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Choose your menu wisely: cuisine-associated food-poisoning risks in restaurants in England and Wales

F. J. GORMLEY, N. RAWAL AND C. L. LITTLE*

Department of Gastrointestinal, Emerging and Zoonotic Infections, Health Protection Agency, Health Protection Services – Colindale, London, UK

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SUMMARY

The food service sector continues to be the most common setting for reported foodborne disease outbreaks in England and Wales. Using restaurant-associated foodborne outbreaks reported in England and Wales from 1992 to 2009, cuisine-specific risk factors were examined. Of 677 restaurant outbreaks, there were 11 795 people affected, 491 hospitalizations, and seven deaths; and Chinese, Indian, British and Italian cuisines were the most commonly implicated (26%, 16%, 13% and 10%, respectively). *Salmonella* spp. accounted for most outbreaks of all cuisine types, and particularly Chinese (76%, 133/175) and Italian (55%, 38/69). Poultry meat was the most frequently implicated food vehicle in outbreaks associated with Indian (30%), Chinese (21%), and British (18%) cuisines while for Italian cuisine, desserts and cakes were more frequently implicated (33%). Rice dishes were also a common outbreak food vehicle in those restaurants serving Chinese (22%) and Indian (16%) cuisine. Cross-contamination was the biggest contributory factor associated with Chinese (46%), British (33%) and Indian (30%) cuisines whereas inadequate cooking (38%) and use of raw shell eggs in lightly cooked or uncooked food (35%) were more often associated with Italian cuisine. Over the surveillance period, the proportion of *Salmonella* Enteritidis PT4 outbreaks in restaurants serving Chinese cuisine significantly decreased ($P<0{\cdot}0001$) and this was mirrored by an increase in *S.* Enteritidis non-PT4 outbreaks ($P<0{\cdot}0001$). Despite this change in proportion, contributory factors such as cross-contamination have continued to cause outbreaks throughout the 18 years. The results show that by stratifying the risks associated with restaurants by cuisine type, specific evidence of food control failures can be used to target foodborne illness reduction strategies.

Key words: Epidemiology, food safety, foodborne infections.

INTRODUCTION

The food service sector remains the most significant contributor of reported outbreaks of foodborne disease in England and Wales [1]. Those individuals involved in food preparation and service play a vital role in prevention of foodborne disease, and their actions can be critical in preventing an outbreak of infection. Nevertheless, the food service sector, and in particular restaurant establishments, have been continually highlighted as an area of concern with regard to occurrence of foodborne outbreaks in England and Wales [1–3] as well as the cause of foodborne

* Author for correspondence: Dr C. Little, Department of Gastrointestinal, Emerging and Zoonotic Infections, Health Protection Agency, Health Protection Services – Colindale, 61 Colindale Avenue, London NW9 5EQ, UK.
(Email: christine.little@hpa.org.uk)

infections from studies of sporadic (non-outbreak associated) foodborne disease [4–6]. This is mirrored by UK surveys on consumer attitudes in that 51% of people are concerned about the safety of food sold in food service establishments, and specifically food hygiene when eating out (36%) and food poisoning (29%) [7], although it should be highlighted that the public are generally reticent about apportioning blame to the domestic catering environment. Furthermore, public perception of food risks tend to highlight *Salmonella* as being of greatest concern, owing to the greater media coverage associated with this pathogen [8].

The European Commission regulation on the hygiene of foodstuffs [9] requires businesses to implement a written food-safety management system based on hazard analysis and critical control point principles (HACCP), and to ensure food handlers are trained or instructed in good hygiene practices. To assist smaller businesses in complying with these legislative requirements, the UK Food Standards Agency (FSA) has provided guidance for implementing food-safety management systems and has also tailored these to businesses serving different cuisines [10–12]. Despite the legal requirements and associated guidance, foodborne outbreak contributory factors associated with food service establishments continue to include cross-contamination, inadequate cooking or reheating food, inappropriate storage, and infected food handlers [1, 3]. Microbiological food studies have further identified that the microbiological safety of ready-to-eat food prepared and served at food service establishments are more likely to be of unsatisfactory quality compared to those from retail establishments [13].

The food service sector is one of the largest industries in the UK, with about 263 000 outlets of different establishments, employing a workforce of 1·7 million people. Restaurants alone employ over 526 000 full-time and part-time staff throughout the UK, 82% of which are employed in England. The UK total weekly household expenditure on eating out at restaurants and cafes in 2008 was £796 million [14]. Cuisine derives from the Latin word 'coquere' and means 'to cook', and involves the combination of region-specific ingredients and cooking technique. Restaurants serving particular cuisine types will often utilize specific culinary practice or use foods particular to the cuisine. Whether partly as a result of cultural diversity or from more exotic travel by the UK population, the UK food market is extremely diverse in terms of the range of cuisines available.

Given the preponderance of foodborne outbreaks at restaurants (often serving select cuisine types) an insight on the role of cuisine type and how and why transmission of foodborne disease occurs in restaurants would contribute to developing better prevention measures. The purpose of this study was to identify factors (season, causative agent, vehicles of infection, contributory factors) that distinguish foodborne outbreaks at restaurants serving particular cuisine types in England and Wales reported to the Health Protection Agency (HPA) electronic foodborne and non-foodborne gastrointestinal outbreak surveillance system (eFOSS).

METHODS

Restaurant-linked outbreaks and cuisine

The HPA surveillance system for general foodborne outbreaks of infection in England and Wales has been described in detail previously [1]. Foodborne outbreaks from 1992 to 2009 recorded in HPA eFOSS are classified by setting type. Restaurants were defined as 'an establishment that serves prepared food and beverages to be consumed on the premises'. The definition covered a multiplicity of restaurant venues, including those also offering takeaway and food delivery services, and a diversity of cuisine styles. Restaurant cuisine type, e.g. Chinese, Indian, Italian, was assigned either by the lead outbreak investigator (through completion of the eFOSS standard questionnaire) or through interrogation of business directories by eFOSS curators, using the premise name and address provided on the questionnaire.

Data abstraction and analysis

Foodborne outbreaks were selected where food service establishments were identified as the outbreak setting. These were stratified by food service setting type. Comparisons within the restaurant group in relation to cuisine type, and between this group and other food service settings, were undertaken. Outbreak contributory factor/food vehicle proportion matrices were constructed to weight the associations between components for the major cuisine types. Implicated food vehicles in outbreaks are ready-to-eat foods, unless stated otherwise.

Descriptive analysis was undertaken using χ^2 or Fisher's exact test (depending on population size) and

Table 1. *Foodborne outbreaks associated with restaurants, England and Wales, 1992–2009: cuisine types in relation to pathogen/toxins*

			Restaurant cuisine type										
	Other food service settings	Restaurants	Chinese	Indian	British	Italian	Continental/ European	Seafood	Not known	American	Sandwich bar	Other cuisines	Total
S. Enteritidis non-PT4	58	136	76	4	17	12	4	0	0	0	5	18	136
S. Enteritidis PT4	133	130	48	12	16	20	8	0	3	5	3	15	130
S. Typhimurium	31	29	7	10	1	5	0	0	0	0	2	4	29
Other *Salmonella* spp.	24	21	2	6	5	1	1	0	2	0	2	2	21
Other pathogen/toxin	98	80	8	11	12	13	2	7	8	4	5	10	80
Not known	61	61	5	14	3	6	3	12	4	5	1	8	61
Bacillus spp.	13	50	15	22	0	1	1	0	6	0	0	5	50
Foodborne viruses	130	50	4	2	11	2	4	8	2	3	5	9	50
Campylobacter spp.	34	39	4	7	11	3	3	1	1	0	0	9	39
Clostridium perfringens	79	38	3	11	6	2	2	0	3	3	0	8	38
Scombrotoxin	26	27	0	0	2	4	7	3	0	0	5	6	27
VTEC O157	10	12	1	5	4	0	0	0	1	0	0	1	12
Mixed pathogens	1	4	2	1	0	0	0	0	0	0	1	0	4
Total	698	677	175	105	88	69	35	31	30	20	29	95	677

VTEC O157, verocytotoxin-producing *Escherichia coli*.
Other food service settings include hotels/guest houses ($n=283$), public houses ($n=177$), catered halls ($n=119$), community centres/clubs ($n=98$), private caterers ($n=14$) and mobile vendors ($n=7$).
Other pathogen/toxin, includes *Giardia lamblia*, *Shigella* spp., *Staphylococcus aureus* and shellfish toxins.
Other cuisines, cuisine types in smaller representative numbers (kebab, French, Greek, Spanish, Mexican, Thai, Japanese, Danish, vegetarian) and mixed cuisines (premises serving more than one type of cuisine).

trends were measured using the χ^2 test for trend. In order to test for associations of exposures with the outcome of acquiring an infection caused by different pathogens, single risk variable analysis was performed and odds ratios calculated. Exposures yielding a P value of $<0{\cdot}1$ upon univariate analysis were included in a multivariate logistic regression model to test for independent association ($P<0{\cdot}05$). These analyses were restricted by cuisine type and limited to those types which had a sufficient number of records for analysis ($n\geqslant 10$).

RESULTS

Restaurants: a major source of food poisoning

Of 1375 foodborne outbreaks associated with food service establishments, 677 (49%) were linked to restaurants (Table 1). From 11 795 people affected in these outbreaks, 491 (4·2%) were hospitalized and seven (0·1%) died. By comparison, in non-restaurant food service settings (Table 1) 18 650 people were affected, 329 (1·8%) hospitalized and six (0·03%) died. A greater proportion of restaurant-associated outbreaks were caused by *Salmonella* spp. compared to non-restaurant food service settings (46·7% *vs.* 35·2%, $P<0{\cdot}0001$) (Table 1). Outbreaks caused by *Salmonella* Enteritidis phage types (PT) other than PT4 accounted for much of this (20·1% *vs.* 8·3%, $P<0{\cdot}0001$) while *S.* Enteritidis PT4 were no more common in restaurants (19·2% *vs.* 19·1%, $P=0{\cdot}944$) (Table 1). Similarly, *Bacillus* spp. outbreaks occurred more often in restaurants compared to other settings (7·4% *vs.* 1·9%, $P<0{\cdot}0001$), while the opposite was observed for *Clostridium perfringens* (5·6% *vs.* 11·3%) and foodborne outbreaks of viral gastroenteritis (7·4% *vs.* 19·0%) ($P<0{\cdot}0001$).

As a proportion of all foodborne outbreaks linked to food service establishments, the number of restaurant outbreaks increased between 1992 and 2009 (43/96 to 47/72, $P<0{\cdot}001$). This was driven by outbreaks linked to Chinese cuisine (4/43 to 13/47, $P<0{\cdot}00001$), while Indian and Italian cuisine-linked outbreaks decreased significantly (10/43 to 6/47,

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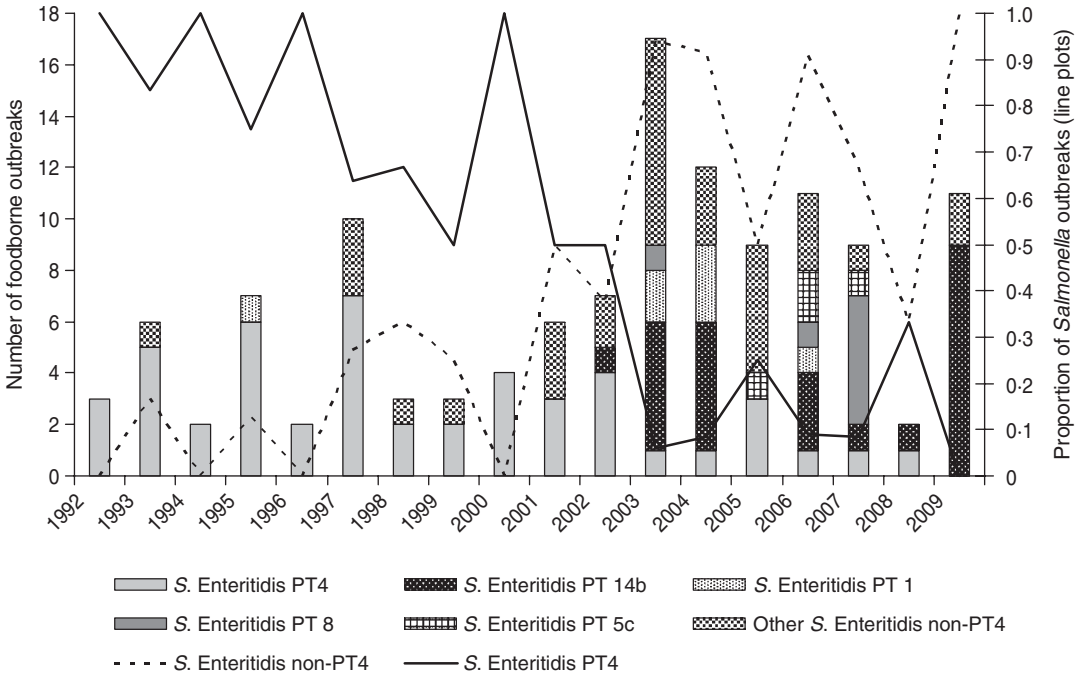

Fig. 1. Change in proportion of *Salmonella* Enteritidis PT4 and non-PT4 outbreaks linked to restaurants serving Chinese cuisine, showing the change in phage-type proportions (England and Wales 1992–2009).

$P=0{\cdot}009$ and 9/43 to 3/47, $P=0{\cdot}00002$, respectively). The proportion of British cuisine-associated outbreaks did not change (4/43 to 5/47, $P=0{\cdot}819$). Most commonly foodborne outbreaks occurred in summer (253/677, 37·4%) with few occurring in spring (105/677, 15·5%).

Cuisine-specific factors

Chinese cuisine was the most common restaurant cuisine type implicated in foodborne outbreaks (175/677, 25·8%), followed by Indian (105, 15·5%), British (88, 13·0%) and Italian cuisine (69, 10·2%) (Table 1).

Chinese cuisine

Salmonella spp. accounted for most of the foodborne outbreaks linked to restaurants serving Chinese cuisine (133/175, 76·0%), followed by *Bacillus* spp. (15/175, 8·6%) (Table 1). Most commonly outbreaks occurred in summer ($n=83$) with fewest in winter ($n=23$).

Between 1992 and 2009, the proportion of outbreaks linked to Chinese cuisine caused by *S.* Enteritidis PT4 decreased while those caused by *S.* Enteritidis non-PT4 increased (Fig. 1). The change in Enteritidis phage-type proportions occurred after 2001 with the number of *S.* Enteritidis PT4 outbreaks decreasing to zero by 2009, while concurrently, *S.* Enteritidis non-PT4 outbreaks increased. The most commonly implicated *S.* Enteritidis non-PT4 strains were *S.* Enteritidis PT14b ($n=25$), PT1 ($n=7$), PT8 ($n=7$) and PT5c ($n=4$).

Rice (39/153, 25·5%), particularly egg fried (20/39, 51·3%), and poultry meat (37/153, 24·2%) were the most frequently implicated food vehicles in the outbreaks (Table 2), while cross-contamination (80/227, 35·2%) and inadequate heat treatment (50/227, 22·0%) were the most common contributory factors (Table 3). All contributory factors were significantly more frequently identified in *S.* Enteritidis outbreaks post-2001 ($P<0{\cdot}05$), with the exception of inappropriate storage conditions (too warm or too long) (11 *vs.* 13, $P=0{\cdot}568$). The proportion of outbreaks linked to consumption of rice or poultry meat did not change over the 18-year period although eggs and egg dishes were more frequently implicated as the outbreak food vehicle post-2001 ($P<0{\cdot}0001$). Comparison of implicated food vehicles with outbreak contributory factors showed that cross-contamination events were most likely to be associated with poultry meat (25·0%), composite/mixed foods (18·8%), rice (17·5%) and eggs/egg dish (16·3%) outbreaks. Inadequate heat treatment was most commonly identified in rice-associated outbreaks (39·5%), while poor hand-washing by food handlers was most often associated

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Table 2. *Foodborne outbreaks associated with restaurants, England and Wales, 1992–2009: implicated food vehicles in relation to cuisine type*

	Poultry meat	Composite/ mixed foods	Crustacea and shellfish	RSE used in uncooked/lightly cooked food*	Rice	Red meat	Dessert, cakes and confectionary	Finfish	Eggs and egg dishes	Vegetables and fruit	Condiments and sauces	Milk and dairy products	Other foods	Total
Chinese	37	28	4	9	39	6	3	0	16	4	4	0	3	153
British	16	7	12	10	0	8	7	6	4	8	5	3	0	86
Indian	32	16	2	1	17	11	0	0	0	5	1	0	1	86
Italian	5	11	4	24	0	5	23	4	5	1	2	1	0	85
Continental/ European	11	2	3	4	1	1	3	7	2	0	1	0	0	35
Seafood	1	0	24	0	0	0	0	3	0	1	0	1	0	30
Sandwich bar	3	11	0	2	0	3	0	5	2	0	2	0	0	28
Not known	2	2	5	0	2	4	0	1	1	4	0	0	0	21
American	3	1	0	1	0	3	1	1	0	2	0	0	0	12
Other cuisines	16	19	12	13	3	10	4	11	6	7	6	1	0	108
Total	126	97	66	64	62	51	41	38	36	32	21	6	4	644

* RSE, raw shell egg as an ingredient.

Other cuisines, cuisine types in smaller representative numbers (kebab, French, Greek, Spanish, Mexican, Thai, Japanese, Danish, vegetarian) and mixed cuisines (premises serving more than one type of cuisine).

with poultry meat (26·7%) and raw shell egg (RSE) used as an ingredient in lightly cooked/uncooked foods (26·7%). Composite/mixed foods were most likely to be associated with poor personal hygiene by food handlers (35·7%). Factors independently associated with *S*. Enteritidis non-PT4 outbreaks linked to Chinese restaurants are presented in Table 4.

Indian cuisine

Most foodborne outbreaks in restaurants serving Indian cuisine were caused by *Bacillus* spp. (22/105, 21·0%), 59·1% of which were *B. cereus* (Table 1). Most Indian cuisine-associated outbreaks occurred in summer and similarly to Chinese cuisine outbreaks involved consumption of poultry meat (32/86, 37·2%) and/or rice (17/86, 19·8%) (Table 2). Contributory factors in these outbreaks were primarily cross-contamination (32/105, 30·5%), inappropriate storage (27/105, 25·7%) and inadequate heat treatment (21/105, 20·0%) (Table 3). Poultry meat was most frequently linked to inadequate heat treatment (61·9%), inappropriate storage (48·1%) and cross-contamination events (37·5%) and rice was commonly implicated in outbreaks where inappropriate storage was identified (29·6%). Factors independently associated with pathogens linked to outbreaks in restaurants serving Indian cuisine are presented in Table 4.

British cuisine

While *S*. Enteritidis non-PT4 and PT4 accounted for the plurality of foodborne outbreaks linked to restaurants serving British cuisine (17/88 and 16/88, respectively), *Campylobacter* spp. (11/88, 12·5%) and foodborne viruses (exclusively norovirus) (11/88, 12·5%) contributed the plurality of the remainder (Table 1). Again, most outbreaks occurred in summer and in addition to poultry meat (16/86, 18·6%), crustacea and shellfish (12/86, 14·0%), and RSE (10/86, 11·6%) were commonly identified food vehicles (Table 2). Cross-contamination was the most frequently identified outbreak contributory factor (29/88, 33·0%), followed by infected food handlers (21/88, 23·9%) (Table 3). Outbreaks associated with poultry meat consumption were frequently associated with poor personal hygiene by food handlers (42·9%), poor hand-washing facilities (40·0%), inadequate heat treatment (35·0%) and inappropriate storage (31·3%), while RSE were most frequently associated

Table 3. *Foodborne outbreaks associated with restaurants, England and Wales, 1992–2009: contributory factors in relation to cuisine type*

	Outbreak contributory factors*						
Cuisine type	Cross contamination	Inadequate heat treatment/ cooking	Storage too long/too warm	Infected food handler	Poor personal hygiene	Poor hand washing facilities	Total
Chinese	80	50	38	30	14	15	227
Indian	32	21	27	18	6	8	112
British	29	20	16	21	7	5	98
Italian	15	26	13	10	2	1	67
Sandwich bar	14	5	9	11	2	2	43
Continental/ European	11	12	10	6	2	1	42
Not known	3	2	3	5	2	1	16
American	2	4	4	4	1	0	15
Seafood	1	4	1	4	0	0	10
Other cuisines	29	31	24	13	5	5	107
Total	216	175	145	122	41	38	737

* More than one contributory factor can be recorded in an outbreak, therefore the total is more than the total number of restaurant associated outbreaks.
Other cuisines, cuisine types in smaller representative numbers (kebab, French, Greek, Spanish, Mexican, Thai, Japanese, Danish, vegetarian) and mixed cuisines (premises serving more than one type of cuisine).

with inadequate heat treatment (35·0%). Crustacea and shellfish were most commonly associated with inadequate heat treatment (10·0%) and infected food handlers (9·5%). Factors independently associated with pathogens linked to outbreaks in restaurants serving British cuisine are presented in Table 4.

Italian cuisine

S. Enteritidis PT4 accounted for most outbreaks linked to Italian cuisine (20/69, 29·0%) (Table 1). Most outbreaks occurred in the summer and RSE (24/85, 28·3%) and desserts, cakes and confectionery (23/85, 27·1%), particularly tiramisu (19/23, 82·6%), were the most commonly identified food vehicles (Table 2). Inadequate heat treatment was the most commonly identified outbreak contributory factor (26/69, 37·7%) (Table 3). Cross-contamination was most frequently associated with RSE (26·7%) and desserts, cakes and confectionery (26·7%). Inadequate heat treatment was also associated with both of these food vehicles (69·2% and 65·4%, respectively). Composite/mixed foods and RSE were the most frequently implicated food vehicles in outbreaks where inappropriate storage was identified (46·1% and 30·8%, respectively). Factors independently associated with pathogens linked to outbreaks in restaurants serving Italian cuisine are presented in Table 4.

Other cuisines

Continental/European cuisine (i.e. restaurants serving a mixture of individual European countries' cuisine, e.g. French, Spanish, Italian, Turkish) was the fifth most common cuisine type identified (35/677, 5·2%) and most outbreaks were caused by *S*. Enteritidis PT4 (8/35, 22·9%) followed by Scombrotoxin (7/35, 20·0%) (Table 1). Outbreaks linked to restaurants serving Continental/European cuisine decreased between 1992 and 2009 ($P=0·02$). Poultry meat (11/35, 31·4%) and finfish (7/35, 20·0%) (Table 2) were the most frequently implicated food vehicles while inadequate heat treatment (12/42, 28·6%), cross-contamination (11/42, 26·2%) and inappropriate storage (10/42, 23·8%) were commonly identified as contributory factors.

Norovirus was reported in 25·8% (8/31) of seafood-associated outbreaks and viruses were suspected in 19·4% (6/31) of the seafood outbreaks of unknown aetiology. Combined therefore, viruses were the confirmed or suspected agent in 45·2% of seafood outbreaks. Most seafood outbreaks occurred in winter (19/31, 61·3%) and 80% (24/30) were associated with consumption of oysters (Table 2). Seafood outbreaks increased overall between 1992 and 2009 ($P<0·0001$).

Despite accounting for only 14 (2·1%) foodborne outbreaks reported between 1992 and 2009.

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Table 4. *Foodborne outbreak independent associations stratified by cuisine type logistic regression analysis*

Cuisine	Organism (outcome)	Exposure	OR	95% CI	*P* value
Chinese	*S.* Enteritidis non-PT4	Autumn occurrence	3·87	1·47–10·15	0·006
		Composite/mixed foods	2·74	1·13–6·69	0·026
		Summer occurrence	2·79	1·20–6·48	0·017
		RSE	8·63	0·93–80·56	0·058
		Inadequate heat treatment	2·93	1·32–6·50	0·008
		Eggs/egg dishes	5·01	1·18–21·22	0·029
Indian	*S.* Enteritidis PT4	Poultry meat	3·71	1·04–13·18	0·043
		Spring occurrence	3·90	1·04–14·68	0·044
	Bacillus spp.	Inadequate heat treatment	0·05	0·003–0·87	0·04
		Rice	67·30	11·87–381·64	<0·0001
		Composite/mixed foods	5·04	1·07–23·80	0·041
	Clostridium perfringens	Red meat	27·90	3·40–228·75	0·002
		Inadequate heat treatment	12·10	1·89–77·91	0·008
		Autumn occurrence	10·30	2·11–49·77	0·004
British	*S.* Enteritidis non-PT4	Eggs/egg dishes	42·00	3·51–502·02	0·003
		Condiments and sauces	34·40	3·00–393·21	0·004
		Autumn occurrence	5·77	1·48–22·51	0·012
	S. Enteritidis PT4	Desserts, cakes and confectionary	13·00	2·22–75·47	0·004
	Foodborne viruses	Infected food handler	13·50	2·59–70·63	0·002
Italian	*S.* Enteritidis PT4	RSE	4·63	1·53–13·98	0·007
	S. Enteritidis non-PT4	Desserts, cakes and confectionary	21·40	2·16–212·34	0·009
		Eggs/egg dishes	145·00	5·53–3807·39	0·003
		Autumn occurrence	8·71	1·49–50·82	0·016

OR, Odds ratio; CI, Confidence interval; RSE, raw shell egg.

S. Enteritidis non-PT4 was responsible for half of these (7/14, 50·0%) (Table 1) and while a variety of food vehicles were implicated (Table 2), cross-contamination was the most common contributory factor identified (10/27, 37·0%) (Table 3).

DISCUSSION

Despite the downward trend in the number of foodborne outbreaks reported in England and Wales over the last two decades [1], the proportion of reported outbreaks linked specifically to restaurants has increased. In seeking to interpret the role of restaurants as an important source of foodborne infection in England and Wales it is important to bear in mind outbreak ascertainment and investigation and their potential to distort the role of certain settings. Foodborne outbreaks occurring in restaurants may be reported more often than those occurring in other settings as affected people may be more inclined to attribute illness to eating food outside the home than to other potential sources [15, 16]. The scale of food preparation in restaurants also means that any breakdown in food safety may be amplified making contaminated food available to a large number of consumers, leading to more illnesses and a greater likelihood of recognition compared to food sold or served at other settings. They might also be more likely to be investigated by public or environmental health professionals and hence reported to national surveillance. Nevertheless, there is no denying that these outbreaks in England and Wales took place; and to our knowledge, the current study is the first to stratify analyses by cuisine type to describe and differentiate restaurant foodborne outbreaks thus providing evidence of specific food safety associations and trends in food safety.

Restaurants serving Chinese cuisine accounted for a quarter of restaurant-linked outbreaks and increased significantly over the surveillance period. Commercial UK market data indicates that Chinese restaurants ranked third as the most visited restaurant type, with an estimated 45% of the population dining here. Ranked top was the traditional British fish and chip shop (50%), followed by British pub restaurant fare (46%), while Indian cuisine ranked fifth (31%) [17]. *Salmonella* spp. accounted for three-quarters of outbreaks linked to Chinese cuisine and given the type of

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meals served in such restaurants, consumption of poultry meat and egg fried rice were unsurprisingly most commonly implicated with cross-contamination and inadequate heat treatment the most frequently identified outbreak contributory factors. Stratification by *S*. Enteritidis phage type revealed that a significant decline in outbreaks caused by *S*. Enteritidis PT4 was mirrored by an increase in those caused by *S*. Enteritidis non-PT4 (mainly PT1 and PT14b) post-2001. In line with this shift in epidemiology of *Salmonella*, egg-associated outbreaks also increased in Chinese restaurants giving strength to the independent association observed with the use of shell eggs. Furthermore, independent associations with inadequate cooking and summertime (where ambient temperatures are higher) demonstrate the risks associated with Chinese restaurants. There is long established national guidance on the safe handling and use of eggs, including the use of pasteurized egg in lightly cooked or uncooked food [18–21]. The findings from our study reaffirm that government advice has not been followed.

Once a problem in the UK, vaccination of UK layer flocks against *S*. Enteritidis PT4 has virtually eliminated these outbreaks and also driven down the number of UK reported sporadic cases of *S*. Enteritidis PT4 [22]. The emergence of egg-associated *S*. Enteritidis non-PT4 causing human infection is of particular importance. These outbreaks were associated with substantive changes in market supply and sourcing of eggs from egg producers in other EU countries, where there was a lack of vaccination of layer flocks against *Salmonella* or controlled assurance [23]. Almost all non-UK eggs are destined for processing or for use in the food service sector [23]. Therefore the potential for inherent contamination of these eggs coupled with poor preparation of eggs and egg dishes in restaurants (including the use of large numbers of eggs and the practice of breaking, pooling, and mixing eggs before use) increase the food-poisoning risks associated with restaurants carrying out such practices, such as those serving Chinese cuisine [24]. A recent UK survey of food hygiene ratings given to restaurants by local authorities has further demonstrated that those serving Chinese cuisine were more likely to fail all legal requirements (55%) aimed at preventing food poisoning in consumers compared to other ethnic cuisines and fast-food restaurants [25]. The investigators concluded that the increased risk was the result of culture and difficulties with language, through lack of understanding of food laws and environmental health practitioners' instructions.

The preponderance of *Bacillus* spp. outbreaks linked to Indian restaurants and the independent associations with rice concur with evidence from microbiological investigations of cooked rice served at UK restaurants that suggested rice from Indian restaurants to be of poorer microbiological quality than that of Chinese restaurants [26]. The degree of contamination of cooked rice with *B. cereus* and other *Bacillus* spp. was directly related to the temperature of storage and length of time the rice was kept before serving. Spores of *B. cereus* often present in uncooked rice will survive boiling, germinate and multiply to high numbers in rice and produce emetic toxins when left long enough at room temperature. Reheating the rice prior to serving will not inactivate the toxin and render the product safe. The association of poultry with Indian cuisine was most clearly demonstrated with *S*. Enteritidis PT4 outbreaks and suggests that a greater appreciation of the need to sufficiently cook and safely handle poultry meat is required. With regard to the safe cooking and handling of rice, poultry meat and other foodstuffs prepared in restaurants the UK FSA has produced the Safer Food Better Business (SFBB) guidance. Developed in line with the FSA foodborne disease reduction strategy, it is designed to protect public health through improved food safety and hygiene practices at these premises, implemented and maintained in line with HACCP principles [10–12].

The high number of outbreaks of campylobacteriosis in British restaurants were primarily the result of a recent upsurge in those specifically linked to consumption of poultry liver pâté dishes and indicated that inappropriate culinary practice (in this case deliberate undercooking of the liver) presents an unacceptable risk to the consumer [27]. Although guidance by the UK FSA has been relayed to caterers describing how to thoroughly cook poultry livers [28], the continued preponderance of these outbreaks in 2010 suggest that more targeted guidance needs to be conveyed to chefs and caterers. It is generally accepted that poultry meat is the predominant source of human campylobacteriosis and control of this organism in poultry meat is a major public health strategy for the prevention of campylobacteriosis [29]. A UK *Campylobacter* risk management programme has been developed by the FSA to reduce levels of *Campylobacter* in UK-produced chicken and will be measured against reduction targets by 2015 [29, 30].

Norovirus outbreaks in restaurants serving British and seafood cuisine were in the main linked to shellfish consumption, notably oysters. In restaurants serving seafood cuisine, most outbreaks of unknown aetiology were suspected to be norovirus, and collectively, norovirus (and suspected norovirus) outbreaks were significantly more prominent in winter. This follows the same seasonal trend as the norovirus epidemiology in the general population [31, 32]. Eating raw or live oysters, considered a delicacy, carries a risk of norovirus infection by their nature of filter feeding and accumulating the virus within their flesh and gut [33, 34]. As a result, norovirus is extremely difficult to remove from contaminated shellfish [32]. Draft proposed Codex (2010) guidelines [35] state that there are no validated post-harvest risk management options and this therefore places the emphasis on effective control strategies for the prevention of contamination. In early 2011, the FSA issued consumer advice on oysters via their website [36]. However, to ensure that consumers can make an informed choice with regard to these products and are adequately informed about the associated risks, consideration should also be given to providing information on restaurants menus that consumption of raw or live bivalve molluscs is a risk factor for contracting acute gastroenteritis particularly caused by norovirus.

Food handlers may also contaminate food if they are working while they are still infectious, and we observed an independent association between norovirus outbreaks and infected food handlers in British cuisine restaurants. This finding suggests that food handlers may not fully appreciate the importance of remaining away from work while ill with gastrointestinal symptoms, that illness in food handlers is not being effectively monitored, or that commitment is lacking to enforce policies regarding ill food handlers. The problem may be exacerbated by the reluctance of employers to provide sickness pay to restaurant staff. A feature of norovirus infection is projectile vomiting, which enables aerosols with high infectivity to be carried over a wide area. Virus particles are difficult to eliminate from kitchens, and can easily be transferred onto foods from contaminated surfaces, utensils or hands. Application of good basic food hygiene would greatly reduce the risk of transmission via infected food handlers as well as reinforcing the importance of remaining away from work while ill with gastrointestinal symptoms [37].

Our analyses have shown that the risk for foodborne illness in restaurants depends both on the presence of a specific source of contamination and food-handling malpractices that allow its transmission. Clearly, *Salmonella* outbreaks have continued to play a major role in food poisoning linked with this sector, and although the relative proportions of infectious phage types have changed, food vehicles such as eggs and poultry, and factors such as cross-contamination and undercooking remain pertinent yet preventable issues. By using cuisine type as a surrogate for other inclusive factors, distinctions on the risk of foodborne illness were made between restaurants serving different cuisines. Despite the availability of food safety guidance tailored to restaurants and other food service businesses [10–12, 20, 21, 36–39], they continue to present a major risk of foodborne illness to consumers when lapses in food safety occur.

Studies have shown that restaurant managers are more likely to have a more thorough knowledge of food safety and prevention of foodborne illness than their staff [40]; and that trained food handlers have a greater knowledge of food safety than non-trained staff [41]. The use of casual and part-time restaurant staff therefore requires strong management to ensure staff are trained adequately and adhere to food safety controls. Seaman & Eves [42] have demonstrated that most UK food industry managers are aware of their responsibilities to train food handlers, but often do not provide adequate support to promote the enactment of safe food-handling practices, or evaluate its effectiveness. Any positive effects gained from food hygiene training programmes are therefore short-lived. This emphasizes the important role of local food authorities in ensuring that effective training and safe food-handling procedures are consistently followed to reduce the risk of foodborne illness. This, however, ultimately relies on centrally issued advice being adopted locally and factored into programmed food hygiene inspections and the continued surveillance to monitor changes.

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DELARATION OF INTEREST

None.

REFERENCES

1. **Gormley FJ, *et al.*** A 17-year review of foodborne outbreaks: describing the continuing decline in England and Wales (1992–2008). *Epidemiology and Infection* 2011; **139**: 688–689.
2. **Evans HS, *et al.*** General outbreaks of infectious intestinal disease in England and Wales: 1995 and 1996. *Communicable Disease and Public Health* 1998; **1**: 165–171.
3. **Hughes C, *et al.*** Foodborne transmission of infectious intestinal disease in England and Wales, 1992–2003. *Food Control* 2007; **18**: 766–772.
4. **Friedman CR, *et al.*** Risk factors for sporadic Campylobacter infection in the United States: A case-control study in FoodNet sites. *Clinical Infectious Diseases* 2004; **38**: 285–296.
5. **Kimura AC, *et al.*** Chicken consumption is a newly identified risk factor for sporadic Salmonella enterica serotype Enteritidis infections in the United States: a case-control study in FoodNet sites. *Clinical Infectious Diseases* 2004; **38**: 244–252.
6. **Rodrigues LC, *et al.*** The study of infectious intestinal disease in England: risk factors for cases of infectious intestinal disease with *Campylobacter jejuni* infection. *Epidemiology and Infection* 2001; **127**: 185–193.
7. **Food Standards Agency (FSA): Social Science Research Unit.** Biannual public attitudes tracker (http://www.food.gov.uk/multimedia/pdfs/trackernov10.pdf), 2010. Accessed 1 March 2011.
8. **Jordan E, Stockley R.** Food Standards Agency citizens' forums – Campylobacter. TNS-BMRB report (http://www.food.gov.uk/multimedia/pdfs/citforumcampy.pdf.), 2010. Accessed 1 March 2011.
9. **European Commission.** Corrigendum to Regulation (EC) No 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs. *Official Journal of the European Union* 2004; **226**: 3–21.
10. **Food Standards Agency (FSA).** Safer food, better business (http://www.food.gov.uk/foodindustry/regulation/hygleg/hyglegresources/sfbb/sfbbcaterers/), 2006. Accessed 27 August 2010.
11. **Food Standards Agency (FSA).** Safer food, better business for Chinese cuisine (http://www.food.gov.uk/foodindustry/regulation/hygleg/hyglegresources/sfbb/sfbbcuisines/), 2006. Accessed 27 August 2010.
12. **Food Standards Agency (FSA).** Safer food, better business for Indian, Pakistani, Bangladeshi and Sri Lankan cuisines (http://www.food.gov.uk/multimedia/pdfs/sfbbindianhow.pdf), 2007. Accessed 27 August 2010.
13. **Little CL, *et al.*** Microbiological quality of food in relation to hazard analysis systems and food hygiene training in UK catering and retail premises. *Communicable Disease and Public Health* 2003; **6**: 250–258.
14. **Office for National Statistics.** Family spending – a report on the 2008 living costs and food survey. Palgrave Macmillan, 2009.
15. **Jones TF, Angulo FJ.** Eating in restaurants: a risk factor for foodborne disease? *Clinical Infectious Diseases* 2006; **43**: 1324–1328.
16. **Little CL, Gillespie IA.** Prepared salads and public health. *Journal of Applied Microbiology* 2008; **105**: 1729–1743.
17. **MINTEL.** British fall hook, line and sinker for fish and chips (http://www.marketresearchworld.net/index.php?option=com_content&task=view&id=601), 2008. Accessed 20 May 2011.
18. **Department of Health.** Press Release 88/285. *Salmonella* and raw eggs, 1988.
19. **Department of Health.** Press Release 88/409. *Salmonella* and eggs, 1988.
20. **Food Standards Agency (FSA).** Eggs – what caterers need to know (http://www.food.gov.uk/multimedia/pdfs/eggleaflet.pdf), 2003. Accessed 12 March 2010.
21. **Food Standards Agency (FSA).** Eggs – advice for caterers (http://www.food.gov.uk/foodindustry/caterers/eggs/), 2009. Accessed 12 March 2010.
22. **Health Protection Agency.** Salmonella by serotype (www.hpa.org.uk/Topics/InfectiousDiseases/InfectionsAZ/Salmonella/EpidemiologicalData/salmDataHuman/), 2011. Accessed 20 May 2011.
23. **Little CL, *et al.*** Survey of Salmonella contamination of non-United Kingdom-produced raw shell eggs on retail sale in the northwest of England and London, 2005 to 2006. *Journal of Food Protection* 2007; **70**: 2259–2265.
24. **Gormley FJ, *et al.*** Pooling raw shell eggs: salmonella contamination and high risk practices in the United Kingdom food service sector. *Journal of Food Protection* 2010; **73**: 574–578.
25. **Hickman M.** Chinese restaurants top of the menu for food poisoning. *The Independent* (http://www.independent.co.uk/life-style/food-and-drink/news/chinese-restaurants-top-of-the-menu-for-food-poisoning-1986191.html), 2010. Accessed 25 September 2010.
26. **Little CL, Barnes J, Mitchell RT.** Microbiological quality of take-away cooked rice and chicken sandwiches: effectiveness of food hygiene training of the management. *Communicable Disease and Public Health* 2002; **5**: 289–298.
27. **Little CL, *et al.*** A recipe for disaster: outbreaks of campylobacteriosis associated with poultry liver pate in England and Wales. *Epidemiology and Infection* 2010; **138**: 1691–1694.
28. **Food Standards Agency (FSA).** Report links undercooked liver to campylobacter food poisoning (http://www.food.gov.uk/news/newsarchive/2010/dec/liver), 2010. Accessed 3 March 2011.
29. **Food Standards Agency (FSA).** The Food Standards Agency's Strategy for 2010–2015 (http://www.food.gov.uk/news/newsarchive/2009/dec/strategy) 2010. Accessed 10 January 2010.
30. **Food Standards Agency (FSA).** The joint government and industry target to reduce campylobacter in UK

produced chickens by 2015 (http://www.food.gov.uk/multimedia/pdfs/campytarget.pdf), 2010. Accessed 3 March 2011.

31. **Lowther JA, Henshilwood K, Lees DN.** Determination of norovirus contamination in oysters from two commercial harvesting areas over an extended period, using semiquantitative real-time reverse transcription PCR. *Journal of Food Protection* 2008; **71**: 1427–1433.
32. **Westrell T, *et al.*** Norovirus outbreaks linked to oyster consumption in the United Kingdom, Norway, France, Sweden and Denmark, 2010. *Eurosurveillance* 2010; **15**: 19524.
33. **Baert L, *et al.*** Reported foodborne outbreaks due to noroviruses in Belgium: the link between food and patient investigations in an international context. *Epidemiology and Infection* 2009; **137**: 316–325.
34. **Baker K, *et al.*** An outbreak of norovirus infection linked to oyster consumption at a UK restaurant, February 2010. *Journal of Public Health*. Published online: 27 October 2010. doi:10.1093/pubmed/fdq089.
35. **Codex Alimentarius Commission.** Proposed draft guidelines for the control of *Campylobacter* and *Salmonella* spp. in chicken meat. ALINORM 10/33/13. 2009.
36. **Food Standards Agency (FSA).** Agency issues advice on oysters (http://www.food.gov.uk/news/newsarchive/2011/jan/oysters), 2011. Accessed 3 March 2011.
37. **Food Standards Agency (FSA).** Food handlers: *Fitness to Work*. Regulatory guidance and best practice advice for food business operators (http://www.food.gov.uk/multimedia/pdfs/publication/fitnesstoworkguide09v3.pdf), 2009. Accessed 3 March 2011.
38. **Food Standards Agency (FSA).** Cooking (http://www.food.gov.uk/northernireland/nutritionni/niyoungpeople/survivorform/dontgetsick/cooking), 2010. Accessed 25 October 2010.
39. **Food Standards Agency (FSA).** Caterers warned on chicken livers (http://www.food.gov.uk/news/newsarchive/2010/jul/livers), 2010. Accessed 29 October 2010.
40. **DeBess EE, *et al.*** Food handler assessment in Oregon. *Foodborne Pathogens and Disease* 2009; **6**: 329–335.
41. **Hislop N, Shaw K.** Food safety knowledge retention study. *Journal of Food Protection* 2009; **72**: 431–435.
42. **Seaman P, Eves A.** Perceptions of hygiene training amongst food handlers, managers and training providers – a qualitative study. *Food Control* 2010; **21**: 1037–1041.