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Salmonella enterica serovar Enteritidis phage type 4 outbreak associated with eggs in a large prison, London 2009: an investigation using cohort and case/non-case study methodology

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SUMMARY

In September 2009, an outbreak of *Salmonella enterica* serovar Enteritidis affected 327 of 1419 inmates at a London prison. We applied a cohort design using aggregated data from the kitchen about portions of food distributed, aligned this with individual food histories from 124 cases (18 confirmed, 106 probable) and deduced the exposures of those remaining well. Results showed that prisoners eating egg cress rolls were 26 times more likely to be ill [risk ratio 25·7, 95% confidence interval (CI) 15·5–42·8, $P<0·001$]. In a case/non-case multivariable analysis the adjusted odds ratio for egg cress rolls was 41·1 (95% CI 10·3–249·7, $P<0·001$). The epidemiological investigation was strengthened by environmental and microbiological investigations. This paper outlines an approach to investigations in large complex settings where aggregate data for exposures may be available, and led to the development of guidelines for the management of future gastrointestinal outbreaks in prison settings.

Key words: Epidemiology, outbreaks, *Salmonella*.

INTRODUCTION

Salmonella spp. are the most common cause of foodborne outbreaks in the UK [1], the greatest proportion of which are caused by a particular *Salmonella enterica* serovar, Enteritidis [2]. Although the number of cases of *Salmonella* Enteritidis (SE) reported has declined in the UK since the 1990s [3], outbreaks continue to occur.

SE outbreak investigations across the UK have helped inform the development of control and prevention strategies [4]. Outbreaks have been reported in a variety of settings (including functions [5–7], fast food outlets [8] and restaurants [9, 10]) and from many different sources (including raw shell eggs [5, 7, 9], chicken [10] and frozen food [6]). SE outbreaks are more commonly reported in schools, private residences and residential institutions where a high number of persons may be exposed to a common contaminated food source, thus resulting in larger

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outbreaks [11]. Prisons are a similar such setting where large populations are at risk of developing foodborne illness [12]. In Japan, an *Escherichia coli* O6:H16 outbreak affected 1310 inmates [13]. Cieslak *et al*. completed a review of foodborne outbreaks in prisons in two US states (Georgia, Delaware) from 1974 to 1991. The authors found *Salmonella* was the most common cause reported, accounting for 37% (15/41) of outbreaks where the cause was known [14]. More recent reports from the USA include a *Clostridium perfringens* outbreak in 1994 which affected 40% of residents in a juvenile detention facility [15] and an outbreak in South Carolina, affecting a total of 688 out of 2317 inmates across four prisons, reportedly the largest outbreak of SE in the USA in 2001 [16].

Outbreaks in a prison setting pose a unique challenge to public health, where decisions on control and intervention must be balanced against external pressures from the judicial system. In this study we report an outbreak of SE in one of the largest prisons in Europe. We present the results of our microbiological, environmental and epidemiological investigations and highlight key considerations for the control and management of foodborne outbreaks in prison settings.

METHODS

Prison setting

The outbreak took place in a category B prison with up to 1680 male inmates and about 700 staff members present at time of the outbreak. Category B prisons house adult male prisoners (aged >21 years) who are a risk to the public but do not need the highest level of security [17]. The average length of stay in the prison was 6–12 months, before transfer or release, and about 30 prisoners per day attend court.

Outbreak notification and control

On 15 September 2009, healthcare staff in the prison identified six cases of diarrhoea and vomiting among prisoners. On 16 September 2009 the prison informed the local Health Protection Unit that about 70 prisoners were reporting gastrointestinal illness. Cases were found across all wings of the prison and a number of staff were affected. An Outbreak Control Team was convened on 17 September 2009 and a full investigation was conducted to identify the extent of the outbreak, the probable vehicle of infection and to advise on appropriate control measures.

Epidemiological investigation

A cross-sectional symptom surveillance questionnaire was completed daily by all prisoners from 17 to 21 September 2009. On the 17 September prisoners were also asked about symptoms over the period 14–16 September 2009. The information collected was used within the prison to determine the total number of prisoners affected each day and to identify symptomatic prisoners who required medical care.

All prisoners who ever reported one or more gastrointestinal symptom (diarrhoea, vomiting, high temperature) on the prison cross-sectional symptom surveillance questionnaire and those who tested positive for SE after providing a stool sample for microbiological testing, were asked to self-complete a structured 'study questionnaire' which included demographic details, clinical history and specific food exposures for the period 12–15 September 2009.

Case definition

Diarrhoea was defined as ⩾3 loose stools during a 24-h period. A confirmed case was defined as a prisoner who had diarrhoea with onset date after 13 September 2009 and had a laboratory-confirmed isolate of SE from a stool sample. A probable case was defined as a prisoner who had diarrhoea with onset after 13 September 2009, in the absence of microbiological confirmation. A secondary case was defined as an individual who had diarrhoeal illness and who shared a cell or had contact with a symptomatic individual (index) and whose symptom onset date was >2 days after the date of onset in the index case.

Analytical studies

(i) *Cohort study*. A retrospective cohort study was completed among prisoners, comparing food consumed by individual cases to aggregated totals of the food consumed by the prisoner population in general. Exposure data for all prisoners were sought from the kitchen where records had been kept of the number of servings (portions of food) prepared and distributed across the entire prison site each day. The total number of servings of each menu item prepared by the prison kitchen for lunch and dinner from 12 to 15 September 2009 was used to establish exposures of all prisoners based on an assumption that any prisoner

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eating a given food item would eat just one portion. For each food item, we used individual data from the study questionnaire to determine the number of exposed and unexposed cases, we then used information on the total number of portions available to deduce the number of those remaining well who were exposed and unexposed.

(ii) *Case/non-case study*. To enable adjustment for confounding, a case/non-case analysis was completed. Of those who completed the study questionnaire, individuals who met the confirmed or probable case definition were compared to non-cases (i.e. those who were identified from the prison cross-sectional symptom surveillance questionnaire as reporting diarrhoea, vomiting or high temperature, but who on completion of the study questionnaire described themselves as being asymptomatic).

Exclusions

Staff were excluded from the study population.

Data entry and analysis

The study questionnaire data was double-entered (to reduce data input error) into EpiData (EpiData Association, Denmark). In the cohort study univariate risk ratios and 95% confidence intervals (CI) were estimated using binary regression commands in Stata (StataCorp, USA). For the case/non-case analysis, univariate food-specific odds ratios for illness and 95% CIs were estimated using a generalized linear model. All exposure variables found to be significant at less than the 10% level ($P<0{\cdot}1$ by χ^2 test or Fisher's exact test as appropriate) were considered in the multivariable analysis. The multivariable logistic regression model was developed hierarchically by adding variables from the univariate analysis according to proportion exposed among those ill and P value, starting with the most stringent and then gradual relaxation of these criteria. At each step, the model was simplified in a backwards stepwise procedure by removing one at a time the least significant variable (i.e. P value $>0{\cdot}05$) which was not a substantial confounder (a substantial confounder defined as any variable whose removal caused the odds ratios of the remaining variables in the model to change by $>20\%$). This process was repeated until all variables had been assessed in this way. To generate the final model and improve parameter estimation precision two further steps were undertaken. First, protective variables were removed one at a time on biological plausibility considerations, and this was followed by the removal of non-significant factors (at the 5% level) provided the inferences of variables remaining in the model were unchanged. Odds ratios and P values from the final model were then estimated by means of exact logistic regression. All analyses were completed in Stata version 10.

Microbiological investigation

On 17 September stool samples were collected from 10 symptomatic prisoners. Further stool samples were collected from symptomatic prisoners during the outbreak.

All stool samples were examined at St George's Hospital Microbiology Laboratory according to protocols based on UK Standards for Microbiology Investigations [18]. Specifically, stool samples were plated on the following media: XLD medium (Oxoid, UK), *Campylobacter* medium (Oxoid) and SMAC (Oxoid), to look for *Salmonella*/*Shigella*, *Campylobacter* and *E. coli* O157, respectively. Samples were also inoculated in mannitol selenite broth (bioMérieux, France) followed by subculture to XLD for enhanced *Salmonella* detection. Samples were examined for *Cryptosporidium* spp. by auramine staining and tested for *Clostridium difficile* toxins using the enzyme immunoassay (EIA) Premier Toxin A/B (Launch Diagnostics, UK).

Salmonella spp. were identified by a combination of agglutination and biochemical methods using the API system (bioMérieux). All *Salmonella* isolates were sent to the Health Protection Agency Salmonella Reference Unit for confirmation of identification, serotyping and phage typing [19, 20].

All stool samples were also sent to the Health Protection Agency London Regional Laboratory based at King's College Hospital for norovirus testing. This was performed using an in-house polymerase chain reaction (PCR) assay.

Symptomatic staff and all kitchen staff were asked to provide stool samples via their general practitioner.

Environmental investigation

Environmental health officers inspected the prison kitchen on 18, 21 and 22 September to assess the food-safety management system with regard to food storage, preparation and cooking, and to verify the procedures for hazard analysis and critical control

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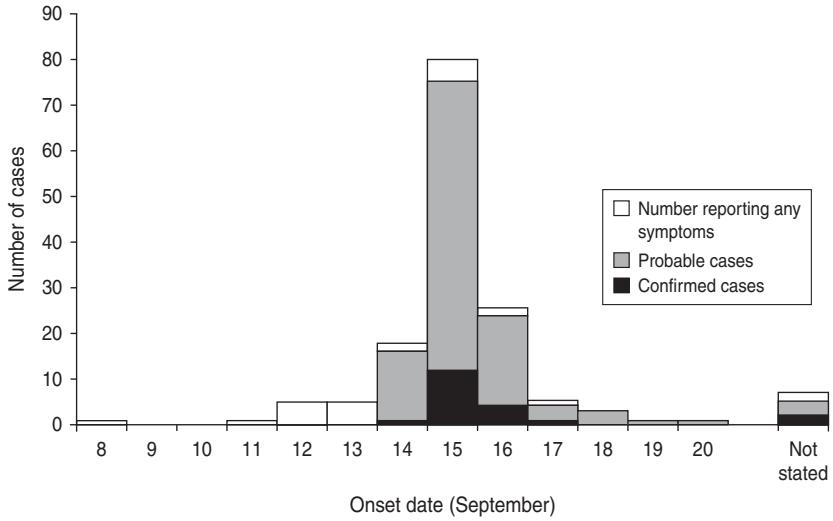

Fig. 1. The number of prisoners reporting symptoms (any of diarrhoea, vomiting, fever, abdominal pain, headache) in the study questionnaire by date of onset ($n = 153/202$).

point (HACCP) plan. On 18 September five environmental swabs were collected from kitchen areas (including mixing machine and bowl used in the preparation of eggs). No food remained from that served over the period 13–15 September, but food samples of eggs from the same supplier as those used during 13–15 September were collected. The source of the eggs was identified and the supplier traced.

RESULTS

Control methods

Immediate control measures included isolating all symptomatic prisoners in their cells, preventing symptomatic prisoners attending court or having visitors, advising the need for hot water, increased cleaning of cells (including in-cell sanitation) and communal areas, and initiating daily reporting of the number of cases to monitor the progression of the outbreak. The prison Command Suite was opened to assist with coordination of the outbreak. Infection control measures disrupted the movement of prisoners within the prison, transfers in and out of prison, court appearances, visitors, and religious ceremonies for 6 days. Three prisoners were hospitalized.

Epidemiological investigation

In total, 327 possible and confirmed cases were identified through the prison cross-sectional symptom surveillance questionnaire and stool sampling. Of these, 202 (61·8%) completed the study questionnaire.

Of the 202 who completed the study questionnaire, 66·8% had diarrhoea (135/202), 62·9% headache (127/202), 61·4% abdominal pain (124/202), 56·9% fever (115/202) and 35·6% vomiting (72/202). A total of 153/202 reported any gastrointestinal symptoms (diarrhoea, vomiting, fever, abdominal pain, headache), and the dates of symptom onset ranged from 11 to 20 September (Fig. 1). The epidemic curve showed a clear peak in cases reporting onset of illness on 15 September.

A total of 124 cases (18 confirmed, 106 probable) were identified (Fig. 2). Confirmed or probable cases were found in all prison wings, with an estimated attack rate ranging from 2·8% to 29·4%. Respondents were aged 21–80 years (median age 37 years). No secondary cases were identified.

Five probable prisoner cases reported they worked in the kitchen, three of whom prepared food. Among these three food handlers symptom onset dates were 15 or 16 September.

Cohort study

The epidemic curve suggested a point-source outbreak with likely exposure between 12 and 14 September based on the usual incubation period of *Salmonella* infection (12–72 h). In the univariate analysis several menu items served over this period were found to be associated with a higher risk of diarrhoeal illness at the 5% level (Table 1). The greatest risk of diarrhoeal illness was in those who consumed egg cress rolls [risk ratio (RR) 25·73, 95% CI 15·46–42·83, $P < 0·001$]. Eighty-one percent

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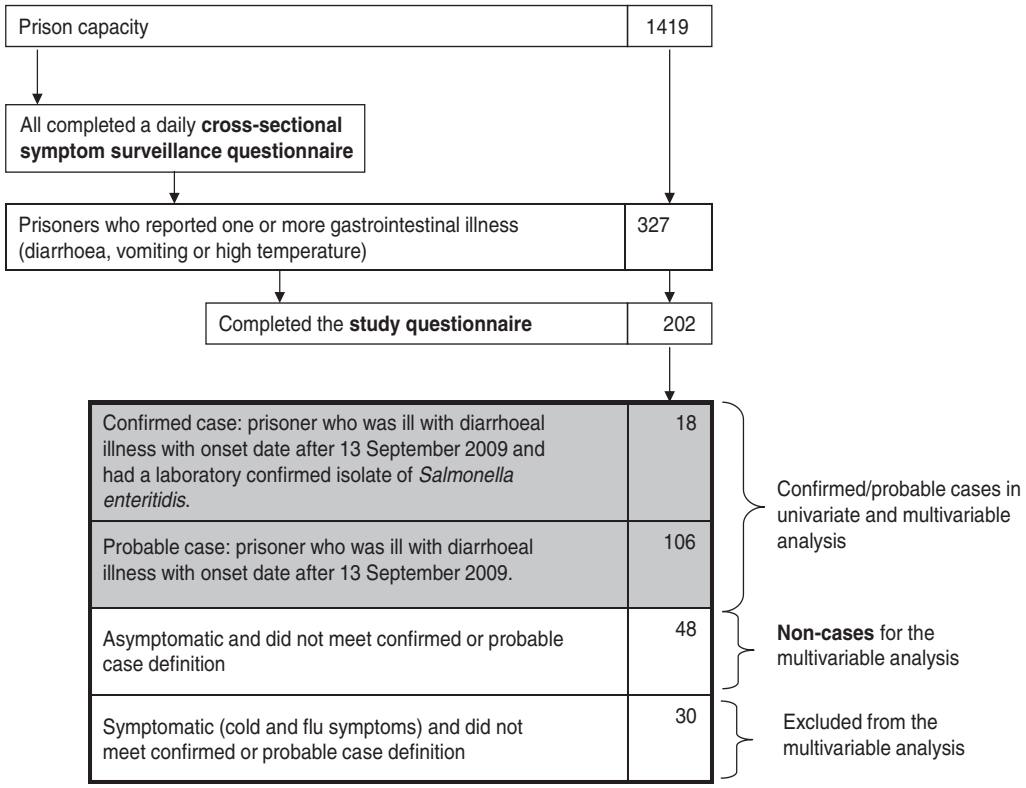

Fig. 2. Flow chart showing the method used to collect information on probable and confirmed cases in a *Salmonella* outbreak in a London prison, 2009.

(108/124) of all confirmed or probable cases re ported they had consumed the egg cress rolls. Other menu items that suggested an increased risk of diarrhoeal illness included a number of vegetarian choices, e.g. vegetarian flan served on 12 September (RR 5·16, 95% CI 3·56–7·48) and vegetarian nuggets on 13 September (RR 6·59, 95% CI 4·71, 9·22) (Table 1).

Case/non-case analysis

In a case/non-case analysis we compared the same 124 cases to 48 non-cases who had provided individual food histories through the questionnaires distributed to prisoners (Fig. 2). Results from this analysis showed that after controlling for possible confounding, the egg cress rolls served for lunch on 14 September remained the only variable of high significance (adjusted odds ratio 41·10, 95% CI 10·28–249·74, $P<0·001$) (Table 2).

Microbiological investigation

On 18 September, preliminary results indicated 8/10 stool samples were positive for SE and 8/9 stool samples were negative for norovirus.

In total, SE was isolated from 33/38 stool specimens tested (32 prisoners and one member of staff). Phage typing was completed on 29 isolates, all of which were found to be phage type 4 (PT4). No pathogens were isolated from the food or environmental samples collected.

Environmental investigation

The environmental investigation revealed the kitchen staff prepared batches of shelled eggs by cracking them into large baking trays (the number of eggs per tray varied from 30 to 60) and cooking the mixture in a steam oven with inadequate temperature and time controls. The contents of all the trays were then mixed together and stored overnight in a refrigerator before being prepared as egg cress rolls. The prison HACCP stated all raw eggs should be hard-boiled or fully fried; therefore the pooled method for cooking eggs was not in line with the prison's own approved HACCP plan. The Environmental Health Officers reported the eggs used were Lion branded and sourced from a large UK catering supplier.

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Table 1. *Food specific attack rates, risk ratios and 95% confidence intervals for food portions distributed across the prison according to date (cohort study)*

	Ate the food item			Did not eat the food item					
Food item and date served	Ill	Total	AR	Ill	Total	AR	RR	(95% CI)	*P* value
Lunch, 12 Sept.									
Asian lamb	22	241	0·09	102	1178	0·09	1·05	(0·68–1·64)	0·814
Turkey lasagne	30	247	0·12	94	1172	0·08	1·51	(1·03–2·23)	0·036
Soya & chick pea casserole	22	64	0·34	102	1355	0·08	4·57	(3·10–6·92)	<0·001
Vegetable flan	23	60	0·38	101	1359	0·07	5·16	(3·56–7·48)	<0·001
Ham pasta	38	142	0·27	86	1277	0·07	3·97	(2·83–5·58)	<0·001
Chicken leg	52	470	0·11	72	949	0·08	1·46	(1·04–2·05)	0·029
Turkey roll	45	195	0·23	79	1224	0·06	3·57	(2·56–4·99)	<0·001
Fresh fruit	43	338	0·13	81	1081	0·07	1·70	(1·20–2·40)	0·003
Cake	63	1057	0·06	61	362	0·17	0·35	(0·25–0·49)	<0·001
Dinner, 12 Sept.									
Beefburger	49	549	0·09	75	886	0·08	1·05	(0·75–1·49)	0·763
Beef chili	27	241	0·11	97	1194	0·08	1·38	(0·92–2·06)	0·118
Vegetarian sausage	21	84	0·25	103	1351	0·08	3·27	(2·17–4·96)	<0·001
Meat ravioli	27	91	0·30	97	1344	0·07	4·11	(2·84–5·95)	<0·001
Sausage, bacon, egg flan	46	328	0·14	78	1107	0·07	1·99	(1·41–2·80)	<0·001
Sardine salad	37	142	0·26	87	1293	0·07	3·87	(2·75–5·46)	<0·001
Fresh fruit	41	346	0·12	83	1189	0·07	1·70	(1·19–2·42)	0·005
Cake	61	1019	0·06	63	416	0·15	0·40	(0·29–0·56)	0·003
Lunch, 13 Sept.									
Curried goat	27	284	0·10	97	1155	0·08	1·13	(0·75–1·70)	0·49
Lamb pie	24	85	0·28	100	1354	0·07	3·82	(2·60–5·63)	<0·001
Spiced vegetables	20	64	0·31	104	1375	0·08	4·13	(2·75–6·21)	<0·001
Poached fish	29	90	0·32	95	1349	0·07	4·58	(3·20–6·53)	<0·001
Roast chicken	35	413	0·08	89	1026	0·09	0·98	(0·67–1·42)	0·903
Beef & Yorkshire pudding	75	503	0·15	49	936	0·05	2·85	(2·02–4·01)	<0·001
Fresh fruit	32	262	0·12	92	1177	0·08	1·56	(1·07–2·28)	0·021
Ice cream	90	265	0·34	34	1133	0·03	0·71	(0·49–1·04)	0·078
Dinner, 13 Sept.									
Cheese and onion	34	238	0·14	90	1158	0·08	1·84	(1·27–2·66)	0·001
Cheese salad	37	219	0·17	87	1177	0·07	2·29	(1·60–3·27)	<0·001
Chicken pasta salad	52	519	0·10	72	877	0·08	1·22	(0·87–1·71)	0·251
Mackerel salad	35	252	0·14	89	1144	0·08	1·79	(1·24–2·58)	0·002
Vegetarian nuggets	26	54	0·48	98	1342	0·07	6·59	(4·71–9·22)	<0·001
Beef bredie (no salad)	27	114	0·24	97	1282	0·08	3·13	(2·14–4·58)	<0·001
Lunch, 14 Sept.									
Korean sesame chicken	25	611	0·04	99	847	0·12	0·35	(0·23–0·54)	<0·001
Greek moussaka	24	144	0·17	100	1314	0·08	2·19	(1·45–3·30)	<0·001
Mushroom pasta	23	95	0·24	101	1363	0·07	3·27	(2·19–4·89)	<0·001
Potato curry	22	64	0·34	102	1394	0·07	4·70	(3·19–6·92)	<0·001
Bulgarian pork stew	22	97	0·23	102	1361	0·07	3·03	(2·00–4·57)	<0·001
Meat pie	21	144	0·15	103	1314	0·08	1·86	(1·20–2·88)	0·004
Egg cress roll	108	303	0·36	16	1155	0·01	25·73	(15·46–42·83)	<0·001
Fresh fruit	42	369	0·11	82	1089	0·08	1·51	(1·06–2·15)	0·022
Cake	64	1053	0·06	60	405	0·15	0·42	(0·29–0·57)	<0·001
Dinner, 14 Sept.									
Chicken burger	63	637	0·10	61	839	0·07	1·36	(0·97–1·90)	0·073
Greek beef stew	24	194	0·12	100	1282	0·08	1·59	(1·04–2·41)	0·031
Curried chickpea	22	81	0·27	102	1395	0·07	3·71	(2·48–5·56)	<0·001
Fish	34	219	0·16	90	1257	0·07	2·17	(1·50–3·13)	<0·001
Steak kidney pie	36	201	0·18	88	1275	0·07	2·59	(1·81–3·71)	<0·001
Chicken salad	32	92	0·35	144	1332	0·11	3·22	(2·24–4·62)	<0·001
Fresh fruit	38	292	0·13	86	1184	0·07	1·79	(1·25–2·57)	0·001
Dessert	65	1024	0·06	59	452	0·13	0·49	(0·35–0·68)	<0·001

AR, Attack rate; RR, risk ratio, CI, confidence interval.

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Table 2. *Multivariable case/non-case exact logistic regression analysis (N = 172)*

Food item and date served	aOR	(95% CI)	*P* value
Milk (breakfast, 12 Sept.)	2·80	(0·11–35·36)	0·723
Ham pasta (lunch, 12 Sept.)	10·94*	(1·10–∞)	0·040
Meat ravioli (dinner, 12 Sept.)	3·76*	(0·38–∞)	0·274
Milk (breakfast, 13 Sept.)	1·90	(0·17–47·60)	0·972
Mackerel salad (dinner, 13 Sept.)	2·66*	(0·26–∞)	0·438
Drink (dinner, 13 Sept.)	1·62	(0·23–10·30)	0·835
Egg cress roll (lunch, 14 Sept.)	41·1	(10·28–249·74)	<0·001
Turkey roll (lunch, 15 Sept.)	4·43	(0·21–380·02)	0·596

aOR, Adjusted odds ratio; CI, confidence interval.
* Median unbiased estimate [26].

DISCUSSION

The results from the epidemiological, microbiological and environmental investigations demonstrated this large foodborne outbreak in a prison was most likely caused by consumption of egg cress rolls contaminated by SE PT4. SE PT4 is the most commonly reported *Salmonella* as documented by the Health Protection Agency [3]. In 2009, a further 11 foodborne outbreaks were reported in UK prison settings, seven caused by norovirus, one by *Clostridium perfringens* and one by *Cryptosporidium* [21].

This outbreak occurred in one of the largest prisons in Europe. Lessons were identified in the management and control of gastrointestinal disease outbreaks in a prison setting and considerations in the design of future analytical studies of outbreak investigations in prisons. These included the need to monitor sickness in staff and prisoners for early identification of outbreaks, good communication in outbreak management, regular audits to ensure local HACCP plans are fit for purpose, and to consider using routinely available data to investigate possible sources of the outbreak [22].

Management and control

The outbreak had significant implications for the management within the prison and on the wider justice system. Because of the potential person-to-person spread, control measures necessitated the isolation of symptomatic prisoners and, as a direct result, their cellmates. This meant access to showers and telephones for these prisoners were limited. The inability to speak to relatives raised concerns among family members and caused unrest among prisoners. Control measures also halted court attendances and the transfer of prisoners in and out of the prison causing an impact on the wider justice system. Limiting the movement of symptomatic prisoners and staff is the most commonly reported method used in the management of enteric outbreaks in prison settings [12].

At the time of the outbreak, there was no published national guidance document for the management and control of gastrointestinal outbreaks in prison settings. In January 2010, the multi-agency contingency plan for the management of outbreaks of communicable diseases or other health protection incidents in prisons in England and Wales was amended to include specific guidance on the management of gastrointestinal outbreaks in prisons and other custodial settings [23]. Specific learning from this outbreak which informed the national guidance included a log sheet to collate information on symptoms among prisoners and staff; the importance of accurate and consistent information for prisoners, employees, relatives and other internal and external agencies [22].

Analytical study

The cross-sectional symptom surveillance questionnaire (developed for patient management rather than as an epidemiological tool) enabled identification of the total number of prisoners who reported feeling unwell each day rather than the number of new cases arising. Prisoners may have been less likely to report symptoms as the outbreak investigation progressed and they became aware of the restrictive control measures imposed on those who were symptomatic. Therefore we cautiously interpreted the epidemic curve for the outbreak to be strongly suggestive of a point source. We wished to investigate the outbreak in a way that minimized disruption at the prison where

staff were already under considerable pressure managing the outbreak. We took into consideration resource constraints, availability of routine data sources and the transient prison population. A cohort study of all prisoners, or within one wing (if representative) would have been possible, but this would have had significant resource implications in a prison of this size (over 1400 prisoners). A case-cohort study was also considered, a design where controls are randomly selected from the entire cohort thus removing the need to include all prisoners in the study. An efficient approach taken was to use the available individual prisoner reported food histories together with information relating to food items prepared and distributed across the site each day. Limitations with this approach include possible inaccuracies in the data provided by the kitchen, which may have under- or overestimated the number of portions of food items available overall. There are also limitations at an individual level as reported food consumption by cases may have been inaccurate and cases may have eaten more than one portion of a given food. This would have resulted in fewer portions being available for other prisoners. If this had occurred we would have overestimated the exposure among non-ill prisoners and potentially reduced our measure of association towards the null. There were anecdotal reports of prisoners taking the egg cress rolls to their cells and eating them later but we do not know if this was by cases or those who were not ill. These various limitations may have resulted in misclassification of exposure in controls. Misclassification may also have occurred for cases as the exposure histories provided in their questionnaires did not always match what they had indicated on their weekly menu choice. Each prisoner completed a weekly prospective menu choice form and the information was used by the prison kitchen to determine the quantity of each food item to prepare each week. There was poor agreement between the food histories as reported by cases in the study questionnaires and their menu choice selections. There is a possibility that absence of language skills in English or reduced literacy may have led to a low response rate which would affect the power of the study.

Without individual-level data for the population at risk it was not possible to complete a multivariable analysis to adjust for confounding in a conventional way. Our second analytical study in which confirmed and probable cases were compared to non-cases enabled adjustment for confounding. This second study strongly supported the conclusions from the first. We believe that in spite of the various limitations to our study we were able to identify a specific food item with a much higher risk of associated illness than any other, served on 14 September 2009, a date that from the epidemic curve looked very likely to have been the day of exposure. Furthermore more than 80% of cases could be accounted for by this exposure.

We believe the epidemiological approach is novel and potentially useful in other residential settings. It yielded a good result but did not require as many resources compared to a full cohort study.

Environmental

Environmental investigations identified a pooled method for cooking raw eggs with inadequate temperature and time controls. This method of pooling of raw eggs would have meant that just one or two eggs among several hundred would be sufficient to contaminate the mixture and result in the outbreak if not cooked sufficiently. The pooled method of cooking eggs was also identified in a *Salmonella* outbreak in a prison in Georgia, USA, which affected 113/640 inmates [14]. Our investigation identified a need for more training, supervision and auditing of individual prison catering managers to ensure the HACCP requirement in the Prison Service Order is correctly implemented.

The eggs used by the prison kitchen were British Lion Quality branded from a large UK catering supplier. Lion Quality eggs means the supplier must adhere to a strict code of practice to reduce/eliminate the risk of contamination. Specific measures include vaccinating hens against SE, routine *Salmonella* testing, hygiene monitoring, time and temperature control for storage and transportation of eggs, and satisfaction of independent audits every 18 months [24]. Despite these control methods it is not possible to guarantee eggs will be free of *Salmonella* and recent surveys estimate the prevalence of *Salmonella* in UK-sourced eggs is 0·38% (95% CI 0·14-0·82%) [25].

In conclusion, this outbreak provided a unique opportunity to perform analytical, microbiological and environmental investigations into the cause of a foodborne outbreak within a prison setting. Recommendations from the investigation have been considered at a national level [25] for the management of future outbreaks in similar settings.

APPENDIX. Members of the Outbreak Control Team

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DECLARATION OF INTEREST

None.

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