Epidem. Inf. (1988). **101**. 249–257
Printed in Great Britain

Salmon as a food-poisoning vehicle – two successive salmonella outbreaks

By K. A. V. CARTWRIGHT

Public Health Laboratory, Gloucester GL1 3NN

and *B. G. EVANS

P.H.L.S. Communicable Disease Surveillance Centre, Colindale, London NW9 5EQ

(*Accepted 6 May 1988*)

SUMMARY

Gastroenteritis due to *Salmonella montevideo* occurred amongst guests attending two social functions held within 24 h, food for both having been provided by the same catering firm. Salmon was the most likely vehicle of infection in each case, although cross-contamination of other foods occurred. There were no deaths; four patients were admitted to hospital, one of whom underwent appendicectomy.

A review of salmon-associated food-poisoning outbreaks suggests that fresh salmon is an infrequent cause of food poisoning in the United Kingdom. The two outbreaks described here resulted from a failure of simple kitchen hygiene measures at a time of high ambient temperatures. Some current cooking instructions for salmon are inadequate.

INTRODUCTION

On 31 August 1984 a Gloucestershire catering firm served a buffet meal for a party of 28 people in Oxford. The guests dispersed widely over the country. During the next few days 22 of the 28 guests developed symptoms of gastroenteritis – primarily diarrhoea and abdominal pain. Eighteen of the 19 staff involved in the preparation and serving of the meal also ate some of the food. Eight subsequently became ill. On the following day the same firm provided a buffet for a local wedding reception party. Fifty-seven out of 120 guests became ill with gastroenteritis.

The index case was one of the guests at the Oxford meal who, on becoming unwell, ascertained that others attending the function had also developed symptoms of gastroenteritis and informed the caterers, who themselves informed the local Environmental Health Department. A stool sample from the index case yielded a *Salmonella* sp. subsequently identified as *S. montevideo*.

A meeting was held on 6 September attended by the Medical Officer of Environmental Health, the Director of the local Public Health Laboratory,

* Current address: Department of Community Medicine, King's College Hospital, London SE5 9RS.

environmental health officers and representatives from the Public Health Laboratory Service Communicable Disease Surveillance Centre (CDSC). Methods for the investigation of the outbreak were agreed.

METHODS

(a) *Epidemiology*

Names and addresses of guests at the two functions and a list of catering staff were drawn up. With the assistance of the caterers a questionnaire was prepared for guests at each of the two functions. Specific inquiry was made about consumption of individual foods, together with a request for details of any resulting illness including symptoms and the time elapsing before their onset. A guest or staff member was defined as a case if he or she had any illness consistent with a gastrointestinal infection following the dinner.

Two guests from the first function and four from the second were telephoned to check the appropriateness of the questionnaires. No alteration was found necessary. Relevant questionnaires were then sent by post to all guests who had attended either function and to all the catering staff. A second questionnaire was sent to non-respondents.

(b) *Investigation of premises and food preparation*

The caterer's premises were visited; raw and cooked foods and environmental swabs were collected. Detailed accounts of the methods used to prepare the various foods were drawn up.

(c) *Microbiology*

Stool samples were obtained from all kitchen staff, from as many symptomatic guests as possible and from all guests who were food handlers; swabs were collected from the kitchen areas; food samples were obtained both as remnants and as whole unconsumed foods.

All specimens were examined by standard methods (PHLS, 1974) including selenite F selective broth enrichment for salmonellas. No effort was made to quantitate salmonellas in foods.

(d) *Temperatures*

Maximum and minimum air temperatures at the time of the outbreak were obtained from the Meteorological Office Headquarters for two recording stations situated 15 and 20 km respectively and in opposite directions from the caterer's premises.

RESULTS

(a) *Foods served*

The foods served at each function are listed in Table 1.

(b) *Questionnaires*

All guests attending the Oxford function returned completed questionnaires (28/28, 100%); 108 of 120 guests at the second function returned completed

Table 1. *Food served at each function*

Outbreak 1
Cold asparagus and cucumber hollandaise
Cold salmon with avocado mousse or salmon mousse
Tomato and orange salad
French bean and mushroom salad with quail eggs
Cold new potatoes with French dressing

Meringue nests and cream with strawberries and kiwi fruit
Colston Bassett (Stilton) – made with unpasteurized milk

Outbreak 2
Cold salmon (frozen)
Honey roast ham carved from the bone
Raw vegetable salad – cabbage, courgettes, cauliflower, mushrooms and vinaigrette
French beans and mushroom salad
Curried rice salad and mayonnaise
Potato mayonnaise
Chicken pieces with honey (deep fried)
Coleslaw and mayonnaise

Fresh fruit Pavolva and cream
Lemon soufflé
Chocolate profiteroles

Stilton
Double Gloucester

Coffee

questionnaires (90%). Nineteen out of 20 (95%) of the catering staff completed questionnaires.

(*c*) *Attack rates*

Twenty-two out of 28 guests at the Oxford dinner (outbreak one) were ill, an attack rate of 79%. Of the 108 guests at the wedding reception (outbreak two) who replied to the questionnaire 57 (53%) met the case definition. Two guests had an illness which preceded the meal and therefore were not included as cases. Eight out of 19 catering staff (42%) were ill.

The principal symptoms experienced by cases were abdominal pains (85%), diarrhoea (76%), headache (67%), shivering and/or fever (63%), muscular aching (52%) and nausea (51%). Vomiting was less frequent (21%). The mode time of onset of symptoms was 18 h in outbreak one and 24 h in outbreak two. Not only was the incubation period shorter for the first outbreak but the clinical features reported tended to be more severe.

Specific inquiry in the questionnaires revealed that four persons were affected sufficiently severely to warrant admission to hospital, and one patient underwent appendicectomy. Many guests at each function lost time from work as a result of gastroenteritis.

(*d*) *Food histories*

In the first outbreak all guests (28/28) ate most of the foods, including cold salmon. The only food consumed by fewer than 25 guests was Stilton cheese (14/

Table 2. *Food-specific attack rates — outbreak 2*

Food	Ate				Did not eat			
	Total	Not Ill	Ill	% Ill	Total	Not Ill	Ill	% Ill
Salmon	95	41	54	57	8	7	1	13 *
Ham	92	39	53	58	7	5	2	29
Vegetable salad	73	30	43	59	19	13	6	31
French bean salad	68	24	44	65	21	15	6	28 **
Potato mayonnaise	79	36	43	54	16	8	8	50
Curried rice salad	57	22	35	61	36	19	17	47
Chicken pieces	83	34	49	59	12	7	5	42
Coleslaw	46	16	30	65	35	20	15	43
Pavlova and cream	38	14	24	63	46	26	20	43
Lemon soufflé	17	9	8	47	60	29	31	52
Chocolate profiteroles	51	24	27	53	37	18	19	51
Stilton cheese	29	12	17	59	52	27	25	48
Gloucester cheese	27	13	14	52	52	24	28	54
Chocolate	68	31	37	54	24	13	11	46
White coffee (cream)	78	33	45	58	20	12	8	40

* $P = 0{\cdot}04$; ** $P = 0{\cdot}007$ (two-tailed Fisher's test).
There was no significant difference in food-specific attack rates in any other foods.

28). Therefore it was not possible to demonstrate differences in attack rates according to the foods consumed for this outbreak.

Table 2 shows the number of guests at the second function who consumed each of the foods available and the number who subsequently fell ill. There was a significant association between illness and the consumption of salmon ($P = 0{\cdot}04$) and the consumption of French beans ($P = 0{\cdot}007$). These associations were independent of each other. There was no significant association between illness and the consumption of other foods.

Two late-arriving guests at the second outbreak ate salmon only and both were ill; one of the catering staff took home profiteroles not consumed at the wedding reception and these were subsequently eaten by two family members, one of whom fell ill. Four others not at the wedding reception subsequently consumed salmon; all developed gastrointestinal symptoms.

(*e*) *Methods of food preparation*

The main interest centres on the salmon preparation because of the short cooking time (see below), the long cooling period and the length of time for which cooked salmon remained unrefrigerated prior to consumption.

Though these three factors were common to the method of preparation of salmon for both functions, the detailed preparation varied. For the first function fresh salmon was cut into 2–3 cm thick cutlets, double wrapped in foil and put into a large fish pan containing cold water. The water was brought to the boil and boiled for between 4 and 10 min. After cooling for 2 h the water was decanted and replaced with cold water. One foil-wrapped piece was unwrapped by hand, tested to check for adequate cooking, rewrapped and returned to the pan. The water was poured off 12 h later and the cutlets refrigerated. The salmon, with other foods,

Table 3. *Foods tested*

S. montevideo found	*S. montevideo* not found
Salmon (unopened foil-wrapped cutlet)	Cream
Various food remnants including salmon	Stilton cheese
Salmon, Chicken } from function 2	Quail's eggs (unopened jar)
	Chicken eggs (raw from suspect batch)
	Aspic jelly powder (sachet)
Raw chicken, Raw veal } not consumed at either function	Hollandaise sauce (remnants)
	Meringue nests
	Second sample of salmon
	Second sample of chicken

was transferred in the back of an unrefrigerated van during the afternoon to the point of consumption, a 3 h journey. The estimated time between completion of cooking and consumption of salmon was about 30 h, with refrigeration for only about 8 h.

For the second function, some of the fish were cooked 2 days and some 1 day prior to the function. Whole, previously frozen salmon (weight about 5 kg) were defrosted, boiled for 10 min and then left to cool overnight in the same water. The fish were skinned by hand and then refrigerated. For the majority of the fish the estimated time between cooking and consumption was 46 h, with refrigeration for only 26 h.

Raw food was being handled in the same area as the cooked food – in particular chicken and veal were being diced for pies at the same time as the salmon was cooking.

(*f*) *Bacteriological results*

(i) *Guests*. Stool samples were obtained from nine guests at the first function, but because guests dispersed widely throughout the country, culture results of only four were available. All four yielded *S. montevideo*.

Thirty-three out of 120 guests at the second function submitted stool specimens of which 25 (76%) yielded *S. montevideo*.

(ii) *Kitchen staff*. Twenty staff were involved in the preparation or serving of food at one or both functions. Eighteen submitted stool specimens of which 17 (94%) yielded *S. montevideo*. The only member of the catering staff with stool specimens negative for salmonellas had not consumed any of the foods used at either function.

(iii) *Foods and environmental swabs*. The results of cultures for salmonellas carried out on various foods, both remnants and food unconsumed at each function, are shown in Table 3. French beans from the second outbreak were not available for culture.

Environmental swabs obtained from the kitchen premises did not yield salmonellas. All surfaces were regularly cleaned, and sampling took place several days after the outbreaks occurred.

Table 4. *Maximum/minimum temperatures (deg. C.) 30 August – 1 September 1984*

Cheltenham Council Offices	Day max.	Night min.
30 August	23·0	14·0
31 August	24·2	15·3
1 September	24·7	16·9
Westonbirt Arboretum		
30 August	21·8	16·1
31 August	21·8	16·4
1 September	22·0	16·4

Figures obtained from Meteorological Office Headquarters, Bracknell

(*g*) *Ambient temperatures*

The maximum and minimum air temperatures recorded at two sites within a few miles of the caterer's premises are shown in Table 4.

(*h*) *Action taken*

The presence of positive stool samples for *S. montevideo* in almost all of the caterer's staff resulted in the company having to cease business for several weeks. The kitchen was cleaned, redesigned and redecorated. The associated delicatessen was closed and all foods not securely packaged were withdrawn from sale. Staff were required to produce three negative stool samples before being allowed to return to work and they were further educated in cooking techniques. Purchase of refrigerated transport was recommended.

DISCUSSION

Several features of these outbreaks are of interest. Epidemiological and bacteriological evidence suggest that salmon was the main vehicle of infection. In each case the method of preparation of the salmon would have permitted contamination by hand to have occurred after completion of the cooking process. In the first outbreak the unwrapping by hand of a foil-wrapped salmon cutlet and its subsequent return to a pan of water holding the remaining cutlets was the probable method of contamination. In the second outbreak whole cooked fish were skinned by hand on the day before they were consumed. Though they were refrigerated overnight they spent several hours at ambient temperatures on the morning of the wedding prior to consumption. The 3-day period during which the food for the two functions was prepared and consumed was very warm. Overnight temperatures in particular were high.

Because of apparent widespread cross-contamination of foods (including at least French beans and profiteroles by the time microbiological examination was undertaken) it is not possible to be certain how salmonellas were originally introduced into the premises. The most likely vehicle by which salmonellas were introduced into the kitchen was the raw chicken (Table 3) used to prepare chicken and veal pies for a separate function at the same time as the salmon were being cooked for the Oxford buffet.

Fresh eggs, used to prepare hollandaise at the first function and mayonnaise for two salads served at the second function, were a second possible source, but there was no significant association between illness and the consumption of mayonnaise-containing salads (Table 2).

Salmon is not a common vehicle of infection, although a variety of infections and infestations have been reported. Nematode infections due to Anisakis larval type 1 have been described in Japan, the Netherlands and America (Rossett *et al.* 1982; Valdiserri, 1981). Diphyllobothriasis is a less commonly recognized nematode infection (Ruttenburger *et al.* 1984). An outbreak of botulism occurred in the UK in 1978 when two out of four elderly people died after eating canned salmon (Ball *et al.* 1979). Other outbreaks associated with canned salmon have occurred (Communicable Disease Report UK, 1982) although canning normally destroys both toxin and spores. Outbreaks of botulism amongst Indian and Eskimo populations in Alaska are not uncommon, and in a review Eisenberg & Bender (1974) estimated that 6 out of 21 outbreaks were associated with salmon.

Following cases of gastroenteritis during 1982 several types of canned salmon were withdrawn from the market (PHLS, 1982; Hayes, 1983). The organism was not identified, though staphylococcal food poisoning was suspected. An unidentified fish biotoxin could have been responsible (PHLS, 1982). Faecally contaminated salmon was established as the vehicle of giardia infection in the employees of a state school in the USA (Osterholm *et al.* 1981).

Five large outbreaks of *Clostridium perfringens* food poisoning associated with the consumption of boiled salmon were reported by Hewitt *et al.* (1986), the incidents occurring between 1974 and 1985. In the four best-documented incidents the number of persons at risk exceeded 200. A common factor in salmon preparation in these outbreaks was a long slow cooling process following cooking of the fish.

There are few reports in which fresh salmon has been incriminated as a vehicle for salmonella food poisoning. In a review of fish and shellfish poisoning in Britain, Turnbull & Gilbert (1982) noted only two fresh salmon-associated salmonella outbreaks between 1965 and 1980. Details of these outbreaks are no longer available. An outbreak of salmonella food poisoning associated with consumption of fresh salmon and affecting 22 out of 35 guests attending a buffet luncheon in Caithness, Scotland was detailed by Watson (1985). In this incident it was also thought that cross-contamination of cooked fish had occurred from chicken stored in the same refrigerator.

The reasons for the outbreaks described here may be summarized briefly and serve to re-emphasize the importance of simple microbiological principles in kitchen hygiene and food transport. There was inadequate separation of raw and cooked foods in the kitchen; salmonellas were probably transferred on the hands of the kitchen staff, suggesting that handwashing practices were inadequate. Salmon for both functions were kept unrefrigerated for long periods between cooking and consumption, allowing time for multiplication of micro-organisms. The outbreaks took place at a time of high ambient temperatures, when correct refrigeration was especially important. These factors have all been noted before (Roberts, 1982) but have clearly yet to be universally heeded. They are

particularly pertinent in the preparation of fresh salmon, which is regarded as being 'in season' during the warmer summer months.

Fresh salmon has become a popular catering item in recent years. Consumption is rising rapidly and the price is falling as a result of the availability of farmed fish. The size of the fish is well suited to large gatherings such as corporate functions, wedding receptions and hotel buffets. In these circumstances fish are likely to be cooked one or more days prior to consumption, creating the conditions for large outbreaks of food poisoning if standards of kitchen hygiene are compromised.

The fact that two outbreaks of food poisoning occurred on successive days emphasizes the need for early reporting of such incidents so that prompt action can be taken to prevent continuing episodes. The catering managers were convinced that their food preparation practices were of a high standard and they were surprised when the possibility of a food-poisoning outbreak became apparent. That they so rapidly informed the local Environmental Health Department permitted early investigation and intervention. The proliferation of small catering businesses underlines the continuing need for education in the principles of food hygiene together with programmes of regular surveillance. During the inspection of catering establishments the main emphasis needs to be placed on working practices, ideally without compromising a thorough physical inspection of the premises.

Perusal of a number of cookery books revealed deficiencies in instructions for cooking salmon. Several recipe books gave no indication of the length of time needed to cook adequately fish of different sizes. One popular book gave the following recipe for cooking salmon: 'Poach (the salmon) the day before in a court bouillon and leave it to cool before skinning it. Bone the salmon, leaving it whole, and keep it overnight in a cool place. Garnish the salmon next morning.' Such advice invites a repetition of the episodes described above. Publishers of cookery books must ensure that the food preparation advice offered is both adequate and microbiologically sound.

The authors wish to thank others involved in the investigation – in particular the staffs of the Gloucester Public Health Laboratory and of the Stroud Environmental Health Department. We also thank Dr N. D. Noah and Dr N. S. Galbraith, PHLS Communicable Disease Surveillance Centre, for invaluable help in the preparation of this paper.

REFERENCES

Ball, A. P., Hopkinson, R. B., Farrell, I. D., Hutchinson, J. G. P., Paul, R., Watson, R. D. S., Page, A. J. F., Parker, R. G. F., Edwards, C. W., Snow, M., Scott, D. K., Leone-Ganado, A., Hastings, A., Ghosh, A. C. & Gilbert, R. J. (1979). Human botulism caused by *Clostridium botulinum* type E: the Birmingham outbreak. *Quarterly Journal of Medicine* **48**, 473–491.

Eisenberg, M. S. & Bender, T. R. (1976). Botulism in Alaska, 1947 through 1974. *Journal of the American Medical Association* **235**, 35–39.

Hayes, A. H. (1983). The food and drug administration's role in the canned salmon recalls of 1982. *Public Health Reports* **98**, 412–415.

Hewitt, J. H., Begg, N., Hewish, J., Rawaf, S., Stringer, M. & Theodore-Gandi, B. (1986). Large outbreaks of *Clostridium perfringens* food poisoning associated with the consumption of boiled salmon. *Journal of Hygiene* **97**, 71–80.

OSTERHOLM, M. T., FORFANG, J. C., RISTINEN, T. L., DEAN, A. G., WASHBURN, J. W., GODES, J. R., RUDE, R. A. & MCCULLOUGH, J. G. (1981). An outbreak of food-borne giardiasis. *New England Journal of Medicine* **304**, 24–28.

PHLS COMMUNICABLE DISEASE SURVEILLANCE CENTRE AND COMMUNICABLE DISEASES SCOTLAND UNIT (1982). Communicable Disease Reports April to June 1982. *Community Medicine* **4**, 287–291.

PUBLIC HEALTH LABORATORY SERVICE (1974). Monograph Series 8, *Isolation of Salmonellas*. London: Her Majesty's Stationery Office.

ROBERTS, D. (1982). Factors contributing to outbreaks of food poisoning in England and Wales 1970–1979. *Journal of Hygiene* **89**, 491–498.

ROSSETT, J. S., MCCLATCHEY K. D., HIGASHI, G. I. & KNISELY, A. S. (1982). Anisakis larval type 1 in fresh salmon. *American Journal of Clinical Pathology* **78**, 54–57.

RUTTENBURGER, A. J., WENIGER, B. G., SORVILLO, F., MURRAY, R. A. & FORD, S. L. (1984). Diphyllobothriasis associated with salmon consumption in Pacific coast states. *American Journal of Tropical Medicine and Hygiene* **33**, 455–459.

TURNBULL, P. C. B. & GILBERT, R. J. (1982). Fish and shellfish poisoning in Britain. In *Adverse Effects of Foods* (ed. E. F. P. Jelliffe and D. B. Jelliffe), pp. 297–306. New York: Plenum Press.

VALDISERRI, R. O. (1981). Intestinal anisakiasis. Report of a case and recovery of larvae from market fish. *American Journal of Clinical Pathology* **76**, 329–333.

WATSON, J. (1985). Another 'fast reactor' in Caithness. *Communicable Diseases (Scotland) Report* 85/49.