

## An outbreak of *Salmonella mikawasima* associated with doner kebabs

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### SUMMARY

During October 1992 an increase in the number of isolates of *Salmonella mikawasima*, a rare serotype, was noted including a cluster of nine cases in the South West Thames region. A case control study was conducted and univariate analysis showed a statistical association between illness and eating at takeaway A for cases compared with household controls ( $P = 0.003$ ) and with neighbourhood controls ( $P = 0.0245$ ). Cases were also more likely to have eaten kebabs than were controls or average takeaway A customers, implicating doner kebabs as the most likely vehicle of infection. Plasmid profile analysis of the nine cases' isolates showed them to be indistinguishable and to be characterized by a single plasmid of approximately 60 MDa.

The original source of the *Salmonella mikawasima* contamination was not determined, but food preparation practices for kebabs at takeaway A were insufficient to protect against illness if contaminated. This outbreak was only recognized because of the unusual serotype, but could be an indication of a more widespread problem with doner kebabs.

### INTRODUCTION

*Salmonella mikawasima* is a rare salmonella serotype with only 55 isolates identified in England and Wales by the Public Health Laboratory Service (PHLS) Laboratory of Enteric Pathogens (LEP) from January 1985 to August 1991 with 21 (38%) of the cases associated with foreign travel [1]. During autumn 1992 an

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increase in suspected cases of *Salmonella mikawasima* was noted including reports of eight persons with gastrointestinal illness from Surrey. Early enquiries suggested that patients had eaten at the same takeaway, and that several had eaten doner kebabs. This report describes the case control study and microbiological investigations conducted to investigate the vehicle source and cause of illness.

## METHODS

### *Epidemiological investigation*

#### *Case definition*

A case was defined as a person resident in South West Thames region who was ill with a diarrhoeal illness with onset date on or after 1 September 1992 from whose stool salmonella was cultured and identified as *S. mikawasima* by LEP. Ill persons who did not meet the case definition, had onset prior to 1 September, had onset within 3 days of travel abroad or were secondary cases (illness more than 3 days after a household case) were excluded from statistical analysis.

#### *Case ascertainment*

Information on additional cases was sought by sending a letter to local General Practitioners (GP), by contacting local clinical microbiology laboratories, by informing district health authorities in England and Wales and by publication of a note in the weekly Communicable Disease Review (CDR) [1].

#### *Selection of controls*

Two types of controls were chosen for cases. Household controls included all members of the case's household who had not been ill with a gastrointestinal illness since 1 September. Neighbourhood controls (two controls per case) included neighbours or friends nominated by the cases, who lived within a five mile radius, and who were matched for age and sex as follows.

Case age	Control age
< 5 years	< 5 years
5–14 years	± 5 years within the same age band
15–44 years	± 10–15 years within the same age band
< 45 years	± 20 years within the same age band

#### *Data collection*

Cases and controls were interviewed over the telephone by public health physicians. One case who could not be contacted by telephone completed a postal questionnaire. A structured questionnaire was used and information was sought on age, sex, symptoms, diarrhoeal illness in the household, contact with others who had a diarrhoeal illness and travel abroad as well as a history of eating outside the home, in the week prior to onset of the case's illness. Cases and controls who had eaten at the suspected takeaway (takeaway A) were asked about consumption of food items listed on a menu which was obtained from the proprietor. In addition, questions were asked about consumption of other foods previously associated with salmonella infection such as poultry, hamburgers, egg, mayonnaise, salad and raw milk.

*Data analysis*

Information derived from the structured questionnaires was compared for cases and household and neighbourhood controls. A matched single variable analysis was undertaken as the data set was too small to conduct a multivariable analysis. *P* values assessing the effects of the foods were calculated using exact methods [2].

*Frequency of kebab consumption*

Information on the average number of customers served each day during the week and during the weekend was obtained from the owner of takeaway A. Details of the types of meals served and the approximate proportion of customers ordering a kebab meal were also obtained. The probability of cases eating kebabs in the frequency detected based on this information, was estimated using the theoretical binomial distribution [2].

*Investigation of other sporadic cases*

Sporadic cases reported from outside South West Thames region were interviewed over the telephone using the same structured questionnaire. These data were analysed separately.

*Environmental investigation*

Employee illness records and food purchasing, handling and cooking practices were reviewed at the premises of takeaway A and at the kebab manufacturer. Faecal samples from all food handlers, specimens of doner kebab (cooked and uncooked), raw meat, dry ingredients and environmental swabs were obtained for bacterial examination.

*Microbiological investigation*

Faecal specimens, food samples and environmental swabs were cultured for bacterial pathogens including salmonella. Salmonella isolates obtained were typed and sent to LEP for confirmation. For plasmid profile typing, partially purified plasmid was extracted by a modification of the method of Kado and Liu [3] as described by Threlfall and co-workers [4].

## RESULTS

*Epidemiologic investigation**Descriptive*

Nine primary cases of *S. mikawasima* were identified in South West Thames region. There was one secondary case in a household contact of a primary case. In addition, there were two persons who became ill with gastrointestinal symptoms within 3 days of eating a kebab from takeaway A, but who did not have positive cultures. One of these did not have a faecal specimen collected and the faecal specimen from the other person (taken 10 days after the onset of illness when the person was on antibiotics for a chest infection) was culture negative.

All 9 primary cases, 6 males and 3 females, suffered diarrhoea and abdominal pain. Other symptoms reported were fever (8), anorexia (6), headaches (5) and

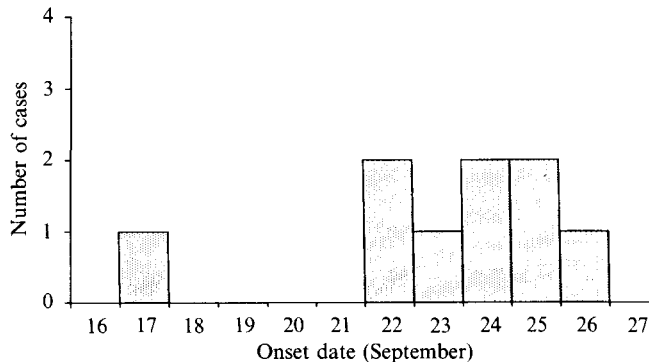


Fig. 1. Dates of onset of illness of cases of *Salmonella mikawasima* infection, South West Thames, September 1992.

Table 1. Comparison of food histories between cases and household controls, South West Thames, September 1992

Variable	Cases			Controls			Exact <i>P</i> value* (matched sets)†
	Ate	Did not eat	% Ate	Ate	Did not eat	% Ate	
Pub	1	6	14	0	18	0	0.500 (7s)
Kebab shop	7	0	100	6	12	33	0.020 (7s)
Burger joint	3	4	43	2	16	11	0.222 (7s)
Takeaway A	8	0	100	6	12	33	0.003 (8s)
Beef outside home	3	5	38	2	16	11	0.089 (8s)
Kebab outside home	8	0	100	2	16	11	0.0004 (8s)
Pizza outside home	1	7	13	0	16	0	0.333 (7s)
Burger outside home	4	4	50	3	15	17	0.056 (8s)

\* *P* value based on one-tailed, exact binomial probabilities [2].

† Indicates the total number of matched sets used in the analysis.

vomiting (4). Duration of symptoms ranged from 5 to 21 days. All cases were seen by a GP, but none was hospitalized and there were no deaths. The dates of onset of illness in cases were between 17 September and 26 September (Fig. 1). All cases lived in or near Walton-on-Thames, Surrey and were aged 15–35 years with a median age of 25 years. Eight cases reported eating doner kebab from takeaway A and one had bought and eaten chicken kebab there prior to the onset of illness. The date of the kebab meal was known for seven cases and the interval from consumption of kebab to onset of illness ranged from 20 to 72 h with a mean of 39 h.

#### Household controls

One case without household controls was excluded from the analysis. Data for the remaining 8 cases and 18 controls were analysed. Single variable matched analysis showed that cases were significantly more likely than controls to have eaten out at a kebab shop ( $P = 0.020$ ) and takeaway A ( $P = 0.003$ ) which served kebabs and pizza. Cases were also more likely to have consumed kebabs, burgers and beef outside the home (Table 1). Restricting the analysis to those who had eaten at takeaway A, showed that a higher proportion of cases than controls had

Table 2. Comparison of food histories between cases and household controls, for persons who ate at takeaway A, South West Thames, September 1992

Variable	Cases			Controls			Exact <i>P</i> value* (matched sets)†
	Ate	Did not eat	% Ate	Ate	Did not eat	% Ate	
Chips	5	2	71	2	4	33	0.250 (4s)
Salad‡	6	1	86	2	4	33	0.239 (4s)
Bread‡	7	0	100	2	4	33	0.125 (4s)
Kebab‡	8	0	100	2	3	40	0.167 (4s)
Any kebab	8	0	100	2	3	40	0.167 (4s)

\* *P* value based on one-tailed, exact binomial probabilities [2].

† Indicates the total number of matched sets used in the analysis.

‡ These variables have been combined to form the new variable 'Any kebab'.

Table 3. Comparison of food histories between cases and neighbourhood controls, South West Thames, September 1992

Variable	Cases			Controls			Exact <i>P</i> value* (matched sets)†
	Ate	Did not eat	% Ate	Ate	Did not eat	% Ate	
Fish & chip shop	0	6	0	3	8	27	1.000 (6s)
Takeaway A	5	0	100	2	9	18	0.025 (5s)
Pork outside home	1	5	17	0	11	0	0.138 (6s)
Kebab outside home	6	0	100	3	8	27	0.166 (6s)
Kebab in home	1	4	20	0	11	0	0.333 (5s)
Pizza outside home	0	6	0	2	9	18	1.000 (6s)
Burger in home	3	2	60	2	9	18	0.074 (5s)
Sausage outside home	1	4	20	0	10	0	0.333 (5s)
Sandwich outside home	2	3	40	1	10	0	0.333 (5s)
Egg in home	1	3	25	6	5	55	1.000 (4s)
Salad in home	2	3	40	8	2	80	0.667 (5s)

\* *P* value based on one-tailed, exact binomial probabilities [2].

† Indicates the total number of matched sets used in the analysis.

eaten kebab and chips (Table 2). There were only four sets available for the matched analysis of the associations between being a case and eating food items which showed that none reached the conventional 5% significance level. However, consumption of kebabs ( $P = 0.17$ ) and bread ( $P = 0.13$ ) showed some evidence of being associated with higher risk of illness. The remaining effects were far from significant and there was insufficient data to conduct a multivariable analysis.

#### Neighbourhood controls

Three cases without neighbourhood controls were excluded from the analysis. Data from the remaining 6 cases and 11 controls were analysed. Single variable matched analysis showed that cases were significantly more likely than controls to have eaten at takeaway A ( $P = 0.025$ ) (Table 3). For foods eaten outside the home, cases were significantly more likely than controls to have eaten kebab ( $P = 0.016$ ). The data set was too small for matched multivariable analysis.

*Frequency of kebab consumption*

In an average week at takeaway A, it was reported that approximately 25% of the 360 customers would have eaten kebabs. All of the nine cases ate kebabs at takeaway A. Using the theoretical binomial distribution, the estimate of kebab consumption was used to obtain the probability of all nine cases eating kebabs. Based on these calculations, cases were found to be significantly more likely to have eaten kebabs ( $P = 0.0000076$ ). Even if the estimate of the proportion of customers eating kebabs had been as high as 66%, rather than the 25% reported, then observing all nine cases eating kebabs would still have been significant at the conventional 5% level of significance.

*Investigation of sporadic cases reported from outside South West Thames Region*

A total of ten sporadic cases were reported. One of these cases resided in South West Thames and was therefore included in the South West Thames study. Of the remaining 9 cases, questionnaires were completed for 7, excluding 2 cases reported to have been associated with travel abroad. None of the 7 cases had eaten at takeaway A. Only 1 case had eaten kebab in the week prior to onset of illness. This kebab was obtained from a local kebab shop and the kebab meat was supplied to it from a local chain of butchers with no links to the kebab manufacturer. Other than 3 cases who ate at the same waffle/sweet shop, there were no exposures in common.

*Environmental investigation*

Raw, frozen kebab meat was delivered from the manufacturer to takeaway A weekly. Cooking practices and temperature control in relation to doner kebabs were poor. At the start of each working day, raw frozen kebab meat was removed from the freezer and thawed on a rotisserie set at low power. Meat was cooked to order by setting the rotisserie to high power. Over-cooked pieces of meat on the rotisserie were carved off and held in an electric bain marie. Probe thermometers were not used. Before closing the premises, unsold meat was removed from the rotisserie, cooled and returned to the freezer. This process was repeated until the meat was sold.

Raw, chilled lamb (mostly UK produced, occasionally New Zealand) was delivered to the kebab manufacturing unit. The lamb was boned, chopped coarsely and then frozen. It was partially thawed and minced finely. The mince was taken out of the mixer by hand and rolled out in a flat circular shape and placed on a skewer. The process was repeated to form a kebab shape. Meat was prepared and distributed (frozen) within 1 week. The staff member who had prepared the implicated kebab meat delivered to takeaway A on 16 September 1992 had not been ill.

Initial environmental control measures for takeaway A included the following advice:

- (i) to defrost meat thoroughly in a refrigerator at 4 °C before placing it on the rotisserie;
- (ii) at the end of each session, to cool the meat before storing in a refrigerator;
- (iii) to remove leftover stored meat from the refrigerator for one further session only and then to discard any unsold meat.

*Microbiological investigation*

No bacterial pathogens were isolated from ten faecal specimens taken from staff: 2 from workers at takeaway A and 8 from the kebab manufacturer. Cultures of 2 doner kebabs, 2 raw meat mixes, 12 dry ingredients and 11 environmental swab specimens showed no evidence of enteric pathogens.

All of the strains of *S. mikawasima* isolated from the nine primary and one secondary cases were indistinguishable and were characterized by a single plasmid of approximately 60 MDa.

## DISCUSSION

The epidemiological investigation of a cluster of cases of *S. mikawasima* infection in South West Thames pointed strongly to an association between illness and eating a kebab meal at a takeaway A. Firstly, a statistical association between illness and eating at takeaway A was demonstrated in the case control study using household controls ( $P = 0.003$ ) and neighbourhood controls ( $P = 0.025$ ). Secondly, a comparison of cases with household controls with respect to exposure to food items at takeaway A showed cases were more likely to have eaten kebabs. The data set was too small to test the independence of the risk factors in a multivariate model or to do an adequate matched analysis. Thirdly, using knowledge about the pattern of trade in an average week at takeaway A, a comparison of consumption of kebabs by cases with the probability expected, also supported the hypothesis that a kebab meal was the incriminated food item ( $P = 0.0000076$ ). Finally, the epidemiologic association was supported by laboratory analyses which showed the cases to have identical plasmid profiles.

An association between consumption of kebab (a meat containing product) and salmonella gastroenteritis was biologically plausible. The method of handling and cooking the kebab meat at takeaway A would have favoured the multiplication of any bacterial pathogens. Finally, the illness could not be explained by a history of consumption of any other food item. While there was a statistical association between illness and consumption of beef outside the home in the case/household control study, only three cases had eaten beef and the same association was not found in the case/neighbourhood control study.

The source of *S. mikawasima* in this outbreak could not be determined. It is possible that raw lamb delivered to the manufacturer was contaminated. Isolation of salmonella from 5.3% of samples of imported packs of boneless frozen mutton has been reported, but not from samples of raw, chilled carcass lamb or mutton taken at the wholesale market [5]. In a 1981–5 study in the Manchester area, salmonellae were isolated more frequently: from 18% of raw lamb samples [6]. In a study of the incidence of salmonella in abattoirs, butchers' shops and home-produced meat and their association with human infections in England and Wales, two strains of *S. mikawasima* were isolated from drain swabs from abattoirs dealing with cattle, sheep and pigs [7]. However, there were no reports of isolations of *S. mikawasima* from human infections in the area of the abattoirs.

It is possible that *S. mikawasima* was introduced into the raw meat during handling at the kebab manufacturing unit. Microbiological investigations were negative; however, all samples were taken 2–3 weeks after onset of illness in cases.



Another possibility is that contamination was introduced into the kebab meat during handling at takeaway A. Deficiencies conducive to multiplication and transmission of bacteria were identified in the handling and cooking practices at takeaway A.

*S. mikawasima* is a rare serotype of salmonella. Between 1985 and August 1991 only 55 human isolations had been identified by the PHLS LEP in England and Wales [1], and it has not been recovered from domestic animals or poultry in Great Britain (written correspondence from Ministry of Agriculture, Fisheries and Food). In the United States, only 21 human isolates were reported to the Centers for Disease Control and Prevention between 1980–91. During the same period only 3 of 16 646 non-human isolates represented this serotype: one from a turtle, one from an unspecified reptile and one from an unspecified 'other' source (written correspondence from CDC). In Canada, *S. mikawasima* has been isolated from aquarium snails imported from Florida, USA [8].

This outbreak came to attention because the serotype of salmonella was unusual. It is possible that many cases of food poisoning may be related to consumption of kebab meals, but the link is not easily recognized with common organisms. Assessments of hygiene risks in restaurants and takeaway shops have shown unsatisfactory results in 23 % (36 of 154) of shops selling kebabs [9, 10]. For kebabs, poor temperature control and risk of contamination (via hand contact or cross contamination) were the most frequent problems encountered. While the temperature was generally satisfactory for reheating kebabs (66 °C), some doner kebab specimens were heated at much lower temperatures [9]. Thus, further studies are needed to assess whether there is a more widespread risk of illness in association with consumption of doner kebabs.

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