Data from population-based studies and national surveillance systems were collated and analyzed to estimate the impact of disease and risks associated with eating different foods in England and Wales. From 1996 to 2000, an estimated 1,724,315 cases of indigenous foodborne disease per year resulted in 21,997 hospitalizations and 687 deaths. The greatest impact on the healthcare sector arose from foodborne Campylobacter infection (160,788 primary care visits and 15,918 hospitalizations), while salmonellosis caused the most deaths (209). The most important cause of indigenous foodborne disease was contaminated chicken (398,420 cases, risk [cases/million servings] = 111, case-fatality rate [deaths/100,000 cases] = 35, deaths = 141). Red meat (beef, lamb, and pork) contributed heavily to deaths, despite lower levels of risk (287,485 cases, risk = 24, case-fatality rate = 57, deaths = 164). Reducing the impact of indigenous foodborne disease is mainly dependent on controlling the contamination of chicken.

Foodborne infection is a major cause of illness and death worldwide (1–4). Recognizing this, the World Health Organization (WHO) developed its Global Strategy for Food Safety (1). In the developing world, foodborne infection leads to the death of many children (2), and the resulting diarrheal disease can have long-term effects on children’s growth as well as on their physical and cognitive development (5,6). In the industrialized world, foodborne infection causes considerable illness, heavily affecting healthcare systems (3,4).

The WHO Global Strategy for Food Safety acknowledges, “Effective control of foodborne disease must be based on evaluated information about foodborne hazards and the incidence of foodborne disease.” Estimates of the contributions of specific pathogens to the overall extent of foodborne infection at a national level are available (3,4). We refined the techniques used to estimate the acute health effects and the risks associated with consuming different foods. Our analyses should inform evidence-based control strategies for foodborne infection.

Methods

Indigenous Foodborne Disease

Indigenous foodborne disease is defined as food-related infectious gastroenteritis acquired and occurring in England and Wales. We derived pathogen-specific estimates for indigenous foodborne disease (Table 1) by using the method of Adak et al. (4) for the following 5 disease parameters: all disease, case-patients seen at a primary care setting (by general practitioners), hospitalizations, hospital occupancy, and deaths (online Appendix 1, stages A–C; available from http://www.cdc.gov/ncidod/EID/vol11no3/04-0191_app1.htm).

Foods Causing Indigenous Foodborne Disease

Outbreaks reported as foodborne, involving a single vehicle of infection and identified by epidemiologic or microbiologic investigations (N = 766, online Appendix 2; available from http://www.cdc.gov/ncidod/EID/vol11no3/04-0191_app2.htm), were extracted from the National Surveillance Database for General Outbreaks of Infectious Intestinal Disease (GSURV) (7). Reported outbreaks in which investigators implicated either no (n = 612) or >1 (n = 234) vehicle of infection were excluded from these analyses. We also excluded outbreaks in which no pathogen was confirmed by laboratory testing (n = 113), although most of these outbreaks were suspected to be due to norovirus and were also linked to the same range of vehicles of infection. Foods were classified into broad food groups, such as poultry, and more specific food types, e.g., chicken (Table 2). A “complex foods” group was created to accommodate dishes consisting of ingredients of various food types in which the precise source of infection was not verified.

We calculated the percentage of outbreaks due to each food type for each pathogen. For disease of unknown origin, we used the percentages as determined above for disease due to all known pathogens. These percentages were applied to the pathogen-specific estimates for the mean values for all disease, visits to general practitioners, hospitalizations, hospital occupancy, and deaths for the years.
1996–2000 to produce pathogen-specific totals by food type for each of the 5 disease parameters used to describe the annual disease impact (Tables 2 and 3, Online Appendix 1, stage D). We then calculated food-specific totals for all disease, visits to general practitioners, hospitalizations, hospital occupancy, and deaths by adding together the appropriate food-specific totals for each pathogen (Online Appendix 1, stage E).

### Food-Specific Risk

The U.K. Government National Food Survey (8) collects population-based food consumption data. These data were used to calculate the number of servings of each food type consumed per resident for the period 1996–2000. These denominators were used to calculate food-specific risks, expressed as cases per million servings for all disease and hospitalizations per billion servings (Table 4, Online Appendix 1, stage F).

### Quality of Evidence

Each of the above steps was classified according to whether the pathogen-specific data elements used were direct measures, extrapolations, or inferences (Table 5). This classification system permitted us to evaluate the effects of potential biases on the final estimates produced.

### Results

#### Causes of Disease

Unknown agents accounted for 49% of all cases but only 23% of all visits to general practitioners, 3% of all hospitalizations, 2% of hospital occupancy, and 12% of all deaths (Table 1). *Campylobacter* spp. had the greatest effect on healthcare provision, according to all of the parameters examined. Nontyphoidal salmonellae and *Clostridium perfringens* caused most deaths. *Listeria monocytogenes* and *Escherichia coli* O157:H7 together accounted for 15% of all deaths but <0.1% of all cases.

#### Disease Impact According to Food

Of the 1,724,315 estimated cases of indigenous foodborne disease in England and Wales, 67,157 (4%) were...
cases in which humans were considered to be the source of infection (foods contaminated by infected food handlers; Tables 2 and 3). Subtracting these cases left 1,657,158 cases in which contaminated food was the likely source. Within this subset, most illness was attributed to eating poultry (502,634, 30%), complex foods (453,237, 27%), and red meat (287,485, 17%). Only 76,623 (5%) patients were infected by eating plant-based foods, i.e., vegetables, fruit, and rice.

Chicken consumption accounted for more disease, deaths, and healthcare usage than any other food type. Milk also exerted a considerable impact on healthcare provision. No other single food type accounted for >8% for any of the healthcare use measures. In general, the healthcare impact arising from plant-based foods was low. The lowest case-fatality rates were associated with plant-based foods. By contrast, foods of bovine origin tended to have the highest case-fatality rates. Shellfish had the lowest case-fatality rate of all of the foods of animal origin.

### Discussion
To our knowledge, our study is the first to examine the impact of and risk for indigenous foodborne disease by food type. When all parameters were considered, infection due to chicken was consistently responsible for more disease, while disease linked to plant-based foods had a minor impact on the population.

### Table 2. Estimated annual impact of indigenous foodborne disease, by food group and type, England and Wales

| Food group/type | Cases (%) | Deaths (%) | Case-fatality rate* |
|-----------------|-----------|------------|---------------------|
| Poultry         | 502,634 (29) | 191 (28) | 38                  |
| Chicken         | 398,420 (23) | 141 (21) | 35                  |
| Turkey          | 87,798 (5)  | 45 (7)    | 52                  |
| Mixed/unspecified | 16,418 (1)  | 4 (1)     | 27                  |
| Eggs            | 103,740 (6)  | 46 (7)    | 44                  |
| Red meat        | 287,485 (17) | 164 (24) | 57                  |
| Beef            | 115,929 (7)  | 67 (10)   | 58                  |
| Pork            | 46,539 (3)   | 24 (4)    | 53                  |
| Bacon/ham       | 17,450 (1)   | 9 (1)     | 53                  |
| Lamb            | 46,239 (3)   | 27 (4)    | 59                  |
| Mixed/unspecified | 61,329 (4)   | 36 (5)    | 59                  |
| Seafood         | 116,603 (7)  | 30 (4)    | 26                  |
| Fish            | 22,311 (1)   | 10 (2)    | 47                  |
| Shellfish       | 77,019 (4)   | 16 (2)    | 21                  |
| Mixed/unspecified | 17,273 (1)   | 4 (1)     | 24                  |
| Milk            | 108,043 (6)  | 37 (5)    | 34                  |
| Other dairy products | 8,794 (0)   | 5 (0)     | 55                  |
| Vegetable/fruit | 49,642 (3)   | 14 (2)    | 29                  |
| Salad vegetables| 37,466 (2)   | 11 (2)    | 28                  |
| Cooked vegetables| 6,870 (0)    | 2 (0)     | 35                  |
| Fruit           | 5,275 (0)    | 1 (0)     | 25                  |
| Rice            | 26,961 (2)   | 5 (1)     | 20                  |
| Complex foods   | 453,237 (26) | 181 (26)  | 40                  |
| Infected food handler | 67,157 (4) | 14 (2) | 20 |
| Total           | 1,724,315    | 687       | 40                  |

*Deaths/100,000 cases.
†Totals given are calculated on the basis of rounding to whole numbers.
Our methods build on approaches to estimate the impact of foodborne diseases in the United States (3) and England and Wales (4). To minimize bias, we avoided using assumptions whenever possible. We concluded that the effects of bias on the etiologic data (Table 1) were moderate (Table 5) because we were able to estimate the incidence of disease for each agent by taking national laboratory surveillance data and applying pathogen-specific multiplication factors that had been determined through a large population-based study (9). We were also able to use direct measurements from special studies and national surveillance systems to estimate the impact of foreign travel. We avoided using expert opinion (Table 5). Techniques such as Delphi (10) are available to assimilate the judgments of expert panels to produce consensus data. However, the Delphi estimate for the incidence of salmonellosis due to the consumption of products made from chicken and eggs (10) in the United Kingdom was >3 times the incidence for all salmonellosis calculated from a national population-based incidence study (9).

The use of data from published outbreak investigations also presents difficulties. Comparing outbreak surveillance data with those from published reports demonstrates a bias that favors the publication of novel findings and exceptional events (11). Therefore, we only used contemporary data drawn from locally based surveillance systems, population-based studies, and surveys (Table 5) (4) in these analyses. Nevertheless, certain reservations apply when using outbreak surveillance data to estimate the proportion of disease due to each food type for each pathogen. Ideally, a full account should be taken of the relative pathogen-specific contributions of each food type to both sporadic and outbreak-associated disease. However, determining the proportion of cases that fall into these 2 categories for any pathogen is problematic.

For sound epidemiologic reasons, case-control studies of sporadic disease test specific hypotheses that might explain disease transmission (12–15). Sample sizes are determined to detect associations for major risk factors. Population-attributable fractions are calculable for only a small number of foods for the small number of pathogens studied with these methods. Each study delivers a snapshot of the epidemiology of disease at a point in time for a particular population. While some of the findings from these studies are generalizable, population-attributable fractions for individual foods are not because food production patterns and consumer preferences change from country to country and with time (8,16,17). Corroborative evidence to support identified associations between disease and food consumption for studies of sporadic disease is usually lacking. However, in outbreak investigations, microbiologic findings, production records, and the like lend weight to the inferences drawn from analytic epidemiology (18–20). We believe that the true impact of outbreak-associated disease has likely been greatly underestimated (21,22).
Accounting for disease caused by intermittent or unpredictable food processing failures is important. For example, an estimated 224,000 people throughout the United States were infected with *Salmonella enterica* serotype Enteritidis after eating ice cream that had become contaminated as a result of a processing failure (20). However, outbreak cases were only formally recognized in Minnesota. The scale of the outbreak emerged because of an unusually detailed epidemiologic investigation. Therefore, under normal circumstances, most of those affected would have been classified as sporadic cases. This outbreak alone would have accounted for 17% of the 1.3 million cases of foodborne salmonellosis in the United States for 1994 (3). The 1996/7 FoodNet case-control study did not find an association between pasteurized ice cream and sporadic salmonellosis (12) because the study was not conducted during the narrow timeframe when the implicated product was on the market. This example is not isolated; milk-processing failures have resulted in hundreds of outbreak cases of *Campylobacter* and *E. coli* O157:H7 infections in the United Kingdom (18). While outbreaks of this type continue to be identified through routine surveillance, others likely go undetected. However, testing for associations between apparently sporadic disease and consumption of contaminated “pasteurized” milk using case-control studies is difficult for several reasons: study participants are unaware of the process history of the milk that they drink; pasteurized milk is very commonly drunk and identifying differences in exposure rates would involve extremely large sample sizes; and since the geographic and temporal distribution of cases would be expected to be heterogeneous, studies would have to extend over long periods and large areas. For these reasons, recent case-control studies of sporadic *Campylobacter* and *E. coli* O157:H7 infections in the United Kingdom failed to show associations between disease and consumption of milk (13,14,23). Similar arguments apply for the role of fruit juice or sprouts in the transmission of *E. coli* O157:H7 (24,25) or salad vegetables and *Salmonella* serotypes (26). While all of these foods have made considerable, if intermittent, contributions to the overall impact of disease in the population, their role in sporadic disease is hard to test and has seldom been demonstrated. Thus, published case-control studies of sporadic infection provide insufficient applicable data for our purposes.

By contrast, GSURV is large, comprehensive, and provides contemporary locally defined evidence-based data that takes into account the contribution of a much broader range of foods. For example, the foods most frequently associated with disease in published studies of sporadic *Campylobacter* infection (15,23), i.e., chicken, pork, red meat, and unpasteurized milk, also feature most prominently in GSURV, but GSURV also takes into account the more minor contributions of foods such as salad vegetables, fruit, and seafood. However, for certain pathogens the amount of outbreak data available is limited. The food distribution percentages for *Campylobacter* were based on 28

| Food group/type          | Disease risk* | Risk ratio | Hospitalization risk† | Risk ratio |
|--------------------------|---------------|------------|------------------------|------------|
| Poultry                  | 104           | 947        | 2,063                  | 4,584      |
| Chicken                  | 111           | 1,013      | 2,518                  | 5,595      |
| Turkey                   | 157           | 1,429      | 645                    | 1,433      |
| Mixed/unspecified        | 24            | 217        | 852                    | 1,893      |
| Eggs                     | 49            | 448        | 262                    | 583        |
| Red meat                 | 24            | 217        | 102                    | 227        |
| Beef                     | 41            | 375        | 153                    | 339        |
| Pork                     | 20            | 180        | 93                     | 208        |
| Bacon/ham                | 8             | 75         | 39                     | 86         |
| Lamb                     | 38            | 343        | 128                    | 285        |
| Mixed/unspecified        | 17            | 157        | 96                     | 214        |
| Seafood                  | 41            | 374        | 293                    | 650        |
| Fish                     | 8             | 75         | 41                     | 92         |
| Shellfish                | 646           | 5,869      | 1,121                  | 2,490      |
| Mixed/unspecified        | NA†           | NA         | NA                     | NA         |
| Milk                     | 4             | 35         | 133                    | 295        |
| Other dairy products     | 2             | 17         | 14                     | 32         |
| Vegetable/fruit          | 1             | NA         | 8                      | NA         |
| Salad vegetables         | 6             | 53         | 103                    | 229        |
| Cooked vegetables        | 0             | 1          | 0                      | 1          |
| Fruit                    | 0             | 2          | 1                      | 1          |
| Rice                     | 11            | 101        | 30                     | 67         |

*aCases/1 million servings.
†Hospitalizations/1 billion servings.
‡NA, not applicable.
outbreaks (Online Appendix 2). Therefore, we have exer-
cised considerable caution in interpreting these data and
have identified this area as one in which the effects of bias
on the final estimates are likely to be most profound (Table
5). Nevertheless, the results are also plausible. In our
analyses, chicken emerges as the most important contribu-
tor to Campylobacter infection. This finding is consistent
with data from food and veterinary studies (27,28), evalu-
ations of the interventions enforced after the Belgian diox-
in crisis (29), and observations on the relationships
between human infection and poultry operations in Iceland
(30). Our estimates for impact and risk for disease linked
to shell eggs is consistent with a U.S. Department of
Agriculture risk assessment on Salmonella Enteritidis in
shell eggs and egg products (31). Therefore, after taking all
of these factors into account, we concluded that GSURV
was the most suitable source of pathogen-specific risk
exposure data.

Our analyses were based on data drawn from 766 out-
breaks in which a single vehicle of infection was identi-
fied. The 612 outbreaks that were reported as foodborne
but had no identified vehicle of infection were excluded
from analysis. In effect, we have made the tacit assumption
that distribution of foods in the subset of outbreaks in
which a vehicle was identified is representative of the
complete population of outbreaks. However, certain vehi-
cles may be more likely to be implicated in outbreak inves-
tigations than others. This situation might occur if
investigators tend to preferentially collect data on the types
of food that are perceived as high risk or when laboratory
methods vary in sensitivity according to food type.
Therefore, a systematic vehicle detection bias could poten-
tially result in our analyses underestimating the contribu-
tion and risks attributable to those foods that were rarely
implicated in outbreak investigations, e.g., salad items
such as sprouts, which are now being recognized as poten-
tial sources of infection (25), fruit, or background ingredi-
ents such as herbs and spices.

Eggs are used as an ingredient in a wide range of foods
such as desserts, sauces, and savories (complex foods).
These dishes always include other ingredients so ascribing
disease-causing ingredients in the complex foods category
is difficult. There are inherent difficulties in demonstrating
epidemiologic association beyond the level of vehicle of
infection to that of source. However, several factors (being
seen by a general practitioner, hospitalization, and case-
fatality rates) linked to complex foods are similar to those
for eggs. Also, ≈70% of the complex foods associated with
illness included eggs as an ingredient. Therefore, we sug-
gest that eggs are probably a major source of infection for
disease related to complex foods.

Eating shellfish was associated with the highest disease
risk. Shellfish tends to be a luxury food, and consumption
levels were low when compared with those of other food
types. Although the number of cases attributed to shellfish
was of the same order as beef or eggs, the level of risk was
much higher. Preharvesting contamination of oysters with
norovirus had a major impact in generating cases of dis-
ease. This finding presents an additional impact to that
arising from the cross-contamination with Salmonella of
ready-to-eat items such as cocktail shrimp (32).

When severity of illness data are taken into considera-
tion, an elevated risk is associated with eating chicken.
Chicken has a lower disease risk ratio than either shellfish
or turkey but has a higher hospitalization risk ratio. This
finding is explained by the relative prominence of Campylo-
Bacter and nontyphoidal salmonellae in illness
attributable to chicken. Infection with these pathogens is
much more likely to result in hospitalization than disease
due to norovirus, which accounts for much shellfish-asso-
ciated illness, or C. perfringens, one of the more common
turkey-associated infections.

### Table 5. Quality of evidence

| Stage                             | Data sources                        | Evidence                  | Principal assumptions                           | Potential effects of bias on final estimates |
|-----------------------------------|-------------------------------------|---------------------------|------------------------------------------------|--------------------------------------------|
| All infectious intestinal disease | Population studies                  | Measured                  | Representivity of data                          | Moderate                                   |
| Etiology                          | Population studies                  | Measured for most; inferred rarely | Accuracy and sensitivity of diagnostic methods | Moderate                                   |
| Indigenous infection              | National laboratory report surveil-
|                                  | lance; special studies              | Measured                  | Completeness of reporting                       | Negligible                                 |
| Foodborne transmission            | National outbreak surveillance (GSURV)* | Measured for most; inferred rarely | Representivity of data                          | Major                                      |
| Food attribution                  | GSURV                               | Measured                  | Representivity of data                          | Major                                      |
| Presentations to primary care     | Population studies                  | Measured                  | Representivity of data                          | Moderate                                   |
| Hospitalizations                  | GSURV; special studies              | Measured                  | Representivity of data                          | Moderate                                   |
| Hospital occupancy                | Hospital episode statistics         | Measured                  | Representivity of data                          | Moderate                                   |
| Deaths                            | GSURV                               | Measured                  | Representivity of data                          | Negligible                                 |
| Food specific risks               | National food survey                | Measured                  | Representivity of data                          | Major                                      |

*GSURV, National Surveillance Database for General Outbreaks of Infectious Intestinal Disease*
Risks associated with eating vegetables were generally low. However, risks associated with cooked vegetables were much lower than those associated with salad vegetables. This finding is mainly because cooking would normally eliminate the pathogens that can contaminate vegetables in the field, the processing plant, the market, or the kitchen through cross-contamination. However, no parallel control process exists for salad vegetables, which are generally regarded as ready to eat.

While these analyses provide data on the impact of disease attributable to different food types, considerable heterogeneity exists in the origin, production, and handling of each of these types of food. Further research is needed to examine the influence of imported foods, organic production, factory farming, and commercial catering.

We have also attempted to define the contribution of foods by infected food handlers. One of the key reasons for conducting these analyses was to provide an evidence base for developing disease control strategies. Controlling transmission of infection from infected food handlers in commercial and domestic catering requires different strategies than controlling foodborne zoonoses through the food chain. The pathogen most frequently transmitted by infected food handlers was norovirus. Given the ubiquity of norovirus infection (9,33), its extreme infectivity, and the sudden and violent onset of symptoms (34), control of transmission is difficult and more focused strategies are needed.

Our evidence-based analyses demonstrate that the most important priority in reducing the impact of indigenous foodborne disease in England and Wales is controlling infection from contaminated chicken. Chicken was associated with relatively high levels of risk and accounted for more disease, health service usage, and death than any other individual food type. Interventions introduced during the mid-1990s to control S. Enteritidis in the Great Britain chicken flock (35) appear to have been successful in reducing the burden of salmonellosis in England and Wales (4). These findings are consistent with analyses from Sweden (36), Denmark (37), and the United States (38), which together demonstrate that foodborne salmonellosis can be substantially reduced by implementing targeted initiatives to control Salmonella in domestic livestock.

The greatest challenge to protect the population from foodborne infection is to develop effective programs to control Campylobacter through the chicken production chain. This intervention is possible, as witnessed in Iceland, where measures at retail level and in the household were introduced to prevent Campylobacter transmission. Parallel declines (>70%) were subsequently observed in the carriage of Campylobacter in broiler flocks and in human infections (29). Finally, the data from Europe and the United States show that the largest benefits in reducing Salmonella and Campylobacter levels have come from implementing controls in farm-to-retail processing rather than in instituting them in domestic kitchens, where the estimated impacts are much smaller in scale (39), although still important.

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Dr. Adak is head of the Environmental and Enteric Diseases Department of the Health Protection Agency Communicable Disease Surveillance Centre in London, UK. He has specialized in the epidemiology of gastrointestinal diseases and has been responsible for managing and developing disease surveillance systems and research projects since 1989.

References

1. World Health Organization. WHO global strategy for food safety: safer food for better health. Geneva: The Organization; 2002.
2. Kosec M, Bern C, Guerrant RL. The global burden of disease, as estimated from studies published between 1992 and 2000. Bull World Health Organ. 2003;81:197–203.
3. Mead PS, Slutsker L, Dietz V, McCaig LF, Bresee JS, Shapiro C, et al. Food-related illness and death in the United States. Emerg Infect Dis. 1999;5:607–25.
4. Adak GK, Long SM, O’Brien SJ. Trends in indigenous foodborne disease and deaths, England and Wales: 1992 to 2000. Gut. 2002;51:832–41.
5. Black RE, Brown KH, Becker S. Effects of diarrhea associated with specific enteropathogens on the growth of children in rural Bangladesh. Pediatrics. 1984;73:799–805.
6. Guerrant DI, Moore SR, Lima AAM, Patrick P, Schorling JB, Guerrant RL. Association of early childhood diarrhea and cryptosporidiosis with impaired fitness and cognitive function four–seven years later in a poor urban community in Northeast Brazil. Am J Trop Med Hyg. 1999;61:707–13.
7. Wall PG, de Louvois J, Gilbert RJ, Rowe B. Food poisoning: notifications, laboratory reports, and outbreaks—where do the statistics come from and what do they mean? Commun Dis Rep CDR Review. 1996;6:R93–100.
8. Department for Environment Food and Rural Affairs and National Statistics. National Food Survey 2000–Annual report on food expenditure, consumption and nutrient intakes. London: The Stationery Office; 2001.
9. Infectious Intestinal Disease Study Team. A report of the study of infectious intestinal disease in London. London: The Stationery Office; 2000.
10. Hanson S. Estimating the incidence of food-borne Salmonella and the effectiveness of alternative control measures using the Delphi method. Int J Food Microbiol. 1997;55:195–204.

11. O’Brien SJ, Gillespie IA, Sivanesan M, Adak GK. Examining publication bias in foodborne outbreak investigations: implications for food safety policy. Conference on Emerging Infectious Diseases. Atlanta, Georgia, March 2002. Atlanta: Centers for Disease Control and Prevention; 2002. Abstract no. 73.

12. Kimura AC, Reddy S, Marcus R, Cieslak PR, Mohle-Boetani JC, O’Brien SJ, Gillespie IA, Sivanesan M, Adak GK. Examining publication bias in foodborne outbreak investigations: implications for food safety policy. Conference on Emerging Infectious Diseases. Atlanta, Georgia, March 2002. Atlanta: Centers for Disease Control and Prevention; 2002. Abstract no. 73.

13. Parry SM, Salmon RL, Willshaw GA, Cheasty T. Risk factors for and prevention of sporadic infections with Vero cytotoxin (Shiga toxin) producing Escherichia coli O157. Lancet. 1998;351:1019–22.

14. O’Brien SJ, Adak GK, Gillham C. Contact with the farming environment as a major risk factor for sporadic cases of Shiga toxin (Vero cytotoxin)-producing Escherichia coli O157 infection in humans. Emerg Infect Dis. 2001;7:1049–51.

15. Neumann J, Engberg J, Mølbak K, Wegener H. A case-control study of risk factors for sporadic campylobacter infections in Denmark. Epidemiol Infect. 2003;130:353–66.

16. Busby JC, Roberts T. Economic costs and trade impacts of microbial foodborne illness. World Health Stat Q. 1997;50:57–67.

17. Hedberg CW, MacDonald KL, Osterholm MT. Changing epidemiology of food-borne disease: a Minnesota perspective. Clin Infect Dis. 1994;18:671–32.

18. Gillespie IA, Adak GK, O’Brien SJ, Bolton FJ. Milkborne general outbreaks of infectious intestinal disease, England and Wales, 1992–2000. Epidemiol Infect. 2003;130:461–8.

19. Bell BP, Goldoft M, Griffin PM, Davis MA, Gordon DC, Tarr PI, et al. A multistate outbreak of Escherichia coli O157:H7-associated bloody diarrhea and hemolytic uremic syndrome from hamburgers—the Washington experience. JAMA. 1994;272:1349–53.

20. Hennessay TW, Hedberg CW, Slutsker L, Baker AR, Whiting R, et al. A national outbreak of Salmonella enteritidis risk assessment for campylobacter jejuni infection—are they more common than we think and what might cause them? Epidemiol Infect. 2003;130:367–75.

21. Rodrigues LC, Cowden JM, Wheeler JG, Sethi D, Wall PG, Cumberland P. The study of infectious intestinal disease in England: risk factors for cases of infectious intestinal disease with Campylobacter jejuni infection. Epidemiol Infect. 1999;127:185–93.

22. Cody SH, Glynn K, Farrar JA, Cairns KL, Griffin PM, Kobayashi J, et al. An outbreak of Escherichia coli O157:H7 infection from unpasteurized commercial apple juice. Ann Intern Med. 1999;130:202–9.

23. Breuer T, Benkel DH, Shapiro RL, Hall WN, Winnett MM, Linn MJ, et al. A multistate outbreak of Escherichia coli O157:H7 infections linked to alfalfa sprouts grown from contaminated seeds. Emerg Infect Dis. 2001;7:977–82.

24. Horby P, O’Brien SJ, Adak GK, Graham C, Hawker J, Hunter P, et al. A national outbreak of multi-resistant Salmonella enterica serovar Typhimurium definitive phage type (DT) 104 associated with consumption of lettuce. Epidemiol Infect. 2003;130:169–78.

25. Jørgensen F, Bailey R, Williams S, Henderson P, Wareing DRA, Bolton FJ, et al. Prevalence and numbers of Salmonella and Campylobacter spp on raw, whole chickens in relation to sampling methods. Int J Food Microbiol. 2002;76:151–64.

26. Newell DG, Shreeve JE, Toszeghy M, Domíngue G, Bull S, Humphrey T, et al. Changes in the carriage of Campylobacter strains by poultry carcasses during processing in abattoirs. Appl Environ Microbiol. 2001;67:2636–40.

27. Vellinga A, Van Loock F. The dioxin crisis as experiment to determine poultry-related Campylobacter enteritis. Emerg Infect Dis. 2002;8:19–22.

28. Stern NJ, Hiett KL, Alfredsson GA, Kristinsson KG, Reisens J, Hardardottir H, et al. Campylobacter spp in Icelandic poultry operations and human disease. Epidemiol Infect. 2003;130:23–23.

29. Hope BK, Baker AR, Edel EH, Hald T, Mølbak K, Wegener H. A case-control study of risk factors for sporadic campylobacter infections in Denmark. Epidemiol Infect. 2003;130:353–66.

30. Jørgensen F, Bailey R, Williams S, Henderson P, Wareing DRA, Bolton FJ, et al. Changes in the carriage of Campylobacter strains by poultry carcasses during processing in abattoirs. Appl Environ Microbiol. 2001;67:2636–40.

31. Bell BP, Goldoft M, Griffin PM, Davis MA, Gordon DC, Tarr PI, et al. A multistate outbreak of Escherichia coli O157:H7-associated bloody diarrhea and hemolytic uremic syndrome from hamburgers—the Washington experience. JAMA. 1994;272:1349–53.

32. Hennessy TW, Hedberg CW, Slutsker L, White KE, Besser-Wiek JM, et al. Point source outbreaks of salmonella enterica serovar Enteritidis in Sweden. In Saeed AM, editor. Salmonella enterica Serovar Enteritidis in humans and animals. Epidemiology, pathogenesis and control. Ames: Iowa State University Press; 1999. p. 291–305.

33. de Wit MAS, Kolkman MPG, Koertbeek LM, Vanwille WJ, Vinje J, van Leusden F, et al. A population-based cohort study on gastrointestinal illness in the Netherlands: incidence and etiology. Am J Epidemiol. 2001;154:666–74.

34. Caul EO. Viral gastroenteritis: small round structured viruses, caliciviruses and astroviruses. Part 1. The clinical and diagnostic perspective. J Clin Pathol. 1996;49:874–80.

35. Advisory Committee on the Microbiological Safety of Food. Second report on salmonella in eggs. London: The Stationery Office; 2001.

36. Engvall A, Andersson Y. Control of Salmonella enterica serovar Enteritidis in Sweden. In Saeed AM, editor. Salmonella enterica Serovar Enteritidis in humans and animals. Epidemiology, pathogenesis and control. Ames: Iowa State University Press; 1999. p. 291–305.

37. Wegener HC, Hald T, Wong DL, Madsen M, Korsgaard H, Berger F, et al. Salmonella control programs in Denmark. Emerg Infect Dis. 2003;9:774–80.

38. Patrick ME, Adcock PM, Gomez TM, Altekruse SF, Holland BH, Tauxe RV, et al. An outbreak of salmonella enteritidis risk assessment for campylobacter jejuni infection—are they more common than we think and what might cause them? Epidemiol Infect. 2003;130:367–75.

39. Koukouzas V, Tsoutsou P, Pappas D, Tsirvakou E, Mavridis V, et al. Salmonella association with fish and shellfish, England and Wales, 1992–1999. Commun Dis Public Health. 2001;4:117–23.

40. Caul EO. Viral gastroenteritis: small round structured viruses, caliciviruses and astroviruses. Part 1. The clinical and diagnostic perspective. J Clin Pathol. 1996;49:874–80.

41. Advisory Committee on the Microbiological Safety of Food. Second report on salmonella in eggs. London: The Stationery Office; 2001.

42. Engvall A, Andersson Y. Control of Salmonella enterica serovar Enteritidis in Sweden. In Saeed AM, editor. Salmonella enterica Serovar Enteritidis in humans and animals. Epidemiology, pathogenesis and control. Ames: Iowa State University Press; 1999. p. 291–305.

43. Wegener HC, Hald T, Wong DL, Madsen M, Korsgaard H, Berger F, et al. Salmonella control programs in Denmark. Emerg Infect Dis. 2003;9:774–80.

44. Patrick ME, Adcock PM, Gomez TM, Altekruse SF, Holland BH, Tauxe RV, et al. Salmonella association with fish and shellfish, England and Wales, 1992–1999. Commun Dis Public Health. 2001;4:117–23.

45. Koukouzas V, Tsoutsou P, Pappas D, Tsirvakou E, Mavridis V, et al. Salmonella association with fish and shellfish, England and Wales, 1992–1999. Commun Dis Public Health. 2001;4:117–23.