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An outbreak of cholera in Australia due to food served in flight on an international aircraft

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SUMMARY

An outbreak of cholera occurred in November 1972 among passengers on an aircraft that had flown from London to Sydney. The infection was confined to economy-class passengers and the available evidence indicates that it was due to a dish of hors d'œuvres served on the aircraft between Bahrain and Singapore. Although one person died, the infection was generally mild, and almost half of those infected were symptomless. There was a significant difference between the immunization status of persons with clinical illness and the immunization status of other passengers. Current cholera immunization appeared to play a significant role in preventing symptoms of the disease, but it did not prevent a person becoming a carrier of the organism.

INTRODUCTION

Because modern air travel freely permits rapid movement from one country to another, it has played an important part in the widespread geographical distribution of cholera during the present pandemic. Cholera has been introduced into Australia, France, Ghana, West Germany, Japan, Sweden, Taiwan, and the United Kingdom by this means (Barua, 1972). However, no report has yet been published of an incident in which a large number of passengers have become simultaneously infected with *Vibrio cholerae* as a result of consuming food or water on board an aircraft. The following report describes such an event. At least 47 persons were infected, and cholera introduced into three different countries as a result of the serving of contaminated food to passengers on a Boeing 747 flight from London to Sydney.

THE OUTBREAK

On 5 November 1972, a patient, who had just arrived by air from overseas, was admitted to a hospital in Sydney, N.S.W., with severe watery diarrhoea. Faeces were collected for culture, and by the following day a presumptive diagnosis of cholera had been made. Further laboratory tests classified the organism as *Vibrio cholerae* El Tor, serotype Inaba. By 7 November two other persons, who had been passengers on the same flight to Sydney, had also been admitted to hospital with a presumptive diagnosis of cholera. As it seemed likely that this outbreak of

cholera might involve others who had travelled on the same aircraft, the Australian Department of Health and the several State Health Departments immediately set about contacting all passengers and crew. By 11 November this had been achieved and arrangements made for the collection and examination of faecal specimens. Persons giving positive laboratory tests for cholera and any suffering from diarrhoea were placed in quarantine. The remainder were put under surveillance. Although there were a few exceptions, in general no attempt was made to immunize the passengers, their contacts or members of the public.

Numbers involved

The aircraft, a Boeing 747, had flown from London to Sydney via Amsterdam, Bahrain, Kuala Lumpur and Singapore. It had an almost complete complement of passengers – 26 first-class and 331 economy-class – when it left Bahrain. Of these, 40 disembarked at Singapore. Two of these disembarking passengers, who later continued their journey to Australia on another flight, were subsequently shown to have positive tests for *V. cholerae*. Forty-seven passengers joined the aircraft in Singapore.

A total of 47 passengers, including 6 persons who had continued their journey to New Zealand on another aircraft, were found to be excreting *V. cholerae* with or without overt signs of illness. No passengers who first boarded the aircraft in Singapore, no crew member, and no passenger travelling first-class, was found to have a positive test for cholera. Only economy-class passengers were subsequently shown to be infected. In what follows the term 'case' will be used to describe a person with a positive laboratory test for *V. cholerae*, and with some (mild to severe) overt signs of illness. The term 'carrier' will be used to describe a person with a positive laboratory test for *V. cholerae*, but with no overt signs of illness. On this basis, of the 47 infected passengers, 25 would be classified as cases and the remaining 22 as carriers.

Although faecal samples were collected from all passengers and crew members, it is possible that some carriers were not detected, either because they were no longer excreting vibrios at the time of examination, or because the laboratory methods used were not sufficiently sensitive. The actual number of persons infected may therefore have been higher than the figures given here indicate.

EPIDEMIOLOGY

Probable source of the infection

Three possible ways in which the infection might have occurred were considered initially. The first was as a result of eating food or drinking water in an airport terminal *en route* to Australia, but it soon became apparent that many of those infected did not eat or drink in any terminal. This was, therefore, considered unlikely to be the source of the infection. The second possibility considered was that the infection occurred as the result of chance contamination of food by a carrier among the cabin staff on the aircraft. When it became known that a large number of persons had been infected this hypothesis seemed unlikely. It was also

learned that, during flight, the meals were stored as pre-packed individual servings on trays in refrigerated modules, and there was little handling of food by the cabin staff. The third and by exclusion the most likely explanation appeared to be that the source of the infection was food or water loaded on the aircraft at Singapore or Bahrain.

In addition to the infections that occurred on the London–Sydney flight, two cases of cholera were detected in England among passengers on a Boeing 747 flight from Sydney to London. This aircraft left Bahrain for London 2 hr. before the eastbound aircraft left Bahrain for Sydney. Singapore and Bahrain were the only stopover points common to both flights.

It has already been stated that all 47 persons infected on the London–Sydney flight were on the aircraft when it left Bahrain; none of the passengers who boarded the aircraft for the first time at Singapore were found to be infected. In addition, two passengers, who had been on board when the aircraft left Bahrain, but who disembarked at Singapore and travelled to Sydney 3 days later, were found to be excreting *V. cholerae*. One of these persons had suffered from diarrhoea while in Singapore.

At the time of the outbreak, Bahrain was experiencing an outbreak of cholera that had begun on 24 October 1972. The outbreak was due to *V. cholerae* El Tor, serotype Inaba, phage type 2, the same type responsible for the infection among the passengers on both aircrafts. This information was kindly provided by the W.H.O. Cholera Reference Laboratory, Calcutta who phage typed the strains of *V. cholerae* from Bahrain and from the cases on the aircraft. Singapore was considered to be 'cholera-free' at the time.

On the available evidence, therefore, it appeared most likely that water or food loaded on the aircraft at Bahrain was the source of the infection. For the purposes of this discussion, the possible roles of water and of food will be discussed separately.

Water

On the Boeing 747, domestic water is loaded on the aircraft through only one filling point. It is then, for engineering reasons such as the trim of the aircraft, fed into three separate tanks of approximately 100 gallons each. It passes from these tanks into one common manifold which services all parts of the aircraft. The water used in first-class and economy-class compartments is therefore the same, and the same water is also used by the 19 crew members, but no case or carrier of cholera was found among first-class passengers or crew. Furthermore, many of the victims were certain they did not drink water, eat ice, or even clean their teeth during the flight. In the economy-class, all drinking vessels are disposable and are not washed during flight. This would appear to be good evidence against the infection being due to contamination of the water supply on the aircraft.

The water used for filling the water carts which service aircraft at Bahrain is also used in the food catering unit and in the snack bars and other amenities at the airport terminal. If there had been a general contamination of this water supply, clinical cases of cholera would probably have occurred among passengers on other airlines and among staff at the airport complex. This was not the case.

Table 1. *Percentage of infected and non-infected passengers who ate the various items on the tray of hors d'œuvres*

Food item	Infected passengers (%)	Non-infected passengers (%)
Pâté	55	50
Duck	83	52
Smoked salmon	74	64
Salami	60	60
Mushroom salad	79	44
Stuffed egg	73	*

* Omitted inadvertently from the questionnaire sent to these passengers.

In addition, several other aircraft were serviced in Bahrain both before and after departure of the two aircraft on which cholera occurred. There were no cases of cholera among passengers on these other aircraft.

Therefore, although it is not possible to be absolutely certain, the available evidence indicates that water loaded on the aircraft at Bahrain was not the cause of the infection.

Food

The meals served to first-class and to economy-class passengers and to crew members were different. Two economy-class meals were loaded aboard at Bahrain. The first meal served was a breakfast consisting of grapefruit cocktail, cereal and milk, bacon, egg, mushrooms and grilled tomato, together with bread, butter and marmalade. It seems unlikely that this meal could have been the cause of the infection. The cereal and milk were eaten by only a small number of the cholera cases. The bacon, eggs, mushrooms and tomato were heated on board the aircraft and it is almost certain that the cooking would have killed any vibrios likely to be present. The grapefruit cocktail was prepared in Bahrain from fruit imported in tins. The pH of this product is within the range 3·5–4·5 which is unsuitable for the growth and survival of *V. cholerae*.

The second meal consisted of cold assorted hors d'oeuvres (pâté in aspic, smoked salmon, glacé duck, salami, stuffed egg and a mushroom salad), an apple flan (individually packed in cellophane wrapping), bread, butter, cheese and biscuits. Tea, coffee and milk were also available.

An almost identical meal was prepared for the westbound flight departing Bahrain for London 2 hr. before the eastbound flight left for Sydney. Items on the hors d'œuvres plate served on both aircraft were prepared by the same staff according to the same recipes from the same batches of food. The breakfast meal was not common to both flights. Cases of cholera were reported among passengers on both flights. These findings strongly support the theory that a hors d'œuvre item was the vehicle of infection.

It has proved impossible to determine which particular item was responsible for the infection. Indeed, because they were arranged very close together on a

Table 2. *Growth of* V. cholerae *El Tor at* 28° *C. in the various food items. 'Good' indicates an increase of at least* 3 *logarithms and 'Fair'* 1–2 *logarithms in the cholera count*

Food item	pH	Growth of *V. cholerae*
Duck	6·9	Good
Pâté	6·5	Fair
Aspic	4·7	Nil
Smoked salmon	5·4	Poor
Salami	5·1	Nil
Stuffed egg	7·15	Very good
Mushroom salad	5·3	Nil
Milk-cream	6·8	Very good

small tray, cross-contamination from one to another, either directly or by means of eating utensils, could readily have occurred. However, an attempt was made to discover which passengers ate which items – infected persons by direct questioning and the remaining passengers by means of a postal questionnaire. The results are summarized in Table 1, but they should be interpreted with caution. Many passengers, particularly older passengers, had difficulty in recalling which items they had indeed eaten. One passenger, a carrier, claimed not to have consumed either food or drink during the entire flight between Bahrain and Singapore. Although Table 1 would seem to show that proportionately more infected than non-infected passengers ate the various hors d'œuvres, and to that extent supports the view that these items were the vehicle for the infection, it provides no evidence concerning which item or items were infected.

Of the food items served as part of the cold meal only the chicken pâté, cold duck, stuffed egg and the 50–50 milk-cream were considered to be possible sources of the infection. The remaining food items were served on other aircraft or were later shown to be poor substrates for the growth of *V. cholerae* (Table 2).

Both the pâté and the duck were cooked the day before serving and stored overnight in a refrigerator. The pâté was covered in aspic and encased in a pastry crust. The same aspic, diluted with water, was used to glaze pieces of duck (breast meat) which were arranged, by hand, on 'squares' of toasted bread. To prepare the stuffed egg, hard-boiled eggs were cut in half, the yolks removed, mixed with cream and placed in a piping bag. This mixture was used to fill each egg white. The egg proved to be a very good substrate for the growth of *C. cholerae*. The milk-cream mixture was prepared away from the main kitchen at a commercial dairy in Bahrain. It was also used for crew meals, and is less likely to be the vehicle of infection, but cannot be completely eliminated, as it was taken by most passengers in tea or coffee and was also served with cornflakes for breakfast.

Meal preparation and assembly

The final preparation and assembly of the meals served on the London–Sydney flight began at 2.00 p.m. Bahrain time on 2 November, and preparation for the London bound flight began approximately 3 hr. later. Both sets of meals were placed in Boeing 747 food modules and stored in the refrigerated-module holding

Table 3. *Incubation period for the 25 cases of cholera among passengers on the London–Sydney flight*

Incubation period (hr.)	Number of cases
–24	1
24–48	16
49–72	6
72–	2

area from about 7.00 p.m. until they were loaded on the flights at 2.00 a.m. (westbound) and 4.00 a.m. (eastbound) on 3 November. Meals were eaten on both flights at approximately the same time, viz. 12.00 noon Bahrain time, 3 November, which was almost 24 hr. after preparation and assembly.

Refrigeration space in the flight kitchen at Bahrain was adequate but there is a possibility that the items prepared at 2.00 p.m. were not refrigerated until both meals were completed, i.e. 7.00 p.m. Growth of contaminating organisms in the foods could have taken place during this period.

Investigation of catering staff

At least three faecal specimens were collected from every member of the staffs of the airport catering unit, the terminal snack bar and the dairy – none of whom was known to have suffered from a cholera-like illness at or about the time in question. The specimens were examined in Bahrain for *V. cholerae* and two members of the catering unit were found to be excreting the organism, although one was positive only in one out of three samples. One of these two carriers had taken part in the preparation of the hors d'œuvre meal served on the aircraft. He was a butcher's assistant who helped chop and mince meat and poultry used in the aircraft meals. The two carriers were not detected until approximately 2 weeks after the outbreak occurred in Australia, and it cannot be stated definitely that either was the source of the infection. However, the findings do indicate that there is a definite possibility that a carrier may have been present in the kitchen at the time of the outbreak and contaminated one or more of the food items served on the aircraft.

CLINICAL FINDINGS

Symptoms (diarrhoea and, occasionally, vomiting) occurred in most cases 24–48 hr. after eating the suspected meal (Table 3). None of the passengers was ill on the aircraft. In general the severity of the illness was mild (Table 4). Thirty-two of the 47 persons infected were either symptomless or suffered only minimal symptoms of one or two loose stools. Of eight cases classified by the attending physicians as severe, five had rice-water stools and symptoms resembling classical cholera. One New Zealand patient, a male aged 65, died. The duration of the illness ranged from a few hours to several days.

Table 4. *Severity of symptoms of the 47 persons infected with* V. cholerae

Severity of symptoms	Number of persons
None (carrier)	22
Mild	10
Moderate	7
Severe	8

Table 5. *Comparison of the age distribution of cholera patients with that of all passengers on the London–Sydney flight*

Age group	Cases		Carriers		All patients		All passengers	
	No.	%	No.	%	No.	%	No.	%
–30	1	4	2	9	3	6	68	18
31–40	1	4	1	5	2	4	42	11
41–50	1	4	1	5	2	4	44	12
51–60	3	12	5	23	8	17	55	15
61–70	10	40	9	41	19	40	96	26
70–	9	36	4	18	13	28	68	18
All ages	25	—	22	—	47	—	373	—

Age distribution

The age of all passengers on the aircraft was obtained from disembarkation cards completed by each passenger (Table 5). From these it was found that 44 % (164/373) of all passengers who disembarked in Australia, 76 % (19/25) of the clinical cases and 59 % (13/22) of carriers were older than 60 years. The difference in age distribution of infected and non-infected persons is significant – the infection being more likely to occur in older persons. Seven of the eight passengers who were severely ill were aged 60 years or over.

Sex distribution

The sex of all passengers on the aircraft was similarly obtained from disembarkation cards; 39 % were male and 61 % female. Of the 47 persons known to be infected with *V. cholerae*, 16 (34 %) were male and 31 (66 %) were female. Therefore, there was no significant difference between the sexes in regard to their susceptibility to *V. cholerae* infection.

Cholera immunization status

Two hundred and twenty non-infected passengers were asked, either personally or by letter, for details of their cholera immunization status, including the date and place of their last inoculation. Two hundred and eleven persons replied to this request. Of these, 28 joined the aircraft in Singapore and, therefore, did not eat the suspected meal. All of these passengers were immunized against cholera, as the Australian quarantine regulations in force at that time required all persons entering Australia from Singapore to be immunized. The immunization status of the remaining 183 persons together with that of all passengers infected with *V. cholerae* is given in Table 6. There was a significant difference between the

Table 6. *Cholera immunization status of infected and non-infected passengers*

Immunization status	Infected passengers		Non-infected passengers
	Cases	Carriers	
Current	1 (4%)	7 (32%)	55 (30%)
Not current	24 (96%)	15 (68%)	128 (70%)

immunization status of persons with clinical illness, and that of other passengers. Current cholera immunization did appear to play a significant role in preventing symptoms of the disease, but it offered no protection against a person becoming a carrier of the organism.

BACTERIOLOGY

Bacteriology of food

Although it was not possible to submit samples of the food items actually served on the two flights to bacteriological examination, duplicate samples of the hors d'œuvres served on these flights were prepared in Bahrain some two weeks after the episode occurred and sent to the School of Public Health and Tropical Medicine, University of Sydney, for examination.

Microbiological analysis of the pâté, duck, aspic, smoked salmon, salami, egg and the mushroom salad was carried out using standard methods. No *V. cholerae* were detected and, although small numbers of faecal coli were found in the duck, pâté and egg, the microbiological quality of the foods was generally satisfactory.

A specimen of the water on board the aircraft collected after its arrival in Melbourne, Australia, was also examined. The plate count (at 30° C.) was $1{\cdot}1 \times 10^4$ organisms per ml, but no *E. coli*, coliform bacilli or *V. cholerae* were detected. However, the water loaded on the aircraft in Bahrain had by then been almost completely replaced by water taken on at Singapore and at Sydney and the sample examined was not truly representative of the Bahrain water.

In addition, the pH of each food sample was determined and the food tested for its ability to support the growth of *V. cholerae*. The strain of *V. cholerae* used in these studies had been isolated from the faeces of a passenger on the London-Sydney flight. Each food sample was inoculated with approximately 500 *V. cholerae* per gram, incubated overnight at 28° C. and the number of *V. cholerae* counted on MacConkey agar. An incubation temperature of 28° C. was chosen because it approximated ambient temperature in Bahrain at the time of the outbreak. The results of these studies are given in Table 2.

Bacteriology of faeces

Faecal samples were collected from all passengers who disembarked in Australia and from all crew members associated with the flight at any stage of its journey from London to Sydney.

Faecal samples were generally examined within 1 hr. of collection, but where it was expected that delays of up to 6 hr. might occur, samples were also submitted

to the laboratory in alkaline peptone water. A long delay requiring the use of a transport medium (e.g. Cary-Blair, Stuart's or sea-salt medium) was experienced on only one occasion. In this case *V. cholerae* was isolated from a rectal swab submitted to the laboratory in Stuart's transport medium.

Because of the widespread dispersal of the passengers throughout Australia samples were examined at several laboratories. Although there is no standard procedure in Australia for the laboratory diagnosis of cholera, most laboratories followed the method laid down in 'Notes on the Laboratory Diagnosis of Cholera' (Commonwealth Department of Health, 1971).

In this laboratory, faeces were immediately inoculated into alkaline peptone water and plated directly on solid media. The tubes of alkaline peptone water were incubated at 37° C. for 6 hr. and subcultured on solid media and into a further tube of alkaline peptone water for overnight incubation. This was plated on solid media if the direct cultures and the 6 hr. alkaline peptone water subcultures were negative.

Initially five solid plating media were used; MacConkey agar, alkaline peptone agar, cholera medium (lauryl sulphate tellurite agar), Monsur's medium (alkaline taurocholate tellurite gelatin agar) and TCBS agar (thiosulphate citrate bile-salt sucrose agar). However, as the workload increased, it was necessary to restrict the number of media used and a combination of TCBS (highly selective) and MacConkey agar (less selective) was chosen.

Colonies suspected of being vibrios were subcultured into peptone water which, after 24 hr. incubation, was examined for motility and used to carry out the usual range of biochemical tests (Carpenter, Hart, Hatfield & Weeks, 1968).

In many instances it was possible to give a presumptive diagnosis by doing the 'string' test (Smith, 1970), oxidase test and slide agglutination with *V. cholerae* antiserum on colonies taken directly from the MacConkey agar plate. Slide agglutination tests were carried out using polyvalent, Inaba and Ogawa antisera.

All organisms identified as *V. cholerae* were tested for chick-cell agglutination, sheep-cell haemolysis and sensitivity to 50 μg Polymyxin B. and all were found to be *V. cholerae* biotype El Tor.

In New South Wales all persons with positive cultures were treated with tetracycline for 5 days, then after a period of 24 hr. during which no antibiotics were given, daily faecal samples were collected and examined. Patients were released from quarantine when three successive negative samples were obtained. In all cases, the first three cultures, collected after antibiotic therapy had ceased, proved to be negative. In five instances a follow-up specimen was collected 2–3 weeks after release from quarantine. All were negative.

Thirteen positive faecal specimens were also examined after standing at room temperature for 2 weeks and again after 1 month. Three of these gave positive results after 2 weeks, but only one sample was positive after 1 month. This specimen, which was a rice-water stool, was still positive after 6 months at room temperature – which varied from 10° C. to 42° C. during the storage period.

DISCUSSION

The outbreak of cholera described here demonstrates the ease with which the organism can be spread to several countries following the contamination of food or water. Fortunately, Australia is a non-receptive area and secondary cases did not occur.

Immunization against cholera is frequently used as a quarantine measure, to prevent the introduction of the disease into non-cholera areas. The results of the present episode indicate that, although immunization may play some part in preventing symptoms of the disease, it does not prevent healthy carriers of the organism entering a country and therefore has little value as a quarantine measure. A good system of sanitation and a high level of personal hygiene, both of which are present in Australia, are far better barriers to infection than immunization. This fact has been recognized for some time, and in the United States of America cholera immunization is no longer considered necessary for persons entering the country, even from a known cholera area.

Cholera is usually considered to be a water-borne disease, but, in this outbreak, the available evidence indicates that a food item served as part of a meal was the most likely vehicle of infection. Exactly how the food was contaminated is a matter for speculation. A carrier of *V. cholerae* may have been present in the kitchen at the time of the outbreak, as two such carriers were detected fourteen days later. However, the possibility of indirect contamination from vegetables (e.g. lettuce) or contaminated mixing bowls or implements cannot be excluded.

Outbreaks of food-borne disease on international aircraft, due to organisms other than *V. cholerae*, have been described in the past (W.H.O. 1972; Cent. Dis. Control 1971). International airline companies are justifiably proud of the elaborate measures they take in relation to mechanical checks on their aircraft to ensure the safety of their passengers. It is, therefore, surprising that little attention has been paid to the urgent need for up-grading the facilities of airport caterers. Mossel & Hoogendoorn (1971) carried out world-wide checks on 25 airport catering units and found that 50 % of toilets had no hand basins, 55 % had no soap or towel and 55 % no fly screens. Refrigeration was inadequate in 30 % of the catering units and in 20 % of the units food-preparation areas were not separated from the washing-up section.

There is a need for the introduction of a code of practice for the supply of food and water to aircraft. This might deal with such matters as the screening of employees, the provision of hand-washing and toilet facilities, the cleaning of kitchens and equipment, the general design of premises including the amount of refrigerated space to be provided, and the devising of guidelines for food hygiene education. Consideration might also be given to recording the chlorine content of water loaded on aircraft, either at the time of loading, or during flight. If the latter, a simple colour-comparator method should be used, which could be easily applied by aircrew or cabin staff. Menus should be revised to eliminate items particularly susceptible to contamination and therefore 'high risk' foods. A system of surveillance of the bacteriological status of meals served on aircraft could be insti-

tuted. Consideration might also be given to the practice of freezing and holding for 48 hr. a sample of each meal prepared in flight kitchens – this is done in New Zealand. The World Health Organization might arrange, possibly through the International Air Transport Association, the necessary co-operation between experts on food hygiene and representatives of the major airlines to formulate such a code of practice. If the recommendations made were realistic, there should be no difficulty in securing adoption of the code by the airline companies, or even in persuading governments to give the code legal sanction if this were thought desirable.

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