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Public health implications of campylobacter outbreaks in England and Wales, 1995–9: epidemiological and microbiological investigations

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SUMMARY

Although campylobacter has been the most commonly recognized bacterial cause of gastro-intestinal infection in England and Wales since 1981, there are few reported campylobacter outbreaks. Of the 2374 general outbreaks of infectious intestinal disease reported to CDSC between 1995 and 1999, for which an aetiological agent was identified, campylobacter accounted for only 50 (2%). Foodborne transmission was identified in 35 outbreaks and the majority took place in commercial catering establishments; waterborne transmission was responsible for a further four outbreaks. Isolates of *Campylobacter jejuni* were referred for typing from 25 outbreaks. In 13 outbreaks all isolates were the same subtype, as defined by serotype and phage type, while in the remainder more than one campylobacter subtype was involved.

INTRODUCTION

Campylobacter has been the most commonly recognized bacterial cause of gastro-intestinal infection in England and Wales since 1981 with a steadily increasing number of reported infections rising to 58059 in 1998 and 54987 in 1999 [1]. The projected incidence from a population based study of infectious intestinal disease in England, is 422200 cases per annum [2]. Despite this number, there are few reported campylobacter outbreaks.

There were 23 general outbreaks of campylobacter infection, i.e. those involving members of more than one household, reported to the Communicable Disease Surveillance Centre (CDSC) between 1989 and 1991 [3]. Between 1992 and 1994, a total of 1590 general outbreaks of gastro-intestinal infection was reported [4], in only 21 of which was campylobacter implicated as the causitive organism. The campylobacter outbreaks in this latter series involved a total of 706 patients, 9 of whom were admitted to hospital. The relative infrequency of campylobacter outbreaks compared with salmonella outbreaks is also seen in data from a single laboratory where campylobacter only accounted for 4 of 250 outbreaks identified over a 4-year period between 1995 and 1998. During this time 28 salmonella and 100 Norwalk-like virus (NLV) outbreaks were investigated [5]. Under-reporting of campylobacter outbreaks is compounded because the investigation of campylobacter infection is often less structured than that for salmonella. While over 90% of United Kingdom Local Authorities surveyed in a recent study always investigated reports of salmonella or *Escherichia coli* O157 infection, only 63% always followed-up reports of campylobacter infections [6]. Indeed, campylobacter scored lowest for follow-up of the 20 likely causes of sporadic food poisoning infections.

One of the reasons given for failure to follow up potential campylobacter outbreaks has been the lack, until recently, of widely available reference typing to

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assist in outbreak investigation [4]. The use of typing to trace the source of campylobacter infections has been successful in some instances. For example, in a series of investigations between 1984 and 1986, a number of clusters and sporadic infections with *Campylobacter jejuni* Lior serotype 1 Penner serotype 4c were traced back to a single supplier of poultry meat [7]. Subsequent interventions on the farm resulted in a decrease in incidence of that particular subtype in the local population.

Outbreaks of infectious intestinal disease are reported to the CDSC by a variety of routes including Public Health and hospital laboratories, Consultants in Communicable Disease Control (CsCDC) and Departments of Environmental Health. Most outbreak associated and sporadic campylobacter infections are reported to CDSC without any further characterization of the causative organism. Since January 1997 the Campylobacter Reference Unit (CRU) in the Laboratory of Enteric Pathogens has provided detailed typing for a proportion of sporadic and all outbreak-associated isolates. While a wide range of methods have been described for typing campylobacter [8], the requirement for operation on a large scale, and providing typing data to a range of recipients in real time, means that, at present, phenotypic methods are the only option for the reference laboratory. Typing in England and Wales is based on serotyping of heat stable antigens using direct agglutination [9], and phage typing [10]. The present paper describes campylobacter outbreaks reported between 1995 and 1999, including those reported to CDSC by the usual channels and those identified via the CRU.

MATERIALS AND METHODS

Epidemiology

An outbreak was defined as an incident involving two or more patients, who experience a similar illness or proven infection (at least one of them being ill), and who have had a common exposure [11]. A general outbreak is defined as an outbreak that affects members of more than one private residence or residents of an institution.

The outbreak surveillance system introduced in CDSC in 1992 [4] receives reports from a number of sources and uses a standard questionnaire which is sent to the appropriate CCDC seeking a minimum set of data. The response rate to the questionnaire is over 80% [12]. Statistical analysis was undertaken using Microsoft Excel 2000, Epi Info version six and Stata version 7 (Stata Corporation Ltd.). Proportions were compared using the χ^2-test and changes in proportions over time were compared by the χ^2-test for trend. Medians were compared by the nonparametric K-sample test on the equality of medians.

Microbiology

Since April 1997 the Campylobacter Reference Unit (CRU) has provided an identification and typing facility for isolates of *Campylobacter* spp. associated with outbreaks in England and Wales. All isolates are speciated using standard tests [13]. Isolates of *C. jejuni* and *C. coli* are then serotyped [9] and phage typed [10]. All isolates are also tested for resistance to a range of antimicrobial agents using an agar incorporation break point method [14]. Where further clarification of strain relationships is required, DNA macrorestriction analysis is performed using pulsefield gel electrophoresis [15].

RESULTS

Between 1 January 1995 and 31 December 1999, 3287 general outbreaks of infectious intestinal disease were reported to CDSC. In 2374 (72%) an aetiological agent was identified and campylobacter ('campylobacter outbreaks') accounted for 50 (2%). Outbreaks of unknown aetiology were excluded from further analysis. Over the surveillance period, the number of campylobacter outbreaks as a proportion of all pathogens increased significantly ($P < 0{\cdot}01$) (Table 1). However, the proportion of campylobacter cases which were recognized as part of outbreaks was only 0·4% compared with 8·0% for salmonella and 15·5% for *E. coli* O157.

Magnitude and severity

A total of 966 people were affected (range 2–89) in the 50 campylobacter outbreaks, with 3 people admitted to hospital, and no deaths reported. The risk of hospitalization (0·03) was significantly lower in campylobacter outbreaks than in other outbreaks (0·019) (risk ratio 0·16; $P < 0{\cdot}001$). The first and last dates of onset were available for 2067 outbreaks, and this was used to calculate outbreak duration. Campylobacter outbreaks lasted for a median of 6 days (range 1–38), which was no different from those involving other pathogens (8; range 1–397) ($P > 0{\cdot}05$).

Table 1. *General outbreaks of campylobacter infection as a proportion of all outbreaks of infectious intestinal disease where a pathogen was identified, England and Wales, 1995–9*

	Pathogen (%)		
Year	Campylobacter	Others	Total
1995	5 (1)	616 (99)	621
1996	9 (2)	560 (98)	569
1997	11 (3)	404 (97)	415
1998	14 (4)	379 (96)	393
1999	11 (3)	365 (97)	376
Total	50	2324	2374

Mode of transmission

Foodborne transmission was identified in 35 of the 50 campylobacter outbreaks (70%) and waterborne transmission occurred in 4 (8%). Animal contact (chicks) and person-to-person transmission were each reported once and for 9 outbreaks (18%) the mode of transmission was not determined. Foodborne (70%) and waterborne (8%) transmission were reported more often in campylobacter outbreaks than in those associated with other pathogens (28% and 1% respectively) ($P < 0{\cdot}001$ and $P < 0{\cdot}01$ respectively). The waterborne outbreaks were all associated with rural locations not linked to the municipal water supply.

Outbreak setting

The majority (32/50; 64%) of campylobacter outbreaks took place in commercial catering premises including 16 in restaurants, 10 in hotels, 4 in public houses or bars, and 1 each in a hall or canteen. Schools (6; 12%) and the armed services (4; 8%) constituted the majority of the remainder (Table 2). Campylobacter outbreaks were more often associated with commercial catering premises (62%) compared with those associated with other organisms (468/2324; 20%) ($P < 0{\cdot}001$). Furthermore, where the data were available, campylobacter outbreaks were more often associated with functions (31/50; 44%) than outbreaks involving other pathogens (351/2323; 20%) ($P < 0{\cdot}001$).

Evidence (foodborne outbreaks only)

More than one form of evidence implicating food vehicles was reported in 29 outbreaks. Analytical evidence (18 cohort studies and 2 case-control studies) was most commonly reported (20/50; 40%), followed by descriptive epidemiology (8; 16%) and microbiological evidence for only 1 (2%) outbreak. For 21 outbreaks the type of evidence on which the report was based was not stated. Analytical evidence was more often reported in campylobacter outbreaks

Table 2. *Settings in general outbreaks of campylobacter infection compared with other identified pathogens, England and Wales, 1995–9*

	Organism (%)		
Place	Campylobacter	Others	Total
Hospital	0	713 (31)	713
Residential	2 (4)	660 (28)	662
Restaurant	16 (32)	174 (7)	190
Hotel	10 (20)	175 (8)	185
School	6 (12)	122 (5)	128
Private	1 (2)	99 (4)	100
Pub/bar	4 (8)	62 (3)	66
Shop/retailer	0	63 (3)	63
Hall/caterers	1 (2)	57 (2)	58
Community	0	36 (2)	36
Canteen	1 (2)	26 (1)	27
Armed services	4 (8)	22 (1)	26
Farm	2 (4)	17 (1)	19
Holiday camp	1 (2)	17 (1)	18
Swimming pool	0	10 (0·4)	10
University/college	0	7 (0·3)	7
Mobile	0	5 (0·2)	5
Other	2 (4)	59 (3)	61
Total	50	2324	2374

Table 3. *Food types in foodborne general outbreaks of campylobacter infection compared with other identified pathogens, England and Wales, 1995–9*

	Organism	
Vehicle category*	Campylobacter	Others
Poultry	14	15
Red meat/meat products	3	5
Fish/shellfish	1	4
Salad/vegetables/fruit	2	6
Sauces	2	7
Desserts	2	8
Milk/milk products	2	9
Water	4	10
Miscellaneous	4	13
Eggs	0	10
Rice	0	11

* More than one vehicle of infection can be reported in an outbreak.

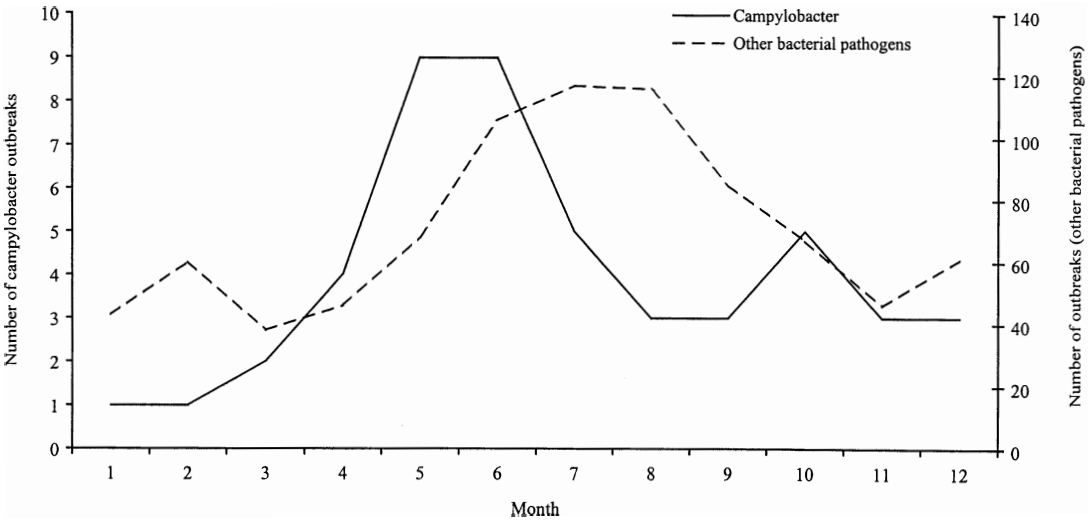

Fig. 1. Seasonality of general outbreaks of Campylobacter infection compared with other bacterial pathogens, England and Wales, 1995–9.

(40%) compared with those involving other pathogens (7%) ($P < 0{\cdot}001$).

Foodborne vehicles of infection

At least one food was reported as the likely vehicle of infection for 24 of the 35 foodborne campylobacter outbreaks. In 5 of these, 2 foods were identified and in 2 outbreaks 3 were identified. Where a food was implicated, poultry products, 13 chicken and 1 duck, were most commonly reported (Table 3). The remainder of the foods were distributed amongst the various food categories. However, it is noteworthy that the four miscellaneous foods reported were all buffet foods including sandwiches and vol au vents.

Food handling faults

Thirty-eight food handling faults were reported by investigators in the foodborne campylobacter outbreaks, one type of fault in each of 17 outbreaks and more than one fault in 9 outbreaks. Cross-contamination (18 outbreaks) was the most commonly reported fault, with inadequate heat treatment (10 outbreaks) and inappropriate storage (7 outbreaks) also featuring.

Seasonality

The first date of onset was available for 2248 outbreaks, and this was used to calculate the month of outbreak. Campylobacter outbreaks showed marked seasonality (Fig. 1). Over a third of outbreaks occurred in May and June (18/48; 36%), and such activity was not observed amongst other pathogens at this time of year (372/1828; 16%) ($P < 0{\cdot}001$). Within this period no single mode of transmission, type of premise, food vehicle or fault predominated. A small peak was also observed in the month of October. These outbreaks were indistinguishable from campylobacter outbreaks in other months, except that all five occurred on commercial catering premises.

Microbiology

A total of 36 campylobacter outbreaks was reported to CDSC between January 1997, when a reference typing sevice first became available, and December 1999. Isolates from 25 of these were referred to CRU for typing (Table 4). In 13 outbreaks, all of the isolates referred were the same subtype as defined by serotype and phage type. In 11 outbreaks more than one subtype was identified (i.e. isolates differed by serotype, phage type or both) while only one isolate was referred from the remaining outbreak. In four outbreaks, index numbers 97/11, 98/4, 98/5 and 99/10, no predominant subtype was identified. In 3 of the 5 water-associated outbreaks the same *C. jejuni* subtype, HS44 PT33, was isolated. Two of these (index numbers 97/5 and 98/9) occurred in the same area in successive summers. In the first outbreak the majority of isolates were HS44 PT38, a phage type which differs from PT33 by a single phage reaction [10].

The case control study for outbreak index number 97/1 implicated poor food handling in a restaurant serving stir-fried chicken [16], and a single *C. jejuni*

Table 4. *Summary of campylobacter outbreaks 1997–9 from which isolates were referred for typing*

Date	Index no	Setting	Vehicle	Evidence*	Referred to CRU	Species	Sero/phage type [number of strains]†
1997	97/1	Restaurant [16]	Chicken	CO D	7	*C. jejuni*	HS50 PT49
1997	97/4	School trip – France		CO	5	*C. jejuni*	HS10 PT5
1997	97/5	School camp – farm	Water	D	12	*C. jejuni*	HS44 PT38 [11]
							HS44 PT33 [1]
1997	97/6	Military camp	Water	D	2	*C. jejuni*	HS 5 PT33
1997	97/10	Hotel	Chicken	CO D	17	*C. jejuni*	HS50 PT5
1997	97/11	College [17]	Mixed foods	CO	12	*C. jejuni*	HS 2 PT35
							HS11 PTUT
							HS18 PTUT
							HS44 PT2
							HS44 PT19
							HSUT PT1 [2]
							HSUT PT14
							HSUT PTUT [3]
1997	97/12	Hotel			2	*C. jejuni*	HS11 PTUT
							HS57 PT8
1998	97/13	Farm	Unpasteurised milk	M	2 (+milk)	*C. jejuni*	HS16 PT20
1998	98/1	Restaurant	Curried meat, prawn salad	CO	14	*C. jejuni*	HS50 PT5 [10]
							HSUT PT44 [4]
1998	98/2	Military camp	Water		5	*C. jejuni*	HS44 PT33
1998	98/4	Asian restaurant			4	*C. jejuni*	HS 7 PT31
							HS11 PT1 [2]
							HS67 PT39
1998	98/5	Turkish restaurant	Lettuce & mayonnaise	CO D	12	*C. jejuni*	HS 6 PT1
							HS50 PT5
							HS69 PT39 [4]
							HSUT PT1
							HSUT PT2
							HSUT PT5 [2]
							HSUT PT6
							HSUT PT18
1998	98/6	Infant school	Handling live chickens	D	8	*C. jejuni*	HS44 PT14
1998	98/7	Hotel	Prawn vol-au-vent	CO	3	*C. jejuni*	HS11 PT1
1998	98/8	English restaurant			2	*C. jejuni*	HS11 PT2
1998	98/9	School camp – farm	Water	D	5	*C. jejuni*	HS44 PT33
1998	98/10	Monastery			3	*C. jejuni*	HS44 PT1
							HS50 PT6
							HSUT PT1

Table 4. (*cont.*)

Date	Index no	Setting	Vehicle	Evidence*	Referred to CRU	Species	Sero/phage type [number of strains]†
1998	98/13	Hotel		D	8	*C. jejuni*	HS11 PT1 HS35 PT2 HS50 PT34 HSUT PT1 [4] HSUT PT34
1999	99/1	Boarding school			4	*C. jejuni*	HS19 PT2
1999	99/2	Holiday camp/activity centre			6	*C. jejuni*	HS6 PT1 [4] HSUT PT2 [1] HS50 PT33 [1]
1999	99/4	Chinese restaurant	Chicken	CO	10	*C. jejuni*	HS16 PT44
1999	99/5	Hotel/restaurant	Chicken	CO	3	*C. jejuni*	HS11 PT39 [2] HS11 PT1 [1]
1999	99/6	Hotel			1	*C. jejuni*	HS18 PT RDNC
1999	99/7	Holiday cottages	Water	M	2	*C. jejuni*	HS50 PT35
1999	99/10	Hotel function			3	*C. jejuni*	HS11 PT44 HS50 PT5 HSUT PT1

* Evidence: CC, case control study; CO, cohort study; D, descriptive (good circumstantial evidence to implicate named vehicle).
† Typing: HS serotype (12), PTphage type (13), RDNC: Reacts with the phages but Does Not Conform to a designated type.
MIXED multiple subtypes with no clear predominant type.

subtype, HS50 PT49 was identified. In contrast, six different campylobacter subtypes were identified among patients from outbreak 97/11 where the epidemiological evidence again suggested that chicken was the source of infection and poor food hygiene in the kitchen resulted in the contamination of a variety of ready to eat foods [17]. Microbiological confirmation of the source of infection was available for one waterborne outbreak, index 99/7, and one associated with the consumption of unpasteurized milk, index 97/13.

DISCUSSION

Despite the fact that campylobacters are the most commonly recognized bacterial cause of gastrointestinal disease in England and Wales [1, 2], general outbreaks of campylobacter infection account for only 2% of all reported intestinal disease outbreaks. Paradoxically, outbreaks are more likely to be investigated using case-control or cohort studies when the causative organism has been identified as campylobacter. The majority of reported outbreaks are foodborne and, since campylobacters are ubiquitous in the environment and can be isolated from a wide range of foodstuffs, the source of an outbreak can be difficult to trace. Campylobacter infections have a longer incubation period than most enteric pathogens so it is rarely possible to obtain microbiological confirmation of the vehicle of infection. There are, however, examples of 'classical' restaurant outbreaks where a single campylobacter strain and food vehicle were implicated, for example, index 97/1 described by Evans *et al*. [16]. Conversely, many campylobacter outbreaks, such as index 97/11 [17] are more complex.

The ability of campylobacter to survive in the domestic and commercial catering environment has been underestimated [18] and both cross-contamination and survival on contaminated kitchen surfaces, are important features of many campylobacter outbreaks with a significant number of outbreaks occurring in commercial catering premises. This is also reflected in the wide range of foods implicated in outbreak investigations. Thus the source of campylobacter contamination may not be the vehicle by which the outbreak is transmitted. Tuna salad was identified as the vehicle of infection in an outbreak in the United States at a summer camp [19]. An outbreak of infection occurred in which the causative organism was identified as *C. jejuni* Penner serotype 33 (heat stable), Lior serotype 18 (heat labile serotype), biotype III. This subtype is widespread in the environment but rarely isolated from humans. The organism was not isolated from water or food samples but there was a statistical association between illness and consumption of a tuna salad. There were a number of deficiencies in food handling practices and it was concluded that contamination of the salad probably occurred through cross-contamination in the kitchen. In outbreak 97/11 described by Gent *et al*. [17] poor food handling in a fast food outlet on a university campus resulted in an outbreak estimated to have involved over 100 students. In this instance 6 different campylobacter subtypes were identified from 11 patients.

The difficulties in linking patients to vehicles and sources of campylobacter infection are compounded by the fact that many potential sources of infection are contaminated with more than one strain of campylobacter and in waterborne outbreaks more than one pathogen may be isolated. In a 1996 report of an outbreak involving a contaminated private water supply [20] *Campylobacter* spp. and *Cryptosporidium* spp. were each isolated from 5 patients and, in 2 cases, both from the same patient. A recent study has shown that 24% of poultry portions, 53% of lambs' liver, 37% of ox liver, and 13% of pork livers sampled on retail sale carried more than one strain of campylobacter [21]. It follows that patients may be exposed to a variety of campylobacter strains following a single episode of poor food handling practice resulting in the contamination of ready-to-eat food. A random sample of 51 patients with confirmed campylobacter infection showed that 4 (8%) were carrying more than one campylobacter strain [22]. It is therefore unsurprising that, in 11 of the 25 outbreaks described above more than one campylobacter subtype was isolated. This is a similar proportion to that seen in a collection of household campylobacter outbreaks that have been typed by the same methods [23] where patients from 9 of 23 family clusters were infected with different campylobacter subtypes.

The nature of the organism and its epidemiology make campylobacter outbreaks difficult to detect and investigate. This is compounded by the lack of follow-up of campylobacter infections and incomplete use of reference facilities. The availability of detailed strain characterization for both outbreak and sporadic infections will help to identify the sources of campylobacter infection and indicate which vehicles and routes of transmission should be targeted for intervention measures. The continuing high levels of campylobac-

ter contamination in food sources, together with an increased understanding of the ability of campylobacter to survive in the domestic and commercial kitchen, emphasise the importance of good food handling practice in the control of both sporadic infections and campylobacter outbreaks.

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