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# Common source outbreaks of *Campylobacter* infection in the USA, 1997–2008

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## SUMMARY

*Campylobacter* is a common but decreasing cause of foodborne infections in the USA. Outbreaks are uncommon and have historically differed from sporadic cases in seasonality and contamination source. We reviewed reported outbreaks of campylobacteriosis. From 1997 to 2008, 262 outbreaks were reported, with 9135 illnesses, 159 hospitalizations, and three deaths. The annual mean was 16 outbreaks for 1997–2002, and 28 outbreaks for 2003–2008. Almost half occurred in warmer months. Foodborne transmission was reported in 225 (86%) outbreaks, water in 24 (9%), and animal contact in seven (3%). Dairy products were implicated in 65 (29%) foodborne outbreaks, poultry in 25 (11%), and produce in 12 (5%). Reported outbreaks increased during a period of declining overall incidence, and seasonality of outbreaks resembled that of sporadic infections. Unlike sporadic illnesses, which are primarily attributed to poultry, dairy products are the most common vehicle identified for outbreaks.

**Key words**: Bacterial infections, *Campylobacter*, epidemiology, foodborne infections, outbreaks.

## INTRODUCTION

The incidence of *Campylobacter* infections reported to the national Foodborne Diseases Active Surveillance Network (FoodNet) was 27% lower in 2010 compared to a 1996–1998 baseline, but much of the observed decrease occurred prior to 2001 [1]. Nonetheless, *Campylobacter* remains a leading cause of foodborne infections in the USA with an estimated incidence of nearly 850 000 domestically acquired foodborne cases annually [2]. *Campylobacter* infections are reported to FoodNet as either outbreak-related or sporadic (i.e. infections not recognized to be epidemiologically linked to an outbreak); sporadic infections account for more than 99% of *Campylobacter* infections in the USA [3]. Exposures most often associated with sporadic infections include consumption of poultry and recent international travel [4]. Although outbreaks of *Campylobacter* infection are uncommon [5], the most common source of reported outbreaks in the USA has historically been raw

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(unpasteurized) milk [6–9]. Poultry and contaminated drinking water have also been implicated in the USA and other countries as vehicles causing outbreaks [5, 10].

The seasonality of sporadic and outbreak-related infections has also differed [7]. Sporadic infections have shown a distinct peak during summer months, which has not been observed with outbreak-related cases [5, 7, 11]. It has been suggested that this lack of seasonality may be related to the differences in the most common contaminated sources among outbreaks (milk) and sporadic infections (poultry) [6]. Whereas carriage and shedding in poultry is thought to increase in summer months [8], the prevalence of *Campylobacter* in dairy cattle faeces increases in spring and autumn [12].

Outbreaks of *Campylobacter* infections can provide valuable information regarding the routes of transmission and commonly contaminated vehicles. In addition, recent interventions by the U.S. Department of Agriculture's Food Safety and Inspection Service (USDA-FSIS) in poultry processing plants aim to reduce poultry-associated human *Campylobacter* illnesses [13]; analysing sporadic and outbreak-related infections can offer insights into the effectiveness of new control strategies and aid in the development of future interventions. To describe the epidemiology of *Campylobacter* outbreaks, we reviewed all outbreaks reported to the Centers for Disease Control and Prevention (CDC) between 1997 and 2008.

## METHODS

In this study, an outbreak was defined as two or more cases of *Campylobacter* infection linked to a common source by a public health investigation. Outbreaks of *Campylobacter* infection from foodborne, waterborne, and animal contact sources were investigated by local, state, and territorial health departments in the USA and reported to CDC. We reviewed data on outbreaks that occurred from January 1997 to December 2008. Outbreaks of *Campylobacter* infection that were either confirmed (two or more culture-confirmed cases) or probable (multiple similar illnesses with a single culture-confirmed case) were included in the current analysis.

Foodborne outbreaks, usually detected through a localized increase in illnesses, were voluntarily reported by investigating officials to the Foodborne Disease Outbreak Surveillance System (FDOSS), which uses a standardized outbreak reporting form (CDC form 52.13) for data collection as described previously [14]. From 1973 to 1997, a paper-based form was used to collect outbreak information (pFORS). In 1998, it was replaced by an electronic data collection form (eFORS). Similar core information was gathered through pFORS and eFORS data collection tools. The number of illnesses, hospitalizations, and deaths; month and year of outbreak (based on first illness onset); implicated food source and setting where food was prepared; and aggregate percentage of cases with specific clinical symptoms are reported. In addition, aggregate demographic information and laboratory results, including identification of *Campylobacter* species and presence of additional pathogens, are included. Implicated foods were classified into one of 17 simple categories, when all ingredients were from that commodity: fish, crustaceans, mollusks, dairy, eggs, poultry, beef, game, pork, grains-beans, oils-sugars, fruits-nuts, fungi, leafy vegetables, root vegetables, sprout vegetables, and vine-stalk vegetables. These categories were then collapsed into the following commodity groups: seafood (fish, crustaceans, mollusks), dairy, eggs, poultry, other meats (beef, game, pork), other foods (grains-beans, oils-sugars), and produce (fruits-nuts, fungi, leafy vegetables, root vegetables, sprout vegetables, vine-stalk vegetables). Outbreaks in which either a single implicated food contained ingredients belonging to multiple categories (complex food) or outbreaks in which multiple food items were implicated were included in a separate category (Multiple food items/complex foods). Food vehicles were reported as confirmed if either microbiological or epidemiological evidence substantiated the role of the food in the outbreak and as probable if, after epidemiological investigation, they were suspected but not firmly established as the vehicle.

Information on reported waterborne outbreaks in the USA was collected through the Waterborne Disease and Outbreak Surveillance System (WBDOSS). This surveillance system is a collaborative effort between the CDC, the U.S. Environmental Protection Agency (EPA), and the Council of State and Territorial Epidemiologists (CSTE) and has been previously described in detail [15]. Local, state, and territorial public health officials report waterborne outbreaks associated with both drinking and recreational water exposures to WBDOSS using a standardized case form (CDC form 52.12). Data reported includes location of the outbreak, number of cases, epidemiological or microbiological evidence, and

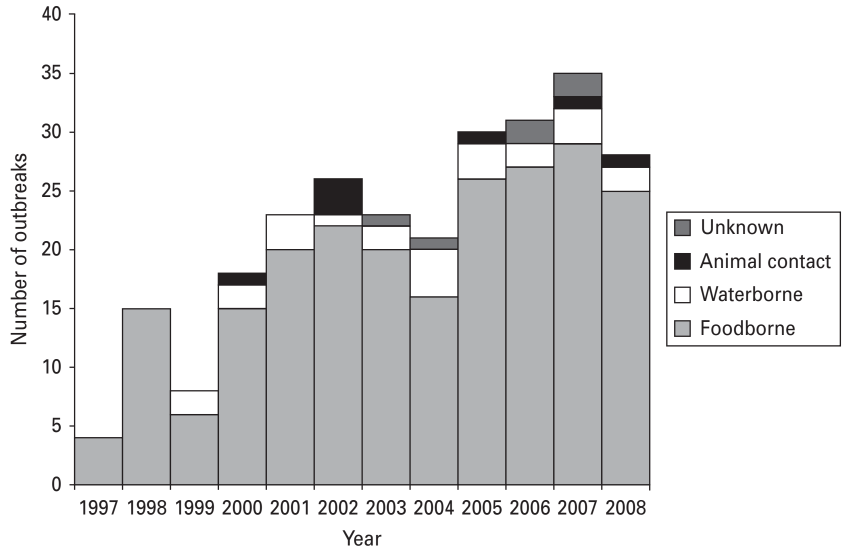


**Fig. 1.** Number of *Campylobacter* outbreaks reported in the USA from 1997 to 2008 by year and route of transmission.

environmental factors which might have contributed to the outbreak. All waterborne *Campylobacter* outbreaks reported through WBDOSS from 1997 to 2008 are included in this study [16].

During the study period, no established surveillance system existed for routinely tracking outbreaks associated with animal contact. However, beginning in 2006, the standardized form for eFORS was expanded to allow for reporting of non-foodborne outbreaks; some outbreaks due to animal contact were captured in this system and included here. Further, a literature review using the PubMed online search engine was conducted to search for additional outbreaks of *Campylobacter* infection associated with animal contact. The search was conducted using the key word *Campylobacter* in conjunction with outbreak, animal, zoonotic, or zoonosis. Finally, information on animal-associated outbreaks was informally solicited from members of the National Association of State Public Health Veterinarians through a general request sent to listserv participants.

Published information is available for some *Campylobacter* outbreaks; however, since FDOSS and WBDOSS are dynamic systems which allow for continuous updating of information, if discrepancies between published and surveillance data occurred, FDOSS or WBDOSS data were considered most accurate and used in the analysis. Outbreaks were grouped by route of transmission, and descriptive summary statistics were calculated in SAS version 9.2 (SAS Institute Inc., USA). Any outbreak reported through multiple surveillance systems was included only once in the analysis, based on the identified or suspected source of infection.

## RESULTS

From 1997 to 2008, 262 *Campylobacter* outbreaks were reported, causing 9135 illnesses, 159 hospitalizations, and three deaths. Two of the reported deaths occurred in a single waterborne outbreak in which both *Campylobacter* and *Escherichia coli* O157:H7 [17] were identified. The number of outbreaks reported annually increased over the study period, ranging from four in 1997 to 28 in 2008, with the highest number ($n=35$) occurring in 2007 (Fig. 1). The mean annual number of outbreaks reported over the 12-year period was 22, with a median of eight illnesses per outbreak, and 213 (81%) outbreaks were confirmed. From 1997 to 2002, the annual mean was 16 outbreaks with a median of ten illnesses per outbreak; from 2003 to 2008, the annual mean increased to 28, while the median number of illnesses decreased to eight per outbreak. Among all outbreaks reported, 124 (47%) occurred in the last 4 years of the study period (2005–2008). One hundred twenty-eight (49%) outbreaks occurred between May and August, with the highest numbers occurring during May ($n=34$) and June ($n=43$) (Fig. 2). The lowest number of outbreaks was observed during December ($n=9$) (Fig. 2). The three largest outbreaks were also reported during warmer months (May, July, August, respectively); a foodborne outbreak affecting 1644 persons, and two waterborne outbreaks affecting 1450 persons and 781 persons.

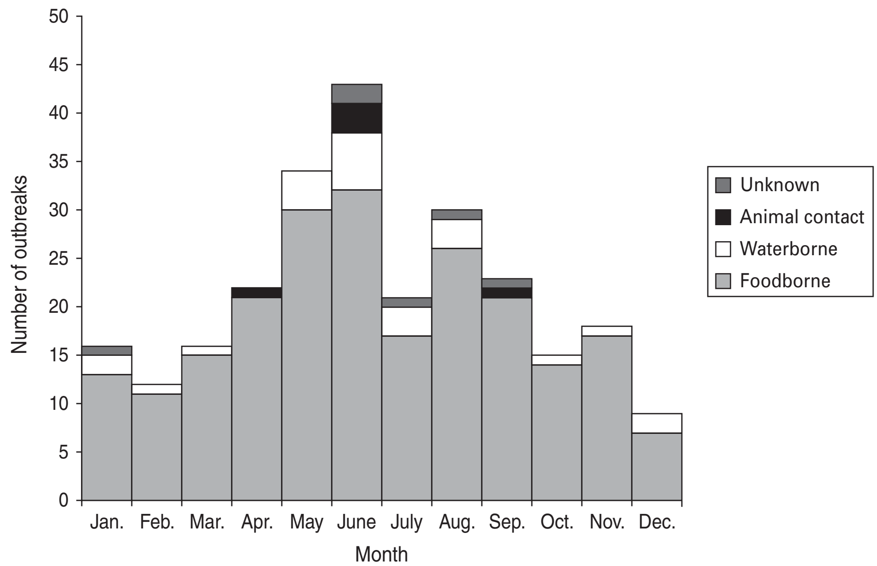


**Fig. 2.** Number of *Campylobacter* outbreaks reported in the USA from 1997 to 2008 by month of first reported illness ($n=259$) and route of transmission. Month of first illness unavailable for three outbreaks.

The most common species isolated was *C. jejuni*, reported in 174 (66%) outbreaks. Two other species of *Campylobacter*, *C. coli* and *C. fetus* accounted for four (2%) and two (1%) outbreaks, respectively, while the species was not reported in 82 (31%) outbreaks. Multiple *Campylobacter* species were identified in three outbreaks: *C. jejuni* and *C. lari* were identified in a waterborne outbreak, *C. jejuni* and *C. coli* in a foodborne outbreak, and *C. jejuni* and an unidentified *Campylobacter* species in a second waterborne outbreak. Co-infections with multiple other bacterial, viral, or parasitic pathogens were reported in 27 (10%) outbreaks; one additional pathogen was reported in 21 (8%) outbreaks, two additional pathogens were reported in five (2%), and three additional pathogens were reported in one (0·4%). Pathogens most commonly co-reported were *Salmonella* (nine outbreaks, 3%) and Shiga toxin-producing *Escherichia coli* (STEC) (six outbreaks, 2%).

Foodborne transmission was reported in 225 (86%) outbreaks, resulting in 5663 (62%) illnesses (Table 1). Confirmed or suspected food vehicles were reported for 158 (70%) of the 225 foodborne outbreaks, of which dairy products accounted for 65 (29%) (Table 1). Of dairy-associated outbreaks, 51 (78%) were linked to raw milk, ten (15%) to raw milk cheese, and one (2%) to ice cream made from raw milk. Three outbreaks of *Campylobacter* infection from dairy products were associated with consumption of pasteurized milk; two occurred in correctional facilities and in both public health investigations indicated that post-pasteurization contamination, whether deliberate or accidental, was likely. Less commonly implicated foods included poultry in 25 (11%) outbreaks, produce in 12 (5%), other meats (beef, pork, game) in five (2%), and seafood in four (2%) (Table 1). More than half ($n=37$, 57%) of the outbreaks attributed to dairy products occurred after 2005, whereas about one-third ($n=9$, 36%) of the outbreaks attributed to poultry did. Dairy products accounted for most outbreak-associated foodborne *Campylobacter* illnesses (2844 cases, 50%), followed by produce (565 cases, 10%), seafood (276 cases, 5%), and poultry (207 cases, 4%) (Table 1). Food consumed abroad was associated with two outbreaks, while another two outbreaks were associated with food products brought into the USA from Mexico. In all but one foodborne outbreak, exposure occurred in a single state; the source of the single outbreak with exposure in multiple states was cheese made from raw milk.

Food prepared at a restaurant or delicatessen was reported in 67 (30%) foodborne outbreaks, followed by food prepared at a dairy, farm, or other agricultural setting ($n=33$, 15%) and food prepared in a private home ($n=33$, 15%). Poultry was the most commonly reported food in outbreaks associated with food prepared at a restaurant or delicatessen ($n=11$, 16%), although in most outbreaks associated with this setting either a food was not identified ($n=27$, 40%) or multiple foods were implicated ($n=18$, 27%).

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Table 1. *Summary of* Campylobacter *outbreaks reported in the USA from 1997 to 2008 by route of transmission and implicated vehicle*

| Exposure | Outbreaks n (%) | Cases n (%) | Median no. of cases/outbreaks |
|---|---|---|---|
| **Foodborne** | **225 (85·9)** | **5663 (62·0)** | **7** |
| Dairy | 65 (28·9) | 2844 (50·2) | 10 |
| Poultry | 25 (11·1) | 207 (3·7) | 5 |
| Produce | 12 (5·3) | 565 (10·0) | 14 |
| Seafood | 4 (1·8) | 276 (4·9) | 3 |
| Other meats* | 5 (2·2) | 128 (2·3) | 15 |
| Other foods† | 3 (1·3) | 126 (2·2) | 19 |
| Multiple food items/complex foods | 44 (19·6) | 687 (12·1) | 5 |
| Unknown food | 67 (29·8) | 830 (14·7) | 5 |
| **Waterborne** | **24 (9·2)** | **3235 (35·4)** | **24** |
| Drinking water | 20 (83·3) | 2970 (92·4) | 33 |
| Recreational water | 4 (16·7) | 245 (7·6) | 6 |
| **Animal contact** | **7 (2·7)** | **138 (1·5)** | **9** |
| **Unknown transmission** | **6 (2·3)** | **99 (1·1)** | **3** |
| **Total** | **262** | **9135** | **8** |

* 'Other meats' includes beef, pork, and game meat.

† 'Other foods' includes grains, legumes, oils, and sugars.

Dairy products accounted for almost all ($n=32$, 97%) of the outbreaks in which food was prepared at a dairy, farm, or other agricultural setting; dairy products accounted for one third of all outbreaks in which food was prepared in a private home ($n=11$, 33%) followed by poultry ($n=6$, 18%).

Demographic and clinical information was available for 186 (83%) foodborne outbreaks. Diarrhoea, abdominal cramps, and fever were reported by more than half of patients in 85%, 75%, and 63% of outbreaks, respectively. Bloody diarrhoea and vomiting were less often reported (14% and 25%, respectively). In 57% of outbreaks, all patients in the outbreak reported diarrhoea. Median incubation time ranged from 3 to 168 hours and median duration of illness from 2 to 336 hours.

Contaminated water was implicated as the source in 24 (9%) of the 262 outbreaks and accounted for 3235 (35%) outbreak-related cases of *Campylobacter* (Table 1). Waterborne outbreaks were reported at a steady rate since 1999, with a mean of two outbreaks (0–4 outbreaks per year) reported annually. Of the 24 outbreaks associated with waterborne transmission, 20 (83%) were associated with contaminated drinking water and four (17%) with recreational water exposure (Table 1). Of the 20 *Campylobacter* outbreaks associated with contaminated drinking water, water at a camp, cabin, or other recreational area (six outbreaks, 30%); water at a private residence (five outbreaks, 25%); water at a factory or other industrial facility (two outbreaks, 10%); and water from a community municipality (two outbreaks, 10%) were most often reported. Thirteen (65%) drinking water-associated outbreaks occurred in public water systems (including nine in non-community systems and four in community systems) which fall under EPA regulations, five (25%) in individual water systems, and one (5%) in an individual, non-community system serving cabins and dining facilities associated with a tourist attraction. Community water systems have $\geqslant 15$ service connections or serve 25 residents year-round while non-community water systems are often temporary or do not serve residents year-round. One (5%) of the 20 outbreaks was associated with drinking water not intended for drinking. Most ($n=13$, 65%) of the drinking water outbreaks were primarily associated with an untreated groundwater deficiency. Other deficiencies included failures in treatment ($n=3$, 15%), a distribution system deficiency ($n=1$, 5%), an untreated surface water deficiency ($n=1$, 5%), a plumbing system deficiency ($n=1$, 5%), and consumption of water not intended for drinking ($n=1$, 5%). Notably, the three (15%) outbreaks with multiple deficiencies had a secondary distribution system deficiency. Of the four outbreaks associated with recreational water, two (50%) were associated with fill-and-drain swimming pools, one (25%) with a permanent swimming pool, and one (25%) with a

Table 2. *Number of outbreaks and number of outbreak-related illnesses in outbreaks due to single* (Campylobacter *alone*) *and multiple* (Campylobacter *and one or more other pathogens*) *aetiologies reported in the USA from 1997 to 2008 by route of transmission and implicated vehicle*

| Exposure | Single aetiology outbreaks *n* (%) | Multiple aetiology outbreaks* *n* (%) | Illnesses in single aetiology outbreaks *n* (%) | Illnesses in multiple aetiology outbreaks* *n* (%) |
|---|---|---|---|---|
| **Foodborne** | **211 (89·8)** | **14 (51·9)** | **5261 (92·1)** | **402 (11·7)** |
| Dairy | 63 (29·9) | 2 (14·3) | 2830 (53·8) | 14 (3·5) |
| Poultry | 22 (10·4) | 3 (21·4) | 163 (3·1) | 44 (10·9) |
| Produce | 12 (5·7) | 0 | 565 (10·7) | 0 |
| Seafood | 4 (1·9) | 0 | 276 (5·2) | 0 |
| Other meats† | 2 (0·9) | 3 (21·4) | 29 (0·6) | 99 (24·6) |
| Other foods‡ | 3 (1·4) | 0 | 126 (2·4) | 0 |
| Multiple food items/ complex foods | 35 (16·6) | 4 (28·6) | 564 (10·7) | 123 (30·6) |
| Unknown food | 76 (36·0) | 5 (35·7) | 708 (13·5) | 221 (55·0) |
| **Waterborne** | **13 (5·5)** | **11 (40·7)** | **276 (4·8)** | **2959 (86·4)** |
| Drinking water | 10 (76·9) | 10 (90·9) | 260 (94·2) | 2939 (99·3) |
| Recreational water | 3 (23·1) | 1 (9·1) | 16 (5·8) | 20 (0·7) |
| **Animal contact** | **5 (2·1)** | **2 (7·4)** | **74 (1·3)** | **64 (1·9)** |
| **Unknown transmission** | **6 (2·6)** | **0 (0·0)** | **99 (1·7)** | **0** |
| **Total** | **235** | **27** | **5710** | **3425** |

* Other aetiologies include *Bacillus* spp., calicivirus, unknown *Campylobacter* spp., *Clostridium*, *Cryptosporidium*, *Helicobacter* spp., Shiga toxin-producing *Escherichia coli*, *Entamoeba* spp., *Giardia*, norovirus, *Salmonella* spp., *Shigella* spp., *Staphylococcus* spp., and *Yersinia* spp.

† 'Other meats' includes beef, pork, and game meat.

‡ 'Other foods' includes grains, legumes, oils, and sugars.

lake; all three outbreaks associated with pools were reportedly using treated water. Overall, waterborne outbreaks accounted for 11 (42%) of the 26 *Campylobacter* outbreaks in which multiple pathogens were reported (Table 2), including ten (39%) associated with contaminated drinking water and one (4%) associated with recreational water exposure (Table 2).

Of all reported *Campylobacter* outbreaks, seven (3%) were associated with animal contact, accounting for 138 (2%) outbreak-related *Campylobacter* cases (Table 1). Three outbreaks were associated with contact with calves, while another was associated with contact with kittens at a day-care centre. Two outbreaks were associated with contact with poultry; in one outbreak, persons with outbreak-associated illnesses were exposed to live chickens while the other occurred among flood volunteers who handled dead turkeys. Another outbreak was associated with contact with chickens and pigs. Three of the outbreaks associated with animal contact occurred during June. In the 2000 outbreak involving calves, *C. jejuni*, *Cryptosporidium*, *Salmonella*, and STEC O111 were isolated from stool samples from both children and calves, and in the 2007 outbreak *C. jejuni* only was isolated from both children and calves. No outbreaks were reported in association with a petting zoo, fair, or other type of public exhibit.

## DISCUSSION

While the number of *Campylobacter* infections reported to FoodNet decreased by 27% from the 1996–1998 baseline to 2010 [1], the number of reported *Campylobacter* outbreaks increased nationwide from 1997 to 2008, particularly since 2005. This increase is most evident for foodborne outbreaks; the number of reported waterborne outbreaks has remained relatively steady throughout the years. Although more outbreaks have been reported since 2003, the median number of illnesses per outbreak decreased, leading to similar numbers of outbreak-related *Campylobacter* illnesses annually throughout the 12-year period. Dairy products, particularly unpasteurized products, remained the most common cause of *Campylobacter* outbreaks. However, poultry accounted for more than 10% of outbreaks, and produce accounted for the second-highest number of outbreak-associated illnesses after dairy products,

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suggesting that control measures for *Campylobacter* in these commodities could lead to decreases in both outbreaks and outbreak-associated illnesses. Although waterborne outbreaks remained relatively uncommon throughout the study period, waterborne outbreaks can result in large numbers of *Campylobacter* cases. In a departure from previous studies [6, 8], more outbreaks occurred during warmer months, similar to the seasonality observed with sporadic infections. Based on the findings of this study, it appears the epidemiology of *Campylobacter* outbreaks may be changing, although raw dairy produce remains the most important cause of outbreaks.

Although the number of *Campylobacter* outbreaks reported in Europe, England, and Wales has remained relatively steady [18–21], a similar trend in increasing frequency and decreasing magnitude of *Campylobacter* outbreaks has been observed in Australia [22]. This increase in the number of outbreaks reported may be due to increased recognition of clusters of *Campylobacter* infections and more vigorous investigation by state and local public health authorities. In Australia, enhanced detection of outbreaks followed the creation of OzFoodNet, a national foodborne surveillance programme [22]. While surveillance methods in the USA were enhanced in 1998 and may explain the changes seen from 1997 to 1999, no substantial changes to surveillance were made later during the study period. Instead, high-profile outbreaks of foodborne infections such as STEC O157 and *Salmonella* have increased public awareness and general public health concern about foodborne illnesses, which may mean that smaller clusters are more likely than in the past to be reported by affected citizens and investigated by health departments, possibly explaining the increase in reported outbreaks seen from 2000 to 2008. However, similar increases have not been observed in the number of reported outbreaks caused by other foodborne pathogens, and it is possible increased detection of small *Campylobacter* clusters may be influenced by other, currently undetermined factors.

In this study, foodborne transmission accounted for almost 90% of all *Campylobacter* outbreaks and more than 60% of outbreak-associated illnesses. Milk and other dairy products were the commodity responsible for the largest proportion of foodborne *Campylobacter* outbreaks, although a smaller proportion than reported to the same surveillance systems during 1978–1996 [8]. The largest outbreak of *Campylobacter* infection reported from 1997 to 2008 involved 1644 inmates in multiple California correctional facilities; public health investigation showed that this outbreak may have resulted from post-processing contamination of pasteurized milk produced at a single prison dairy (CDC, unpublished data). However, unpasteurized milk was the source of the great majority of dairy-associated outbreaks for which the pasteurization status was reported, and the two outbreaks due to pasteurized dairy products only accounted for 6% of such dairy-associated outbreaks. Pasteurization is well established as an effective way to eliminate *Campylobacter* from milk and prevent outbreaks [23, 24].

Poultry, particularly when prepared outside the home or consumed under-cooked, has previously been identified as the major risk factor for sporadic *Campylobacter* infections and is the most common cause of outbreaks in Europe [25]. In the UK and Australia, consumption of raw or undercooked poultry liver dishes (e.g. liver pâté dishes, foie gras) have been increasingly associated with outbreaks of *Campylobacter* infection [26, 27]. In the USA, poultry liver was reported as the possible vehicle for five outbreaks, but was confirmed in only two of them. In this study, although poultry was the second most frequent cause of foodborne outbreaks, it accounted for only 4% of foodborne illnesses. In contrast, more than twice as many persons became ill from contaminated produce than contaminated poultry. This suggests that while dairy and poultry remain important commodities in *Campylobacter* outbreaks, produce should also be considered as a possible vehicle in outbreak investigations through either direct contamination or cross-contamination from live animals or foods such as raw poultry [28, 29].

Outbreak data is more useful for overall food source attribution for some pathogens than for others. Compared to other foodborne pathogens, outbreaks of *Campylobacter* infections are relatively rare, perhaps due to decreased ability of the bacteria to survive or reproduce in the environment [7]. In Europe, outbreak data has proven unreliable for source attribution of *Campylobacter* infections due to the low frequency of *Campylobacter* outbreaks [10]. Similarly, in the USA $<1\%$ of *Campylobacter* infections reported to active surveillance have been outbreak-related [3]. Therefore, it is unsurprising that differences in sources of sporadic and outbreak-associated illness exist [4, 7]; outbreak data, although useful in highlighting food sources of infection, may be of limited value in determining the proportion of all *Campylobacter* infections attributable to these sources.

Although waterborne outbreaks accounted for only 10% of all outbreaks, they were responsible for 36% of all reported illnesses. Contaminated drinking water was the most common cause of waterborne *Campylobacter* outbreaks, usually from public water systems. Notably, 65% of these drinking water outbreaks were associated with untreated groundwater deficiencies, including the largest outbreak of *Campylobacter* infections associated with drinking water, and the second-largest reported outbreak overall during this time period. This outbreak was believed to result from sewage contamination of an untreated groundwater source and affected 1450 people using individual and non-community water systems [30]. However, it is important to note that this outbreak probably involved sewage contamination and therefore involved multiple pathogens so that *Campylobacter* may not have caused all of these illnesses. Waterborne outbreaks also accounted for 42% of outbreaks involving multiple pathogens; most of these outbreaks were associated with contaminated drinking water.

The outbreaks reported here are likely to under-represent the impact of outbreak-associated *Campylobacter* infections. This study relied on passive surveillance data reported by local, state, and territorial health officials and published outbreak information. Since *Campylobacter* reporting requirements vary from state to state, the intensity of surveillance varies. Differences in epidemiological capacity at local and state health departments may also impact the ability to detect and investigate *Campylobacter* outbreaks. Some outbreaks may not have been reported to FDOSS or WBDOSS, and guidelines for reporting animal-contact associated outbreaks do not currently exist, leading to an underestimation in the total numbers of outbreaks and cases. Additionally, a food vehicle was suspected or confirmed in only 70% of foodborne outbreaks. Therefore, additional food commodities may not have been identified, or the impact of identified food commodities may be incorrectly assessed. Without better capabilities for detection of multi-jurisdictional *Campylobacter* outbreaks, including laboratory techniques to determine the relatedness of isolates, most large multistate outbreaks, and the vehicles that cause them, will remain unidentified.

Of all *Campylobacter* outbreaks reported, only one involved exposure in multiple states. PulseNet USA, a national surveillance network, is used to rapidly detect clusters of bacterial foodborne pathogens with matching pulsed-field gel electrophoresis (PFGE) patterns, indicating isolates may have arisen from a common source. PulseNet has been a powerful tool for detecting multistate outbreaks of *E. coli* O157:H7, *Listeria monocytogenes* and a variety of *Salmonella* serotypes; however, it is not used for that purpose for *Campylobacter* because of testing limitations [31]. Routine subtyping of *Campylobacter* has been shown to be of limited value because of the high genetic diversity and weakly clonal population structure of *C. jejuni* and genetic instability that can lead to changes in PFGE profile, which can complicate interpretation of results; PulseNet recommends confirmatory subtyping of strains when *Campylobacter* outbreaks are detected by other means [32]. Therefore, recognition of *Campylobacter* outbreaks typically relies on reports of localized increases in infections, which means that more dispersed or multistate outbreaks in which patients do not clearly share common exposures are not likely to be detected.

The seasonality of outbreak-related *Campylobacter* infections appears to have changed. We observed a prominent summer peak in outbreaks that closely matches the typical July peak observed in reports of sporadic cases, but was not present in summaries from previous decades [11]. Mirroring reports from England and Wales [33], we observed more outbreaks in June than in other months, and the overall seasonality of sporadic and outbreak-related *Campylobacter* infections appears more similar than previously reported in the USA [7, 8].

Many current prevention strategies target reducing the incidence of *Campylobacter* infections associated with poultry. In 2010, the USDA-FSIS passed the first industry performance standards for *Campylobacter* on raw poultry, which it estimates will reduce the number of *Campylobacter* illnesses by 39 000 annually [13, 34]. Implementation of these new guidelines should also decrease *Campylobacter* outbreaks. Although no longer the only recognized vehicle of foodborne *Campylobacter* outbreaks, raw milk and products made from it remain the most common cause of infections. Of all fluid milk-borne outbreaks reported in the USA between 1990 and 2006, more than half were caused by raw milk, with more outbreaks due to raw dairy products occurring in the latter half of that time period [35] which is consistent with a recent study that demonstrated raw milk and/or raw milk products were

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disproportionately responsible for foodborne outbreaks associated with dairy products [36]. Although the Food and Drug Administration (FDA) banned interstate sale of raw milk and/or raw milk products in 1987 [37], many states currently allow some type of intrastate sale of raw milk or raw milk products. Laws banning interstate commerce of these products may contribute to geographical clustering of cases, thus making these outbreaks easier to detect. To the extent that consumption of raw milk increases among the general population [38], we can expect similar increases in outbreak-associated *Campylobacter* illnesses. In this study, we also found produce to be an increasingly important vehicle. The FDA has recently proposed development of new food safety rules for fresh produce to update 1998 and 2009 guidelines [39]. Implementation of these rules could contribute to a reduction in outbreaks and outbreak-related cases.

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## DECLARATION OF INTEREST

None.

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