J. Hyg., Camb. (1982), **89**, 491–498
Printed in Great Britain

Factors contributing to outbreaks of food poisoning in England and Wales 1970–1979

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(*Received* 11 *May* 1982; *accepted* 2 *July* 1982)

SUMMARY

Epidemiological data accompanying reports of more than 1000 outbreaks of food poisoning have been studied to determine the factors which most frequently contributed to the outbreaks. Preparation of food in advance of needs combined with improper storage and inadequate cooking, cooling and reheating were the most common factors. Infected food handlers did not play a significant role except in instances of *S. aureus* food poisoning.

INTRODUCTION

Published reports on the incidence of bacterial food poisoning and salmonella infection in England and Wales give information on the number of outbreaks and cases, location, causal agent and type of food as well as details of outbreaks of special interest and prevalence of particular serotypes and phage types of the organisms implicated. There is available less information on the malpractices in food preparation processes that lead to food poisoning. In 1978 Bryan analysed the factors contributing to 81 outbreaks reported in the United Kingdom from 1969 to 1976. The information was abstracted from reports in the British Medical Journal and only represented a small proportion of the outbreaks during that period. Other surveys on factors contributing to outbreaks have been carried out in the United States (Bryan, 1972, 1975, 1978). The present analysis includes data from more than 1000 outbreaks reported between 1970 and 1979 and includes many of the outbreaks analysed by Bryan.

MATERIALS AND METHODS

The data have been extracted from routine reports of general and family outbreaks of food poisoning made to the PHLS Communicable Disease Surveillance Centre (CDSC) by laboratories and local authorities in England and Wales. These have been supplemented by published reports and from correspondence accompanying cultures of *Clostridium perfringens*, *Staphylococcus aureus* and *Bacillus cereus* sent to the Food Hygiene Laboratory for serotyping and for toxin testing; and also from questionnaires on food preparation and storage procedures

Table 1. *Distribution of general and family outbreaks of food poisoning analysed by aetiological agent*

Causal agent	Number of outbreaks
Salmonella spp.	396
C. perfringens	387
S. aureus	133
B. cereus and other *Bacillus* spp.	53
Other-bacterial	
V. parahaemolyticus	8
E. coli	3
C. botulinum	1
Y. enterocolitica	1
Other-non-bacterial	
scombrotoxin	47
red kidney beans	7
virus	1
Not known	7
Total	1044
Total outbreaks reported 1970–9 (Anon 1980)	6457

which the laboratory sends out when insufficient information is received with cultures of *C. perfringens* from outbreaks.

The outbreaks studied were mostly due to bacteria, i.e. *Salmonella* spp., *C. perfringens*, *S. aureus*, *B. cereus*, other *Bacillus* spp., *Vibrio parahaemolyticus*, *Escherichia coli*, *C. botulinum* and *Yersinia enterocolitica*. Other episodes included scombrotoxic fish poisoning, red kidney bean poisoning and viral gastroenteritis. The reports analysed varied in the amount of detail furnished concerning the history of ingested food, with one factor recorded in some instances and as many as 5 or 6 in others. It is likely that when only single factors were recorded other factors were involved but, clearly, these could not be included in the analysis.

RESULTS

Between 1970 and 1979 sufficient data were obtained from 1044 general and family outbreaks of food poisoning to include in the analysis (Table 1). Over this period there were 6457 such outbreaks reported to the PHLS (Anon, 1980) and although some of the outbreaks studied were not included in this figure it is still apparent that in only a small proportion of outbreaks was adequate epidemiological data supplied. In 67 % of the outbreaks studied (609 of 1044) the food was prepared in restaurants, hotels, clubs, hospitals, institutions, schools and canteens and in only 20 % (206 of 1044) was food prepared in family homes (Table 2). In 817 (78 %) of the outbreaks the food consumed was meat (444, 42 %) or poultry (373, 36 %). Of the remaining 227 outbreaks the food incriminated varied with the agent involved. In outbreaks of salmonellosis the principal food vehicle apart from meat

Table 2. *Place of consumption or origin of food incriminated in* 1044 *general and family outbreaks of food poisoning in England and Wales* 1970–1979

Place or function	*Salmonella* spp.	*C. perfringens*	*S. aureus*	*B. cereus* and other *Bacillus* spp.	Other-bacterial	Other-nonbacterial	Not known	Total (%)
Restaurants, hotels, clubs, holiday camps	83	48	13	27	4	1	3	179 (17·1)
Hospitals	28	80	6	1	—	—	—	115 (11·0)
Banquets, dinners, receptions, parties	90	18	16	—	2	—	1	127 (12·2)
Institutions	9	73	14	—	1	—	—	97 (9·3)
Schools	13	62	15	1	1	—	—	92 (8·8)
Canteens, meals-on-wheels	7	76	5	—	—	—	1	89 (8·5)
Shops, bakeries, take aways	36	1	22	20	—	1	—	80 (7·7)
Farms	43	—	—	—	1	—	—	44 (4·2)
Outings, holiday parties	3	4	2	—	—	1	—	10 (1·0)
Ships, aeroplanes	1	—	—	—	3	—	—	4 (0·4)
Not known	—	—	1	—	—	—	—	1 (0·1)
Family homes	83	25	39	4	1	52	2	206 (19·7)
Total	396	387	133	53	13*	55†	7	1044 (100)

* *V. parahaemolyticus* (8), *E. coli* (3), *C. botulinum* (1), *Y. enterocolitica* (1).
† Scombrotoxin (47), red kidney beans (7), virus (1).

and poultry was raw milk while most of the *B. cereus* outbreaks were associated with rice.

Of the factors which most commonly contributed to outbreaks in England and Wales (Table 3), preparation of the food more than half a day in advance of needs occurred in more than 60%. Other major contributing factors were storage at ambient temperature (40%), inadequate cooling (32%), inadequate reheating (29%) and the use of contaminated processed food (19%). The latter included such foods as cooked meats and poultry, pies and take-away meals prepared in premises other than those in which the final dish was consumed but did not include canned foods.

Infected food handlers did not play a significant role except in instances of *S. aureus* food poisoning. In many of these (41 of 44) the same phage and enterotoxin producing type of *S. aureus* was isolated from both food handler and food. Although infected food handlers were recorded in 126 salmonella outbreaks, in only 9 (7%) was there evidence to suggest that they were the original source of the contaminating organism. In two of the outbreaks the food handlers had recently

Table 3. *Factors contributing to* 1044 *outbreaks of food poisoning in England and Wales* 1970–1979 *by aetiological agent*

Contributing factor	Number of outbreaks in which factor recorded: *Salmonella* spp.	*C. perfringens*	*S. aureus*	*B. cereus* and other *Bacillus* spp.	Other-bacterial	Other-nonbacterial	Not known	Total (%)
Preparation too far in advance	173	338	66	49	4	—	3	633 (60·6)
Storage at ambient temperature	115	208	54	32	1	2	1	413 (39·6)
Inadequate cooling	71	236	10	16	—	—	—	333 (31·9)
Inadequate reheating	47	215	4	29	3	—	2	300 (28·7)
Contaminated processed food (excluded canned)	105	9	25	4	9	46	1	199 (19·1)
Undercooking	91	62	1	1	1	4	1	161 (15·4)
Inadequate thawing	42	22	—	—	—	—	—	64 (6·1)
Cross contamination	57	3	2	—	—	—	—	62 (5·9)
Improper warm holding	9	42	—	8	1	—	—	60 (5·7)
Infected food handlers	9	—	44	—	1	—	—	54 (5·2)
Use of left overs	21	20	8	1	—	—	—	50 (4·8)
Raw food consumed	37	—	—	—	1	8	—	46 (4·4)
Extra large quantities prepared	13	17	2	—	—	—	—	32 (3·1)
Contaminated canned food								
(*a*) freshly opened	2	3	16	1	1	3	3	29 (2·8)
(*b*) not freshly opened	—	—	8	—	1	—	—	9 (0·9)
(*c*) not known	—	—	7	—	—	—	—	7 (0·7)
Total	792	1175	247	141	23	63	11	2452 factors

returned from holidays in Spain, while in the other seven the food handlers had continued to prepare food while suffering symptoms of gastroenteritis. In most instances food handlers are victims, not sources, and become infected either from frequent contact with contaminated raw food, from tasting during preparation or from eating left over contaminated cooked food.

Although in most types of food poisoning preparation in advance and storage at ambient temperature were the two main factors involved (Table 3) certain factors appeared to be associated with particular organisms. In outbreaks due to salmonellas use of contaminated processed food (27%), undercooking (23%) and inadequate cooling (18%) were the next most commonly involved factors. Con-

taminated processed food was associated with more outbreaks caused by *Salmonella* spp. than any of the other types of bacterial food poisoning. In outbreaks due to *C. perfringens* multiple factors were frequently recorded with inadequate cooling (61 %) and inadequate reheating (56 %) figuring prominently together with preparation in advance (87 %) and storage at ambient temperature (54 %). Infected food handlers (33 %) and contaminated processed food (19 %) were important factors in outbreaks due to *S. aureus*; a significant proportion of these outbreaks were attributed to the consumption of canned food (23 %) of which more than half were reported as being freshly opened just prior to consumption.

Of the 53 outbreaks due to *Bacillus* spp. 45 of the 52 caused by *B. cereus* followed the consumption of rice at restaurants or from take away shops. One outbreak attributed to *B. licheniformis* was associated with a commercially produced meat pie. The factors contributing to outbreaks were similar to those associated with *C. perfringens*.

Other food poisoning outbreaks

Of the 13 outbreaks studied (Table 1) due to bacteria other than those mentioned above, nine were associated with fish and shellfish (*V. parahaemolyticus* and *C. botulinum*), one with coleslaw (*Y. enterocolitica*), two with meat products (*E. coli*) and one with raw milk (*E. coli*). In this small group of outbreaks processed food contaminated with the agent or its toxin was the most frequently implicated factor. The one episode of botulism was caused by canned salmon from Alaska which contained *C. botulinum* type E (Ball *et al.* 1979). The can was shown to have a small defect through which the *C. botulinum* entered after the product was processed.

There were 55 outbreaks (Table 1) in which the cause of illness was a non-bacterial toxin. In those due to red beans, the toxin (red bean haemagglutinin) occurs naturally in the food itself whereas in those due to scombrotoxin, the toxin is produced by bacteria acting on the food. In one large outbreak the infectious agent was a virus (Appleton & Pereira, 1977).

In seven outbreaks various contributing factors were reported but a causal agent was never identified. Three of these were associated with freshly opened canned foods.

DISCUSSION

In the sequence of events which occurs when persons succumb to bacterial food poisoning, one or more factors may cause the initial contamination in a food item to become an infectious or intoxicating dose. The initial dose of organisms in a food is usually insufficient to cause food poisoning but the presence of sufficient nutrients, moisture and warmth, together with a time lapse before consumption may allow the microorganisms to reach harmful levels. In the case of *C. perfringens*, multiplication can be extremely rapid as this organism has a high optimum temperature for growth (43–47 °C) and a short generation time of about 12 min. Other characteristics of the food that may also play a part in allowing bacterial multiplication are pH, water activity (a_w), redox potential and levels of other organisms which may compete with or inhibit the growth of potential pathogens or both.

This analysis shows that although there are a number of factors which continually contribute to outbreaks there is a wide variety of other factors which play a part, depending on the organism involved and the type of food consumed. For example the food most frequently implicated in the outbreaks of salmonella food poisoning studied was poultry. A recent survey showed that 79 of 100 frozen chickens purchased from normal retail outlets contained salmonellas, some containing more than one serotype (Communicable Disease Surveillance Centre, 1980). The procedures carried out from thawing a frozen bird to serving the cooked meat offer many opportunities for the spread of contamination via hands, equipment and surfaces and for the survival and multiplication of salmonellas if there is not strict control of hygiene and temperature of food storage at all stages. Thus in reports of outbreaks factors such as inadequate thawing, undercooking and cross contamination are important contributory factors.

In 168 outbreaks (123 *Salmonella* spp., 45 *C. perfringens*) the type of poultry implicated was turkey, often large ones (25 lbs or more) and frozen. These birds are a particular problem because their size creates difficulties in thawing, cooking, cooling and storing adequately to prevent growth of surviving or recontaminating organisms (Anon. 1974*a*, *b*; Noah, 1975). The increasing number of turkey associated outbreaks led to the issue of a Health Notice and Local Authority Social Services Letter on the Safe Preparation of Turkeys in 1977 (Department of Health and Social Security, 1977).

During cooking oxygen will be driven out of food so that an anaerobic environment is created. The heat-resistant spores of *C. perfringens* that survive most conventional cooking procedures will be heat activated and during any long slow cooling process there will be germination and rapid multiplication. As *C. perfringens* is widespread in the environment and is usually present in the animal intestine, it will be present naturally in most foods, particularly those of animal origin. Therefore prevention of this type of food poisoning depends almost entirely on temperature control during the whole process from raw to cooked food. This is well illustrated in Table 3, the four factors which were most frequently implicated in outbreaks of *C. perfringens* food poisoning all related to time and temperature at which the food was held prior to consumption.

The main source of *S. aureus* in relation to food poisoning outbreaks is the person preparing the food. The organism is frequently carried in the anterior nares, less commonly on the skin and, perhaps most importantly in relation to food poisoning, in septic lesions on the hands. Strains from any of these sites may be enterotoxigenic. The foods which act as vehicles of intoxication are usually those which have received much handling during preparation and which are consumed without further heat treatment, although the toxins are not necessarily inactivated even if the food is reheated. *S. aureus* can tolerate relatively high concentrations of salt and sugar so cured meats such as ham can provide an ideal environment for their growth while inhibiting other organisms and removing any competition.

B. cereus is a widespread naturally-occurring organism commonly found in cereals. Its spores can survive cooking so that when boiled rice is kept at kitchen temperature for frying on demand there is opportunity for germination and multiplication (Public Health Laboratory Service Working Party, 1976). The organisms produce enterotoxins and these can cause either an emetic or a

diarrhoeal syndrome; the outbreaks associated with rice have been the emetic type. The emetic toxin is very heat stable (Melling & Capel, 1978) and is not inactivated by frying. Prevention of this type of food poisoning depends on temperature control of the food and as *B. cereus* is similar to *C. perfringens* in that it produces heat resistant spores the factors contributing most frequently (Table 3) to both types of outbreaks are similar.

Although bacteria are involved in episodes of scombrotoxic fish poisoning they are not directly the infectious agent. Scombroid fish (tuna, mackerel, bonito) are rich in histidine and during storage at warm temperatures this is decarboxylated to histamine by the normal fish flora. Histamine is the toxic factor or is closely associated with the toxic factor and symptoms (principally a sharp or peppery taste in the mouth, hot flushing of the face and neck, sweating, bright red rash and headache with sometimes diarrhoea and nausea) are produced very rapidly after eating the fish (Gilbert *et al.* 1980). The toxin is very stable and cannot be destroyed by curing or heating so outbreaks can occur from canned fish (Murray, Hobbs & Gilbert, 1982). Scombrotoxic fish poisoning is probably beyond the control of the consumer, but is nevertheless preventable at the processing stage by ensuring that only fresh or frozen fish is used.

The outbreaks associated with red kidney beans were all due to consumption of the food in an uncooked or undercooked state. The toxin is inactivated by cooking the beans until soft (Noah *et al.* 1980).

This study has summarized data from outbreaks reported between 1970 and 1979. In 1980 a system was introduced by which Medical Officers for Environmental Health and Environmental Health Departments could report outbreaks to CDSC as part of the rationalisation of food poisoning surveillance. The new report forms have been useful in documenting factors contributing to outbreaks in more detail and more consistently than is possible in laboratory reports (Anon. 1981). However, even with the new report forms information on contributory factors was provided in only some of the outbreaks (31 % *Salmonella* spp., 74 % *C. perfringens*).

Food poisoning statistics for Scotland in 1980 (Collier *et al.* 1981) also give some information on factors involved in outbreaks, although, as with England and Wales, data were only available for a proportion of the outbreaks reported (44 of 147 general and family outbreaks). The factors recorded were similar to those described in the present study although the main factors, preparation in advance and storage at ambient temperature were not listed in the Scottish study. Those most frequently recorded for Scotland were unsafe source, inadequate cooking, cooling, thawing and reheating. The majority (120 of 147) of the Scottish outbreaks were caused by *Salmonella* spp.

Attempts are being made to reduce the level of contamination of meat and poultry but it is not going to be possible to remove all organisms. Moreover those occurring naturally, *C. perfringens* and *B. cereus*, and the human contaminant, *S. aureus*, will remain as potential causes of food poisoning. Thus prevention will require education of those involved in the preparation, processing and service of food, both on the commercial and domestic scale. The results of the analysis indicate that nearly all food poisoning could be prevented by eating food within 90 min of preparation. This is not always practical and, indeed, early preparation only leads to an outbreak of food poisoning when it is combined with other factors.

The general standard of hygiene in food premises could be improved to prevent cross-contamination by thorough cleaning and disinfection between processes, especially when both raw and cooked foods are being processed. However, the analysis shows that factors related to temperature control, i.e. storage at ambient temperature, inadequate cooling or reheating, warm holding and undercooking, are more frequently associated with outbreaks. Emphasis placed on improving this aspect would undoubtedly significantly reduce the number of outbreaks of food poisoning.

I am grateful to Dr N. S. Galbraith, Director and Dr N. D. Noah, Consultant Epidemiologist, both of the PHLS Communicable Disease Surveillance Centre, Colindale, London and their colleagues for assistance in carrying out this study and also to Dr R. J. Gilbert, Director of the Food Hygiene Laboratory, Central Public Health Laboratory, Colindale for his guidance and encouragement.

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