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The role of outbreaks in developing food safety policy: population based surveillance of salmonella outbreaks in Wales 1986–98

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SUMMARY

In developing public policy on food safety, systematic identification and thorough investigation of all general outbreaks is necessary in order to avoid bias towards highly publicised outbreaks. In Wales, from 1986 to 1998, 87 general foodborne outbreaks of salmonellosis were identified. Most outbreaks occurred at functions or were associated with small catering outlets such as bakeries and sandwich bars. In 50 outbreaks, a vehicle of infection was confirmed microbiologically and/or epidemiologically. The most common food vehicles were those containing shell eggs. *Salmonella enteritidis* outbreaks were significantly more likely than outbreaks of other serotypes to be associated with vehicles containing shell eggs, suggesting that eggs were also the source of infection in many outbreaks. The routine use of analytical epidemiological studies to identify vehicles in outbreaks is recommended.

INTRODUCTION

Outbreaks of foodborne disease have had an important influence on the development of public health policy. The Stanley Royd outbreak of *Salmonella typhimurium* [1] played a significant part in the setting up the Acheson review of the public health function in the United Kingdom [2]. Outbreaks of *Salmonella enteritidis* in the late 1980s fuelled the public alarm which led up to the Richmond Report [3], The Food Safety Act 1990, the establishment of the Advisory Committee on the Microbiological Safety of Food [4], and ultimately to the proposal for a Food Standards Agency [5]. Similarly, following the large verocytoxin producing *Escherichia coli* (VTEC) O157 outbreak in Scotland, wide-ranging recommendations to improve food hygiene have been made [6]. But the features of outbreaks which attract media attention such as size and severity are due in part to chance events such as how many eat the food and the age of those exposed. Such outbreaks, though significant in themselves, do not necessarily reflect the most important risk factors for disease in the general population [7]. Furthermore, most cases are sporadic and not part of recognized outbreaks. To overcome this bias and to enable public policy decisions to be set on a firm evidence base, population surveillance is required to identify systematically and review outbreaks [8] against trends in sporadic cases.

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METHODS

Since 1986, general salmonella outbreaks (outbreaks affecting members of more than one private residence) in Wales (population 2·8 million) have been reported to the Public Health Laboratory Service Communicable Disease Surveillance Centre Wales (CDSC) by microbiologists, public health physicians and environmental health officers. In addition, since 1991 salmonella isolations from all laboratories in Wales, and statutory notifications for food poisoning, have been reviewed weekly to detect clusters of cases. Since 1992 following the Richmond Committee's recommendations [3] CDSC (Wales) has used a standard outbreak surveillance form [9], completed by the lead investigator, to record the main details including date and location, number of cases and number at risk, the vehicle of infection, evidence for identifying vehicle of infection, and faults thought to have contributed to the outbreak. We reviewed these reports together with reports from outbreak control teams, where available, for all salmonella outbreaks between 1986 and 1998. Epidemiological evidence to identify a vehicle was defined as a cohort or case control study where the association between a food and illness was independently significant at the 0·05 level. Microbiological evidence was defined as the isolation of the same strain of salmonella from affected patients and the suspect food items. Circumstantial evidence was defined as descriptive epidemiology linking food(s) with illness. Food vehicles containing (hen's) shell eggs were defined as those which contained eggs purchased in their shells as an ingredient (as opposed to liquid or powdered egg). A raw egg vehicle was defined as a food where the recipe did not include thorough cooking.

RESULTS

From 1986–98, 97 outbreaks were reported with a total of 2961 cases (Fig. 1). This represents 15% of the 19194 total cases in Wales over this period (CDSC Wales, personal communication). Sixty eight outbreaks were caused by *S. enteritidis*, of which 52 were phage type (PT) 4, six were PT6 and 10 were other phage types. Seventeen outbreaks were due to *S. typhimurium*. Phage types reported for 10 of the 17 *S. typhimurium* outbreaks were 204a, DT135, DT170, DT193, PT49, PT66, DT104 (4). The remaining outbreaks were due to *S. dublin* (1), *S. hadar* (1), *S. havana* (1), *S. heidelberg* (1), *S. kedougou*/*S. panoma* (1), *S. montevideo* (3), *S. newport* (1), and *S. virchow* (1). In two outbreaks the serogroup was not recorded.

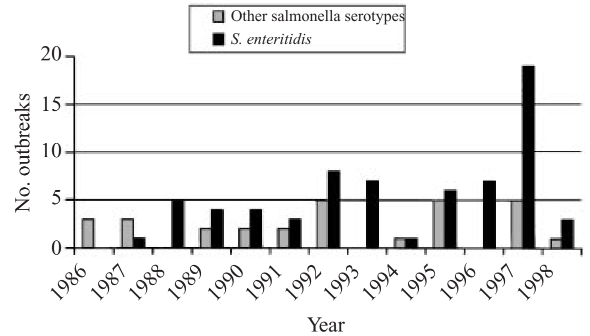

Fig. 1. Number of general salmonella outbreaks per year in Wales: 1986–98.

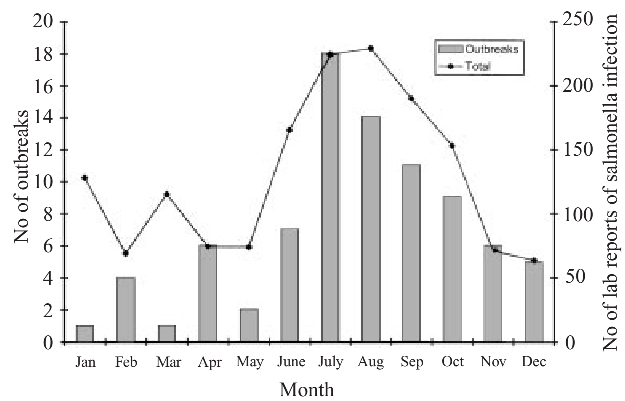

Fig. 2. Salmonella outbreaks 1986–98 and total laboratory reports of salmonella in 1998 in Wales.

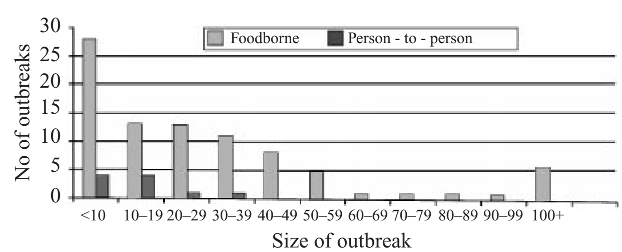

Fig. 3. General outbreaks of salmonella in Wales in 1986–98 by size of outbreak.

The dates of outbreaks ($n = 86$) followed the general seasonal pattern of salmonellosis, with a peak in July (Fig. 2). Outbreaks due to *S. enteritidis* peaked in July and outbreaks due to *S. typhimurium* peaked in September and October.

Ten outbreaks, with 129 cases, all located in hospitals, nursing homes or residential homes for the elderly, were attributed to person-to-person spread (*S. enteritidis* 5, *S. typhimurium* 3, *S. havana* 1, *S. kedougou*/*S. panama* 1). Four of these outbreaks involved fewer than 10 cases (Fig. 3). The average

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Table 1. *Locations of general foodborne salmonella outbreaks in Wales 1986–98*

Location	1986–9	1990–2	1993–5	1996–8	Total (%)
Campsite	0	1	1	0	2
Commercial catering premises	6	5	8	15	34
Community	0	1	3	3	7
Community hall	0	2	0	1	3
Farm	1	0	0	1	2
Hospital	1	1	0	0	2
Military base	1	0	1	0	2
Prison	1	0	0	0	1
Private dwellings	3	1	1	0	5
Nursing/ residential home	0	1	0	6	7
School/college	1	2	0	2	5
Small retail outlets	3	7	4	3	17
Total	17	21	17	28	87

Table 2. *Trends in vehicle identification in foodborne salmonella* outbreaks in Wales 1986–98*

Identification of food vehicle	1986–9	1990–2	1993–5	1996–8	Totals
Strong circumstantial evidence	1(1)[6 %]	1(0)[5 %]	1(1)[5 %]	6(5)[19 %]	9(7)[10 %]
Food microbiology†	8(3)[47 %]	8(6)[38 %]	2(2)[12 %]	2(1)[11 %]	20(12)[25 %]
Epidemiology only	6(6)[35 %]	9(6)[43 %]	6(4)[35 %]	9(9)[29 %]	30(25)[35 %]
Other	2(0)[12 %]	3(2)[14 %]	9(6)[47 %]	14(11)[46 %]	28(19)[30 %]
Total	17(10)[100 %]	21(14)[100 %]	18(13)[100 %]	31(26)[100 %]	87(63)[100 %]

* *S. enteritidis* in parenthesis.
† with or without analytical epidemiological evidence.

number of cases in foodborne outbreaks was 33 (range 2–635).

There were 87 reported foodborne outbreaks at a rate of 2·6 outbreaks/10^6 population per year (80 cases/10^6/year). Twenty-nine (33 %) were at functions such as weddings or parties in pubs, restaurants, community halls or clubs. Of the 17 retail shop outbreaks, 3 were associated with butchers, 11 with bakeries or sandwich bars and 3 were specialist takeaway outlets (Table 1). There were no outbreaks associated with other retail outlets such as supermarkets. Seven community clusters of cases were presumed outbreaks, but no common source of food was identified. There were twice the number of outbreaks in commercial catering premises from 1993–8 as there were from 1986–92, and the proportion of all outbreaks in this category also increased significantly ($\chi^2 = 4{\cdot}13$, $P < 0{\cdot}05$).

Food vehicles

A specific food vehicle was implicated in 44 (70 %) of the 63 foodborne *S. enteritidis* outbreaks and in 15 (63 %) of the 24 other outbreaks (Table 2). In 50 (57 %) outbreaks there was strong microbiological and/or epidemiological evidence to implicate a specific vehicle. The success rate in identifying a vehicle fell from 82 % (31/38) in the period 1986–92 to 39 % (19/49) from 1993–8 ($P < 0{\cdot}001$). This was explained mainly by a fall in all types of outbreak setting in the numbers of outbreaks where there was positive food microbiology. Case-control or cohort studies were carried out in 45 outbreaks, and in 35 (78 %) one or more food vehicles were confirmed by significantly elevated odds ratios or relative risks (Table 3).

In 8 (16 %) of the 50 outbreaks raw egg was an ingredient of the food vehicle (Table 4). These foods were cassata/ice cream (2), cheesecake (1), egg mayonnaise sandwiches (2) and mousse (3). In another 23 (46 %) of the outbreaks the vehicle contained cooked eggs; these vehicles were scotch eggs (5), egg sandwiches (5), scrambled egg (2), other egg containing foods (11). In two of these outbreaks, two vehicles were both significantly and independently associated with illness (roast beef and eggs-à-la-russe; chicken, and egg sandwiches). Vehicles in other outbreaks were beef and chicken (1), chicken (3), pork

Table 3. *Case-control and cohort studies carried out as part of investigation of general salmonella outbreaks in Wales, 1986–98 indicating the main suspected vehicle*

			Case-Control			Cohort			
Place of outbreak [reference]	Vehicle suspected	No of cases	Cases exp/total	Control exp/total	O/R (lower 95% CI)	Exp ill/total	Not exp ill/total	RR (lower 95% CI)	*P*
Hospital staff [10]	Chicken	197				182/213	15/54	3·1 (2·0)	⩽ 0·001
Pub [11]	Egg sandwiches	3				3/7	0/17	–	< 0·05
Prison [11]	Scrambled egg	22	17/20	18/37	6·0 (1·3)				< 0·05
Hospital staff [12]	Scotch eggs	17	10/11	1/15	140 (5·8)				⩽ 0·001
Home party [12]	Cheesecake	5				5/6	0/5	–	< 0·05
Restaurant [12]	Egg sandwiches	37	6/36	0/57	–				< 0·01
Pub [11]	Egg mayonnaise	43				27/31	16/30	1·6 (1·1)	< 0·01
Home party	Sea trout with raw egg stuffing	12				12/12	0/2	–	< 0·05
College	Egg mayonnaise	65	16/19	0/47	–				⩽ 0·001
Hospital [13]	Beef rissoles with egg binding	109				87/190	13/82	2·9 (1·7)	⩽ 0·001
Campsite	Lemon meringue	42				40/41	0/7	–	⩽ 0·001
Shop	Custard slices	57	27/34	9/57	20·6 (6·2)				⩽ 0·001
Golf Club	Eggs	28				15/25	13/48	2·2 (1·3)	< 0·05
	Beef					23/48	5/25	2·4 (1·0)	< 0·005
Hotel	Turkey	21				21/24	0/1	–	0·16
Bakery [14]	Custard slices	22	16/22	8/56	16 (4·2)				⩽ 0·001
Community	'Ice cream van'	32	17/22	7/12	2·4 (0·4)				0·27
Bakery [14]	Rolls and cakes	52	13/27	0/41	–				⩽ 0·001
Club	Chicken pieces	38				N/A	N/A		
Residential home	Custard slices	20	11/12	9/22	15·9 (1·6)				< 0·01
Community Hall	Scotch eggs	26				15/24	7/26	2·3 (1·2)	< 0·05
Club	Scotch eggs	41				26/42	8/60	4·6 (2·3)	⩽ 0·001
Butcher	Pre-cooked ham	28	12/20	4/34	11·3 (2·4)				⩽ 0·001
Bakery	Custard slices	35	22/32	5/59	23·8 (6·5)				⩽ 0·001
Bakery	Fresh cream cakes	34	9/21	1/22	15·8 (1·6)				< 0·01
Comm hall	Chicken drumsticks	16				11/26	0/14	–	< 0·01
Retail	Egg sandwiches	53	5/5	20/67	–				< 0·01
Pub/Rest	Egg foods	10				3/3	7/12	1·7	0·5
Takeaway	Egg mayo sandwiches	74				23/29	12/27	1·8 (1·1)	< 0·05
Army	Roast pork	39	16/33	14/73	4·0 (1·5)				< 0·01
Hotel	Scotch eggs	50				41/70	10/68	4·0 (2·2)	⩽ 0·001
Campsite [15]	Lemon meringue	46				42/42	3/6	2·0 (0·9)	< 0·01
Domestic	Raw egg/strawberry mousse	21				13/21	8/40	3·1 (1·5)	< 0·01
Take away [16]	Kebabs	52	11/22	6/41	5·8 (1·5)				< 0·01
Hotel	Scotch egg	46				N/A	N/A		
Pub/rest	Chocolate mousse	33				11/15	20/83	3·0 (1·9)	< 0·001
Hotel	Chicken bites	42				35/55	6/30	3·2 (1·5)	< 0·001
Club	Turkey	31				N/A	N/A		
Pub/rest.	Raw egg pastry	19				18/20	1/8	7·2 (1·1)	⩽ 0·001
Res. Home	Scrambled egg	15				5/7	10/27	1·9 (1·0)	0·20
Pub/rest	Sausages	22				12/22	1/6	3·3 (0·5)	0·17
Pub/rest	Cauliflower cheese	15	N/A	N/A					
Club	Egg sandwich/roll	46				40/41	7/25	4·7 (2·0)	⩽ 0·001
Retail	Not known	7	N/A	N/A					
School/coll	School made cakes	20	7/17	1/14	9·1 (0·8)				< 0·05
School/coll	Proprietary dessert	50				N/A	N/A		

Table 4. *Trends in salmonella* outbreaks associated with eggs 1986–98*

	1986–9	1990–2	1993–5	1996–8	Totals
Vehicle contains cooked shell egg	7(6)[50%]	9(7)[53%]	3(2)[38%]	4(4)[36%]	23(19)[46%]
Vehicle contains raw shell egg	2(2)[14%]	1(1)[6%]	3(3)[38%]	2(2)[18%]	8(8)[16%]
Other vehicle	5(1)[29%]	7(4)[41%]	2(1)[25%]	5(4)[45%]	19(10)[38%]
Total	14(9)[100]	17(12)[100]	8(6)[100]	11(10)[100]	50(37)[100]

* *S. enteritidis* in parentheses.

(2), other cooked meats (2), turkey (2), yoghurt dressing (1), cauliflower cheese (1), rolls and cakes (3), raw milk (1) and dessert (1).

In 27 (73%) of 37 *S. enteritidis* outbreaks, the vehicle contained raw ($n = 8$) or cooked shell eggs ($n = 19$), compared to 4 of 13 non-enteritidis outbreaks (OR = 6·1:1·3–30·9, $P \leqslant 0·05$); none of these 4 contained raw egg.

DISCUSSION

Much attention has been focussed on the prompt investigation of outbreaks in order to prevent further cases and to identify routes of transmission and risk factors [17, 18]. More recently computational methods for the rapid identification of outbreaks from population surveillance data have been developed [19, 20]. Less attention has been given to the use of outbreaks as surveillance events [8]. Caution is needed before generalizing from unusual outbreaks which have attracted media attention since there is a potential ascertainment bias akin to the publication bias when relying solely on published papers in meta analyses [21]. But systematic investigation of outbreaks within the framework of a comprehensive population surveillance system can be a powerful public health tool. Such systematic investigations played an important part in establishing hens' eggs as a major cause of the *Salmonella enteritidis* pandemic in the 1980s and 1990s [9, 22].

In Wales, population surveillance identified 87 suspected general foodborne salmonella outbreaks in 13 years. Most general outbreaks occurred in establishments catering for functions, or in small retail bakeries and sandwich shops. There was some indication of an increasing trend of such outbreaks both in absolute numbers and as a proportion of all outbreaks. None were associated with large retail outlets. In over half of these outbreaks case-control or cohort studies were carried out as part of the outbreak investigation. The commonest vehicle of infection was food containing shell eggs.

The validity of generalizing from this outbreak picture to foodborne salmonellosis in the population as a whole needs to be examined carefully. Firstly, it has to be acknowledged that outbreak ascertainment is subject to bias. Outbreaks occurring amongst large groups at functions such as weddings will be more readily recognized and reported than outbreaks from foods distributed widely in the community. Paradoxically, in the latter situation outbreaks of rare serotypes are more likely to be identified than commoner serotypes. Therefore it is likely that many more outbreaks of this type go undetected.

The attribution of outbreaks to egg-containing foods may also be subject to biases arising from the beliefs of the investigators [23]. However, well conducted case-control or cohort studies should overcome this bias if all possible foods available to cases are investigated. In our series, *Salmonella enteritidis* outbreaks were no more likely to be investigated thoroughly than other serotypes, and no more likely to have case-control or cohort studies applied. The association between *Salmonella enteritidis* outbreaks and food vehicles containing eggs is therefore not explicable by biased investigation. In any single outbreak, cross-contamination from a non-egg source to an egg-containing vehicle could be postulated, but the cumulative picture cannot be explained in this way [22], since there is no reason to suppose egg containing foods were more likely to be contaminated, unless from the raw eggs and shells. Our conclusion is that eggs were the probable source and not just the vehicle in most of these outbreaks. Our data are consistent with the results of two case-control studies [11, 24] in Wales, the most recent in 1996, and with the results of the PHLS microbiological survey of *S. enteritidis* in retail purchased eggs [25].

Overall, 62% of outbreaks were attributed (by microbiological or epidemiological evidence) to a vehicle which contained shell egg. In eight outbreaks the food vehicle contained raw egg, which suggests that Government advice on the use of raw eggs in catering was not being followed. One interesting feature is the use of egg as a binder in six outbreaks where the food had subsequently been fried. Rapid frying may not raise the internal temperature of the food high enough to kill salmonellas [14].

Given the impact which outbreaks can have on food safety policy, the quality of outbreak investigation is very important [18]. Factor which can influence success rates in identifying vehicles of infection include sensitivity of surveillance systems to identify outbreaks, the preparedness and expertise of the investigating team, and the setting of the outbreak. Most outbreaks occurred in catering premises where food is rarely kept for more than a few days, and any remaining infected food has often been discarded by the time the outbreak is recognized. Investigators therefore need to rely more heavily on analytical epidemiological methods. During the period of this study, the use of analytical epidemiology became routine in outbreaks in Wales and it has been consistently successful in identifying food vehicles over the period. This is true despite small numbers of cases in many outbreaks. Our results should encourage investigations to undertake cohort or case-control studies even when sample size is small, since often the strength of association between infection and a food is very high.

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