

## Food hygiene on board ship

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### INTRODUCTION

Outbreaks and sporadic cases of gastro-enteritis occur frequently at sea as well as on land. They occur amongst passengers and crew on expensive luxury cruises, and amongst tourist-class passengers on deep-sea voyages and the crews and passengers on cargo ships. The incidents tend to occur irregularly; one voyage may be practically free from illnesses of this sort while the next may have a high proportion of passengers and crew affected. Numerous explanations have been put forward to account for the enteritis such as extreme changes of temperature, a surfeit of food, abundance of fruit in the diet, and other physiological and environmental disturbances in the usual routine. In the past, except for a few outbreaks known to have been caused by salmonellae and shigellae, and usually following shore-meals, investigation has been hampered by the absence of a bacteriological laboratory on board; so that little is known about the part played in the causation of these incidents by food poisoning organisms.

Previous investigations, whether by the use of temporary installed bacteriological laboratories on troopships during the last war (Bensted, personal communication) and on the S.S. *President Monroe* (Yoell, 1957), or by the use of transport media (Briejer & Wolff, 1960) have been mainly concerned with the detection of salmonella or shigella organisms in the stools of patients. So far as is known, these investigations did not include any detailed laboratory studies of food hygiene in the galleys, or of the food served.

It was in the light of knowledge acquired in recent years with regard to various bacteriological causes of gastro-enteritis in institutional and communal feeding on shore that the present investigation was undertaken.

As a result of discussions between the Medical Department of the Shipping Company and the Public Health Laboratory Service the work was carried out in two large passenger ships—one a modern luxury liner cruising in the Mediterranean in July 1959, and the other, an older vessel with a smaller galley, on a round voyage through the tropics of 3 months' duration from August to October 1959. In each ship a temporary bacteriological laboratory was set up in the hospital quarters; equipment from the first laboratory was transferred to the second so that the apparatus and media used in the ships were identical. The two bacteriologists doing the work in the two ships were, however, different. An experienced Health Inspector was present for part of the Mediterranean cruise, who checked all sanitary arrangements, collected samples and helped in the laboratory.

There were two main objects: (a) to check the bacteriological purity of the water

supplies, milk and the various foodstuffs, raw and prepared, and to study the galley and food service hygiene in order to determine the hazards to which food was exposed; (b) to make bacteriological examinations of the stools of patients suffering from enteritis in order to determine, if possible, the cause.

The Shipping Company generously agreed to offer all facilities for this work.

#### MATERIALS AND METHODS

Most of the work consisted in the examination of food in the raw or prepared state; in this there was the fullest co-operation from the staff of the galleys and dining saloons. There was also close liaison with the medical staff, so that any gastro-intestinal illness among passengers or crew could be investigated bacteriologically and epidemiologically.

The laboratories were adequately equipped for the work undertaken. Quantities of prepared culture media, either bottled or in Petri dishes, were taken on board and this was supplemented when necessary by the use of both Oxoid and Difco dried products. Two hot plates, one gas and one electric, a small pressure cooker, the use of the small operating theatre autoclave, fitted with a specially designed basket, and a hot-air oven provided all the necessary equipment for media making and sterilization. Calor gas supplied Bunsen flames and other burners when electricity was not suitable. Disposable plastic Petri dishes were used. Apparatus for re-use, such as test tubes, was autoclaved when necessary, boiled in soap solution in a large fish pan and transferred to the surgeon's small laboratory for rinsing and plugging. Plastic equipment, such as measuring cylinders, were used when possible. Anaerobic cultural methods presented some difficulty; hydrogen cylinders were forbidden in the ship, and hydrogen for small anaerobic jars was evolved from zinc, chrome, sulphuric acid and copper. Freon gas, which proved a useful substitute for hydrogen, was also employed.

Samples of water from ships' tanks, particularly when fresh supplies were taken on at various ports, were readily obtainable; samples were also taken from water barges and from stand-pipes on shore.

Samples of drinking water, and of swimming-bath and washing-up waters, also of thawed ice, wash water from fruit and salad vegetables, and rinses from churns, dish covers, trays, savoy bags, galley cloths and swabs were examined generally by the method described in Report no. 71 of the Ministry of Health (Report, 1956). The coli-aerogenes (37° C.) or *Escherichia coli* (44° C.) counts are expressed as probable numbers per 100 ml. of water and the general bacteriological count as the number of colonies per ml. of water. A shortened coliform technique using duplicate dilutions up to 1/1000 in single strength MacConkey broth was sometimes used.

The galley cloths, collected from the owners while in use, were pounded with a sterile pestle in a sterilized saucepan with 200–350 ml. of sterile quarter-strength Ringer's solution. Alginate wool was used for swabbing cutlery, crockery, cutting-boards and other surfaces and utensils. For crockery and cutlery two swabs were used for each batch of five or more articles (Higgins, 1950); for cutting-boards and other surfaces two swabs were used for each 6 sq. in. examined. The swabs

were dissolved in 1% sodium hexametaphosphate in quarter-strength Ringer's solution.

Milk and ice-cream samples were examined by the recognized methylene blue dye tests (Reports, 1950 and 1960); colony and coliform counts were also carried out.

Miscellaneous foods, including meat and sweet dishes, crayfish, imitation cream and cream cakes, and ice-cream and meringue powders were examined for colony counts at 37° C. and for coliform bacilli by using duplicate food specimen dilutions in single strength MacConkey broth at 37° C. and subcultured for incubation at 44° C. Direct blood agar cultures were made and also enrichment cultures in selenite broth for salmonellae, 10% salt-cooked meat was used for staphylococci and, when possible, the ordinary cooked meat medium was used for anaerobes.

Enrichment cultures in selenite were plated on to deoxycholate citrate and Wilson & Blair agar media after 24 and 72 hr. incubation at 37° C., and the salt-cooked meat media on to 7.5% salt and blood agar plates.

Swabs from external nares and hands of galley staff were examined for *Escherichia coli* and coagulase-positive staphylococci.

Stool samples from most of the reported cases of gastro-enteritis were received, either on toilet paper or as faeces in a waxed carton. They were examined for salmonellae after subculture from selenite on to deoxycholate citrate and Wilson & Blair agars. Some of the samples were examined for heat-resistant *Clostridium welchii* after steaming in cooked meat for 1 hr., incubating the cooked meat overnight and subculturing on to blood agar for anaerobic culture. Direct microscopic examination of wet films was carried out on most faecal samples, and medical histories were obtained from patients amongst both passengers and crew. The faecal specimens were often quite inadequate. This together with the difficulty of anaerobic cultural work and the failure to attempt to apply anaerobic techniques during the early part of the voyages made this part of the work less complete than it might have been.

Altogether some 1400 bacteriological examinations were made in the temporary laboratories, 200 in one ship and 1200 in the other. The results from the two ships have been bulked and presented as a single report.

## RESULTS

### *Waters*

#### *Drinking water (107 samples)*

Except for the mains supply from the ports of London and Southampton, water from all ports was chlorinated (1 p.p.m.) immediately after being taken on board. In one ship, water from the mainland was supplemented by water distilled from the sea, reinforced with the necessary salts and chlorinated; on the other ship mainland water was used exclusively.

Samples of chlorinated water taken from taps in the ships gave satisfactory results on the whole, but nine of sixteen samples of English mains water—from taps on board and hosepipes—were found to have probable coli-aerogenes counts of 2 to 110 and of *Esch. coli* less than 1 to 45 per 100 ml. of water. Thus ships might sail from England with their tanks filled with mildly polluted water. The probable

reason for this being that the hosepipes, supplied by the Dock Authorities, for connecting the stand-pipes to the ship's tanks, were kept on the quay and were often seen lying on the ground alongside the ship. On the other hand, observations on the cross-channel ferries revealed the fact that their water hosepipes were rolled on a wheel when not in use and stored in the ship; furthermore, metal nozzles were provided and filling operations were carried out with specially trained staff. Records of the bacteriological results from water supplies taken from these ferry boats have been consistently good (Haydon, personal communication).

Samples were taken from hose, barge or water pipes at various ports, including those in the Mediterranean, Egypt, Arabia, Ceylon and Bombay. The results varied from less than 1 coli-aerogenes and *Esch. coli* per 100 ml. to 1800+ coli-aerogenes and 900 *Esch. coli* per 100 ml. of water respectively. Water from Arabia and Ceylon gave the worst results and from Bombay and Egypt the best. Differences in the results of samples from mains supplies and those from barge tanks and hosepipes suggested lack of cleanliness in the tanks and within and around the ends of hosepipes. Observations on the Port Said water barges, however, indicated that they were well cared for and received some form of chlorine treatment. The hoses were made of strong rubber with wire reinforcement, and coupled to the end of the rubber hose were short lengths of canvas hose used to put in the filler shutes. The hoses were kept in a locker on the barges. In Aden the canvas hoses were rubber lined and in good condition. In Bombay hoses were left lying on the dock side and one was seen to be dropped in the sea after fitting, although the four samples of water examined from barges and hoses gave reasonably good results. In Sydney it was observed that a hose was allowed to lie on the wharf for some time before connexion and that it had a large number of perforations wrapped around with bits of rag and rope; coli-aerogenes and *Esch. coli* counts varied from less than 1 to 80 per 100 ml. of water (four samples).

#### *Ice and Iced water (18 samples)*

Regular examinations of ice and iced water from the plant making ice for the First Class Saloon were carried out on ship I, and coli-aerogenes bacilli, up to 350/100 ml., and occasionally *Esch. coli* up to 11 per 100 ml., were noted on a number of occasions. The water from ice at the bottom of a butter dish was found to be polluted with non-faecal (180+/100 ml.) and faecal coliform bacilli (30/100 ml.). Simple chlorination of the ice-making machine eliminated the coliform bacilli but 5 days later the contamination returned, it was suggested that chlorination should be instituted as a routine procedure. Later, it was discovered that a fault in the ice-making plant led to pollution from a waste pipe which flowed back into the water supplied for the ice. The fault in the machine, which was newly installed, was due to incorrect assembly by the suppliers; it might have remained long undiscovered had it not been for this type of comprehensive bacteriological examination. Cube-ice prepared in the domestic refrigerators from the ship's chlorinated water supply was satisfactory except where there was evidence of handling of the cubes.

*Swimming-bath water (22 samples)*

Sea water was used to fill the swimming baths and each was emptied, at least twice daily, and freshly filled; there was no chlorination. Faecal pollution in a few of the samples was demonstrated, but on the whole the results were thought to be reasonably good. On ship II occasional samples were unsatisfactory, particularly at the end of a busy swimming day in the tropics. Eleven of twenty-two samples gave coliform counts of less than 1 up to 25 per 100 ml. for both coli-aerogenes and *Esch. coli*, but three gave figures of 130 to 550 for both 37° and 44° C. counts and one gave 1600 for both. The desirability of chlorination for swimming baths while passing through tropical waters might be considered.

*Milk and churns (36 samples)*

Ship I used, predominantly, liquid pasteurized milk supplied from England in 10 gallon churns, stored in the cold and transferred to 5 gallon churns for use in the galley. Samples were taken on eight different occasions from the 10 gallon churns as delivered, and from the 5 gallon churns in use. The  $\frac{1}{2}$  hr. Methylene Blue Test failed on one occasion only, when a sample was collected late in the afternoon from a churn already in use in the galley. Plate counts were usually less than 100,000 per ml. at 37° C. The 5 gallon churns were washed and steam-sterilized before re-use in the galley. It was observed that although most of these empty churns were clean and dry, some contained a small amount of milky sour-smelling fluid and one such sample of fluid showed *Esch. coli* in a dilution of 1/1000 ml. and a colony count of 10 million per ml. at 37° C. Washings from a 'cleaned and dried', but not sterilized, churn showed coli-aerogenes organisms in a dilution of 1/100 ml., *Esch. coli* in 1 ml. and a colony count of more than 2 million per ml. whereas washings from churns which had been cleaned and sterilized gave no coliform organisms in 1 ml. and low colony counts. The sterilized and the unsterilized churns were stacked close together so that an unsterilized one might be mistaken for a sterile churn. It was suggested that 5 gallon churns only should be used on the ship to eliminate the necessity for pouring from the 10 to the 5 gallon container. If this suggestion were adopted the 5 gallon churns would only require cleaning after use; they would not be re-used during the voyage.

Ship I used rehydrated dried milk rarely, and only towards the end of a cruise when the fluid milk supply was exhausted, but ship II used rehydrated dried milk exclusively. The rehydration procedures were unsatisfactory; often, with air temperatures of 29.4°–32.2° C. (85°–90° F.) the powdered milk was emptied by hand over the water inlet pipe into the mixing vat below and a cake of damp powder formed on to which perspiration from the worker frequently dripped. The perspiration itself was innocuous bacteriologically, but a suspension of the caked mass showed 1800+ coli-aerogenes and 250 *Esch. coli* per 100 ml. The steam pressure for the pasteurization was inadequate and the temperature was never higher than 49°–54° C. The milk powder itself was bacteriologically excellent, but after reconstitution there were 1600 coli-aerogenes per 100 ml.

Swabs from the mixer outlet and cooler while in use and rinsings from the cloths

used in the dairy, when suspended in 100 ml. Ringer's solution, gave counts up to 18,000+ *Esch. coli*. After thorough cleaning and steam sterilization of the mix outlets no coliform organisms were found from swabs.

#### *Ice-cream (7 samples)*

Two batches of ice-cream powder were sampled on ship II, one gave satisfactory results, while from the other high colony and coliform counts were obtained. Five samples of made-up ice-cream were examined on ship I, four batches had been made from powder in the galley and the fifth was taken from a prepacked carton. Four samples failed to decolorize methylene blue in 4 hr. and were therefore Grade 1. Another sample, however, taken after handling in the galley and immediately before serving was Grade 2, and showed faecal coliform bacilli in 1/100 ml. and a count of 18,400 per ml. This result was not considered to be bad, but indicated the gradual bacteriological deterioration from dairy to consumer.

### *Foods*

#### *Meat, fish and sweets (168 samples)*

Twenty-five samples from ship I were examined for colony and coliform counts as well as for pathogens. Many of the freshly prepared made-up meatstuffs sampled from the refrigerator, for example, the galantines and terrines of game and chicken, gave excellent results with low counts and absence of coliform bacilli in 1/10 ml. dilutions. Coagulase-positive staphylococci were sometimes isolated through enrichment media, but providing low temperature storage was maintained for 2-3 days only, the number of staphylococci in such samples would be too small for the accumulation of enterotoxin to constitute a food poisoning hazard.

Results obtained from similar foods taken after exposure to atmospheric temperature on the deck buffet table showed that the coliform and colony counts could increase greatly; a sample of Melton Mowbray pie had a plate count greater than 25 million per gram and *Esch. coli* was found in 1/100 dilutions (higher dilutions not made). Brawn, cold roast beef, pork, ham and meat taken from sandwiches before passengers had left for shore excursions were positive for *Esch. coli* in 1/100 dilutions and had colony counts from 300,000 to 900,000 per gram. Sandwiches with this initial degree of contamination could, after an interval, be very heavily contaminated; it was recommended that meat returned from the deck buffet should not be re-issued.

Steak pie prepared the same day was examined, stock used for gravy, gravy sauce, and vegetable and tomato stock all sampled in the galley gave excellent results and were almost sterile. Nottingham pie and salmon pie gave low counts but there were coli-aerogenes organisms in 1/100 and 1/1000 dilutions. A 'helping' of lemon meringue pie with imitation cream from the dining saloon showed coli-aerogenes in 1/1000 and *Esch. coli* in 1/100 dilution. Two samples of galley-prepared mayonnaise gave low counts, but coli-aerogenes and *Esch. coli* organisms were found in 1/100 dilution of one sample. The pH of this mayonnaise was 5.8, higher than in similar commercial products, and it was suggested that the addition of more vinegar would

increase its safety. Few attempts were made to isolate heat-resistant *Cl. welchii* from foods sampled in ship I.

143 samples of food from ship II were examined for salmonellae, coagulase-positive staphylococci and *Cl. welchii*. The meat samples included beef (13), veal (4), lamb (21), tongue (4), pork (4), ham (10), corned beef (11), pie (18), brawn (7), galantine (12), sausages (12), duck (5), lunch sausage (3), Devon roll (1), boneless beef (6), sirloin strip (1), rump steak (2); other foods examined were fish (3), scrambled egg (1), flour paste (1), icing (1), cooking fat (1) and baby food (2). Non-haemolytic *Cl. welchii* were found in seven samples including cooked beef, tongue, corned beef, brawn, sausage and pies but salmonellae or staphylococci were not found.

#### *Crayfish (21 samples)*

Crayfish salad is a frequently suspected cause of ship-borne gastro-enteritis, and a preliminary examination of samples of cold cooked crayfish suggested that doubts as to its bacteriological cleanliness were justified. Colony counts of the flesh were approximately a million per gram, and coli-aerogenes organisms were found in 1/1000 and *Esch. coli* in 1/100 dilutions. Rinsings from the outside shell resting on the plates gave counts of 25 million per gram and had *Esch. coli* in 1/1000 dilution. In a more detailed investigation carried out on both ships, samples were taken from the galley during preparation of headless frozen Australian crayfish. They included an uncooked frozen crayfish, one sampled immediately after boiling for 20 min., half of a cooked crayfish (after being split longitudinally and the 'cord' removed by hand in the fish-room, where all raw fish were cleaned and cut on the same cutting-boards and slabs with the same knives) and a halved sample after cool storage for 1-2 hr. and immediately before serving. Salmonellae and staphylococci were not found, but *Esch. coli* and general colony counts revealed an enormous increase in contamination after the cooked crayfish had been split in the fish-room. The uncooked sample was positive for coli-aerogenes in 1/100 to 1/1000 dilutions and for *Esch. coli* in 1/10 to 1/100 dilutions, colony counts were 100,000 to 600,000 per gram of flesh or ml. of shell rinse. After cooking there were no coliform organisms in 1/10 dilutions and the colony counts were low, but in the samples of split crayfish as prepared for serving, coli-aerogenes were found in 1/1000 dilution, *Esch. coli* in 1/10 to 1/1000 dilutions and the colony counts were greater than 3 million per gram of flesh or ml. of shell rinse. It was presumed that contaminants came from knives, cutting-boards and hands during the splitting procedure and it was considered that the observed degree of re-contamination constituted a serious hazard. Recommendations were given that the cooked crayfish should be halved in a place other than that used for raw fish or any other uncooked food, and that the operation should be carried out on an impermeable surface with clean knives.

#### *Imitation cream and savoy bags (25 samples)*

Imitation cream, from a reputable firm, was stored at atmospheric temperature in sealed gallon cans. Two samples taken from freshly opened cans showed coli-aerogenes organisms in a 1/10 dilution of one sample only; *Esch. coli* was absent in

1/10 dilutions and colony counts were less than 500 per gram. A sample from a partly used can gave a colony count of 3 million per gram, but no coliform organisms in a 1/10 dilution. Three samples taken after whipping, however, showed *Esch. coli* in 1/100 or 1/1000 dilution and the highest colony count was 500,000 per ml. Similar results were obtained from cream scraped from a savoy bag, from a portion of lemon meringue and cream pie and from a cream bun.

Rinse suspensions from eleven savoy bags gave probable number counts of *Esch. coli* up to 18,000 + /100 ml., and colony counts from 9000 to uncountable. One savoy bag which had been washed and dried still showed *Esch. coli* in a 1/100 dilution of rinse and a colony count of 2.5 million per ml., another which had been boiled and dried gave a presumptive coli-aerogenes count of 35/100 ml. and less than one *Esch. coli*. Savoy bags used for piping hot mashed potato gave better results and coli-aerogenes bacilli were found in 1/10 dilution of the rinse from one bag only; these results were probably related to the temperature of the potato passing through the bags.

The results from the imitation cream were in line with previous experience and showed that the manufacturer's canned product was bacteriologically satisfactory and that contamination occurred during whipping from the hands and from the utensils. It has been shown (Newell, Hobbs & Wallace, 1955) that bacterial multiplication occurs readily in cream on, or within, bakers' confectionery stored in warm surroundings. The use in cream of 0.01% hydrogen peroxide, which would prevent the multiplication of food poisoning contaminants, was suggested in 1954 (Hobbs & Smith, 1954).

The observations that savoy bags may not be freed from contaminants by washing and drying or even after 'boiling' is not novel; intestinal pathogens have been known to pass from one batch of cream confectionery to another through piping bags. It is suggested that nylon or plastic bags would be more easily cleaned.

#### *Salad vegetables and raw fruit (23 samples)*

In both ships there was a heavy consumption of lettuce and other salads at the midday meal. Ship I, making the short voyage, was provided with salad ingredients bought in England, but for the longer voyage (ship II) additional stocks had to be picked up at the various ports of call. This also applied to many of the fresh fruits. Unwashed salads and fruit, whatever their origin, are generally contaminated with coliform bacteria and therefore could conceivably also be contaminated with intestinal pathogens. In this connexion lettuce and watercress are of special importance since they have been incriminated in outbreaks of intestinal infection.

An examination of eight samples of wash waters from English, French and Egyptian lettuces showed that the untreated wash waters had coli-aerogenes and *Esch. coli* probable counts up to 1800 + /100 ml. There was no significant difference in the counts from lettuces originating from the different countries. Table 1 summarizes the results of examinations of wash water from a variety of salad vegetables and fresh fruit.

The routine treatment adopted in the galleys of both ships was not standardized and consisted, in the case of lettuces, of tumbling a rather indefinite number into



about 10 gallons of water containing either 1 oz. of sodium hypochlorite solution containing 13% available chlorine, or a 'knife point' of potassium permanganate. The lettuces were then rinsed in untreated water in a second sink. Table 2 sets out the results obtained with the two methods, but whereas the concentration of the hypochlorite was controlled there was no proper measure of the amount of permanganate added to the wash water. It was considered unnecessary to rinse lettuces after treatment by either method: within 1½ hr. of washing lettuces in hypochlorite all odour had disappeared and their taste was normal.

Table 1. *Results of bacteriological examination of wash water from salad vegetables and fruit*

Sample	No. samples examined	Probable no. per 100 ml. at 37° C.		
		Coli-aerogenes	<i>Esch. coli</i>	General colony count at 37° C.
<b>Salad vegetables</b>				
Lettuce	8	250-1800+	17-1800+	2,000-uncountable
Tomatoes	4	1800+	1600-1800+	500-uncountable
Cucumbers	2	425-1800+	175-425	Uncountable
Spring onions	1	130	< 1	8,000
Radishes	1	1800+	< 1	64,000
Radish and celery	1	1800+	1800+	Uncountable
<b>Fruit</b>				
Pears	1	1800+	1800+	Uncountable
Gooseberries	1	1800+	1800+	19,000
Cherries	1	1800+	11	14,000
Plums	1	550	25	5,600
Greengages	1	1600	130	2,400
Black grapes	1	50	35	1,500

Table 2. *Results of experiments on treatment of lettuce*

Sample	Probable no. per 100 ml. at 37° C.		General colony count at 37° C.
	Coli-aerogenes	<i>Esch. coli</i>	
<b>Water</b>			
Untreated wash	1800+	1600	2,300
Hypochlorite wash (60-80 p.p.m. available chlorine)	< 1	< 1	1,000
Untreated rinse	25	5	1,100
Potassium permanganate wash	45	7	13,000
Untreated rinse	170	50	480

The contamination of lettuces with coliform organisms and *Esch coli* is almost universal, furthermore the soil in market gardens which is usually heavily manured may contain organisms of the salmonella group also. The hazard is often considered greater with lettuces grown in some overseas market gardens in which human manure is used, owing to the frequency of salmonellae in this material; the long viability of these organisms in soil and the fact that the soil contaminates even the

inner leaves of lettuces increases the hazards. Routine washing of all lettuces, and green salads which are eaten raw, in water containing 60–80 p.p.m. chlorine would be a simple and reliable procedure for removing the danger of infection from the consumption of untreated green salads and this is recommended. Laboratory experiments in the Food Hygiene Laboratory at Colindale have shown that wash

Table 3. *Results of examination of lettuce wash water with and without chlorine*

Sample	No. samples examined	Probable no. per 100 ml. at 37° C.		General colony count per ml. at 37° C.
		Coli-aerogenes	<i>Esch. coli</i>	
Wash water without added chlorine	3	1800+	<1–5	100,000–1,000,000
Wash water + 80 p.p.m. available chlorine				
After 30 sec.	1	<1	<1	1,000
After 1 min.	1	5	<1	7,800
After 2 min.	1	<1	<1	100
After 3 min.	1	80	<1	100
After 5, 10, 15 and 20 min.	4	<1	<1	1,200–14,000
Wash water + 59 p.p.m. available chlorine				
After 30 sec.	1	<1	<1	300
After 2, 5 and 10 min.	3	<1	<1	<100–1,300
Rinse water	3	2–8	<1	100–28,000

Table 4. *Results of examination of watercress wash water*

Sample	Probable no. per 100 ml. at 37° C.		General colony count per ml. at 37° C.
	Coli-aerogenes	<i>Esch. coli</i>	
<i>A</i>	1800+	50	250,000
<i>B</i>	1800+	30	150,000
<i>C</i>	1800+	50	75,000
<i>X</i>	4	0	3,500

Samples *A*, *B* and *C*, wash waters not containing chlorine; sample *X*, wash water containing 60 p.p.m. chlorine.

water containing 80 p.p.m. of chlorine is an effective method for the rapid destruction of coli-aerogenes organisms contaminating lettuce and watercress. Within 30 sec. of adding the hypochlorite a wash-water count of 1800 coli-aerogenes per 100 ml. is reduced to a negligible figure. Lower concentrations of chlorine are also effective but they may require longer periods of contact. The main results of these experiments are summarized in Tables 3 and 4.

*Washing up**Wash and rinse waters (44 samples); crockery and cutlery (200 articles)*

All but one of the samples of wash and rinse waters came from dish-washing machines and were examined for coliform organisms and *Esch. coli* by the usual methods; swabs from the plates, spoons and forks were examined in batches of five to thirteen articles. Most of the rinse-water temperatures varied from 53° to 62° C.; these gave low counts of 4–200 organisms per ml., and coliform bacilli were not found in 1 ml. quantities. The highest colony count for rinse water at these temperatures was 390,000/ml. Cutlery examined immediately after removal from the machines gave counts varying from 12 to 60 per utensil and for plates the counts were 10–314 per plate.

Counts from wash and rinse waters with temperatures below 42° C. included probable numbers of *Esch. coli* of 1800 + /100 ml., and the results from swabs of crockery and cutlery varied accordingly.

In one ship the stewards washed the cutlery from their own tables in bowls of warm water; samples of this water, when it was lukewarm, were found to contain *Esch. coli* in the highest dilution examined—1/100 ml. Swabs from cutlery washed in this way gave counts of 350–710 per fork or spoon. It was recommended that all cutlery should be washed in the machines and that the rinse water should be maintained at a temperature greater than 60° C.

*Chef's pot wash (4 samples)*

Pots and pans and other articles used for cooking were washed and rinsed in two large galvanized iron tanks. Both wash and rinse waters were sampled twice. The temperatures were between 35° and 42° C. which were much below the desirable optimum and *Esch. coli* were found in 1/1000 dilution, indicating a probable number of 1800 + /100 ml. The general colony count was up to 14 million per ml. After washing and rinsing the cooking utensils were wiped with a damp cloth.

Experience has demonstrated the value of bactericidal detergents for washing cooking utensils of this sort and the use of high temperatures for rinse waters not only results in the utensils being virtually sterile but also obviates the need for wiping or drying them with a cloth which may re-infect them. It was therefore suggested that a suitable bactericidal detergent should be added to the wash water and that the temperature of the rinse water should be raised by steam infiltration and maintained at a constant temperature of 70°–80° C. by a thermostatic control. After removal from the hot rinse water the utensils should be inverted on racks and allowed to drain dry.

*Metal plate covers (86 samples)*

Dish covers, used to protect food during its carriage from galley to dining saloon, were frequently seen to have particles of dried food attached to the under part of the beading. Rinse water from these covers after they had been swilled and swabbed gave *Esch. coli* counts of up to 1800 + /100 ml. of rinse. *Cl. welchii* was

isolated also from one of them and coagulase-positive staphylococci from another. It was recommended that these covers should be thoroughly washed and sterilized more frequently.

*Cloths (50 samples)*

Forty-three cloths were collected from various parts of the galley and dining saloons, including the cold meat, steward's and engineer-officer's pantries, the vegetable, baker's and butcher's shop, the washing-up department and the stewards' aft dining saloon. All but one or two were found to be bacteriologically dangerous; this refers particularly to cloths used for wiping various surfaces, from which rinse waters gave *Esch. coli* counts of up to 18,000 + /100 ml.

Some of the cloths used in one of the ships were originally the muslin wrappings in which the carcasses were delivered to the butcher's shop. It was found that some members of the galley staff were in the habit of collecting these muslin cloths in batches from the butcher's shop, washing them in hot water or perhaps in water with added Teepol and then using them as general purpose cloths in the galley. Galley staff like to use these cloths because of their soft texture. Such cloths were often seen to be saturated with serum and blood from the butcher's shop. The constant incubator temperature of the tropics would encourage the growth of micro-organisms in the mesh of the cloth, and it is probable that most of the cloths were contaminated with coliform bacilli before being used in the galley. Because these cloths are useful it was necessary to find a means of sterilization. Steeping overnight in chloride of lime produced low bacterial counts, with less than 1 *Esch. coli* per 100 ml. of rinse for six of seven cloths. It was recommended that all cloths should be collected at the end of each day and treated in sodium hypochlorite solution containing 130 p.p.m. of available chlorine; after a rinse next morning the cloths should be regarded as reasonably safe.

Cloths of the tea-towel type were also used. These were issued daily to the galley staff and, before each meal, to the stewards responsible for serving. It was observed that the dining room stewards always polished and cleaned dishes and cutlery with a cloth before placing them on the table, and that the same cloth was used to remove crumbs and other spilled food and drink from the table. Nevertheless, cloths used by the table stewards were dry and unlikely to be so important in the spread of contamination as those of the workers in the galley who continued to use their cloths when they were wet.

*Cutting-boards (48 swabs)*

The problem of cutting-board contamination is similar to that of cloths, and is concerned with the saturation of surfaces with nutritive products from meat and other foods. Fibres of meat may be driven into chinks in the board by the cutting knife; they may remain there indefinitely and at tropical temperatures bacterial contamination may increase alarmingly.

Swabs from 38 of 40 meat, fish, bakery and vegetable cutting-boards showed varying counts of *Esch. coli* up to 18,000 + /100 ml. of diluent. On the other hand, a tomato board and one examined when freshly dry, after scrubbing, were negative for coli-aerogenes organisms.

In two instances lecithinase-positive clostridia were found on boards used for slicing cold meats; the spread of spores and vegetative cells of food poisoning strains of *Cl. welchii* from one portion of meat to another could readily occur in this manner. The subsequent multiplication of the organism to numbers able to cause symptoms would depend on the time and temperature of storage, and might be assumed to occur irregularly according to the position of slices in a pile of meat, the temperature and Eh, how far ahead of requirements the meat was prepared, and whether it was held over from one day to the next after meals.

Experiments on the sterilization of eight cutting-boards were carried out on ship II. After baking a board for 2 hr. in an oven, organisms were not found from a swab or scrapings from the crack, but the board was warped. Two methods of decontamination were found which did not affect the boards adversely: (1) steeping overnight in sodium hypochlorite solution containing 130 p.p.m. available chlorine in a similar way to that suggested for cloths; five boards were freed from coli-aerogenes and almost sterilized by this method. (2) Hard brushing with a stout wire at the end of each day; the two boards tested were freed from coli-aerogenes organisms and the general count considerably lowered. A control board for both these experiments gave a probable *Esch. coli* count of 18,000+/100 ml. of swab diluent. It was suggested that a combination of the two methods should be used. The harder the surface, the more easily it is cleaned, but for cutting-boards there must be a compromise between hygiene and the risk of damage to the cutting edge of knives; a thinner and less durable type of hard-board or plastic could be used and replaced frequently.

#### *Miscellaneous swabs and samples (24)*

Ten swabs taken from various places including a slate where the boards were kept, sides and edges of sinks and a floor swab in the sink room gave *Esch. coli* counts of 1800+/100 ml. of swab diluent; two samples of water from the sump also gave counts of 1800+/100 ml.

Six swabs from knives gave variable results from less than 1/100 ml. of coli-aerogenes organisms on the tomato knife, although lecithinase-positive clostridia were found, to 18,000+/100 ml. of *Esch. coli* on fish and meat knives.

The blade of the slicing machine gave a probable number of 1800+ *Esch. coli* per 100 ml. of diluent. Other miscellaneous articles were swabbed, such as a tin opener which was satisfactory, the inside of a drip tin in the refrigerator (9000 *Esch. coli* per 100 ml.), a fish tray, fish dish (monel metal) and the outside of a tray; the *Esch. coli* counts were 1800+ to 18,000+, according to the dilutions put up. These faecal coliform counts are similar to those of condemned sewage-polluted water.

If in the environment of the galley, *Esch. coli* can be regarded as an indicator organism of general uncleanness and spread of intestinal contamination, then it may be assumed that intestinal pathogens could be transported from one food to another by articles in general use. It was recommended therefore that greater care should be taken to clean and sterilize galley or kitchen utensils frequently.

## GASTRO-ENTERITIS

*Passengers and crew (194 stool samples)*

On the first Mediterranean cruise thirty-six cases of gastro-enteritis were reported, mostly from the third to the seventh day at sea, and nineteen faecal samples were submitted. Nineteen cases occurred between the U.K. port of embarkation and the first port of call, and of the ten faeces samples received, three yielded heat-resistant strains of *Cl. welchii*; no salmonella or dysentery bacilli were found. In the second week fewer cases were reported and some of these were undoubtedly associated with food eaten ashore.

Symptoms in these cases of ship-borne enteritis were typical of those associated with *Cl. welchii* food poisoning, i.e. diarrhoea and abdominal pain usually without vomiting and pyrexia (Hobbs, Smith, Oakley, Warrack & Cruickshank, 1953). When records were obtainable it was found that the onset of symptoms was early morning or afternoon.

The menus were so extensive and varied that it was difficult for patients to remember exactly what they had eaten, even the day before the onset of symptoms; and sometimes they were unwell a few days before coming to the medical department. It was therefore impossible to set a precise time for the incubation period.

Eighteen incidents only were recorded on the second Mediterranean cruise, and nine specimens of faeces were received. Again the majority of cases occurred within the first few days of the cruise before the first port of call; eight of the nine faeces samples were received during a 3-day period commencing 24 hr. after leaving the U.K. port of embarkation; heat-resistant *Cl. welchii* were isolated from one specimen and no other intestinal pathogens were found.

The combined figures show that heat-resistant *Cl. welchii* were isolated from six of twenty-eight (21%) samples. The percentage was higher than would be expected either from normal people (2-6%) or from cases of diarrhoea due to other causes (2.1-7.7%) (Hobbs *et al.* 1953; Collee, Knowlden & Hobbs, 1961); although patients and healthy personnel in hospitals seem to have an unduly high carrier rate (20-30%) (Dische & Elek, 1957; Leeming, Pryce & Meynell, 1961). A few incidents were attributable to staphylococcal enterotoxin food poisoning from shore-meals.

On the outward half of the long-distance voyage, 137 patients with gastro-enteritis reported to the surgeon and 121 samples of faeces were submitted. In addition, faecal samples from ten members of the galley staff were examined. The results revealed one carrier of *Shigella sonnei*, although subsequent samples were negative, a clinical case of *Salm. typhimurium* infection, and *Cl. welchii* from a case of food poisoning with symptoms typical of those associated with *Cl. welchii* food poisoning.

Attention was centred chiefly on coagulase-positive staphylococci and salmonellae but, as on the other ship, many samples were received on toilet paper with insufficient material for any other examination. When, towards the end of the outward voyage it became clear that neither staphylococci nor salmonellae were likely to be the cause of the diarrhoea, greater attention was paid to the isolation of heat-resistant anaerobes. On the return journey all faecal specimens were examined for

clostridia as well as for salmonellae, but gastro-enteritis was less prevalent and a total of thirty-five patients produced thirty-five faeces samples, of which six (17%) yielded lecithinase-positive clostridia. No salmonella or dysentery bacilli were found. On the outward journey there were two groups of enteritis incidents, comprising thirty-two and thirty-nine cases respectively, but on the homeward journey the cases were all sporadic. As on ship I the majority of the gastro-enteritis patients presented a clinical picture in keeping with that of food poisoning by *Cl. welchii*, and this observation combined with the identification of lecithinase-positive clostridia in the stools of patients and the fact that meat dishes in the galley contained these organisms can be regarded as evidence that *Cl. welchii* was probably one cause of gastro-enteritis.

Conditions in the galley of ship II were cramped and food was stored for long periods at the incubator temperatures of the tropics. It could be assumed, although there was no proof, that spores and vegetative cells of *Cl. welchii* acquired from various surfaces had multiplied on sliced meats. It would have been a matter of chance which slices were able to support anaerobic growth.

It is possible that some of the incidents were not microbiological in origin and that they were concerned with sea-sickness, food and drink excesses or aperients. Others were obviously acquired from port-meals, but there was almost certainly a proportion due to bacterial agents in food eaten in the ship. The bacteriological work carried out in the galleys indicated that there was ample opportunity for the spread of contamination in the galley if food poisoning organisms were introduced. On the other hand, in ship I foods were eaten freshly cooked and most left-over food was destroyed at the end of the day; good use was also made of refrigeration.

Direct microscopic examination of wet films carried out on most faecal samples revealed nothing significant.

#### *Food-handlers (329 swabs)*

A series of swabs were taken from the nostrils and fingers of the staff responsible for the dining saloons in ship II. 111 swabs were taken; all were taken from both nostrils and they yielded one culture of coagulase-positive staphylococci only; it is possible that more staphylococci would have been isolated had nasopharyngeal swabs been taken rather than swabs from the anterior nares only. The remaining 218 swabs were taken from all ten digits of twenty-one men, and yielded two cultures of coagulase-positive staphylococci and six of *Esch. coli*. It was concluded from these results that the standard of personal cleanliness was reasonably good.

A few swabs were taken from the hands of the galley staff in ship I. *Esch. coli* was isolated from one man, coli aerogenes organisms from four and coagulase-positive staphylococci from one.

#### DISCUSSION

The advantage of the type of investigation described in this paper is that it can reveal hygienic defects in the preparation, storage and serving of foods which are not possible by ordinary methods of inspection or by bacteriological tests for defined bacteria. Counts of coliform bacteria and *Esch. coli* in wash waters from foods and from utensils employed during their preparation are valuable indicators

of the bacteriological cleanliness or otherwise of a particular procedure. In the relatively few cases in which there were indications from these counts of some fault it was usually possible to suggest measures either for the correction of the fault itself or for a reduction of the hazard.

It has been suggested that 'ship-enteritis' in tropical waters is directly due to the physiological effects on those exposed to these temperatures; it is often overlooked that tropical temperatures may also encourage the multiplication of bacteria contaminating foodstuffs. It should also be borne in mind, in comparing galley conditions in the two ships, that ship II had been designed some 30 years previously (she is now out of commission) and lacked many of the improvements of galley construction found in modern ships, such as ship I.

The over-all picture presented by this study is probably not dissimilar from that found in shore establishments where catering is carried out on a large scale, but the problems presented in this connexion in a ship at sea in tropical waters are peculiar and cannot be compared to those obtaining ashore.

While there was no evidence of any outbreak of food-borne shigella, salmonella or staphylococcal infections that could be traced to meals taken in the ships there was a good deal to indicate that a significant proportion of the cases of enteritis might be due to the consumption of food contaminated with *Cl. welchii*; this organism was isolated from the patients affected, from certain meat samples and from related galley equipment, but the chain of evidence is not as complete as could be wished. Owing to the technical difficulties of anaerobic culture in the ships these studies were somewhat restricted and, although there seems to be no doubt about the importance of the observations relating to the contaminations in the galley with *Cl. welchii* and the clinical cases of enteritis, further and more intensive studies of the problem are obviously desirable.

#### SUMMARY

1. A bacteriological laboratory was provided in the medical departments of two passenger ships—a modern luxury liner cruising in the Mediterranean for 1 month and an older vessel, now out of commission, on a 3 months round voyage through the tropics. Galley hygiene in relation to gastro-enteritis was investigated on both ships.

2. 125 samples of water and iced water were examined. Samples of water chlorinated on the ships were usually satisfactory. Many port waters sampled from the barge or hosepipe were contaminated—some mildly, some profusely. A fault in an ice-making machine led to pollution of ice used for various purposes. Swimming-bath water was usually mildly polluted only; occasionally in the tropics when the baths were very popular the count rose to 1600 *Esch. coli* per 100 ml.

3. Thirty-five samples of milk, ice-cream and churn washings were examined. English liquid pasteurized milk stored in the cold gave satisfactory results, but the rehydrated dried milk used exclusively on the round voyage through the tropics and swabs from the apparatus used in its preparation were contaminated with *Esch. coli*. Ice-cream samples from ship I gave satisfactory results, and of two



samples of ice-cream powder examined on ship II one was satisfactory and the other gave a poor result. Occasional churns which had been superficially cleaned but not sterilized had a high general and *Esch. coli* count.

4. 189 samples of food were examined, twenty-two for general and coliform counts only. Results were variable according to foodstuff and atmospheric temperature. Some cold cooked meatstuffs gave low counts and absence of coliform bacilli in 1/10 g.; others had plate counts of 300,000 to 25 million per gram with *Esch. coli* in 1/1000 dilution, e.g. crayfish ready for the table. Salmonellae were not found in any samples but occasionally small numbers of coagulase-positive staphylococci and non-haemolytic *Cl. welchii* were isolated.

5. Sixteen samples of imitation cream and washings from savoy bags were examined. Samples from freshly opened cans of cream gave satisfactory results. In whipped cream and in cream from cakes and sweets, *Esch. coli* was found in 1/1000 dilutions, and rinsings from savoy bags in use gave probable numbers of *Esch. coli* of 18,000 + /100 ml. Counts were still high after the bags had been washed and dried and they were far from sterile even after 'boiling' and drying.

6. Twenty-three samples of wash water from salad vegetables and fruit had high counts of *Esch. coli*. After these articles had been washed in water containing 80 p.p.m. sodium hypochlorite, coliform organisms were not found in 100 ml. of water. Potassium permanganate was considered to be of doubtful value. The results of laboratory experiments to confirm the concentration of hypochlorite and time necessary to destroy *Esch. coli* on lettuce and watercress are shown in Tables 3 and 4.

7. Results from forty-four samples of wash and rinse waters from dish-washing machines and one bowl showed that the temperatures were often too low; with temperatures above 50° C. coliform bacilli were absent in 1 ml. quantities, but waters at temperatures below 42° C. gave probable *Esch. coli* counts of 1800 + /100 ml. The bacteriological condition of the crockery and cutlery varied according to the wash and rinse waters. Rinses from metal dish covers gave poor results, with 1800 + *Esch. coli* per 100 ml. of rinse and occasionally *Cl. welchii* and coagulase-positive staphylococci. Wash and rinse waters, with temperatures of 35°–42° C. used for pots and pans gave probable *Esch. coli* counts of 1800 + /100 ml.

8. Rinse waters from twenty cloths used in the galleys, pantries and dining rooms were nearly all heavily contaminated with *Esch. coli*, with probable numbers of 18,000 + /100 ml.; these counts were reduced to negligible figures by soaking the cloths in chloride of lime.

9. Swabs were taken from thirty-eight cutting-boards and twenty-six surfaces of sinks, shelves and miscellaneous articles. Many boards were heavily contaminated, the probable number of *Esch. coli* being 18,000 + /100 ml. of diluent; lecithinase-positive clostridia were found also. The boards could be sterilized by brushing with a stout wire brush followed by chlorination.

Other surfaces, and swabs from various knives in the kitchen, including the blade of the slicing machine, frequently gave high counts of *Esch. coli*.

10. 329 swabs from nostrils and fingers of saloon and galley staffs yielded one culture of coagulase-positive staphylococci from 111 nasal swabs and three cultures

of coagulase-positive staphylococci and seven of *Esch. coli* from 218 finger swabs from twenty-seven men.

11. Twenty-eight faecal specimens were examined from fifty-four cases of gastro-enteritis reported on the Mediterranean cruises; salmonellae were not found, but heat-resistant *Cl. welchii* was isolated from six samples (21%), and the clinical picture was that of *Cl. welchii* food poisoning.

12. 121 faeces samples from 137 patients with gastro-enteritis were examined chiefly for salmonellae and coagulase-positive staphylococci on the outward leg of the round voyage through the tropics. *Salm. typhimurium* was isolated from a clinical case and *Cl. welchii* from one typical case of food poisoning. On the return journey all samples were examined also for *Cl. welchii*; of thirty-five stool samples from thirty-five patients, six (17%) yielded lecithinase-positive clostridia; salmonellae were not found.

13. Heat-resistant strains of *Cl. welchii* were also isolated from two chopping-boards, a knife, cold beef, brawn, two wiping cloths, a dish cover, two samples of pie and corned beef.

#### RECOMMENDATIONS

Arising out of these findings the following recommendations were made to the Shipping Company, who examined them and took appropriate action where possible:

I. Water from *all* ports should be chlorinated immediately it is taken on board.

II. Ice-making machines should be checked frequently.

III. Swimming-bath water should be chlorinated in the tropics.

IV. Liquid milk taken on board should be stored in 5 gallon churns; once empty, the churns should be cleaned and sterilized but not re-used.

V. Greater care should be taken with the rehydration of dried milk.

VI. Dried products such as ice-cream and meringue powders, coconut and dried or frozen egg and also imitation cream should be of good bacteriological quality and free from salmonellae.

VII. Cooked crayfish should not be split in the raw fish department, but on a clean, impermeable surface elsewhere.

VIII. There should be more care in ensuring the cleanliness of the hands and utensils during the operation of whipping and decorating with imitation cream.

IX. Plastic and nylon savoy bags should be used and boiled thoroughly after cleaning.

X. Sodium hypochlorite should be added to the wash water to give 80 p.p.m. for salad vegetables and dessert fruit.

XI. Dish covers should be washed and sterilized regularly.

XII. The temperature of rinse waters for washing-up should be raised and maintained at 70°–80° C., particularly those used for pots and pans; otherwise a bactericidal detergent should be used.

XIII. An overnight soak in sodium hypochlorite solution for cloths and cutting-boards should be made a routine procedure.

We are grateful to the Shipping Company and the Public Health Laboratory Service for the opportunity to carry out the work described in this paper and for the facilities offered to us to enable the work to be undertaken. Thanks are due to the Captains of the two ships, their Officers and Staff who were most co-operative and helpful, particularly the Medical Officers and their staff from whom we received much direct assistance in the actual work undertaken. We are grateful to Miss M. E. Smith and Miss N. Cockman of the Food Hygiene Laboratory, to the Media Department of the Central Public Health Laboratory at Colindale for their valuable help in planning and organizing the work, and to Mr D. E. Madeley for his help during one of the cruises. We also wish to thank a Ship's Surgeon for his interest in the subject of this inquiry and for the information he contributed, which forms the basis of the Addendum.

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## ADDENDUM

Soon after the completion of the investigations described in the body of this paper an opportunity occurred for further study of gastro-enteritis in ships at sea through the kindness of the Surgeon of a small cargo ship trading between the United Kingdom and the African ports and further East, with a crew of eighty-eight and twelve passengers.

Attention was directed to this ship after two voyages to and from the East when thirty-four people (passengers and crew) were ill with gastro-enteritis at some stage of the voyages. There were no facilities for bacteriological examination of stool samples; crew and passengers dispersed rapidly when the ship docked, so that although the high incidence of gastro-enteritis was reported to the Port Health Authorities, it would have been almost impossible to collect stool samples at that stage. Water samples were, however, collected from all the ship's tanks and it was reported that no pathogenic organisms were found. Of the crew, white staff only were affected; there were two doubtful cases only in the Asian crew of sixty-six. According to their usual custom, the Asians cooked and ate their meals (mostly curry dishes) in their own quarters, quite separate from the white crew and

passengers who all received food prepared in the main galley. A few samples of food were examined but they were obviously unrelated to any particular incident. The ship was visited and discussion with the Surgeon and members of the galley staff led to certain hygienic improvements to the general routine of the galley.

Before the next voyage, stool examinations were carried out on all the saloon stewards and food handlers, including cooks and pantry staff. Two members were excreting cysts of *Entamoeba histolytica* and another cysts of *Giardia lamblia*. There was one *Shigella flexneri* carrier, and one person was excreting heat-resistant *Clostridium welchii*. The amoebic dysentery carriers were hospitalized and the *Sh. flexneri* and *Cl. welchii* carriers were treated.

The members of the crew were instructed in personal hygiene, in methods of cleaning and disinfection, with special reference to bathrooms, bathtubs, showers and toilets. In the galley all vegetables and fruits were soaked in chlorine water (30 p.p.m.) followed by rinsing in fresh filtered water. All food handlers had regular hand inspections and those with septic sores were barred from the galley. The Captain's weekly sanitary inspections disclosed no obvious defects except that the ship was heavily infested with cockroaches. Insecticidal measures kept them at bay but did not eliminate them, and it was suggested that the ship be disinfested.

On the first voyage after these measures were taken, the incidents of diarrhoea dropped to four cases, and on the following voyage there were no cases which could be described as gastro-enteritis. It was the considered opinion of the ship's Surgeon that the rigorous attention paid to galley and toilet hygiene together with the adequate treatment of all apparently healthy persons found to be excreting pathogenic organisms were responsible for the improved results. He acknowledged the full co-operation of all those working in the galley and those engaged in cleaning duties. The galley and cleaning staff were unchanged throughout the period.

Many other aspects of the gastro-enteritis which had occurred on previous voyages were discussed, including the group characteristics of the patients both amongst passengers and crew with regard to sleeping, eating and drinking. However, no pattern emerged except for the general sharing of food prepared in the same galley. It may have been fortuitous that the incidence of gastro-enteritis on board this ship dropped immediately care was taken with kitchen and toilet hygiene and with carriers, but the results were at any rate suggestive.