for children under 15 years old with ESRD show that by the end of year one, 24 percent were undergoing outpatient hemodialysis, 23 percent were undergoing peritoneal dialysis at home, 6 percent died, and 47 percent received a kidney transplant (HCFA 1992, table 7 on p. 11).

In general, for each year, we computed total costs of dialysis for patients with chronic illness due to HUS by multiplying the average annual cost of dialysis by the estimated number of chronic *E. coli* O157:H7 disease cases who required dialysis. We then summed these annual dialysis costs over the 77 years in the average life span to estimate the total costs of dialysis. Because the costs of in-facility hemodialysis are reimbursed at the same rate as that of at-home peritoneal dialysis, the costs for pediatric dialysis patients reflect the same costs for both types of dialysis (as previously mentioned, $130.50 per patient per day or roughly $47,631 per year in 1993 dollars).[60]

Assuming that the onset of illness occurs halfway through the initial year and that no chronic patients receive a transplant during the acute phase (Eggers personal communication with Marks (ERS) 1993), chronic patients require 6 months of dialysis in the initial year (minus 12 days that were accounted for in the acute phase), for a total cost of $22,249/case. The annual costs of dialysis per case for subsequent years is estimated at $47,631.

All patients who had chronic illness due to HUS received dialysis in the first year. A declining number received dialysis in subsequent years as more kidney transplants were performed and as the number of premature deaths from complications from dialysis and kidney transplants increased over time.[61] Table 14 shows the low and high estimates of the number of dialysis recipients each year after onset of HUS illness at 4 years old. The estimated total costs of dialysis for the 30 to 62 cases with chronic illness due to HUS range from $7.0 million to $16.6 million. We later combined these estimated dialysis costs with the estimated costs of kidney transplants and drug therapy to calculate the total chronic medical costs, which were then discounted using a 3-percent rate.

The total cost of the kidney transplants for the cases with chronic illness due to HUS is the product of the number of transplant recipients and the average cost per transplant. Table 15 provides the breakdown of the 26 to 53 kidney transplants by year of operation (as previously described).[62] All transplants were estimated to occur within the 6 years following the *E. coli* O157:H7 infection. The average cost of a kidney transplant was from medicare reimbursement data and was updated to 1993 dollars to get an average of $110,844.23 per transplant.[63] The total costs for the 26 to 53 cases that had kidney transplants ranged from $2.9 million to $5.9 million. As previously mentioned, we combined these estimated costs with the estimated costs of dialysis and drug therapy, and then discounted them using a 3-percent rate.

[60]For simplicity, most of this manuscript uses the generic word "Dialysis" to represent the many kinds of dialysis.

[61]We assumed that dialysis is no longer needed after kidney transplants.

[62]Often, a second or third transplant or a return to dialysis is necessary. Our analysis does not include the additional medical expenses due to additional transplants.

[63]Eggers (1993, table 49) provides an estimate of $89,600 per kidney transplant in 1991. This number was updated to 1993 dollars using the general medical care CPI (1991 CPI from *U.S. Statistical Abstract of the United States 1993*: table 163; 1993 CPI from personal communication with BLS in June 1994). Eggers does distinguish between the costs of a transplant using a cadaver kidney and a transplant using a living-related kidney.

Table 14—Estimated dialysis costs for chronic illness from *E. coli* O157:H7 disease, 1993[1]

Year	Age	Dialysis		Dialysis costs/case[2]	Total costs of dialysis	
		Low	High		Low[2]	High[2]
		Number			*Dollars*	
0	4	30	62	22,249	667,484	1,379,468
1	5	15	31	47,631	714,463	1,476,556
2	6	8	17	47,631	381,047	809,724
3	7	5	11	47,631	238,154	523,939
4	8	3	8	47,631	142,893	381,047
5	9	2	7	47,631	95,262	333,416
6	10	2	5	47,631	95,262	238,154
7	11	2	5	47,631	95,262	238,154
8	12	2	5	47,631	95,262	238,154
9	13	2	5	47,631	95,262	238,154
10	14	2	5	47,631	95,262	238,154
11	15	2	5	47,631	95,262	238,154
12	16	2	5	47,631	95,262	238,154
13	17	2	5	47,631	95,262	238,154
14	18	2	5	47,631	95,262	238,154
15	19	2	5	47,631	95,262	238,154
16	20	2	5	47,631	95,262	238,154
17	21	2	4	47,631	95,262	190,523
18	22	2	4	47,631	95,262	190,523
19	23	2	4	47,631	95,262	190,523
20	24	2	4	47,631	95,262	190,523
21	25	2	4	47,631	95,262	190,523
22	26	2	4	47,631	95,262	190,523
23	27	2	4	47,631	95,262	190,523
24	28	2	4	47,631	95,262	190,523
25	29	2	4	47,631	95,262	190,523
26	30	2	4	47,631	95,262	190,523
27	31	2	4	47,631	95,262	190,523
28	32	2	4	47,631	95,262	190,523
29	33	2	4	47,631	95,262	190,523
30	34	2	4	47,631	95,262	190,523
31	35	2	4	47,631	95,262	190,523
32	36	2	4	47,631	95,262	190,523
33	37	2	4	47,631	95,262	190,523
34	38	2	4	47,631	95,262	190,523
35	39	2	4	47,631	95,262	190,523
36	40	2	4	47,631	95,262	190,523
37	41	1	3	47,631	47,631	142,893
38	42	1	3	47,631	47,631	142,893
39	43	1	3	47,631	47,631	142,893
40	44	1	3	47,631	47,631	142,893
41	45	1	3	47,631	47,631	142,893
42	46	1	3	47,631	47,631	142,893
43	47	1	3	47,631	47,631	142,893
44	48	1	3	47,631	47,631	142,893
45	49	1	3	47,631	47,631	142,893
46	50	1	3	47,631	47,631	142,893
47	51	1	3	47,631	47,631	142,893
48	52	1	3	47,631	47,631	142,893
49	53	1	3	47,631	47,631	142,893
50	54	1	3	47,631	47,631	142,893
51	55	1	3	47,631	47,631	142,893
52	56	1	3	47,631	47,631	142,893

See footnotes at end of table.

--Continued

Table 14—Estimated dialysis costs for chronic illness from *E. coli* O157:H7 disease, 1993[1]--Continued

Year	Age	Dialysis		Dialysis costs/case[2]	Total costs of dialysis	
		Low	High		Low[2]	High[2]
		Number			*Dollars*	
53	57	1	3	47,631	47,631	142,893
54	58	1	3	47,631	47,631	142,893
55	59	1	3	47,631	47,631	142,893
56	60	1	3	47,631	47,631	142,893
57	61	1	3	47,631	47,631	142,893
58	62	1	3	47,631	47,631	142,893
59	63	1	3	47,631	47,631	142,893
60	64	1	3	47,631	47,631	142,893
61	65	1	3	47,631	47,631	142,893
62	66	1	3	47,631	47,631	142,893
63	67	1	3	47,631	47,631	142,893
64	68	1	3	47,631	47,631	142,893
65	69	1	3	47,631	47,631	142,893
66	70	1	3	47,631	47,631	142,893
67	71	1	3	47,631	47,631	142,893
68	72	1	3	47,631	47,631	142,893
69	73	1	3	47,631	47,631	142,893
70	74	1	3	47,631	47,631	142,893
71	75	1	3	47,631	47,631	142,893
72	76	1	3	47,631	47,631	142,893
73	77	1	3	47,631	47,631	142,893
Total	N/A	N/A	N/A	N/A	6,954,757	16,621,341

N/A = Not applicable.
[1] At this stage, costs have not been discounted.
[2] Costs were rounded for this table.

Table 15—Estimated kidney transplant costs for chronic illness from *E. coli* O157:H7 disease, 1993

Year	Transplant recipients		Transplant cost/case[2]	Total cost of transplants	
	Low[1]	High[1]		Low[3]	High[3]
	Number			*Dollars*	
0	0	0	110,844	0	0
1	15	31	110,844	1,622,663	3,436,171
2	6	12	110,844	665,065	1,330,131
3	3	5	110,844	332,533	554,221
4	1	3	110,844	110,844	332,533
5	1	1	110,844	110,844	110,844
6	0	1	110,844	0	110,844
Total	26	53	110,844	2,881,950	5,874,744

[1] Given an estimated 30 to 62 cases of chronic illness due to HUS, transplant recipients were determined using HCFA data on end stage renal disease in children (Eggers, personal communication with Marks, 1993).
[2] Eggers (1993, table 49) provides an estimate of $89,600 per kidney transplant in 1991. This number was updated to 1993 dollars using the general medical care CPI (1991 CPI from *U.S. Statistical Abstract of the United States 1993*: table 163: 1993 CPI from personal communication with BLS in June 1994).
[3] At this stage, costs have not been discounted.

Transplant recipients require immunosuppressant drug therapy for the remainder of their lives to prevent the body from attacking the foreign kidney cells. While advances in this type of drug therapy have occurred over recent years, the possibility of rejection of the new kidney still exists. Drug therapy for survivors costs $4,237.77 per year in 1993 dollars.[64] The total costs of drug therapy for the 30 to 62 cases of chronic illness due to HUS is $4.7 million to $10.0 million (not discounted at this stage) (table 16).

- Subtotal. Estimated total medical costs for kidney transplants, dialysis, and drug therapy for the 30 to 62 cases of chronic kidney failure caused by *E. coli* O157:H7 disease were discounted at a rate of 3 percent to total $9.0-$19.5 million (table 17).

Productivity Losses for Acute E. Coli O157:H7 Disease

For those who do not die, the value of time lost is derived by estimating the amount of time lost from regular activities and multiplying it by the rate of daily earnings. Time spent by parents caring for sick children, as well as payment to paid caretakers, is included in the productivity loss estimates. For cases that required hospitalization, days of lost productivity during recuperation were also considered.

Productivity losses because workers stayed home with their sick children were approximated by the average weekly earnings for production or nonsupervisory workers in private nonagricultural jobs published by BLS, plus estimated fringe benefits.[65] Pre-tax wages and fringe benefits are used because they approximate the worker's full marginal product. We assumed fringe benefits of 39 percent to cover health plans, vacations, and retirement benefits.[66] The average age of the parent or paid caretaker was assumed to be 25-44 years of age. The value of an hour of time was assumed to be the same for everyone, regardless of gender or race. Assuming a civilian labor force participation rate of 84 percent for a typical labor force aged 25 to 44 years (personal conversation between U.S. BLS and Buzby, June 1994), the average daily loss of productivity is $87.58. Table 18 presents the costs of lost productivity during acute illness caused by *E. coli* O157:H7 by severity category.

- No physician visited. For each of the estimated 5,000 to 10,000 children who had a mild illness and did not visit a physician or a hospital, we assumed that a parent or paid caretaker stayed home to take care of the child and missed 2 days of work. Griffin and Tauxe (1991, p. 64) estimate that on average, hemorrhagic colitis caused by *E. coli* O157:H7 lasts from 6 to 8 days. Because those cases that did not seek medical care are even milder than hemorrhagic colitis, we assumed that these mild cases experienced 4 days of illness. Evaluated at the average private sector wage rate of roughly $88 per day, this productivity loss totals $0.9-$1.8 million annually.

- Physician visit only. For those 3,200 to 6,400 children who visited a physician but were not hospitalized, we assumed 4 work days would be missed by a parent or caretaker to take care of the sick child. Evaluated at the average private sector wage rate of $88 per day, the productivity loss totals between $1.1 million and $2.2 million annually.

- Hospitalized for hemorrhagic colitis. We assumed that time spent at home recovering from hemorrhagic colitis was twice as long as the number of days of hospitalization. Therefore, children with hemorrhagic colitis were ill for a total of 19.5 days (6.5 days in the hospital as previously mentioned, 13 days at home). We assumed parent or paid caretaker to be with the child in the hospital and home with the child until the child is well. Adjusting for weekends, the average time lost from work would be 14 days which was evaluated at the average wage. For the estimated 1,340 to 2,630 cases with hemorrhagic colitis who did not die, total productivity losses ranged from $1.6 million to $3.2 million.[67]

[64]Cost estimate of $4,000 in 1990 is from conversation with Eggers (and Marks, 1993), but was updated to 1993 dollars using the general medical care CPI (1990 CPI from *Statistical Abstract of the United States 1993*: table 163; 1993 CPI from personal communication with BLS in June 1994).

[65]BLS reports that average weekly earnings in 1993 were $373.64 (BLS, *Economic Indicators*, July 1994). This translates into roughly $74.73 per day.

[66]The *Statistical Abstract of the United States 1993* (table 677) provides employer costs for employee compensation per hour worked and divides this total compensation into wage/salary (71.8 percent) and total benefit (28.2 percent) components. Fringe benefits equal to 39 percent of wages were calculated by dividing the proportion attributed to total benefits by the proportion attributed to wage/salary (28.2/71.8 = 39.3 percent).

[67]Out of the low estimate of 1,440 patients with hemorrhagic colitis, 100 died and 1,340 patients recovered. Similarly, out of the high estimate of 2,880 patients with hemorrhagic colitis, 250 died and 2,630 recovered. Productivity losses for those who died are discussed in the deaths section.

Table 16—Estimated drug therapy costs for kidney transplant survivors, 1993[1]

Year	Age	Transplant survivors		Drug therapy	Total costs, drug therapy	
		Low[2]	High[2]	costs/year[3]	Low	High
	Years	*-----Number-----*		*----------Dollars----------*		
0	4	0	0	0	0	0
1	5	14	29	4,238	59,329	122,895
2	6	19	39	4,238	80,518	165,273
3	7	21	44	4,238	88,983	186,462
4	8	21	44	4,238	88,983	186,462
5	9	21	44	4,238	88,983	186,462
6	10	20	44	4,238	84,755	186,462
7	11	20	42	4,238	84,755	177,986
8	12	20	42	4,238	84,755	177,986
9	13	19	41	4,238	80,518	173,749
10	14	19	41	4,238	80,518	173,749
11	15	19	41	4,238	80,518	173,749
12	16	19	41	4,238	80,518	173,749
13	17	18	41	4,238	76,280	173,749
14	18	18	40	4,238	76,280	169,511
15	19	18	40	4,238	76,280	169,511
16	20	18	40	4,238	76,280	169,511
17	21	18	40	4,238	76,280	169,511
18	22	18	39	4,238	76,280	165,273
19	23	18	36	4,238	76,280	152,560
20	24	17	36	4,238	72,042	152,560
21	25	16	36	4,238	67,804	152,560
22	26	16	36	4,238	67,804	152,560
23	27	16	36	4,238	67,804	152,560
24	28	16	36	4,238	67,804	152,560
25	29	16	35	4,238	67,804	148,322
26	30	16	35	4,238	67,804	148,322
27	31	16	35	4,238	67,804	148,322
28	32	16	35	4,238	67,804	148,322
29	33	16	35	4,238	67,804	148,322
30	34	16	35	4,238	67,804	148,322
31	35	16	34	4,238	67,804	144,084
32	36	15	34	4,238	63,567	144,084
33	37	15	34	4,238	63,567	144,084
34	38	15	33	4,238	63,567	139,846
35	39	15	32	4,238	63,567	135,609
36	40	15	31	4,238	63,567	131,371
37	41	15	31	4,238	63,567	131,371
38	42	15	30	4,238	63,567	127,133
39	43	15	30	4,238	63,567	127,133
40	44	15	30	4,238	63,567	127,133
41	45	15	30	4,238	63,567	127,133
42	46	15	30	4,238	63,567	127,133
43	47	15	30	4,238	63,567	127,133
44	48	15	30	4,238	63,567	127,133
45	49	14	30	4,238	59,329	127,133
46	50	14	29	4,238	59,329	122,895
47	51	14	29	4,238	59,329	122,895
48	52	13	29	4,238	55,091	122,895
49	53	13	29	4,238	55,091	122,895
50	54	13	29	4,238	55,091	122,895
51	55	13	29	4,238	55,091	122,895
52	56	13	29	4,238	55,091	122,895
53	57	13	29	4,238	55,091	122,895

See footnotes at end of table.

--Continued

Table 16—Estimated drug therapy costs for kidney transplant survivors, 1993[1]--Continued

Year	Age	Transplant survivors Low[2]	Transplant survivors High[2]	Drug therapy costs/year[3]	Total costs, drug therapy Low	Total costs, drug therapy High
	Years	*-----Number-----*		*----------Dollars----------*		
54	58	13	29	4,238	55,091	122,895
55	59	13	27	4,238	55,091	114,420
56	60	13	26	4,238	55,091	110,182
57	61	13	26	4,238	55,091	110,182
58	62	13	26	4,238	55,091	110,182
59	63	12	26	4,238	50,853	110,182
60	64	12	26	4,238	50,853	110,182
61	65	12	25	4,238	50,853	105,944
62	66	12	25	4,238	50,853	105,944
63	67	12	25	4,238	50,853	105,944
64	68	12	25	4,238	50,853	105,944
65	69	12	23	4,238	50,853	97,469
66	70	12	23	4,238	50,853	97,469
67	71	12	23	4,238	50,853	97,469
68	72	12	23	4,238	50,853	97,469
69	73	11	23	4,238	46,615	97,469
70	74	11	23	4,238	46,615	97,469
71	75	10	23	4,238	42,378	97,469
72	76	10	22	4,238	42,378	93,231
73	77	10	22	4,238	42,378	93,231
Total	N/A	N/A	N/A	N/A	4,674,260	9,958,759

N/A = Not applicable.

[1]At this stage, costs have not been discounted. Note that no transplants occurred in year 0.

[2]Transplant survivors in this table is the sum of those surviving with cadaver donor kidneys and living-related donor kidneys. Given the number of transplants in the previous table, we use HCFA data on living-related donor transplant patient survival (1992, table 37, p. 42) and on cadaver donor transplant patient survival (1992, table 36, p. 41), we assumed 56% of transplants used cadaver donors and 44% had living-related donors (personal communication; Eggers and Marks, 1993).

[3]Cost estimate of $4,000 in 1990 is from conversation with Eggers and Marks, (1993), but was updated to 1993 using the general medical care CPI (*Statistical Abstract of the United States 1993*: table 163 for 1990 CPI; personal communication with BLS in June 1994 for 1993 CPI).

- Hospitalized cases with acute HUS. Of the estimated 260-470 children with acute HUS who were hospitalized but did not die, 230 to 408 recovered and 30 to 62 developed chronic illness due to HUS. Productivity losses for the chronic cases are discussed in the next section. Productivity losses for the acute HUS cases were estimated in a parallel fashion to those hospitalized for hemorrhagic colitis where recuperation at home is estimated to be twice the time spent in the hospital (15 days in the hospital as previously mentioned, 30 days at home). Adjusting for weekends, parents and paid caretakers missed an estimated 32 days per case. The total acute illness productivity losses for the 260 to 470 acute HUS cases who did not die were estimated to range from $0.7 million to $1.3 million.

- Deaths. For each of the 200 to 500 persons estimated to die prematurely from acute *E. coli* O157:H7 disease each year, the value of life was estimated at approximately $1.2 million in 1993 dollars, an average of the values given for male and female children 4 years old, according to Landefeld and Seskin's adjusted human capital/willingness-to-pay method.[68] The total productivity loss associated with deaths from acute *E. coli* O157:H7 disease cases was estimated to range from $241.7 million to $604.2 million annually.

- Subtotal. Productivity losses for the four disease severity categories of acute *E. coli* O157:H7 disease were estimated to total between $246.1 million and $612.8 million annually.

[68]Updated as previously described.

Table 17—Estimated medical costs of chronic *E. coli* O157:H7 disease, 1993

Year	Age	Undiscounted medical costs		Discounted medical costs	
		Low[1]	High[1]	Low[2]	High[2]
	Years			*Dollars*	
0	4	667,484	1,379,488	667,484	1,379,468
1	5	2,436,455	5,035,623	2,365,490	4,888,954
2	6	1,126,630	2,305,128	1,061,957	2,172,804
3	7	659,680	1,264,622	603,701	1,157,309
4	8	342,730	900,041	304,511	799,675
5	9	295,099	630,722	254,555	544,066
6	10	180,017	535,460	150,761	448,440
7	11	180,017	416,141	146,370	338,360
8	12	180,017	416,141	142,107	328,505
9	13	175,779	411,903	134,720	315,689
10	14	175,779	411,903	130,796	306,494
11	15	175,779	411,903	126,987	297,567
12	16	175,779	411,903	123,288	288,900
13	17	171,542	411,903	116,811	280,486
14	18	171,542	407,665	113,409	269,515
15	19	171,542	407,665	110,106	261,665
16	20	171,542	407,665	106,689	254,043
17	21	171,542	360,034	103,785	217,827
18	22	171,542	355,796	100,763	208,993
19	23	171,542	343,083	97,828	195,656
20	24	167,304	343,083	92,632	189,957
21	25	163,066	343,083	87,656	184,424
22	26	163,066	343,083	85,103	179,053
23	27	163,066	343,083	82,624	173,837
24	28	163,066	343,083	80,218	168,774
25	29	163,066	338,845	77,881	161,834
26	30	163,066	338,845	75,613	157,121
27	31	163,066	338,845	73,411	152,544
28	32	163,066	338,845	71,272	148,101
29	33	163,066	338,845	69,196	143,788
30	34	163,066	338,845	67,181	139,600
31	35	163,066	334,608	65,224	133,839
32	36	158,828	334,608	61,679	129,941
33	37	158,828	334,608	59,882	126,156
34	38	158,828	330,370	58,138	120,930
35	39	158,828	326,132	56,445	115,902
36	40	158,828	321,894	54,801	111,064
37	41	111,197	274,263	32,249	91,872
38	42	111,197	270,026	36,164	87,819
39	43	111,197	270,026	35,111	85,262
40	44	111,197	270,026	34,088	82,778
41	45	111,197	270,026	33,095	80,367
42	46	111,197	270,026	31,132	78,026
43	47	111,197	270,026	31,196	75,754
44	48	111,197	270,026	30,287	73,547
45	49	106,960	270,026	28,284	71,405
46	50	106,960	265,788	27,460	68,237
47	51	106,960	265,788	26,661	66,250
48	52	102,722	265,788	24,859	64,320
49	53	102,722	265,788	24,135	62,447
50	54	102,722	265,788	23,432	60,628
51	55	102,722	265,788	22,749	58,862
52	56	102,722	265,788	22,087	57,148
53	57	102,722	265,788	21,443	55,483
54	58	102,722	265,788	20,819	53,867

See footnotes at end of table.

—Continued

Table 17—Estimated medical costs of chronic *E. coli* O157:H7 disease, 1993--Continued

Year	Age	Undiscounted medical costs		Discounted medical costs	
		Low[1]	High[1]	Low[2]	High[2]
	Years			*Dollars*	
55	59	102,722	257,312	20,212	50,631
56	60	102,722	253,075	19,624	48,346
57	61	102,722	253,075	19,052	46,938
58	62	102,722	253,075	18,497	45,571
59	63	98,484	253,075	17,217	44,244
60	64	98,484	253,075	16,716	42,955
61	65	98,484	248,837	16,229	41,006
62	66	98,484	248,837	15,756	39,811
63	67	98,484	248,837	15,298	38,652
64	68	98,484	248,837	14,852	37,526
65	69	98,484	240,361	14,419	35,192
66	70	98,484	240,361	13,999	34,167
67	71	98,484	240,361	13,592	33,172
68	72	98,484	240,361	13,196	32,206
69	73	94,246	240,361	12,260	31,268
70	74	94,246	240,361	11,903	30,357
71	75	90,009	240,361	11,037	29,473
72	76	90,009	236,123	10,715	28,110
73	77	90,009	236,123	10,403	27,291
Total		14,501,967	32,454,843	8,977,515	19,482,273

[1] These costs have not been discounted and they are the sum of the costs of dialysis, kidney transplants, and drug therapy for chronic *E. coli* O157:H7 disease patients, by year.

[2] Discounted at 3 percent.

Table 18—Estimated productivity losses of acute *E. coli* 0157:H7 disease, 1993[1]

Severity of illness	Daily wage rate[2]	Work missed	Rate/ case[2]	Cases		Total costs[2]	
				Low	High	Low	High
	Dollars	*Days*	*Dollars*	*Number*		*Million dollars*	
No physician visit[3]	88	2	175	5,000	10,000	0.9	1.8
Visited physician[3]	88	4	350	3,200	6,400	1.1	2.2
Hospitalized (and survived)[4]							
Hemorrhagic colitis	88	14	1,220	1,340	2,630	1.6	3.2
HUS	88	32	2,815	260	470	0.7	1.3
Death during acute illness (present value)[5]	1,208,488	all	1,208,488	200	500	241.7	604.2
Total	N/A	N/A	N/A	10,000	20,000	246.1	612.8

N/A = Not applicable.

[1] For those cases who do not die, lost productivity is derived by multiplying the amount of time lost from regular activities and by the rate of daily earnings. We adjust BLS's average weekly earnings for all private, nonagricultural jobs (BLS, *Economic Indicators*, July 1994) for fringe benefits of 39% (of earnings, *Statistical Abstract of the United States 1993*: table 677) to cover health plans, vacations, and retirement benefits, the civilian labor force participation rate of 84% for a typical work force aged 25-44 years (personal conversation with BLS and Buzby, June 1994), and five work days per week to get the average daily loss of productivity is $87.58.

[2] Figures were rounded for this table.

[3] Average duration of illness 6-8 days; (Griffin and Tauxe). We assume that parents and caretakers miss 2 days of work for those cases with no physician visit and 4 days for cases with physician visit.

[4] Assume work missed for 3 times the number of days hospitalized adjusted for weekends by multiplying by 5/7.

[5] Landefeld and Seskin's (1982) adjusted willingness to pay per human capital estimate for 4-year-olds, updated to 1993 prices using the change in average weekly earnings (BLS).

Productivity Losses for Chronic Illness Due to HUS

The annual productivity loss due to chronic illness from HUS is the sum of the value of those who died prematurely because of chronic illness due to HUS and the survivors' lost productivity (until the age of 16, the parents or caretakers' time is valued for staying home to take care of the sick child and to take the child to medical treatments).

- HUS survivors. This category consists of two components; productivity losses of caretakers of children under 16 with HUS and productivity losses of HUS patients over 16 years of age. A parent or paid caretaker is assumed to spend 18 hours out of a 40-hour work week with their child's hemodialysis treatment as a hospital out-patient, or a loss of 45 percent of work time during the initial year of illness.[69] In the second year, all children who did not yet receive a transplant are assumed to have switched to peritoneal dialysis, resulting in a 1-percent decline in productivity until the child is age 16 (Conversation with Mary O'Shay, nurse in the pediatric ESRD unit in a hospital in Buffalo, New York, and Marks of ERS).[70] Assuming the parent was in the 25 to 29-year-old age group when the child was born (the modal age group for first birth—*Statistical Abstract of the United States 1993*: table 93), an average age of 31 is assumed when the child reaches the age of 4. The value of annual productivity lost is computed as the 45-percent (first year) and 1-percent (subsequent years) productivity loss times BLS' average weekly earnings times 52 for a 31-year-old in year 1 (for a 32-year-old in year 2, and so on) multiplied by BLS' labor force participation rate by age group (personal conversation, BLS and Buzby, June 14, 1994) until year 12 when the child is 16. The reduced stream of earnings is converted into present values.

At age 16 and after, productivity losses were computed by adjusting the patient's annual earnings by age. Transplant recipients 16 to 40 years of age have a 23-percent productivity loss from what they would have earned without any illness, 40-64 year olds a 39-percent loss, and 65 plus a 13-percent loss (Garner 1984). Dialysis patients aged 16 to 40 encounter a 37-percent

[69]Productivity losses for a parent or caretaker of a sick child (less than 16 years of age) are based on the time necessary to obtain treatment. Because over 80 percent of the chronically ill children receive transplants by the fourth year after acute illness, these productivity losses mostly involve taking the child to the hospital for hemodialysis or caring for a child on peritoneal dialysis until the transplant operation. Hemodialysis involves 4-hour treatments three times per week at a hospital. Allowing a half hour before and after each treatment for scheduling variability, 15 hours per week are required for hemodialysis. In addition, there is travel time to and from the hospital (estimated at 1 hour for each trip) and time missed from school (3 half days per week). Most facilities have Monday through Saturday hours, so conceivably treatments can be scheduled after school or on Saturdays to avoid missing school. (However, the 4-hour duration of treatments and the limited number of dialysis machines limits the possibility of after-school time). Some facilities do not have flexible scheduling. Others offer tutoring to compensate for time missed from school. Moreover, since children must go to hospital facilities and not to free-standing facilities as adults can, travel time may be increased to get to a limited number of facilities. Assuming 1 hour per trip and no loss of school time, the minimum amount of time required for children on hemodialysis is 18 hours per week. Since children are encouraged to switch to peritoneal dialysis and then transplantation as soon as possible, all of the patients' parents/caretakers require this time commitment for the half year of dialysis in the acute phase and 24 percent require this time commitment by the end of year 1, with the remainder assumed to be on peritoneal dialysis by end of year 2. For a hemodialysis patient's parents/caretakers, 18 hours out of a 40-hour productive week results in a 45 percent productivity loss.

[70]Among the two major types of peritoneal dialysis, Continuous Ambulatory Peritoneal Dialysis (CAPD) and Continuous Cyclic Peritoneal Dialysis (CCPD), CCPD is preferred for younger patients and CAPD for older patients. CCPD requires a machine which fills and drains solution into the child's peritoneum while she/he sleeps (10 to 12 hours per night every night). This requires the help of a parent/caretaker to connect the catheter to the child at night and disconnect it in the morning. While parents and the child can sleep during the treatment, the child must be monitored (blood pressure, weight, check for infections) during the day. Most, if not all, parents can relegate these responsibilities, possibly to a school nurse, so that they can still work full time. In rare instances, the parent may decide to pull the child from school and oversee her/his care. This may happen in 1 to 2 percent of cases. We assume a 1 percent productivity loss for a parent/caretaker of a child on CCPD peritoneal dialysis until age 16. CAPD does not require a machine and, as such, provides greater freedom. Instead, the solution required for dialysis is emptied into a bag attached to the catheter leading to the peritoneum. The solution is left in the abdomen for 4 hours and then emptied into a bag. This draining process is done five times per day for children (4 times per day for adults) and takes 30 to 40 minutes each time (totaling about 3 hours per day or 21 hours per week). Generally, a child needs help by a parent/caretaker (possibly by the school nurse) with this process until she/he is mature enough to do it by her/himself. Although the age of maturity depends on the child, estimates are that between ages 11 and 16 the child can perform the exchange by her/himself. We assume that by age 16, children will have switched from CCPD to CAPD peritoneal dialysis and that there will be no productivity loss for a parent/caretaker since the child will be performing the procedure by her/himself. While the child must also be monitored (blood pressure, etc.) with CAPD, we assume parents will be able to work full-time with this form of dialysis.

loss, 40-64 have a 46-percent loss, and 65 plus a 5-percent loss. At and after time period 12, when the patients are age 16 and over, 88 percent of all survivors have received transplants, while 12 percent remain on dialysis. The disability loss per year was computed as the appropriate percentage productivity loss times the average weekly earnings times 52 weeks multiplied by the labor force participation rate by age group. Given that the average life span in the United States is 77 years, over this life span productivity lost for survivors of chronic illness due to HUS, discounted at 3 percent annually, ranged from $2.7 million to $5.9 million.

Table 19 shows the present value of lost productivity of survivors of chronic illness from *E. coli* O157:H7 disease for a typical year in 1993 dollars (undiscounted and discounted at 3 percent).

- Chronic illness deaths. As previously mentioned, of the 30 to 62 cases with chronic illness due to HUS (*i.e.*, kidney failure), 19 to 37 died prematurely of complications during dialysis or a kidney transplant operation (and an estimated 10 to 17 of these children died before the age of 16)(HCFA Medicare data, personal communication with Eggers and Marks (ERS), 1991). For those who die prematurely from chronic illness due to HUS, LS's VOSL was used to represent the cost of lost productivity.[71] Table 20 shows the present value of lost lives due to chronic illness from *E. coli* O157:H7 disease for a typical year in 1993 dollars. After discounting by 3 percent, the present value of the productivity loss for the 19 to 37 premature deaths from chronic illness due to HUS was estimated at $14.5-$27.9 million.

- Subtotal. The total productivity loss due to chronic illness deaths and lost productive output ranged from $17.3-$33.9 million annually.

Total Costs of E. Coli O157:H7 Disease from All Sources

Total annual costs of *E. coli* O157:H7 disease in the United States were estimated to range between $301.8 million and $726.0 million (table 21). Estimated medical costs total $38.4-$79.4 million and are small relative to the estimated productivity losses which total $263.3-$646.6 million. Of the estimated medical costs, costs for acute illness account for $29.4-$59.9 million annually and chronic costs range from $9.0-$19.5 million. Of the estimated productivity losses, costs for acute illness account for $246.1-$612.8 million, while chronic illness productivity losses total between $17.3 million and $33.9 million (discounted at a rate of 3 percent). Deaths during the acute phase of the illness are the largest cost component accounting for roughly 81 percent of all costs.

Note that these cost estimates vary from those found in Roberts and Marks (1995) largely because we: (1) used improved incidence estimates, (2) divided acute illness deaths differently, and (3) reported estimates in 1993 dollars as opposed to 1992 dollars.

Medical costs are only 12 percent of total estimated costs, roughly 9 percent during the acute illness and 3 percent during chronic illness due to HUS (*i.e.*, kidney failure). Productivity losses account for 88 percent of estimated costs: 81 percent for persons who die during the acute phase of the illness, 2 percent for persons who survive the acute illness, 4 percent for persons who die during the chronic illness, and 1 percent for survivors with reduced productivity because of chronic illness due to HUS.[72]

Costs of Foodborne E. Coli O157:H7 Disease

If we assume that 80 percent of the estimated human illnesses due to *E. coli* O157:H7 are attributed to food, the estimated total costs of foodborne *E. coli* O157:H7 disease ranges from $0.2-$0.6 billion annually. The assumption that 80 percent of all *E. coli* O157:H7 cases are from food (CDC unpublished outbreak data) appears reasonable in light of the relatively low number of cases from contaminated water and Martin *et al.*'s (1990) estimate that an upper bound of 16 percent of cases are from person-to-person transmission in day care centers.

Remarks

Some HUS cases have more than one transplant operation but only one was included in the costs. A few HUS cases have multiple complications, including blindness, cardiac involvement, respiratory com-

[71]LS's VOSL updated to 1993 dollars and averaged across gender, as previously described.

[72]These are approximations of the ranges used in the analysis.

Table 19—Present value of lost productivity of survivors due to chronic illness from *E. coli* O157:H7 disease, 1993

Year	Age	Total survivors		Dialysis					Transplant					Productivity loss			
				Recipient		Dis. loss/ recipient	Disability loss		Survivors		Dis. loss/ case	Disability loss		Undiscounted		Discounted	
		Low	High	Low	High		Low	High	Low	High		Low	High	Low[1]	High[1]	Low[2]	High[2]
		Number				*Dollars*			*Number*		*Dollars*						
0	4	30	62	30	62	5,906	177,175	366,162						177,175	366,162	177,175	366,162
1	5	28	58	15	31	5,879	88,183	182,245	14	29	281	3,933	8,148	92,116	190,393	89,433	184,847
2	6	27	55	8	17	281	2,248	4,776	19	39	281	5,338	10,957	7,586	15,734	7,150	14,830
3	7	25	55	5	11	281	1,405	3,091	21	44	281	5,900	12,362	7,305	15,453	6,685	14,141
4	8	24	52	3	8	341	1,023	2,728	21	44	341	7,162	15,007	8,185	17,735	7,273	15,757
5	9	23	50	2	7	341	682	2,387	21	44	341	7,162	15,007	7,844	17,394	6,767	15,004
6	10	22	49	2	5	341	682	1,705	20	44	341	6,821	15,007	7,503	16,712	6,284	13,996
7	11	22	47	2	5	341	682	1,705	20	42	341	6,821	14,324	7,503	16,030	6,101	13,034
8	12	22	47	2	5	341	682	1,705	20	42	341	6,821	14,324	7,503	16,030	5,923	12,654
9	13	21	46	2	5	341	682	1,705	19	41	341	6,480	13,983	7,162	15,689	5,489	12,024
10	14	21	46	2	5	341	682	1,705	19	41	341	6,480	13,983	7,162	15,689	5,329	11,674
11	15	21	46	2	5	341	682	1,705	19	41	341	6,480	13,983	7,162	15,689	5,174	11,334
12	16	21	46	2	5	1,455	2,910	7,275	19	41	1,455	27,644	59,653	30,554	66,928	21,430	46,942
13	17	20	46	2	5	1,455	2,910	7,275	18	41	1,455	26,189	59,653	29,099	66,928	19,815	45,574
14	18	20	45	2	5	2,247	4,494	11,235	18	40	2,247	40,445	89,877	44,939	101,112	29,710	66,847
15	19	20	45	2	5	2,247	4,494	11,235	18	40	2,247	40,445	89,877	44,939	101,112	28,844	64,900
16	20	20	44	2	5	5,708	11,417	28,542	18	40	5,708	102,750	228,333	114,166	256,874	71,145	160,076
17	21	20	44	2	4	5,708	11,417	22,833	18	40	5,708	102,750	228,333	114,166	251,166	69,073	151,960
18	22	20	43	2	4	5,708	11,417	22,833	18	39	5,708	102,750	222,624	114,166	245,458	67,061	144,181
19	23	20	40	2	4	5,708	11,417	22,833	18	36	5,708	102,750	205,499	114,166	228,333	65,107	130,215
20	24	19	40	2	4	5,708	11,417	22,833	17	36	5,708	97,041	205,499	108,458	228,333	60,051	126,422
21	25	18	40	2	4	10,397	20,794	41,587	16	36	10,397	166,349	374,284	187,142	415,871	100,598	223,551
22	26	18	40	2	4	10,397	20,794	41,587	16	36	10,397	166,349	374,284	187,142	415,871	97,668	217,040
23	27	18	40	2	4	10,397	20,794	41,587	16	36	10,397	166,349	374,284	187,142	415,871	94,823	210,719
24	28	18	40	2	4	10,397	20,794	41,587	16	36	10,397	166,349	374,284	187,142	415,871	92,061	204,581
25	29	18	39	2	4	10,397	20,794	41,587	16	35	6,580	105,285	230,312	126,079	271,899	60,216	129,860
26	30	18	39	2	4	10,397	20,794	41,587	16	35	6,580	105,285	230,312	126,079	271,899	58,462	126,078
27	31	18	39	2	4	10,397	20,794	41,587	16	35	6,580	105,285	230,312	126,079	271,899	56,759	122,406
28	32	18	39	2	4	10,397	20,794	41,587	16	35	6,580	105,285	230,312	126,079	271,899	55,106	118,841
29	33	18	39	2	4	10,397	20,794	41,587	16	35	6,580	105,285	230,312	126,079	271,899	53,501	115,379
30	34	18	39	2	4	10,397	20,794	41,587	16	35	6,580	105,285	230,312	126,079	271,899	51,943	112,019
31	35	18	38	2	4	12,621	25,242	50,483	16	34	7,988	127,808	271,591	153,049	322,074	61,218	128,826
32	36	17	38	2	4	12,621	25,242	50,483	15	34	7,988	119,820	271,591	145,061	322,074	56,333	125,073
33	37	17	38	2	4	12,621	25,242	50,483	15	34	7,988	119,820	271,591	145,061	322,074	54,692	121,431
34	38	17	37	2	4	12,621	25,242	50,483	15	33	7,988	119,820	263,603	145,061	314,086	53,099	114,970
35	39	17	36	2	4	12,621	25,242	50,483	15	32	7,988	119,820	255,615	145,061	306,099	51,552	108,782
36	40	16	34	2	4	12,621	25,242	50,483	15	31	7,988	119,820	247,627	145,061	298,111	50,051	102,858
37	41	16	34	1	3	12,621	12,621	37,862	15	31	7,988	119,820	247,627	132,440	285,490	44,365	95,634
38	42	16	33	1	3	12,621	12,621	37,862	15	30	7,988	119,820	239,639	132,440	277,502	43,073	90,251
39	43	16	33	1	3	12,621	12,621	37,862	15	30	7,988	119,820	239,639	132,440	277,502	41,819	87,622
40	44	16	33	1	3	12,621	12,621	37,862	15	30	7,988	119,820	239,639	132,440	277,502	40,601	85,070
41	45	16	33	1	3	15,984	15,984	47,953	15	30	13,464	201,958	403,916	217,942	451,869	64,866	134,489
42	46	16	33	1	3	15,984	15,984	47,953	15	30	13,464	201,958	403,916	217,942	451,869	62,976	130,572
43	47	16	33	1	3	15,984	15,984	47,953	15	30	13,464	201,958	403,916	217,942	451,869	61,142	126,769

See footnotes at end of table

--Continued

Table 19—Present value of lost productivity of survivors due to chronic illness from *E. coli* O157:H7 disease, 1993--Continued

				Dialysis					Transplant					Productivity loss			
		Total survivors		Recipient		Dis. loss/	Disability loss		Survivors		Dis. loss/	Disability loss		Undiscounted		Discounted	
Year	Age	Low	High	Low	High	recipient	Low	High	Low	High	case	Low	High	Low[1]	High[1]	Low[2]	High[2]
		Number				*Dollars*			*Number*		*Dollars*						
44	48	16	33	1	3	15,984	15,984	47,953	15	30	13,464	201,958	403,916	217,942	451,869	59,361	123,076
45	49	15	33	1	3	15,984	15,984	47,953	14	30	13,464	188,494	403,916	204,478	451,869	54,072	119,492
46	50	15	32	1	3	15,984	15,984	47,953	14	29	13,464	188,494	390,452	204,478	438,405	52,497	112,555
47	51	15	32	1	3	15,984	15,984	47,953	14	29	13,464	188,494	390,452	204,478	438,405	50,968	109,276
48	52	14	32	1	3	15,984	15,984	47,953	13	29	13,464	175,030	390,452	191,015	438,405	46,225	106,093
49	53	14	32	1	3	15,984	15,984	47,953	13	29	13,464	175,030	390,452	191,015	438,405	44,879	103,003
50	54	14	32	1	3	15,984	15,984	47,953	13	29	13,464	175,030	390,452	191,015	438,405	43,572	100,003
51	55	14	32	1	3	9,667	9,667	29,002	13	29	8,143	105,858	236,145	115,525	265,147	25,585	58,720
52	56	14	32	1	3	9,667	9,667	29,002	13	29	8,143	105,858	236,145	115,525	265,147	24,839	57,010
53	57	14	32	1	3	9,667	9,667	29,002	13	29	8,143	105,858	236,145	115,525	265,147	24,116	55,350
54	58	14	32	1	3	9,667	9,667	29,002	13	29	8,143	105,858	236,145	115,525	265,147	23,414	53,737
55	59	14	30	1	3	9,667	9,667	29,002	13	27	8,143	105,858	219,859	115,525	248,861	22,732	48,968
56	60	14	29	1	3	9,667	9,667	29,002	13	26	8,143	105,858	211,716	115,525	240,718	22,070	45,986
57	61	14	29	1	3	9,667	9,667	29,002	13	26	8,143	105,858	211,716	115,525	240,718	21,427	44,646
58	62	14	29	1	3	9,667	9,667	29,002	13	26	8,143	105,858	211,716	115,525	240,718	20,803	43,346
59	63	13	29	1	3	9,667	9,667	29,002	12	26	8,143	97,715	211,716	107,383	240,718	18,773	42,084
60	64	13	29	1	3	9,667	9,667	29,002	12	26	8,143	97,715	211,716	107,383	240,718	18,226	40,858
61	65	13	28	1	3	129	129	387	12	25	317	3,799	7,915	3,928	8,302	647	1,368
62	66	13	28	1	3	129	129	387	12	25	317	3,799	7,915	3,928	8,302	628	1,328
63	67	13	28	1	3	129	129	387	12	25	317	3,799	7,915	3,928	8,302	610	1,290
64	68	13	28	1	3	129	129	387	12	25	317	3,799	7,915	3,928	8,302	592	1,252
65	69	13	26	1	3	129	129	387	12	23	317	3,799	7,282	3,928	7,669	575	1,123
66	70	13	26	1	3	129	129	387	12	23	317	3,799	7,282	3,928	7,669	558	1,090
67	71	13	26	1	3	129	129	387	12	23	317	3,799	7,282	3,928	7,669	542	1,058
68	72	13	26	1	3	129	129	387	12	23	317	3,799	7,282	3,928	7,669	526	1,028
69	73	12	26	1	3	129	129	387	11	23	317	3,483	7,282	3,612	7,669	470	998
70	74	12	26	1	3	129	129	387	11	23	317	3,483	7,282	3,612	7,669	456	969
71	75	11	26	1	3	129	129	387	10	23	317	3,166	7,282	3,295	7,669	404	940
72	76	11	25	1	3	129	129	387	10	22	317	3,166	6,965	3,295	7,352	392	875
73	77	11	25	1	3	129	129	387	10	22	317	3,166	6,965	3,295	7,352	381	850
Total in millions		N/A	N/A	N/A	N/A	1.0	2.4	N/A	N/A	N/A	N/A	6.2	13.3	7.2	15.6	2.7	5.9

N/A = Not applicable.

[1] These costs have not been discounted.

[2] Discounted at 3 percent.

Table 20—Present value of lost productivity of lost lives due to chronic illness from *E. coli* O157:H7 disease, 1993

Year	Age	Total deaths		Lifetime earnings in 1993 $	Discounted lifetime earnings in 1993 $[1]	Productivity loss due to deaths	
		Low	High			Low	High
		Number		*Dollars*			
1	5	2	4	1,232,869	1,196,960	2,393,920	4,787,840
2	6	1	3	1,257,249	1,185,078	1,185,078	3,555,234
3	7	2	0	1,281,630	1,172,873	2,345,745	0
4	8	1	3	1,308,213	1,162,330	1,162,330	3,486,991
5	9	1	2	1,334,796	1,151,407	1,151,407	2,302,814
6	10	1	1	1,361,379	1,140,134	1,140,134	1,140,134
7	11	0	2	1,387,962	1,128,541	0	2,257,081
8	12	0	0	1,414,546	1,116,655	0	0
9	13	1	1	1,438,530	1,102,513	1,102,513	1,102,513
10	14	0	0	1,462,514	1,088,247	0	0
11	15	0	0	1,486,497	1,073,877	0	0
12	16	0	0	1,510,481	1,059,421	0	0
13	17	1	0	1,534,465	1,044,896	1,044,896	0
14	18	0	1	1,544,493	1,021,092	0	1,021,092
15	19	0	0	1,554,521	997,788	0	0
16	20	0	1	1,564,549	974,975	0	974,975
17	21	0	0	1,574,577	952,645	0	0
18	22	0	1	1,584,605	930,789	0	930,789
19	23	0	3	1,574,730	898,047	0	2,694,140
20	24	1	0	1,564,855	866,422	866,422	0
21	25	1	0	1,554,980	835,878	835,878	0
22	26	0	0	1,545,105	806,379	0	0
23	27	0	0	1,535,229	777,888	0	0
24	28	0	0	1,506,486	741,091	0	0
25	29	0	1	1,477,742	705,778	0	705,778
26	30	0	0	1,448,998	671,893	0	0
27	31	0	0	1,420,254	639,383	0	0
28	32	0	0	1,391,510	608,197	0	0
29	33	0	0	1,361,425	577,716	0	0
30	34	0	0	1,331,340	548,495	0	0
31	35	0	1	1,301,255	520,485	0	520,485
32	36	1	0	1,271,170	493,642	493,642	0
33	37	0	0	1,241,085	467,922	0	0
34	38	0	1	1,205,340	441,208	0	441,208
35	39	0	1	1,169,594	415,654	0	415,654
36	40	1	2	1,133,849	391,215	391,215	782,429
37	41	0	0	1,098,104	367,846	0	0
38	42	0	1	1,062,358	345,507	0	345,507
39	43	0	0	1,018,773	321,681	0	0
40	44	0	0	975,188	298,950	0	0
41	45	0	0	931,602	277,271	0	0
42	46	0	0	888,017	256,601	0	0
43	47	0	0	844,431	236,899	0	0
44	48	0	0	803,427	218,831	0	0
45	49	1	0	762,423	201,614	201,614	0

See footnotes at end of table.

–Continued

Table 20—Present value of lost productivity of lost lives due to chronic illness from *E. coli* O157:H7 disease, 1993--Continued

Year	Age	Total deaths		Lifetime earnings	Discounted lifetime earnings	Productivity loss due to deaths	
		Low	High	in 1993 $	in 1993 $[1]	Low	High
		Number		*Dollars*			
46	50	0	1	721,418	185,214	0	185,214
47	51	0	0	680,414	169,599	0	0
48	52	1	0	639,410	154,736	154,736	0
49	53	0	0	598,929	140,719	0	0
50	54	0	0	558,449	127,386	0	0
51	55	0	0	517,969	114,711	0	0
52	56	0	0	477,489	102,666	0	0
53	57	0	0	437,009	91,226	0	0
54	58	0	0	401,484	81,369	0	0
55	59	0	2	365,960	72,009	0	144,018
56	60	0	1	330,436	63,125	0	63,125
57	61	0	0	294,911	54,698	0	0
58	62	0	0	259,387	46,708	0	0
59	63	1	0	237,002	41,434	41,434	0
60	64	0	0	214,617	36,428	0	0
61	65	0	1	192,232	31,678	0	31,678
62	66	0	0	169,847	27,174	0	0
63	67	0	0	147,462	22,905	0	0
64	68	0	0	136,672	20,611	0	0
65	69	0	2	125,881	18,431	0	36,861
66	70	0	0	115,090	16,360	0	0
67	71	0	0	104,300	14,394	0	0
68	72	0	0	93,509	12,529	0	0
69	73	1	0	86,870	11,301	11,301	0
70	74	0	0	80,231	10,133	0	0
71	75	1	0	73,592	9,024	9,024	0
72	76	0	1	66,953	7,971	0	7,971
73	77	0	0	60,314	6,971	0	0
Total	N/A	19	37	N/A	N/A	14,531,290	27,933,531

N/A = Not applicable.
[1] Discounted at 3%.

plications, neurological damage, pancreatic destruction, and intestinal surgery such as colostomy. One mother wrote that her surviving child's medical bills during his intensive care were $300,000 (Heersink 1994).

The January 1993 *E. coli* O157:H7 outbreak in the Northwest demonstrates the difficulty of identifying the incidence of foodborne diseases and the need for new data collection systems. CDC reported: "Despite the magnitude of this outbreak (with 500 culture-confirmed cases and 4 deaths in four States), the problem may not have been recognized in three States if the epidemiological link had not been established in Washington" (CDC April 16, 1993, p. 262).[73] CDC claims that reports of subsequent *E. coli* O157:H7 outbreaks are increasing, largely because of increased public awareness (FDA Consumer 1994, p. 1923).

[73]As previously mentioned, the 1994 AGA Consensus Conference (1995, p. 1923) estimates that this outbreak caused over 700 cases.

Table 21—Cost summary for U.S. *E. coli* O157:H7 disease cases, 1993[1]

Cost category	Table	Estimated cost	
		Low	High
		Million dollars	
Medical costs:[2]			
Acute illness medical costs—			
No physician visit		0.0	0.0
Physician visit		0.5	2.0
Hospitalized-hemorrhagic colitis		16.2	32.4
Hospitalized-HUS		12.7	25.5
Subtotal	13	29.4	59.9
Chronic illness medical costs			
Chronic cases (present value)	17	9.0	19.5
Total medical costs		38.4	79.4
Productivity losses:[3]			
Acute illness productivity losses—			
No physician visit		0.9	1.8
Visited physician		1.1	2.2
Hospitalized-hemorrhagic colitis		1.6	3.2
Hospitalized-HUS		0.7	1.3
Deaths (present value)		241.7	604.2
Subtotal	18	246.1	612.8
Chronic illness productivity losses—			
Survivors (present value)	19	2.7	5.9
Deaths (present value)	20	14.5	27.9
Subtotal		17.3	33.9
Total productivity losses		263.3	646.6
Total		301.8	726.0

If 80% are foodborne, foodborne costs are $0.2-0.6 billion annually.

[1]Numbers may not total due to rounding.

[2]Medical costs were estimated using data from the American Hospital Association's Hospital Statistics and the U.S. Health Care Financing Administration.

[3]Productivity losses were estimated using data from the U.S. Bureau of Labor Statistics and Landefeld and Seskin's (1982) estimated values of statistical life. The 219-537 premature deaths include 200-500 deaths from the acute illness and 19-37 deaths from chronic complications.