

Outbreaks of diarrhoeal illness on passenger cruise ships, 1975–85

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SUMMARY

We reviewed data from the Vessel Sanitation Program (VSP), established by the US Public Health Service in 1975, to describe the epidemiology of shipboard diarrhoeal outbreaks, determine the risk of outbreak-related illness among cruise ship passengers, and evaluate changes in rates and patterns of shipboard diarrhoeal illness since the VSP was implemented. When the programme began, none of the cruise ships passed periodic VSP sanitation inspections; since 1978, more than 50% of ships have met the standard each year. On cruises lasting 3–15 days and having at least 100 passengers, diarrhoeal disease outbreaks investigated by the Centers for Disease Control decreased from 8·1 to 3·0 per 10 million passenger days between 1975–79 and 1980–85. The proportion of outbreaks due to bacterial pathogens (36%) did not change. Seafood cocktail was implicated in 8 of 13 documented food-borne outbreaks. The risk of diarrhoeal disease outbreaks on cruise ships appears to have decreased since implementation of the VSP but has not been eliminated.

INTRODUCTION

Following shipboard outbreaks of typhoid fever (Davies *et al.* 1972) and shigellosis (Merson *et al.* 1975*a*) in 1970 and 1973, the United States Public Health Service (PHS) instituted a Vessel Sanitation Program (VSP) in 1975. The VSP established a surveillance system that requires the captain of any cruise ship that docks in the United States to report by radio 24 h before arrival the number of passengers who consulted the ship physician for diarrhoea. This 24-h notice alerts public health officials to the possibility of an outbreak in time to organize an investigation before passengers disembark.

The Centers for Disease Control (CDC) are notified of any cruise on which 3% or more of the passengers are reported to have consulted the ship physician for diarrhoea during the cruise. The decision to send CDC personnel onboard ship to investigate is based on several factors, including the percentage of passengers ill per week, the percentage ill in the previous week, the severity of the illness, whether the dates of onset of illness appeared to cluster, and the timeliness of the ship captain's report.

In addition to surveillance for diarrhoeal illness on cruise ships, VSP sanitarians conduct unannounced inspections of cruise ships approximately twice a year. The inspection scoring system is based on 37 weighted items in four categories: water, food preparation, potential food contamination, and general cleanliness. Scores of 86–100 points are considered 'satisfactory' and scores of less than 86 points are 'not satisfactory' (US Public Health Service, 1987). The results of these inspections are published biweekly and are available to public health officials, representatives of the travel industry, and the general public.

Although sanitation inspections in restaurants and other eating establishments are an important component of many local public health programmes, the effectiveness of these inspections in reducing the incidence of outbreaks of gastrointestinal disease has not been well documented. Similarly, the effectiveness of the VSP in reducing the incidence of shipboard outbreaks has not been previously evaluated. We reviewed shipboard outbreak investigation reports and cruise ship diarrhoea surveillance data for the years 1975–85 to (1) describe the epidemiology of shipboard diarrhoea outbreaks, (2) determine the risk of outbreak-related diarrhoeal illness among cruise ship passengers, and (3) evaluate changes in rates and patterns of shipboard diarrhoeal illness since implementation of the VSP. We also reviewed ship sanitation inspection scores to identify temporal trends.

METHODS

Since 1 April 1975, CDC has maintained a computerized list of ship captains' reports of diarrhoeal illness for cruises docking at US ports. Information includes the name of the vessel, the port, cruise itinerary, dates and length of cruise, number of passengers, and number of passengers reported by the ship captain to have consulted a physician for diarrhoeal illness during the cruise. During the periodic sanitation inspections, the number of cases of diarrhoea recorded in the ship physician's log for the previous five cruises is compared with the number actually reported by the ship captain. For this study, we obtained sanitation scores from PHS ship inspection logs and data on outbreaks of shipboard diarrhoeal illness from published and unpublished CDC investigation reports, notes, and laboratory records.

To reduce possible detection bias and confounding by cruises of extreme length and small size, we restricted our analyses of outbreaks and possible outbreaks to cruises lasting 3–15 days and having at least 100 passengers. On the very short cruises (less than 3 days), illnesses could begin after disembarkation and thereby escape detection (Merson *et al.* 1975*b*). On the very long cruises (which generally were also those with the smallest number of passengers), investigation of potential outbreaks was difficult because illness frequently occurred several weeks before the VSP was notified at the end of the cruise. No common-source illnesses could be confirmed on these long cruises because passengers often had difficulty recalling such distant events and acute stool specimens were not available for analysis. Cruises to Alaska which originated and terminated in British Columbia (outside VSP jurisdiction) were also excluded from the analyses of outbreaks and possible outbreaks.

We defined a possible outbreak as a captain's report that at least 3% of passengers had consulted the ship physician for diarrhoea during the cruise. We

defined an outbreak of shipboard diarrhoeal illness as the occurrence of diarrhoea among at least 3% of passengers on a cruise which was investigated by CDC and in which there was no epidemiological evidence for an onshore exposure. Two or more outbreaks occurring on consecutive cruises were considered to be the same outbreak if they were caused by the same or an unidentified pathogen.

RESULTS

Ship captains' reports – diarrhoeal illness

Ship captains' surveillance reports were obtained for 22767 cruises docking at US ports between 1 April 1975 and 31 December 1985. Between 1976 and 1985, the annual number of cruises and cruise ship passengers increased more than twofold, and passenger-days increased from 7 to 14 million per year. There was little seasonal variation in the number of passengers taking cruises.

Length of cruises ranged from 1 to 140 days; 44.9% lasted 7 days, and 3.1% were longer than 15 days. Mean cruise length decreased from 9 days in 1975 to 5 days in 1985, while the proportion of cruises lasting less than 3 days increased from 2.0% to 31.9%. There was a corresponding decrease in the proportion of cruises longer than 15 days, from 7.3% in 1975 to 1.0% in 1985.

Mean cruise size remained between 597 and 727 passengers since 1975; however, the proportion of cruises with more than 1000 passengers increased from 6.3% in 1975 to 21.3% in 1985. Cruises with fewer than 100 passengers were more likely to be long; 846 (3.7%) cruises had fewer than 100 passengers, and 34% of these lasted longer than 15 days. Of cruises lasting longer than 15 days, 41% had fewer than 100 passengers.

Miami and Port Everglades, Florida were the ports of arrival for 62% of all cruises, followed by San Juan, Puerto Rico (11%), New York City (11%), Los Angeles (8%), multiple ports in Alaska (5%) and San Francisco (2%). Each of the remaining ports of arrival accounted for less than 1% of cruises. Ports in the Caribbean or Mexico were on the itinerary of 82% of cruises; 64% of cruises stopped only in the Caribbean.

Ship captains on 98.8% of all cruises reported diarrhoeal illness in less than 3% of passengers. The proportion of cruises reporting at least 3% of passengers ill during the cruise was highest for cruises longer than 15 days (23%) and lowest for cruises less than 3 days (0%). Reporting at least 3% of passengers with diarrhoeal illness during the cruise was also more likely for cruises that stopped at ports around the world (21.3%), in South America (14.6%), or in Mexico (1.9%) than for cruises in the Caribbean (0.3%).

To assess the reliability of the ship captain's report of diarrhoeal rates, the captain's report was compared with the ship physician's log. Both the ship captain's report and data from the ship physician's log were available for 13682 (60.1%) cruises. The numbers from the two sources were identical for 61.4% of cruises and differed by less than 1% of ship passengers for 97% of cruises. According to the physician's log, less than 3% of passengers had consulted the ship physician for diarrhoea on 98.6% of all cruises. Compared with the physician's log, the ship captain's report had a sensitivity of 76.5% and a specificity of 99.5% in identifying ships on which at least 3% of passengers had diarrhoea.

Table 1. *Cruise ships docking at US ports on which captains reported that at least 3% of passengers consulted the ship physician for diarrhoeal illness, 1975-85**

Classification of possible outbreaks	Number
All cruises reporting at least 3% diarrhoeal illness	98
Cruises investigated by CDC	49
Onshore exposure	4
Shipboard outbreaks	45
Cruises evaluated but not investigated by CDC	49
Late notification	2
Mexican origin, cruise duration 7 days or less	20
Illness rate less than 3% per week	16
Other	11
Peak of illness at beginning of cruise	
No temporal clustering of cases	
Mild illness	

* Excludes cruises with fewer than 100 passengers, cruises less than 3 or more than 15 days long, and cruises to Alaska from British Columbia.

Outbreaks of shipboard diarrhoea

Of the 22767 cruises, 3280 (14.4%) lasted less than 3 days, 710 (3.1%) lasted more than 15 days, 846 (3.7%) had fewer than 100 passengers, and 1168 (5.1%) originated and terminated in British Columbia; these cruises (23.9%) are excluded from further consideration. Ship captains on 98 (0.6%) of the remaining 17322 cruises reported that at least 3% of passengers had consulted the ship physician for a diarrhoeal illness during the cruise, meeting our definition for a possible outbreak.

Investigations were not considered warranted for 49 (50%) of these 98 possible outbreaks for the reasons shown in Table 1. Twenty of these cruises originated in Mexico and arrived in Los Angeles within 7 days. Diarrhoeal illness consistently occurred during the first few days of these cruises; on alternate weeks, when the ship sailed from Los Angeles to Mexico, diarrhoea rates were less than 3%, suggesting that exposure was occurring in Mexico before boarding the ship. Illness on 16 additional cruises was not investigated because the illness rate was less than 3% per week and there was no temporal clustering of cases.

CDC investigated 30 (67%) of 45 cruises in 1975-9 on which at least 3% of passengers were reported by the ship captain to have consulted the ship physician for diarrhoea. In 1980-5, this proportion decreased to 36% (19 of 53 cruises). However, 19 of the 20 Mexico-to-Los Angeles cruises occurred during the latter period; if these are excluded, CDC investigated 19 (56%) of 34 cruises in 1980-5 reported to have at least 3% of passengers with diarrhoea.

Of the 49 outbreaks investigated by CDC during 1975-85, four were associated with exposure onshore, and three of these were associated with onshore buffet luncheons. In one of these outbreaks, *Shigella flexneri* was the causative agent; the other two outbreaks associated with onshore luncheons involved multiple bacterial pathogens (Berkelman *et al.* 1983).

The other 45 outbreaks were considered to be shipboard outbreaks. As determined by standardized, self-administered questionnaires distributed to all

Table 2. *Pathogens associated with outbreaks of diarrhoeal illness on cruise ships docking at US ports, 1975-85*

Pathogen	Outbreaks	
	No.	%
Bacteria	16	36
<i>Vibrio parahaemolyticus</i>	6	
<i>Escherichia coli</i>	5	
<i>Salmonella enteritidis</i>	1	
<i>Salmonella heidelberg</i>	1	
<i>Shigella flexneri</i>	1	
<i>Staphylococcus aureus</i>	2	
Norwalk or Norwalk-like virus	6	13
Unknown	23	51
Total	45	100

Table 3. *Vehicles implicated in outbreaks of diarrhoeal illness on cruise ships docking at US ports, 1975-85*

(n = 45)

Vehicle	No. outbreaks
Food	
Seafood cocktail/salad	8
Lobster	1
Chicken/egg salad	1
Turkey	1
Potato salad	1
Cream pastries	1
Water	5
Probable person-to-person	2
Unknown	25

passengers during the investigations, mean outbreak size was 306 passengers. In comparison, the mean size of these outbreaks as determined by ship captains' reports was 63 passengers, a 4.9-fold difference. Bacterial pathogens were associated with 36 % of shipboard outbreaks (Table 2); this proportion did not change significantly between 1975 and 1985. The major bacterial pathogens were *Vibrio parahaemolyticus* and *Escherichia coli*. Norwalk or Norwalk-like virus was implicated in 6 (13%) outbreaks, and for 23 (51%) outbreaks the pathogen was unknown. There were no significant differences between outbreaks associated with viral pathogens and those caused by bacteria with regard to symptoms, median duration of illness, outbreak size, or cruise itinerary. Mean outbreak size decreased from 328 passengers during 1975-9 to 275 passengers during 1980-5.

Thirteen food-borne outbreaks were documented, with a mean size of 353 persons; seafood salad was the implicated vehicle in eight (Table 3). Five outbreaks were associated with drinking water, and in two, person-to-person transmission was suspected. The vehicle was unknown in 25 outbreaks. Both the vehicle and pathogen were identified in 16 outbreaks. Seafood was implicated in all six of the outbreaks caused by *V. parahaemolyticus*, compared with 1 of 10 outbreaks caused by other pathogens ($P = 0.0009$, Fisher exact test). Norwalk or

Table 4. *Outbreaks of diarrhoeal illness on cruise ships docking at US ports 1975-79 and 1980-85**

(*n* = 45)

Time period	Outbreaks per year	Outbreaks per 1000 cruises	Outbreaks per 1000000 passengers	Outbreaks per 10000000 passenger days	Outbreak-related illnesses per 100000 passenger days
1975-9	5.6	4.1	5.9	8.1	26.6
1980-5	2.8	1.6	2.0	3.0	8.2

* Excludes four shore-related outbreaks.

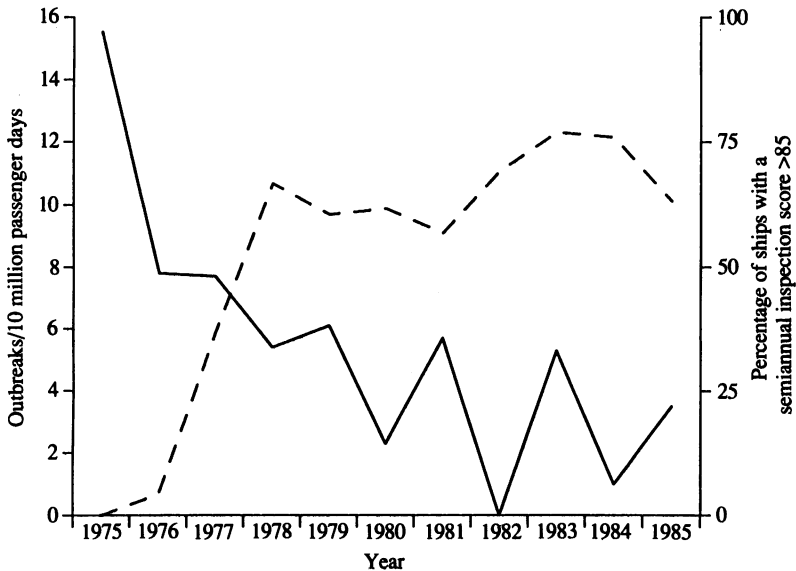


Fig. 1. Outbreaks of gastrointestinal illness per 10 million passenger days (—) and percentage of all cruise ships calling at US ports meeting VSP inspection standard (---), by year, 1975-85.

Norwalk-like virus was implicated in both outbreaks in which person-to-person spread was considered to be the mode of transmission, compared with 2 of 14 outbreaks in which person-to-person transmission was not documented ($P = 0.05$).

Between 1975-9 and 1980-5, the mean number of outbreaks per year and the number of outbreaks per 1000 cruises, per million passengers, and per 10 million passenger-days all decreased (Table 4, Fig. 1). The number of possible outbreaks (cruises reporting diarrhoea in at least 3% of passengers) per 10 million passenger days also decreased from 14 in 1975-9 to 9 in 1980-5. The mean number of passengers reported by ship captains to have consulted a ship physician for any diarrhoeal illness (whether or not it was associated with an outbreak) decreased from 3.0/1000 passengers per week in 1975-9 to 2.2/1000 per week in 1980-5.

Inspection scores

The proportion of cruise ships obtaining passing scores on the sanitation inspection increased sharply in the first several years of the programme (Fig. 1). When the VSP began in 1975, none of the cruise ships met the standard; since 1978, at least 50% of ships have met the standard each year. The percentage of ships meeting the standard did not appreciably change when ships limited to cruises with less than 100 passengers or lasting less than 3 or more than 15 days were included in the analysis.

DISCUSSION

The VSP was established to 'achieve and maintain a level of sanitation that will lower the risk of gastrointestinal disease outbreaks and provide a healthful environment on board passenger vessels' (US Public Health Service, 1987). Implementation of the VSP in 1975 was followed by an increase in the number of ships passing the inspection standard and a rapid decrease in the number and rate of shipboard outbreaks of diarrhoeal disease. The temporal association of these events must be interpreted with caution because other unidentified factors may have prevented outbreaks. The inspection scores were designed to provide a general indication of shipboard sanitation rather than to predict outbreaks. Nonetheless, low inspection scores have been associated with an increased risk of both shipboard outbreaks (Centers for Disease Control, 1988) and possible outbreaks (Dannenberg, Yashuk & Feldman, 1982). In contrast, low ship inspection scores do not appear to be associated with increased rates of sporadic diarrhoeal illness (Dannenberg, Yashuk & Feldman, 1982); other factors, such as cruise itinerary, seem to play an important role in the occurrence of non-outbreak-related disease.

The VSP surveillance system was established to identify outbreaks of shipboard diarrhoeal illness. In a review of ships' medical logs in 1973, only 3% of cruises had a recorded incidence of gastrointestinal illness among more than 3% of passengers, and a passenger survey showed that the actual incidence was at least four times as high as that recorded in the medical logs (Merson *et al.* 1975*b*). When the VSP was established in 1975, a ship captain's report of at least 3% of passengers with diarrhoea was therefore considered to be indicative of a possible shipboard outbreak. As the VSP developed, it became clear that additional factors, including the rate of diarrhoeal illness per week, the duration of the cruise, the itinerary, and the nature of the epidemiological curve were also important considerations in determining whether a captain's report of 3% of passengers ill represented a shipboard outbreak. Consequently, the proportion of possible outbreaks investigated by CDC declined between 1975-9 and 1980-5. This change, however, does not explain either the sharp decrease in the number of outbreaks between 1975 and 1978 nor the overall decline from 1975 to 1985, since the rate at which possible outbreaks occurred also decreased during this period.

Since 1975, average cruise length has shortened. Diarrhoeal illness on short cruises may be less likely to be reported (Merson *et al.* 1975*b*), but the trend towards shorter cruises does not explain the decrease in the rate of outbreaks, since the shortest cruises (less than 3 days) were excluded from the analysis.

For 50% of cruises reporting at least 3% of passengers ill, a complete investigation was not considered warranted, since available data did not suggest that a shipboard outbreak had occurred. It is possible that common-source outbreaks occurred on these or other cruises which were neither recognized nor subsequently reported. Confining our definition of outbreaks to those confirmed by epidemiological investigation may give a falsely low number of outbreaks, but it greatly increases the specificity of our estimate of outbreak-related shipboard diarrhoeal illness.

The sensitivity of the VSP surveillance system in detecting outbreaks is difficult to measure. Completeness of physician reporting in the medical log could not be assessed with the available data, but compared with the ship's medical log, the relatively low sensitivity (77%) of the ship captains' reporting when at least 3% of passengers had sought medical attention for diarrhoea suggests that some outbreaks escape detection. Ill passengers may not seek medical attention if the diarrhoea is mild; in addition, they may be reluctant to pay the ship physician's fee or may disembark before the onset of severe symptoms. These factors may also contribute to the fivefold difference in estimates of outbreak size given by the ship physician's report and by questionnaires distributed to all passengers during an investigation.

Common-source food-borne outbreaks onboard ship appear to be considerably larger (mean of 353 persons) than similar outbreaks reported to CDC from local and state health departments (mean of 30 in 1982) (Centers for Disease Control, 1985). While this difference may be due to better surveillance and more complete case ascertainment in the cruise ship setting, it probably also reflects the fact that on cruise ships each food item is eaten by unusually large numbers of persons.

Vibrio parahaemolyticus was the most frequently isolated bacterial pathogen. In Japan, where seafood makes up a large part of the diet, *V. parahaemolyticus* is recognized as a major cause of diarrhoeal disease (Zen-Yoji *et al.* 1965). *V. parahaemolyticus* is ubiquitous in coastal waters (Blake, Weaver & Hollis, 1980); if present in low numbers in undercooked or contaminated seafood, the organism can rapidly proliferate at temperatures of 25–44 °C (Aiso, 1967). Thorough cooking, adequate refrigeration, and proper handling of seafood may be difficult when preparing food for hundreds of passengers, but these measures are the key to preventing outbreaks due to *V. parahaemolyticus*.

It is difficult to determine the risk of diarrhoeal illness on passenger cruise ships relative to the risk of diarrhoea among non-travellers in the United States: data are limited, and it is hard to define an appropriate control group. Between 1975 and 1985, cruise ship passengers sought medical attention from the ship physicians for diarrhoeal illness at a rate of 0.13 per passenger-year. In comparison, a prospective community-based study in the United States reported one episode of enteric illness per year for persons at least 20 years old (Monto & Koopman, 1980); a physician was consulted for 14% of these episodes (that is, 0.14 per person-year). These limited data suggest that risk of diarrhoeal illness may be similar for cruise ship passengers and non-passengers in the United States.

VSP surveillance was established to identify outbreaks of diarrhoea; 45 shipboard outbreaks were detected in 92 million passenger-days of exposure between 1975 and 1985, for a rate of 5 outbreaks (approximately 1500 outbreak-

related illnesses) per 10 million passenger days. To put this denominator in perspective, 10 million person-days would be accumulated in 1 year by a community of 27400 persons. Outbreaks of diarrhoeal disease tend to be underreported in most communities, but it is unlikely that a town of 27400 people would normally experience five large outbreaks in a single year. Differences in data collection and quality make comparisons with national surveillance data difficult, but in the United States in 1982, 656 food-borne and 40 water-borne outbreaks (22836 cases) were reported to CDC, for a rate of 0.1 outbreak and 2.8 outbreak-related illnesses per 10 million person-days (Centers for Disease Control, 1983, 1985).

In summary, implementation of the VSP in 1975 was followed by a marked decline in the number of shipboard outbreaks of diarrhoeal illness. Since 1978, rates of outbreak-associated diarrhoeal illness have remained relatively constant at a level that appears to be higher than would be expected for the rest of the US population. The increase in inspection scores suggests that shipboard sanitation has improved. However, the potential for large common-source outbreaks remains as the popularity of vacation aboard cruise ships increases and even larger ships are added to expanding fleets. Further reduction in the risk of shipboard outbreaks will require continued surveillance for diarrhoeal illness, prompt investigation of outbreaks, careful attention to foodhandling practices and shipboard sanitation, and an ongoing programme of cruise ship inspection.

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