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Foodborne transmission of infectious intestinal disease in England and Wales, 1992–2003

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Abstract

This paper reports information on foodborne outbreaks of infectious intestinal disease (IID) in England and Wales during the period 1992–2003 collected as part of a major investigation into Breakdowns in Food Safety. Between 1992 and 2003, 7620 general outbreaks of IID were reported to the Communicable Disease Surveillance Centre and in 1729 (23%) the mode of transmission was described as foodborne. In total, 39,625 people were affected and 68 deaths reported.

Salmonella spp. were implicated in over half of all foodborne outbreaks. During the surveillance period, the proportion of outbreaks attributed to *Salmonella* spp., *Clostridium perfringens* and Vero cytotoxin-producing *Escherichia coli* O157 decreased, whereas the proportion of outbreaks attributed to *Campylobacters* increased.

Keywords: Foodborne illness; Outbreak surveillance; Food safety

1. Introduction

Foodborne infection is of great concern to governments, the food industry and the public alike. In 2000 alone, there were over 1.3 million estimated cases of foodborne infectious intestinal disease (IID) (Adak, Long, & O'Brien, 2002). Food represents the third largest component of average household expenditure (over £2,000 per annum) (Craggs, 2004).

The creation of the Food Standards Agency in April 2000 was the UK Government's response to the high public and political profile of food safety issues in recent years. In its Strategic Plan 2001–2006, one of the Agency's priorities was to 'reduce foodborne illness by 20% by improving food safety right through the food chain' (Food Standards Agency, 2001).

The Health Protection Agency (HPA[2]) Communicable Disease Surveillance Centre (CDSC) has operated a system of surveillance for general outbreaks of IID in England and Wales since 1992. This resulted from a recommendation by the Richmond Committee that the Public Health Laboratory Service CDSC should improve the surveillance of outbreaks, particularly those occurring in institutions or affecting the community at large (Evans et al., 1998; The Committee on the Microbiological Safety of Food, 1990). The surveillance system captures information on outbreaks of IID whatever the mode of transmission (Djuretic et al., 1996). A minimum data on each outbreak enables a better understanding of the aetiological agents and contributing

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factors of IID outbreaks and inform decisions on prevention. The surveillance system for outbreaks of infectious intestinal disease in England and Wales is probably one of the most comprehensive systems worldwide. Its main advantage over other systems (Adak et al., 2002; Tirado & Schmidt, 2001) is that all infectious intestinal disease outbreaks are recorded, no matter what the mode of transmission. This means that foodborne disease outbreaks can be considered in the context of other modes of transmission.

The purpose of this paper is to review the epidemiology of foodborne general outbreaks of IID in England and Wales reported to CDSC between 1992 and 2003.

2. Methods

2.1. The surveillance system for general outbreaks of IID in England and Wales

The system of surveillance for general outbreaks of IID (Gsurv) is based on a standard, structured questionnaire, which is issued to the lead investigator following the initial report of an outbreak. General outbreaks are defined as those affecting members of more than one household or an institution. Initial reports of outbreaks are usually generated through reports from environmental health officers or consultants in communicable disease control. Continuous monitoring of laboratory report surveillance, including information from reference laboratories, is also undertaken in order to identify potential outbreaks. As soon as the initial report is received, or a potential outbreak detected through laboratory report surveillance, an outbreak surveillance form is posted to the lead investigator, requesting that they complete the form once the outbreak is deemed to be over. The minimum dataset includes details of the outbreak setting (e.g. on domestic premises, or commercial catering premises), mode of transmission, causative organism and details of epidemiological and laboratory investigations performed (Gillespie, Adak, O'Brien, & Bolton, 2003). In foodborne outbreaks the food preparation site takes precedence over where the food was served, when determining the outbreak setting. In addition to seeking information on implicated food vehicles, the type of evidence leading to the suspicion of a food vehicle is also sought. Thus, a distinction can be made between credibly identified vehicles, and vehicles assumed on the basis of, for example, biological plausibility (O'Brien, Elson, Gillespie, Adak, & Cowden, 2002). Up to three reminders are sent to the lead investigator, at one month, three months and six months after the first questionnaire was sent. The response rate is consistently high – of the order of 80% over the whole duration. Questionnaire data are entered onto an EPIINFO database and double data entry is performed in order to validate the data.

2.2. Data abstraction

Only those outbreaks where food was thought to be the primary route of transmission (in some outbreaks foodborne transmission is followed by person-to-person transmission) were selected for analysis. These data were extracted into Microsoft Excel to facilitate analysis.

2.3. Data analysis

Frequency tables for the following variables were calculated in Microsoft Excel: annual numbers of outbreaks, implicated pathogens/toxins, outbreak setting and food vehicles. Morbidity and mortality were also described. Statistical analyses were undertaken using Epi Info version 6.04d and Stata version 7 (Stata Corporation). For each of the variables listed above, relative proportions and relative proportions over time were compared using the χ^2-test and the χ^2 for trend, respectively. For smaller samples, Fisher's exact test was used. Means were compared using Student's *t*-test.

3. Results

Between 1992 and 2003, 7620 general outbreaks of infectious intestinal disease (IID outbreaks) were reported to CDSC (Table 1). In 1729 of these (23%) the mode of transmission was described as foodborne. The proportion of foodborne IID outbreaks decreased over the surveillance period ($p < 0.001$).

3.1. Pathogens/toxins

Salmonella spp. as a whole were implicated in over half of all foodborne outbreaks (Table 2a). *Clostridium perfringens* (*Cl. perfringens*) and viral pathogens (mainly Norovirus (122/126; 97%)) were also commonly reported. The proportion of outbreaks attributed to *Salmonella* spp. ($p = 0.02$), *Cl. perfringens* ($p = 0.05$) and Vero cytotoxin-producing *Escherichia coli* (VTEC) O157 ($p = 0.01$) decreased during the surveillance period, whilst the proportion of outbreaks attributed to *Campylobacters* increased ($p < 0.001$).

Table 1
General outbreaks of infectious intestinal disease (IID) and foodborne general outbreaks of IID reported to CDSC, England and Wales, 1992–2003

Year	Mode of transmission (row %)				Total
	Non-foodborne		Foodborne		
1992	149	(40)	224	(60)	373
1993	229	(50)	225	(50)	454
1994	298	(61)	192	(39)	490
1995	654	(78)	183	(22)	837
1996	568	(77)	165	(23)	733
1997	369	(62)	222	(38)	591
1998	489	(80)	121	(20)	610
1999	424	(81)	97	(19)	521
2000	559	(85)	98	(15)	657
2001	461	(86)	77	(14)	538
2002	1260	(95)	61	(5)	1321
2003	431	(87)	64	(13)	495
Total	5891	(77)	1729	(23)	7620

Table 2a
Foodborne general outbreaks of IID reported to CDSC, England and Wales, 1992–2003 (pathogen/toxin by year)

Year	Implicated pathogen/toxin (row %)									Total
	Viruses	*Bacillus* spp.	Campylobacters	*Cl. perfringens*	VTEC O157[a]	*Salmonella* spp.	Scombrotoxin	*Staph. aureus*	Mixed/other/unknown	
1992	10 (4)	8 (4)	4 (2)	32 (14)	3 (1)	138 (62)	1	7 (3)	21 (9)	224
1993	13 (6)	2 (1)	3 (1)	32 (14)	6 (3)	132 (59)	2 (1)	1	34 (15)	225
1994	22 (11)	7 (4)	5 (3)	21 (11)	–	92 (48)	8 (4)	2 (1)	35 (18)	192
1995	16 (9)	10 (5)	4 (2)	18 (10)	5 (3)	90 (49)	9 (5)	3 (2)	28 (15)	183
1996	8 (5)	6 (4)	6 (4)	19 (12)	7 (4)	89 (54)	6 (4)	5 (3)	19 (12)	165
1997	8 (4)	9 (4)	7 (3)	36 (16)	4 (2)	122 (55)	10 (5)	2 (1)	24 (11)	222
1998	9 (7)	–	11 (9)	20 (17)	4 (3)	58 (48)	4 (3)	–	15 (12)	121
1999	5 (5)	1 (1)	7 (7)	7 (7)	7 (7)	45 (46)	8 (8)	4 (4)	13 (13)	97
2000	11 (11)	–	8 (8)	6 (6)	6 (6)	35 (36)	3 (3)	–	29 (30)	98
2001	9 (12)	–	3 (4)	15 (19)	1 (1)	35 (45)	–	1 (1)	13 (17)	77
2002	10 (16)	–	7 (11)	4 (7)	1 (2)	31 (51)	1 (2)	–	7 (11)	61
2003	5 (8)	–	2 (3)	1 (2)	1 (2)	43 (67)	–	–	12 (19)	64
Total	126 (7)	43 (2)	67 (4)	211 (12)	45 (3)	910 (53)	52 (3)	25 (1)	250 (14)	1729

[a] Vero cytotoxin-producing *E. coli* O157.

Table 2b
Foodborne outbreaks of salmonellosis reported to CDSC, England and Wales 1992–2003 (breakdown by the most frequently reported serotypes by year)

Year	Serotype (row %)					Total
	Enteritidis PT4	Enteritidis (other PTs)	Typhimurium	Virchow	Other serotypes	
1992	92 (67)	12 (9)	18 (13)	4 (3)	12 (9)	138
1993	98 (74)	14 (11)	15 (11)	2 (2)	3 (2)	132
1994	53 (58)	11 (12)	18 (20)	5 (5)	5 (5)	92
1995	55 (61)	9 (10)	14 (16)	4 (4)	8 (9)	90
1996	50 (56)	18 (20)	12 (13)	1 (1)	8 (9)	89
1997	61 (50)	37 (30)	16 (13)	2 (2)	6 (5)	122
1998	34 (59)	15 (26)	4 (7)	–	5 (9)	58
1999	18 (40)	11 (24)	2 (4)	–	14 (31)	45
2000	17 (49)	7 (20)	7 (20)	–	4 (11)	35
2001	10 (29)	16 (46)	3 (9)	1 (3)	5 (14)	35
2002	10 (32)	14 (45)	3 (10)	–	4 (13)	31
2003	6 (14)	32 (74)	3 (7)	–	2 (5)	43
Total	504 (55)	196 (22)	115 (13)	19 (2)	76 (8)	910

Of the salmonellas, *Salmonella enterica* serovar Enteritidis Phage Type four (*S.* Enteritidis PT4) was the most common serotype (%) with other phage types of *S.* Enteritidis and *S.* Typhimurium constituting much of the remainder (Table 2b). Whilst *S.* Enteritidis PT4 was the most common serotype over the study period as a whole, from 2001 other phage types of *S.* Enteritidis predominated and by 2003, 74% of outbreaks of salmonellosis were caused by *S.* Enteritidis of phage types other than PT4. The phage type distribution of the non-PT4 *S.* Enteritidis is shown in Table 2c.

3.2. Morbidity and mortality

In total, 39,625 people were affected in the 1729 foodborne outbreaks (range 2–530; mean 23), with 1573 cases admitted to hospital (range 0–65; mean 1.3) and 68 deaths reported (range 0–10; mean 0.1; Table 3).

3.2.1. Morbidity and mortality in relation to pathogen/toxin

Salmonellas accounted for the majority of people affected (22,585; 57%), and most of the hospital admissions and deaths. Outbreaks of viral gastroenteritis were often larger than those attributed to other pathogens/toxins (mean 37 people affected vs. 22 people affected; $p < 0.001$) but few hospital admissions and no deaths were reported as a result of these outbreaks. Outbreaks of VTEC O157 infection were responsible for the highest mean number of hospital admissions (4.1 vs. 1.2; $p < 0.001$).

3.3. Outbreak setting

The majority of foodborne outbreaks occurred in or were linked to commercial catering premises (canteens, halls or caterers, hotels, mobile caterers, public houses or bars, shop/caterers and restaurants; Table 4). Residential settings (armed service bases, holiday camps and residential homes) (Kessel et al., 2001) and private homes accounted for the majority of the remainder. The number of outbreaks linked to the most commonly reported locations declined during the surveillance period.

3.3.1. Outbreak setting in relation to pathogen/toxin

Salmonellas (46%) and *Cl. perfringens* (11%) were most commonly implicated organisms in outbreaks linked to

Table 2c
Foodborne outbreaks of salmonellosis reported to CDSC, England and Wales 1992–2003 (Breakdown by the most frequently reported *Salmonella* Enteritidis non-PT4 phage types by year)

Year	Phage type (row %)							Total
	6	1	14B	24	6A	8	Other	
1992	–	1 (11)	–	2 (22)	–	2 (22)	4 (44)	9
1993	2 (15)	3 (23)	–	3 (23)	–	1 (8)	4 (31)	13
1994	4 (40)	1 (10)	–	–	–	1 (10)	4 (40)	10
1995	1 (14)	3 (43)	–	–	–	–	3 (43)	7
1996	5 (28)	3 (17)	–	2 (11)	2 (11)	1 (6)	5 (28)	18
1997	10 (29)	1 (3)	1 (3)	1 (3)	5 (14)	1 (3)	16 (46)	35
1998	1 (7)	1 (7)	1 (7)	–	4 (27)	1 (7)	7 (47)	15
1999	3 (27)	1 (9)	1 (9)	–	1 (9)	2 (18)	3 (27)	11
2000	3 (50)	–	1 (17)	–	1 (17)	–	1 (27)	6
2001	6 (40)	–	–	1 (7)	1 (7)	2 (13)	5 (33)	15
2002	–	1 (7)	3 (21)	–	1 (7)	–	9 (64)	14
2003	3 (10)	6 (20)	7 (23)	1 (3)	2 (7)	3 (10)	8 (27)	30
Total	38 (21)	21 (11)	14 (8)	10 (5)	17 (9)	14 (8)	69 (38)	183

Table 3
Foodborne general outbreaks of IID reported to CDSC, England and Wales 1992–2003 (morbidity and mortality in relation to implicated pathogen/toxin)

Pathogen/toxin	Number of outbreaks	Affected[a]				Hospitalised[b]				Died[c]			
		Min	Max	Sum	Mean	Min	Max	Sum	Mean	Min	Max	Sum	Mean
Salmonella spp.	910	2	530	22585	24.8	0	65	1218	1.8	0	10	56	0.1
Cl. perfringens	211	2	300	4398	21	0	16	28	0.3	0	2	7	0.1
Viruses	126	2	200	4620	36.7	0	3	17	0.2	–	–	–	–
Campylobacter spp.	67	2	110	1383	20.6	0	3	9	0.2	–	–	–	–
Scombrotoxin	52	2	46	277	5.3	0	10	57	1.5	–	–	–	–
VTEC O157	45	2	114	657	14.6	0	28	169	4.1	0	2	5	0.1
Bacillus spp.	43	2	106	358	8.3	0	2	2	0.1	–	–	–	–
Staph. aureus	25	2	125	433	18.0	0	13	28	2.3	–	–	–	–
Mixed/other/unknown	250	2	113	4914	19.7	0	21	45	0.2	–	–	–	–
Total	1729	2	530	39625	23.0	0	65	1573	1.3	0	10	68	0.1

Data available for [a]1729, [b]1187 and [c]1043 outbreaks.

Table 4
Foodborne general outbreaks of IID reported to CDSC, England and Wales 1992–2003 (outbreak setting by year)

Year	Outbreak location (row %)												Total
	Club/centre	CCP[a]	Community	Farm	Hospital	Other	Private	Residential settings[b]	School	Shop/retailer	University/college	Workplace	
1992	7 (3)	100 (45)	4 (2)	3 (1)	5 (2)	–	46 (21)	27 (12)	6 (3)	20 (9)	5 (2)	1	224
1993	6 (3)	105 (47)	2 (1)	3 (1)	8 (4)	3 (1)	34 (15)	42 (19)	7 (3)	8 (4)	6 (3)	1	225
1994	5 (3)	101 (53)	4 (2)	4 (2)	3 (2)	2 (1)	25 (13)	28 (15)	10 (5)	7 (4)	–	3 (2)	192
1995	7 (4)	109 (60)	2 (1)	2 (1)	–	2 (1)	20 (11)	21 (11)	6 (3)	11 (6)	2 (1)	1 (1)	183
1996	8 (5)	94 (57)	–	5 (3)	1 (1)	2 (1)	26 (16)	16 (10)	3 (2)	9 (5)	1 (1)	–	165
1997	8 (4)	133 (60)	2 (1)	1	4 (2)	4 (2)	26 (12)	29 (13)	4 (2)	9 (4)	2 (1)	–	222
1998	4 (3)	68 (56)	1 (1)	4 (3)	2 (2)	3 (2)	9 (7)	18 (15)	2 (2)	10 (8)	–	–	121
1999	4 (4)	49 (51)	3 (3)	3 (3)	2 (2)	1 (1)	8 (8)	12 (12)	6 (6)	8 (8)	1 (1)	–	97
2000	5 (5)	60 (61)	4 (4)	1 (1)	2 (2)	2 (2)	2 (2)	9 (9)	3 (3)	9 (9)	–	1 (1)	98
2001	9 (12)	48 (62)	1 (1)	–	2 (3)	1 (1)	4 (5)	6 (8)	1 (1)	5 (6)	–	–	77
2002	4 (7)	34 (56)	7 (11)	1 (2)	–	1 (2)	2 (3)	5 (8)	1 (2)	5 (8)	–	1 (2)	61
2003	3 (5)	48 (75)	3 (5)	–	1 (2)	2 (3)	–	5 (8)	–	2 (3)	–	–	64
Total	70 (4)	949 (55)	33 (2)	27 (2)	30 (2)	23 (1)	202 (12)	218 (13)	49 (3)	103 (6)	17 (1)	8 (0)	1729

[a] CCP (commercial catering premises) = canteens, halls or caterers, hotels, mobile caterers, public houses or bars, restaurants and shop/caterer.
[b] Residential settings = armed services, holiday camp, residential home.

commercial catering premises. These two pathogens were also the most common in outbreaks linked to residential settings (52% and 29%, respectively). Three quarters of outbreaks in private households were attributed to salmonellas.

Outbreaks attributed to VTEC O157 were more commonly linked to commercial catering premises (29% $p < 0.001$) farms (22% vs. 1%; $p < 0.001$) and shops/retailers (22% vs. 7%; $p < 0.001$) than other pathogens. The majority

Table 5
Foodborne general outbreaks of IID reported to CDSC, England and Wales 1992–2003 (reported food vehicles by year)

Year	Implicated food vehicle (row %)									Total
	Poultry	Red meat	Fish and shellfish	Salad, fruit and vegetables	Sauces	Desserts	Milk and milk products	Eggs	Rice	
1992	47 (26)	45 (25)	21 (12)	15 (8)	4 (2)	25 (14)	6 (3)	12 (7)	5 (3)	180
1993	35 (26)	41 (30)	13 (9)	6 (4)	5 (4)	26 (19)	4 (3)	7 (5)	–	137
1994	20 (15)	30 (23)	21 (16)	17 (13)	3 (2)	21 (16)	5 (4)	10 (8)	6 (5)	133
1995	30 (21)	31 (22)	25 (18)	5 (4)	6 (4)	21 (15)	6 (4)	9 (6)	8 (6)	141
1996	41 (27)	23 (15)	22 (14)	17 (11)	3 (2)	23 (15)	4 (3)	10 (7)	10 (7)	153
1997	43 (25)	26 (15)	31 (18)	5 (3)	12 (7)	30 (18)	6 (4)	11 (6)	7 (4)	171
1998	21 (24)	15 (17)	12 (14)	6 (7)	7 (8)	16 (18)	3 (3)	6 (7)	2 (2)	88
1999	22 (30)	13 (18)	12 (16)	7 (10)	3 (4)	6 (8)	6 (8)	4 (5)	–	73
2000	14 (24)	12 (21)	10 (17)	9 (16)	2 (3)	7 (12)	2 (3)	–	2 (3)	58
2001	16 (33)	11 (22)	9 (18)	4 (8)	1 (2)	3 (6)	–	4 (8)	1 (2)	49
2002	8 (25)	3 (9)	2 (6)	1 (3)	3 (9)	6 (19)	3 (9)	6 (19)	–	32
2003	6 (20)	2 (7)	2 (7)	4 (13)	–	4 (13)	1 (3)	11 (37)	–	30
Total	303 (24)	252 (20)	180 (14)	96 (8)	49 (4)	188 (15)	46 (4)	90 (7)	41 (3)	1245

of *Bacillus* spp. (81%) and *Campylobacter* spp. outbreaks (66%) were linked to commercial catering premises, as were outbreaks of viral gastroenteritis (63%).

3.3.2. Outbreak setting in relation to morbidity and mortality

Outbreaks linked to commercial catering premises (20,130; 51%), private homes (4353; 11%) and residential settings (3994; 10%) accounted for almost three quarters of the 39,625 people affected, over half of the hospital admissions (37%, 12% and 11%, respectively; 59%) and also over half of the deaths (10%, 3% and 44%, respectively; 57%). Outbreaks in the community tended to be larger than those elsewhere (mean 75 people affected vs. 22 people; $p < 0.001$) whilst those in other settings (mainly day care centres and national outbreaks) were associated with the highest levels of morbidity (mean 8.5 hospital admissions vs. 1.3; $p < 0.001$) and mortality (mean 1 deaths vs. 0.1; $p < 0.001$). Shop/retailers are notable in that despite being associated with outbreaks that affected a relatively small number of people (2983, 8%), these outbreaks resulted in the second highest number of hospital admissions (250; 16%) and also the same number of deaths attributed to outbreaks that occurred in commercial catering premises (7; 3%).

3.4. Food vehicles

In most outbreaks (1011; 60%) one food vehicle was reported, in 159 (9%) two were reported and in 85 (5%) three were reported. In a quarter of outbreaks (429; 25%) it was not possible to identify a food vehicle. Poultry was the most commonly reported food type, followed by red meat, desserts (e.g. mousse, tiramisu and meringue) and fish and shellfish (Table 5). The proportion of outbreaks where red meat/meat products or eggs were reported decreased significantly over the study period ($p < 0.001$ and 0.004, respectively).

Information on the use of raw shell egg was recorded in 223 outbreaks. This ingredient was more often reported in outbreaks where desserts were reported as a vehicle of infection (139/217; 64%) compared with those where it was not (78/217; 36%; $p < 0.001$).

3.5. Food vehicles in relation to pathogen/toxin

Desserts, poultry, red meat and eggs accounted for over three quarters of the *Salmonella* outbreaks (Table 6). The majority of *Cl. perfringens* outbreaks were linked to the

Table 6
Foodborne general outbreaks of IID reported to CDSC, England and Wales 1992–2003 (food vehicles by pathogen)

Pathogen	Food vehicle (row %)									Total
	Poultry	Red meat	Fish and shellfish	Salad, fruit and vegetables	Sauces	Desserts	Milk and milk products	Eggs	Rice	
Viruses	5 (8)	5 (8)	28 (47)	13 (22)	2 (3)	4 (7)	2 (3)	–	–	59
Bacillus spp.	9 (22)	6 (15)	3 (7)	–	1 (2)	2 (5)	–	–	20 (49)	41
Campylobacter spp.	25 (57)	3 (7)	1 (2)	5 (11)	2 (5)	–	8 (18)	–	–	44
Cl. perfringens	64 (33)	104 (54)	3 (2)	9 (5)	6 (3)	3 (2)	–	–	4 (2)	193
Cryptosporidium spp.	–	–	–	–	–	–	1 (100)	–	–	1
VTEC O157[a]	3 (12)	11 (42)	–	2 (8)	–	–	10 (38)	–	–	26
Salmonella spp.	169 (25)	94 (14)	38 (6)	39 (6)	34 (5)	171 (26)	22 (3)	89 (13)	9 (1)	665
Scombrotoxin	–	–	48 (100)	–	–	–	–	–	–	48
Staph. aureus	9 (41)	9 (41)	1 (5)	–	1 (5)	–	–	1 (5)	1 (5)	22
Mixed/other/unknown	19 (13)	20 (14)	58 (40)	28 (19)	3 (2)	8 (5)	3 (2)	–	7 (5)	146
Total	303 (24)	252 (20)	180 (14)	96 (8)	49 (4)	188 (15)	46 (4)	90 (7)	41 (3)	1245

[a] Vero cytotoxin-producing *E. coli* O157.

Table 7
Foodborne general outbreaks of IID reported to CDSC, England and Wales 1992–2003 (food vehicles by outbreak setting)

Outbreak setting	Implicated food vehicle (row %)									Total
	Poultry	Red meat	Fish and shellfish	Salad, fruit and vegetables	Sauces	Desserts	Milk and milk products	Eggs	Rice	
Club/centre	13 (23)	13 (23)	9 (16)	4 (7)	2 (4)	10 (18)	–	4 (7)	2 (4)	57
CCP[a]	177 (26)	114 (17)	129 (19)	66 (10)	36 (5)	85 (13)	10 (1)	26 (4)	34 (5)	677
Community	2 (9)	4 (18)	–	6 (27)	–	1 (5)	4 (18)	5 (23)	–	22
Farm	–	–	–	–	–	–	24 (96)	1 (4)	–	25
Hospital	1 (8)	3 (25)	–	2 (17)	–	1 (8)	1 (8)	4 (33)	–	12
Private	55 (32)	22 (13)	24 (14)	8 (5)	6 (4)	37 (22)	3 (2)	14 (8)	2 (1)	171
Residential settings	23 (17)	47 (36)	4 (3)	4 (3)	2 (2)	19 (14)	3 (2)	28 (21)	2 (2)	132
School	4 (17)	2 (8)	4 (17)	1 (4)	1 (4)	8 (33)	1 (4)	3 (13)	–	24
Shop/Retailer	22 (25)	36 (41)	1 (1)	2 (2)	1 (1)	22 (25)	–	4 (5)	–	88
University/College	3 (19)	3 (19)	4 (25)	1 (6)	–	4 (25)	–	–	1 (6)	16
Workplace	–	2 (50)	–	1 (25)	1 (25)	–	–	–	–	4
Other	3 (18)	6 (35)	5 (29)	1 (6)	–	1 (6)	–	1 (6)	–	17
Total	303 (24)	252 (20)	180 (14)	96 (8)	49 (4)	188 (15)	46 (4)	90 (7)	41 (3)	1245

[a] Commercial catering premises.

consumption of red meats and poultry. Outbreaks of VTEC O157 infection were commonly linked to red meats and milk/milk products whilst poultry and milk/milk products accounted for the majority of *Campylobacter* spp. outbreaks.

3.5.1. Food vehicles in relation to outbreak setting

Poultry, fish and shellfish and red meats were commonly reported in outbreaks linked to commercial catering premises but no one food vehicle dominated (Table 7). Poultry was also the most commonly reported vehicle in outbreaks in private homes. In residential settings red meats, eggs and poultry were most frequently reported.

4. Discussion

One of the major advantages of having collected a standard dataset on outbreaks of IID since 1992 is the ability to examine trends. There has been a marked decline in the number of foodborne outbreaks of IID reported to the CDSC. This is unlikely to be accounted for by reporting fatigue since the number of outbreaks due to other modes of transmission increased almost eightfold. One of the most striking features of the 1992–2003 surveillance period was a marked decline in the number of salmonella outbreaks, especially *S.* Enteritidis PT4. Implicated food vehicles in these outbreaks were predominantly poultry, eggs or desserts. For the latter, raw shell egg was often identified as an ingredient. The declining trend in general outbreaks of *S.* Enteritidis PT4 is encouraging, reflecting a national decrease in sporadic salmonella infection, which is probably due, at least in part, to vaccination of poultry flocks (Gillespie, O'Brien, & Adak, 2001). Falling salmonella outbreaks also means reducing substantially the burden of morbidity and mortality associated with foodborne outbreaks of IID in general and salmonella outbreaks in particular. No other organism stood out in terms of either the number of outbreaks or disease burden save Vero cytotoxin-producing *E. coli* O157 (VTEC O157). Although the number of foodborne outbreaks of VTEC O157 was small, there was substantial associated morbidity.

There was a substantial proportion of outbreaks for which an aetiological agent was known but no food vehicle was identified. Similarly, there were outbreaks where a food vehicle was implicated but no causative organism was found. These two situations almost certainly reflect limitations in investigation (Jones et al., 2004). Identifying a food vehicle through microbiological examination depends very much on the speed with which the outbreak comes to official attention. The longer this takes the less likely it is that the suspected food will be available for examination. Similarly implicating a food vehicle through analytical epidemiology may be affected by recall bias, the longer the interval between outbreak occurrence and investigation.

Though the outbreak dataset in England and Wales is comprehensive, there are inherent weaknesses. The first is that household outbreaks (by virtue of the surveillance definition) and those associated with foreign travel are not included. The rationale for not including household outbreaks arises from lack of clarity concerning the transmission route. Members of the same household may be affected in an outbreak, either because they are all exposed to the same source (i.e. a point source outbreak), or through person-to-person spread between family members. Though contaminated food might be the cause of illness in the index case, others might become affected by infection transmitted person-to-person. Therefore the role of contaminated food in household outbreaks might be over-emphasised in causation.

Another implication of the choice of outbreak case definition is that outbreaks linked to commercial catering premises are more likely to be included in the dataset than outbreaks linked to domestic premises. In a previous review, foodborne outbreaks of IID in the home appeared to occur when individuals catered for slightly larger groups than usual, thus handling, cooking and storing larger quantities of food than normal, probably with inadequate facilities (Gillespie et al., 2001).

The exclusion of outbreaks where disease is acquired abroad is largely pragmatic. However, from the perspective of developing food safety policy within the UK, the most important outbreak data are captured i.e. foodborne disease acquired in the UK.

A second weakness is that the system is passive and is triggered by external reports from CCDCs and EHOs. In its favour, however, are that the response rate to questionnaires has been consistently high throughout the surveillance period, and there is a back-up system for identifying potential outbreaks by means of scrutinising laboratory reports from local laboratories and reference laboratories. Nevertheless, not all outbreaks are captured (Marshall, Wareing, Durband, & Wright, 2000). Moreover in a previous review, information supplied to CDSC by local investigators was found to be variable and tends to be influenced by the individual characteristics of outbreaks such as size and duration, outbreak setting, causative organism, vehicles of infection and time of year (O'Brien et al., 2002).

Despite its weaknesses, the IID outbreak dataset is one of the most comprehensive databases worldwide and, to our knowledge, is unique in containing data on all IID outbreaks no matter what the mode of transmission. The system allows a more reliable evaluation of the contribution of different pathogens, foods, and venues than the highly biased sample represented by published investigations (O'Brien et al., 2006). A second strength of the system is the inclusion of the strength of evidence implicating a food vehicle (O'Brien et al., 2002).

Controlling *Salmonella* in British poultry flocks appears to have made an important contribution to public health in the UK. Improvements in catering, particularly in the commercial catering trade are needed, in order to realise further public health benefits.

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