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An outbreak of *Salmonella typhimurium* DT170 associated with kebab meat and yoghurt relish

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SUMMARY

During July 1995, an outbreak of *Salmonella typhimurium* definitive type (DT) 170, an unusual strain, occurred in South Wales. A case-control study found that illness was associated with eating kebabs (odds ratio undefined, $P = 0{\cdot}002$), doner kebabs (odds ratio 7·9, 95% confidence interval 1·5–20·5, $P = 0{\cdot}02$) and kebabs with yoghurt based relish (odds ratio undefined, $P = 0{\cdot}009$) but not with eating kebabs with mayonnaise-based relish (odds ratio 2·4, 95% confidence interval 0·4–13·9, $P = 0{\cdot}53$). Environmental investigations discovered a complex web of producers and wholesale suppliers. Kebab meat and yoghurt had been supplied to the two main implicated outlets by a single wholesaler. Samples of raw minced lamb and several environmental swabs taken at the wholesaler were positive for *S. typhimurium* DT170. Blood-stained, unsealed yoghurt pots were observed to be stored under a rack of raw lamb. Investigators of food poisoning outbreaks linked to takeaway food should consider cross-contaminated relishes and dressings as well as undercooked meat as potential vehicles of infection.

INTRODUCTION

During 1992–4, 61 of 412 (15%) salmonella outbreaks reported in England and Wales were due to *Salmonella typhimurium* and of these, 38 were foodborne [1]. Red meat or meat products were implicated as the food vehicle in 16 (42%) outbreaks, poultry or poultry products in 11 (29%) and milk or milk products in 4 (11%). *S. typhimurium* definitive type (DT) 170 is uncommon in the United Kingdom and no previous outbreaks have been reported.

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THE OUTBREAK

In mid July 1995, 22 isolates of *Salmonella typhimurium* DT170 were confirmed in the South Wales area over a 2-week period by the Public Health Laboratory Service (PHLS) Laboratory of Enteric Pathogens (LEP). This compares with a background rate of 2–3 cases per year in the South Wales area and

73 cases in the whole of England and Wales during 1994. The PHLS Communicable Disease Surveillance Centre was informed and an outbreak control team convened on 19 July 1995. Cases were distributed over two health authority and several local authority areas. Initial enquiries found a high proportion of cases to be young, single men (aged 18–24 years) who had eaten takeaway food, particularly kebabs, in the 3 days before illness onset. However, no single takeaway outlet was implicated and there were no reports of undercooked meat. We carried out a case-control study and environmental investigations to identify the vehicle of infection and the source of the outbreak.

METHODS

Epidemiological investigation

Case searching

Recently reported cases of *S. typhimurium* from South Wales were reviewed. All microbiology laboratories throughout Wales were alerted to the incident using the local electronic network (EPINET) [2] and asked to report any suspected *S. typhimurium* isolates to the outbreak control team. LEP was asked to provide the outbreak team with information on all *S. typhimurium* DT170 isolates from England and Wales since 1 January 1995.

Case-control study

A case-control study was carried out to test the hypothesis that gastrointestinal illness was associated with eating takeaway food, specifically kebabs, relishes or dressings. Cases were defined as persons living in South Wales with onset of illness after 15 June 1995 and a stool specimen positive for *S. typhimurium* DT170. Secondary cases (onset of illness more than 24 h after illness in a household index case) and cases who had travelled abroad were excluded from the study. Two case-nominated neighbourhood controls matched for sex, age (within 5 years) and area of residence were sought for each case. Controls with gastrointestinal illness or a history of recent travel abroad were excluded. Interviews were conducted by telephone (or if not contactable, at a home visit) using a structured questionnaire. Subjects were asked about gastrointestinal illness, household contacts with diarrhoea, recent foreign travel and all food items eaten in the 3 days before illness (or the comparable period in controls). Details of frequency of consumption, date and place of purchase and any relishes or dressings used were sought for a range of foods including burgers, kebabs, other takeaway dishes and sandwiches.

Data analysis

Data analysis was carried out using Epi Info Version 6 [3]. Food preference tables were constructed and matched analyses were carried out to calculate Mantel–Haenszel summary odds ratios (OR) with Robins, Greenland, Breslow 95% confidence intervals (CI) [4]. Differences in categorical variables were tested using Mantel–Haenszel summary χ^2 with Yates' correction.

Environmental and microbiological investigation

Environmental health officers inspected all takeaway premises that were associated with cases and obtained details of suppliers of all meat, relishes and dressings. Further enquiries were then made to trace the supply chain to source. At the two kebab houses primarily implicated, faecal samples were sought from all kebab house employees and food samples including raw minced lamb, kebabs, burgers, chicken, salad, yoghurt and garlic dressing submitted for microbiological examination. The implicated wholesale premises was also inspected and samples of food and food debris, including minced lamb, chicken, and yoghurt, and environmental swabs from work, storage and floor surfaces submitted for examination. All specimens were cultured for bacterial pathogens including salmonella, and all salmonella isolates were typed and sent to LEP for confirmation.

RESULTS

Epidemiological investigation

Descriptive study

Preliminary data was available for 22 cases. The majority had become ill during the last week in June or the first week in July (week numbers 26 and 27). Cases were geographically clustered in Cardiff and Newport and most were young, single men. Several cases had eaten takeaway food from kebab houses or bought meat from halal meat (prepared as prescribed by muslim law) suppliers. One case was the child of a kebab house owner and one outlying case from West Wales had bought a takeaway meal from a kebab house in Cardiff.

Three case clusters were reported by LEP. The first

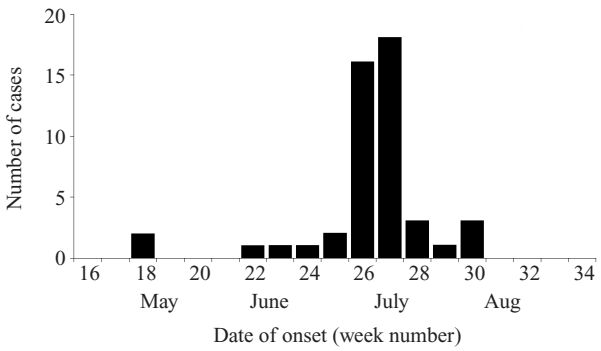

Fig. 1. Epidemic curve of cases of *Salmonella typhimurium* DT170 infection, South Wales, July 1995 ($n = 48$, where date of onset of illness was known).

had occurred in the north of England during April 1995 and been linked to a faulty pork processing plant. The second was a small family cluster in South-west England involving an employee of a small pork processor and his children. The third involved six cases in South-east England associated with a kebab house. This did not involve halal meat and could not be linked to South Wales.

Altogether, 52 cases of *S. typhimurium* DT170 occurred in South Wales between 1 May and 31 July 1995 (Fig. 1). The two cases in week 18 were a family cluster. Cases in week 26 mostly lived in Cardiff and cases in week 27 mostly lived in the Newport area. Three cases were probably the result of secondary household spread. Only one case had recently been abroad. Thirty-three cases (63%) were men and median age was 22 years (range 1–56 years). Six cases required hospital admission but there were no deaths.

Case-control study

Thirty-one people met the case definition (4 cases had been ill before 15 June, 9 cases had not yet been phage typed at the time of the study, and for 4 cases no information was available). Interviews were completed for 26 cases (5 cases were on holiday) and 41 controls, providing data on 22 matched pairs. Illness was associated with eating any kebab, (matched OR undefined, $P = 0{\cdot}002$) and doner kebab (spit-roasted minced lamb) (matched OR 7·9, 95% CI 1·5–40·5, $P = 0{\cdot}02$) but not with eating beefburgers, other takeaway food or sandwiches (Table 1). There was also a highly significant association between risk of illness and eating kebabs with any type of yoghurt dressing (matched OR undefined, $P = 0{\cdot}009$) but not with eating kebabs with mayonnaise-based relish (matched OR 2·4, 95% CI 0·4–13·9, $P = 0{\cdot}53$). Illness was also associated with buying a kebab from one of two kebab houses (matched OR 8·7, 95% CI 1·5–66·3, $P = 0{\cdot}01$) (Outlets A and B).

Environmental and microbiological investigation

Environmental investigation

Altogether, 36 of the 52 confirmed cases were associated with consumption of halal meat from a kebab house or Indian restaurant. Twenty-five of the 36 people (including 8/11 cases in the case-control study) had eaten kebabs from one of two kebab houses, Outlet A in Cardiff and Outlet B in Newport. Meat sold at Outlet A included doner and shish kebabs (both made from minced lamb), chicken kebabs and beefburgers. Various salads and dressings were displayed under refrigeration including green salad, tomatoes, home made yoghurt and mint dressing, and proprietary chilli and barbecue sauces. Food safety standards were considered by the inspecting environmental health officer to meet statutory requirements. Outlet B sold a similar variety of meats as Outlet A together with a choice of salads, dressings (including a home-made yoghurt and garlic dressing) and fries. Poor food hygiene practices identified included potential cross-contamination from raw chicken and inadequate refrigerator temperatures. There were no reports of gastrointestinal illness in food workers at either premises.

Enquiries about food suppliers to premises associated with cases identified a complex web of wholesalers and distributors (Figs 2, 3). Retailers frequently changed their suppliers, invoice trails were difficult to follow and some wholesalers had changed ownership during the period under investigation. The yoghurt and minced lamb used by both Outlets A and B, although from different producers, were traced to the same wholesaler (Wholesaler C). On inspection, the wholesale premises were found to be dirty and structurally unsuitable. The business consisted of a retail shop area for the sale of halal meat and rooms at the rear for storage and processing of lamb carcasses. The yoghurt was supplied in unsealed 425 g plastic containers and stored by Wholesaler C in uncovered boxes directly underneath hung lamb carcasses in a walk-in chiller unit. Several yoghurt cartons were observed to have loose fitting lids and to be visibly contaminated with blood. The yoghurt producer made 12 batches per day (each of 1000 litres) of live, natural yoghurt which were then distributed throughout England and Wales. The yoghurt had a

Table 1. *Matched analysis of foods eaten by cases and controls in* S. typhimurium *DT170 outbreak, South Wales, 1995*

Food	Case ($n = 22$)		Control ($n = 41$)		Matched OR (95% CI)	*P* value
	Ate	Not ate	Ate	Not ate		
Sandwiches	10	12	15	26	2·15 (0·58–7·93)	0·41
Any takeaway food	19	3	31	10	1·80 (0·45–7·27)	0·60
Any burger	14	8	21	20	1·50 (0·51–4·37)	0·63
Cheeseburger	5	17	9	32	1·03 (0·32–3·32)	0·81
Beefburger	8	14	10	31	1·50 (0·48–4·64)	0·68
Veggie burger	1	21	3	38	0·57 (0·03–11·93)	0·75
Chicken burger	4	18	5	36	1·33 (0·37–4·80)	0·91
Other burger	1	21	0	41	Undefined	0·72
Any kebab	11	11	6	35	Undefined	0·002
Doner kebab	9	13	5	36	7·86 (1·52–40·49)	0·02
Lamb kebab	1	21	1	40	2·25 (0·15–33·37)	0·90
Chicken kebab	0	22	1	40	Undefined	0·72
Other kebab	1	21	0	41	Undefined	0·72
Kebab with any relish	6	16	2	39	4·70 (0·95–23·23)	0·05
Kebab with any yoghurt-based relish	5	17	0	41	Undefined	0·009
Kebab with any mayonnaise-based relish	3	19	2	39	2·40 (0·41–13·90)	0·53
Kebab without any relish	5	17	4	37	4·00 (0·55–38·7)	0·24
Kebab without any yoghurt-based relish	6	16	6	35	6·50 (0·51–256)	0·25

28-day shelf-life and all routine bacteriological sampling by the yoghurt producer was negative.

Microbiological investigation

Faecal samples were obtained from 7 of 8 food workers and all were negative. Thirteen food samples taken from Outlets A and B (on 19 and 25 July, respectively) were negative. Seven food samples (including 2 lamb and 2 yoghurt samples), 7 food debris samples and 24 environmental swabs were obtained from Wholesaler C on 27 July. *S. typhimurium* DT170 was isolated from one food sample (minced lamb used as kebab meat) and from three food debris samples (ice scrapings from a freezer, table top scrapings and scrapings from a storage room floor).

Control measures

Retail outlets associated with cases were visited and advised on the importance of food hygiene training, appropriate food storage temperatures and segregation of raw and cooked foods. Wholesaler C was served with statutory improvement notices, given specific advice about avoiding cross-contamination and sealing yoghurt pots, and monitored to ensure compliance with all remedial measures. One further linked case occurred, a secondary household case. Five other cases of *S. typhimurium* DT170 were reported in South Wales during the remainder of 1995, including a family cluster of four cases, but none were linked with meals from kebab houses.

DISCUSSION

Successful outbreak investigations are frequently a synthesis of epidemiological, microbiological and environmental investigations. In this, the first outbreak of *S. typhimurium* DT170 to be described in the United Kingdom, investigation identified doner kebabs and yoghurt-based dressings as the probable vehicles of infection. Evidence for this hypothesis was threefold. Firstly, the case-control study found illness to be strongly associated with buying takeaway food from kebab houses and specifically with eating kebab meat and yoghurt (rather than mayonnaise) dressing. Secondly, environmental inspection of the wholesaler who supplied both implicated kebab houses found that yoghurt may have been cross-contaminated from raw meat during storage, because of the practice of storing loose-lid yoghurt pots under a rack

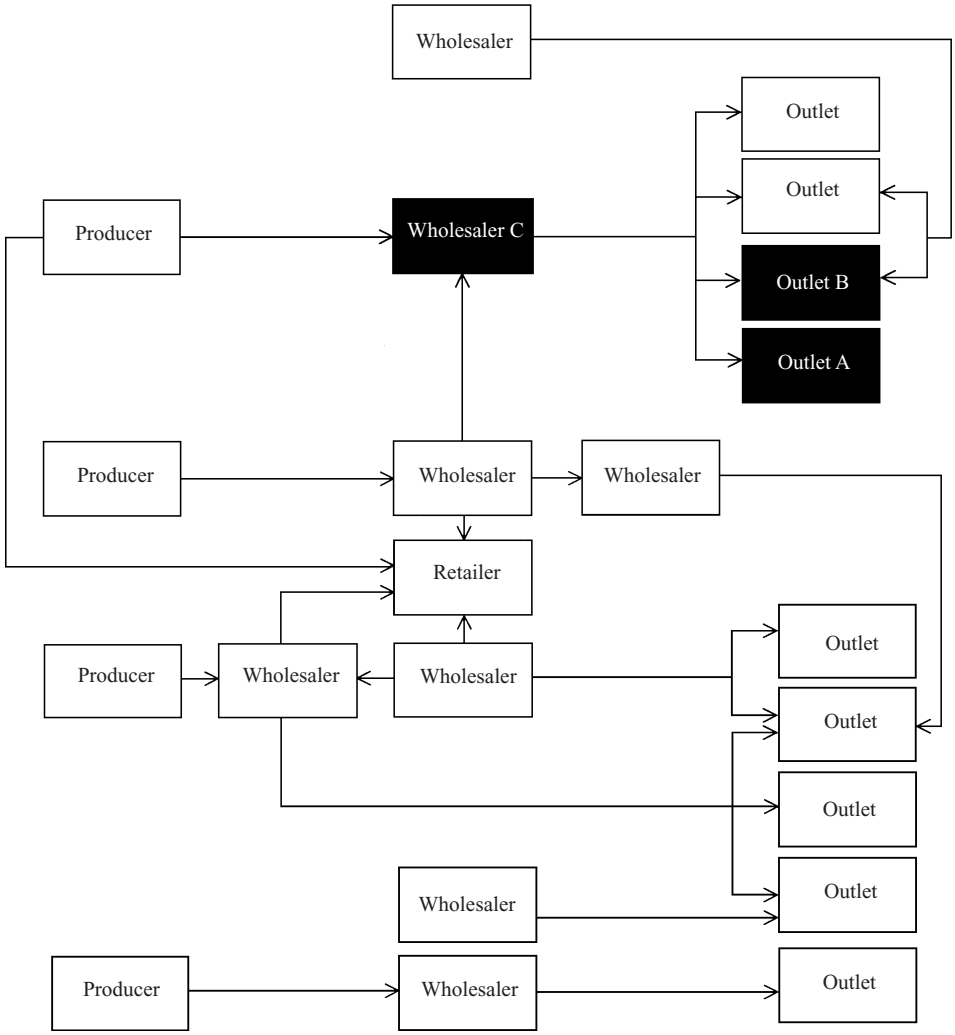

Fig. 2. Food chain for lamb associated with outbreak of *Salmonella typhimurium* DT170 infection, South Wales, July 1995 (all outlets and the retailer were associated with at least one case).

of raw lamb. Finally, *S. typhimurium* DT170 was found in minced lamb (used as kebab meat) and in several environmental samples obtained at the wholesaler indicating the raw lamb was the likely source of the outbreak strain and that widespread environmental contamination had occurred.

Although 25 cases were linked with two kebab houses (Outlets A and B), 8 other outlets (Figs 2, 3) were associated with 1 or 2 cases each. All of the outlets were either kebab houses or Indian restaurants. Most were not linked with Wholesaler C, but several were supplied halal meat by the same producer. We hypothesize that these cases may either have resulted from a common contaminated lamb source (perhaps by a variety of vehicles of infection) or may represent failure to completely elucidate the wholesale distribution and supply chain. Cases occurring in week 26 were mostly linked to Outlet A and cases in week 27 to Outlet B suggesting two separate point source outbreaks. Substantial undercooking of kebab meat would be necessary to explain the larger numbers of cases associated with Outlets A and B in comparison with other retailers. Alternatively, a heavily contaminated uncooked vehicle such as yoghurt relish was responsible. No salmonella was cultured from yoghurt, but samples were not obtained until 3 weeks after the outbreak. Yoghurt may have been cross-contaminated from raw meat whilst in storage at the wholesale distributor rather than during the process of manufacture. As a result, cases were linked to more than one takeaway food outlet and with eating a range of yoghurt-based relishes including plain yoghurt, garlic sauce, cucumber raita and chilli sauce served with kebabs.

The case-control method used in the epidemiological investigation also has several potential limita-

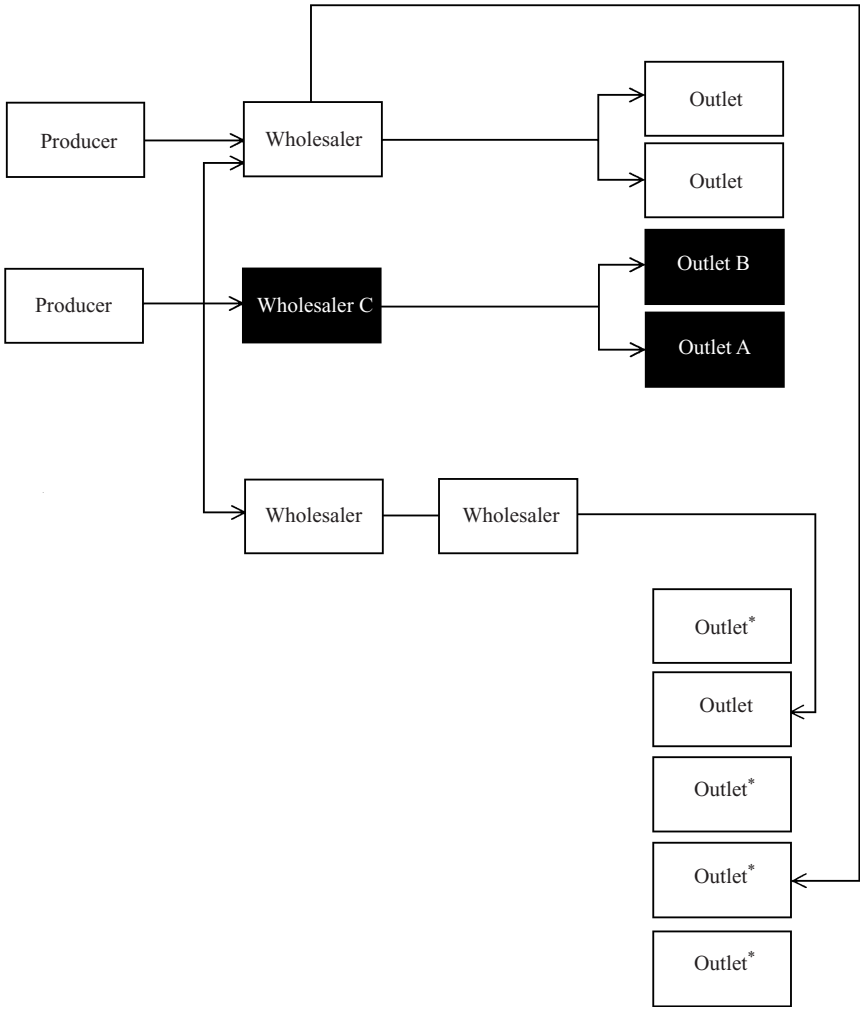

Fig. 3. Food chain for yoghurt associated with outbreak of *Salmonella typhimurium* DT170 infection, South Wales, July 1995.
* Outlets using home-made yoghurt.

tions, particularly from sampling and recall bias. Case-nominated controls were used because of the distinctive age and sex distribution of cases. General practitioner or telephone directory controls could have been used, but some cases were not registered with a doctor and some did not have a telephone. The study concentrated on early confirmed cases to avoid any delay in investigation. Even so, the delay inherent in phage-typing salmonella isolates meant that many cases were interviewed 3 weeks after the onset of illness. Obtaining detailed food histories therefore presented considerable problems of recall bias, for example, not all subjects could remember (or identify) the range of dressings and relishes they had eaten with their food. This may partly explain why consumption of kebabs or yoghurt relish only accounts for a fraction of the cases. It should not invalidate the study results unless there was differential recall bias between cases and controls. Since neither kebabs nor yoghurt are widely perceived by the public as a cause of salmonella food poisoning, this is unlikely to have occurred.

One previous salmonella outbreak associated with doner kebabs has been described [5]. This was linked to a single kebab house with numerous deficiencies in handling and cooking practices. The cause of the outbreak was thought to be inadequate cooking and/or cross-contamination of kebab meat. The outbreak only came to attention because of the unusual salmonella serotype involved. The authors therefore raised the possibility of a more widespread risk of illness associated with eating doner kebabs.

Outbreaks of infectious intestinal disease associated with milk and dairy products are not uncommon. Twenty such outbreaks affecting 600 people were reported in England and Wales during 1992–6 [6]. Eleven (55%) were caused by *Salmonella* species, of which six were due to *S. typhimurium*. The suspected

vehicles of infection were milk (8), ice cream (2) and cheese (1). None were associated with yoghurt, although outbreaks of botulism [7] and *Escherichia coli* O157 [8] have been reported after eating contaminated yoghurt. In the botulism outbreak, contamination was introduced by the use of inadequately heated hazelnut conserve used to flavour the yoghurt. The low acidity of the conserve allowed growth of *Clostridium botulinum* and production of toxin unlike the more acid fruit mixtures used by the same company [7]. In the *E. coli* O157 outbreak, no specific flavour was involved and the yoghurt was probably cross contaminated by contact with unpasteurized milk during the manufacturing process [8].

Growth of salmonellas is inhibited in yoghurt by a combination of the effect of lactic acid and pH. Lactic acid appears to have bactericidal activity even at pH 5·5, but below this the inhibitory activity is due to hydrogen ion concentration [9]. Some salmonella isolates appear to develop enhanced tolerance to a range of stressful environments, including acidic conditions [10]. Isolates that are more tolerant of low pH achieved with hydrochloric acid will survive longer in the presence of lactic acid (T. J. Humphrey, personal communication), and isolates which survive acidic conditions are also better able to cause infection in chickens [11]. Yoghurt is a relatively protective environment so that contamination by even a small number of salmonellas may pose an infection risk. Although we have not shown that salmonellas can grow experimentally in yoghurt, it is possible that under certain conditions yoghurt could be a vehicle for salmonella transmission.

This outbreak has several important features. It demonstrates the value of investigating the possibility of unusual or unlikely vehicles of transmission and serves to remind outbreak investigators of the potential for relishes and dressings to be vehicles of infection. It also highlights the difficulties that may be encountered in tracing the food supply chain and the potential for a wide variety of food outlets to be supplied from a common source. These can pose a considerable challenge to those concerned with investigating food poisoning outbreaks and maintaining food safety.

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