

Gastroenteritis outbreaks on cruise ships: are sanitation inspection scores a true index of risk?

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ABSTRACT

Background: The utility of cruise ship sanitation scores as indicators of future gastroenteritis outbreak was investigated by means of a 5-year review of inspection scores and outbreaks of gastroenteritis as reported under the Vessel Sanitation Programme of the United States Public Health Centers for Disease Control.

Materials and methods: Between 2012 and 2017 a total of 1197 inspections were published online, with a mean score of 95.7 out of 100. During the same interval there were 50 separate outbreaks of acute gastroenteritis.

Results: No significant difference was found between pre-outbreak inspection scores, mean 96.4, and inspections that were not followed by an outbreak, mean 95.1 ($z = 0.81$, $p = 0.42$).

Conclusions: This study shows that the current format of the inspection audits carried out under the Vessel Sanitation Programme generates scores that have no prognostic value with regard to future outbreaks of gastroenteritis on board cruise ships.

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Key words: acute gastroenteritis, outbreak, Vessel Sanitation Programme, United States Centres for Disease Control and Prevention, cruise ships, norovirus

INTRODUCTION

An outbreak of acute gastroenteritis (AGE) on a cruise ship represents a significant concern for all concerned: the cruise line's management, the ship's crew-members and certainly the ship's passengers. The enclosed nature of cruise ships, in combination with a resident population that remains more or less constant throughout a voyage, presents ideal conditions for the proliferation of infectious agents such as norovirus, the commonest cause of AGE outbreak on ships [1].

To mitigate the threat, cruise lines take a very pro-active approach to hygiene and sanitation on their vessels by implementing procedures and policies aimed at preventing and reacting to cases of AGE on board. Assistance in this endeavour is provided by the United States Centres for Disease Control and Prevention (CDC) which, since 1975, has been running the Vessel Sanitation Programme (VSP). This programme applies to cruise ships that enter the United States carrying 13 or more passengers. It has two major components: continual surveillance of AGE cases on-board

and periodic audit inspections of on-board hygiene and sanitation standards, as defined within the VSP Operations Manual [2].

Disease surveillance mandates that all ships sailing into a United States port from outside the country are required to report every case of AGE arising amongst the crew and passengers throughout the voyage. Compliance with the VSP Operations Manual is assessed by means of unannounced sanitation inspections that are periodically undertaken by the VSP's own environmental health officers. Each inspection generates a final score, with points being subtracted from 100 for each important infringement. A score above 85 is considered acceptable, a pass.

An outbreak of AGE is defined as gastro-intestinal illness that cumulatively affects three or more per cent of either the crew population or the passenger population over the entire duration of the cruise, or over the 15 days immediately prior to arrival in a United States port for longer voyages [2]. Data from each outbreak and each audit inspection are made available on the VSP website [3, 4]. The site provides

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a variety of resources for public health professionals, travel agents and cruise ship travellers seeking information about gastro-intestinal illness on cruise ships. There is a searchable database of inspections extending back to 1990, along with individual pages listing recent inspection scores and inspections that resulted in a perfect score of 100. The website encourages use of the data by the general public, viz., “The cruising public can take a proactive approach to staying healthy on vacation by finding out a ship’s sanitation score...” [5].

By analysing data drawn from the online VSP databases this study sought to examine the extent to which outbreaks of AGE on cruise ships are related to the inspection scores of food hygiene and environmental sanitation on-board.

MATERIALS AND METHODS

The study was based on information collected from cruise ships visiting United States ports and made public by the CDC. A search was made of the VSP website page: “Advanced Cruise Ship Inspection Search” [4], to retrieve the available data for ship inspections under the programme. Data for voyages registering outbreaks of AGE were retrieved from a second page of the same website: “Outbreak Updates for International Cruise Ships” [3].

The study concerned the five complete calendar years between January 1st, 2013 and December 31st, 2017. If a ship reported outbreaks on two consecutive voyages they were, for the purposes of this study, viewed as a single event and details from the initial voyage were used in the subsequent analysis.

The total number of inspections were recorded and charted by score. The number of individual ships inspected was noted. Mean, median and interquartile range (25th to 75th centile) were calculated from the data for all inspections, from all inspections that preceded outbreaks and from all inspections that were not followed by outbreaks.

For each case of AGE outbreak the following data were registered: causative pathogen; month when the outbreak occurred; percentage of passengers and percentage of crew members affected; the ship’s last VSP inspection score prior to the outbreak and the lead time (number of weeks between the last inspection and the outbreak); inspection scores over the 12 month period prior to each outbreak for all ships of the same cruise line as the outbreak ship (from which a mean was calculated that included data from the outbreak ship itself); inspection scores over the 12 month period prior to each outbreak for all ships in the VSP at that time (from which a mean was calculated that included data from the outbreak ship itself).

There were 7 instances where an outbreak occurred in the first year of the study and the most recent inspection had taken place in the previous calendar year. Data from these

inspections were collected and included in the analysis of outbreaks even though they predated the study interval.

The results were tabulated according to whether the ship faced a single outbreak during the study (Table 1) or had several distinct outbreaks (Table 2).

Statistical analysis of inspection scores that preceded an outbreak and inspection scores not followed by outbreak was undertaken using the Mann-Whitney U test, owing to the skewed distribution of the data. A corrective calculation of standard deviation was undertaken [6, 7] in view of the many tied ranks.

RESULTS

During the 5-year study 1197 inspections were conducted on 182 ships as part of the VSP. The highest possible score of 100 was also the modal score and was achieved on 194 (16.2%) occasions. A failure score of 85 or less was recorded in 40 (3.3%) inspections. The distribution pattern of inspection audit scores was not Gaussian (Figs. 1, 2). The mean score of all inspections was 95.7, the median score was 96 and the interquartile range (IQR) was 93 to 99.

There were 54 reported AGE outbreaks on 37 cruise ships visiting United States ports. On four occasions ships reported outbreaks on two consecutive voyages; these ‘back-to-back’ outbreaks were viewed as a single event. Most of the 50 outbreaks occurred in the winter and early spring, with 70% (35/50) of outbreaks occurring in the first 4 calendar months and 24% (12/50) in the last 4 months of the year (Fig. 3).

Of the 50 outbreaks, 3 occurred on ships that had never previously been inspected, leaving 47 outbreaks with all data available for review. Inspection details are presented in Table 1 for ships reporting an outbreak on only one occasion and in Table 2 for those reporting an outbreak on more than one occasion during the 5-year period.

Every one of the 50 outbreaks in this study occurred within the passenger population, involving 3.3–30.3% of the passengers. In 4 cases there was also a crew outbreak, involving 3.3–4.7% of the crew population. There were no crew-only outbreaks.

The causative agent was identified in 46 of the 50 outbreaks (Tables 1, 2). Norovirus was the sole agent involved in 89.1% (41/46) and was found along with Enterotoxigenic *Escherichia coli* (ETEC) in two other outbreaks. On the four occasions when a ship reported outbreaks on two consecutive voyages, norovirus was the cause for both voyages in all instances.

INSPECTION SCORES FOLLOWED BY OUTBREAKS

The mean pre-outbreak inspection score in the 47 previously inspected ships (Fig. 2) was 96.4, the median score

Table 1. Vessel Sanitation Program inspection details of the 28 cruise ships that had only one gastroenteritis outbreak within the 5-year study period 2013–2017. The data were accumulated and/or calculated from information published by the United States Centres for Disease Control and Prevention [3]

Case number	Infectious agent responsible	Passenger % reporting symptoms	Crew % reporting symptoms	Ship's pre-outbreak score ⁽¹⁾	Lead time ⁽²⁾ [weeks]	Fleet 12 month mean score ⁽³⁾	Industry 12 month mean score ⁽⁴⁾
1	Norovirus	7.5	1.6	90	1	95.5	94.5
2	Unidentified	5.7	0.2	100	34	96.7	94.6
4	Unidentified	22.8	3.3	94	53	94.0	94.9
5	Norovirus	8.0	0.8	91	13	96.7	95.0
6	Norovirus	3.3	0.5	96	7	96.7	95.0
7	Norovirus	4.6	0.2	99	9	96.7	95.0
8	Norovirus	3.6	0.3	100	27	96.2	95.7
10	Norovirus	4.9	2.8	96	35	96.7	95.7
11	Unidentified	3.4	0.5	93	25	89.8	95.5
12	Norovirus	4.9	1.4	99	19	98.4	95.9
13	Norovirus	30.3	1.7	96	28	96.0	95.8
16	ETEC	6.2	3.6	98	7	96.0	95.8
17	Norovirus	5.8	0.4	100	44	95.6	95.8
18	Norovirus	3.3	1.0	–	–	96.5	95.8
19	Norovirus & ETEC	10.5	1.8	–	–	97.3	95.8
25	Norovirus	5.2	1.5	96	5	96.6	95.5
26	Norovirus	5.8	1.4	96	100	95.2	95.3
29	Norovirus	7.7	0.9	–	–	97.0	95.3
31	Norovirus	5.9	1.2	95	18	95.6	95.3
32	Norovirus	4.9	0.7	97	14	96.9	95.1
40	Norovirus	20.6	4.7	95	1	96.3	95.3
41	Norovirus	5.6	1.2	94	12	95.4	95.3
43	Norovirus	15.3	1.4	99	4	97.0	94.8
44	Norovirus	6.3	1.7	90	40*	95.7	95.5
45	Norovirus	15.3	3.9	96	31*	95.3	95.5
47	Norovirus	6.4	0.2	95	58*	95.4	95.5
49	Norovirus	8.5	0.8	99	17*	97.1	95.8
50	Norovirus	5.9	0.4	95	20*	97.2	95.8

⁽¹⁾ The most recent inspection score prior to the outbreak voyage.

⁽²⁾ The number of complete weeks between the most recent inspection and the outbreak.

⁽³⁾ The mean score of all inspections of the outbreak ship's parent company fleet over the 12 months prior to the ship's outbreak voyage, including the outbreak ship.

⁽⁴⁾ The mean score of all inspections of all ships of all companies over the 12 months prior to the ship's outbreak voyage, including the outbreak ship.

*Outbreak occurred in the first quarter of 2013 and the most recent inspection before the outbreak was in 2012. Data for comparative 12-month averages includes some inspection scores from 2012 accordingly.

ETEC – Enterotoxigenic Escherichia coli

was 96 and the IQR was 95 to 99. These calculations include 7 instances where the outbreak arose in the first year of the study interval and the most recent pre-outbreak inspection had taken place in the preceding year.

INSPECTION SCORES NOT FOLLOWED BY OUTBREAKS

The mean score of the 1157 inspections that were not followed by an AGE outbreak (Fig. 1) was 95.1 with a median

Table 2. Vessel Sanitation Programme inspection details of the 9 cruise ships (A-I) that had more than one (range: 2–4) gastroenteritis outbreak within the 5-year study period 2013–2017. The data were accumulated and/or calculated from information published by the United States Centres for Disease Control and Prevention [3]

Ship	Case number	Infectious agent responsible	Passenger % reporting symptoms	Crew % reporting symptoms	Ship's pre-outbreak score ⁽¹⁾	Lead time ⁽²⁾ [weeks]	Fleet 12 month mean score ⁽³⁾	Industry 12 month average score ⁽⁴⁾
A	3	Clostridium perfringens	6.2	1.0	99	5	95.0	94.8
A	21	Norovirus	5.9	2.1	97	33	97.1	95.7
A	34	Norovirus	5.3	1.2	91	24	94.5	95.1
A	35	Norovirus & ETEC	3.9	2.6	95	21	95.8	95.3
B	14	Norovirus	8.1	0.8	96	2	95.0	95.8
B	20	Norovirus	3.2	0.0	94	6	94.7	95.8
B	24	Norovirus	6.4	1.6	94	38	95.4	95.8
C	22	Norovirus	5.1	1.9	100	16	97.5	95.9
C	38	Norovirus	9.0	1.7	99	3	96.7	95.4
C	46	ETEC	4.9	1.7	92	27*	95.3	95.5
D	9	Norovirus	7.8	2.8	100	1	96.4	95.7
D	28	Norovirus	5.1	1.4	97	24	96.1	95.3
E	23	Norovirus	5.0	1.1	99	11	97.2	95.9
E	39	Norovirus	5.8	1.0	98	17	95.8	95.4
F	27	Norovirus	5.9	2.1	95	18	97.4	95.3
F	37	Unidentified	5.9	1.4	99	12	97.2	95.3
G	30	Norovirus	5.0	0.6	100	0	97.6	95.3
G	48	Norovirus	4.8	2.1	97	23*	95.1	95.7
H	33	Norovirus	10.2	1.2	99	5	96.6	95.1
H	36	Norovirus	5.2	0.8	94	16	96.2	95.3
I	15	Norovirus	4.4	0.6	97	29	95.4	95.7
I	42	Norovirus	4.3	0.3	100	17	95.1	95.2

⁽¹⁾ The most recent inspection score prior to the outbreak voyage.

⁽²⁾ The number of complete weeks between the most recent inspection and the outbreak.

⁽³⁾ Mean score of all inspections of the outbreak ship's parent company fleet over the 12 months prior to the ship's outbreak voyage, including the outbreak ship.

⁽⁴⁾ The mean score of all inspections of all ships of all companies over the 12 months prior to the ship's outbreak voyage, including the outbreak ship.

*Outbreak occurred in the first quarter of 2013 and the most recent inspection before the outbreak was in 2012. Data for comparative 12-month averages includes some inspection scores from 2012 accordingly.

ETEC – Enterotoxigenic Escherichia coli

score of 96 and IQR of 93 to 99. There was no significant difference at the 5% level between the median scores of the 1157 inspections not followed by outbreak and the 47 inspections that were: $z = 0.81$, two-tailed $p = 0.42$.

FAILED INSPECTIONS

There were 40 failed inspections during the study period, affecting 34 ships. On no occasion did an outbreak arise on a ship that had failed its most recent inspection. Six ships failed on two occasions; none of them had an outbreak, either before or after the failed inspection. No ship failed three or more inspections.

There were 148 ships that never failed an inspection; outbreaks occurred in 32 (22%) of these ships. Of the 34 ships that failed one or more inspections, 5 (15%) had outbreaks of AGE, either before or after the inspection date. In every case a subsequent inspection had been passed in the interim. Two of the five ships had an outbreak after failing an inspection (8 months and 18 months later, respectively) and two ships failed inspection following an outbreak (2 weeks and 5 weeks later, respectively). There was one ship that had outbreaks either side of the failed inspection: an outbreak occurred 6 months after failing an inspection and three other outbreaks occurred 35 months, 30 months and 15 months before the failed inspection.

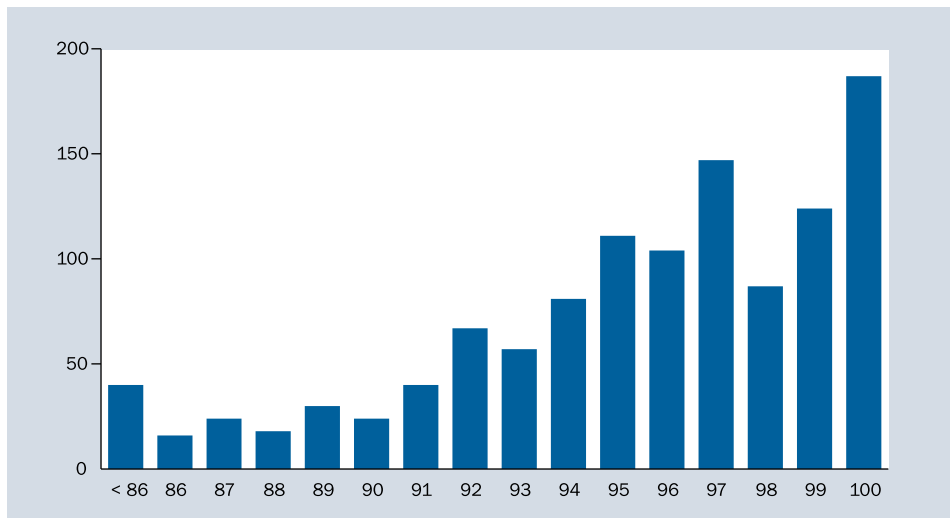


Figure 1. All Vessel Sanitation Programme inspection scores not followed by a gastroenteritis outbreak during the 5-year study period 2013-2017 (n = 1157) [4]

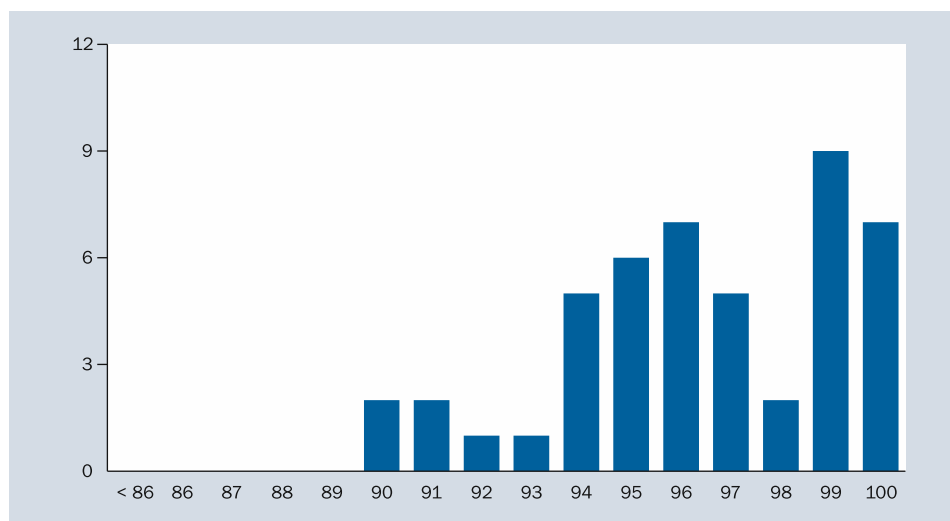


Figure 2. All Vessel Sanitation Programme inspection scores that preceded a gastroenteritis outbreak in the 5-year study period 2013-2017 (n = 47) [4]. This includes 7 inspections from 2012 which were the most recent pre-outbreak inspection for 7 ships that had outbreaks in the first months of 2013

OUTBREAKS AFTER FAULTLESS INSPECTION SCORES

On seven occasions a ship had an outbreak after scoring 100% on the most recent inspection. In 2 cases this inspection very closely preceded the outbreak (by 11 days in 1 case and 0 days in the other, i.e. the inspection took place on the same day that the outbreak voyage commenced).

INSPECTION SCORES IN RELATION TO PARENT COMPANY AND INDUSTRY STANDARDS

In 72% of cases (36/50) the ship having an outbreak belonged to a cruise line whose average inspection score over the previous 12 months was greater than the industry-wide

average for the same interval. In 64% of cases (30/47) the most recent pre-outbreak inspection score exceeded the mean industry-wide score of all ships in the preceding 12 months. The pre-outbreak score exceeded the parent cruise line mean over the 12 months prior to the outbreak in 55% of cases (26/47).

SINGLE OUTBREAKS

Twenty-eight ships experienced a single outbreak. This included the three never-inspected ships. In 60% of cases (15/25) the outbreak ship's most recent inspection score was greater than the industry-wide mean score over the 12 months prior to the outbreak in 60% of cases (15/25) and

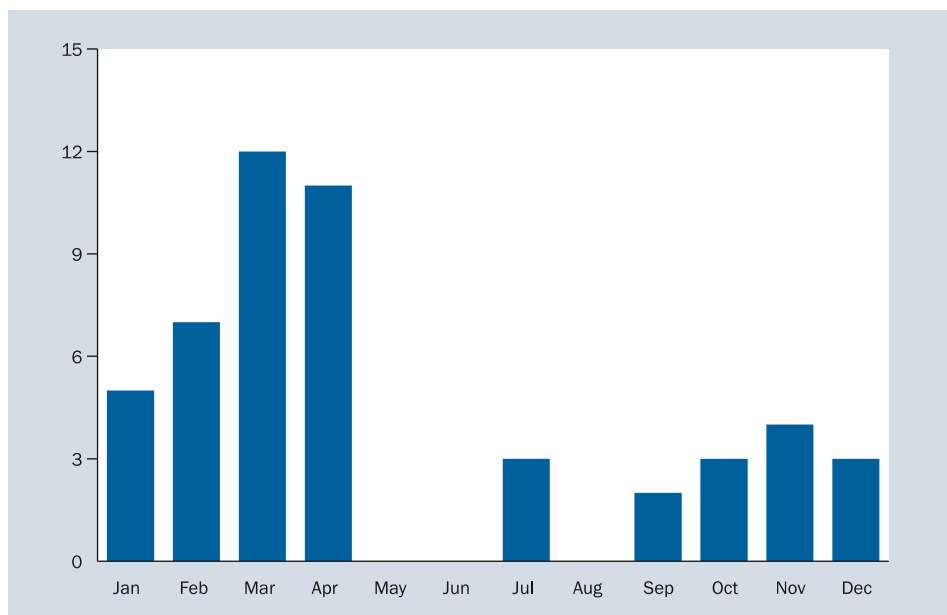


Figure 3. Distribution of gastroenteritis outbreaks (n = 50) by month during the 5-year study period 2013–2017 [3]. Outbreaks on consecutive voyages are counted as a single event

greater than the parent company mean in 48% of cases (12/25). The score of the outbreak ship was identical to the parent company mean in two other cases.

MULTIPLE OUTBREAKS

Nine ships had multiple outbreaks involving non-consecutive voyages. Only one failed an inspection at any time during the study (see above). These 9 ships accounted for 22 outbreaks. The most recent pre-outbreak inspection score of these ships exceeded the industry-wide mean score in the 12 months prior to the outbreak in 73% of cases (16/22) and was greater than the parent company mean in 64% of cases (14/22).

DISCUSSION

Cruise lines commit considerable resources towards implementing the food hygiene and environmental sanitation standards defined in the VSP Operations Manual [2]. The results of periodic audit inspections assessing on-board compliance with these directives are posted online and are of great consequence for an industry dependent on further bookings for its success; a poor audit performance can jeopardize not only future sales but also present-day seafaring careers. The audits are lengthy, thorough and exacting. Achieving a perfect score requires a sustained prioritisation of health and hygiene procedures by the ship's crew and management. This study found that successful audit inspections did not translate into fewer AGE outbreaks; the mean scores of audits that preceded an AGE outbreak did not significantly differ from those that were not followed by an outbreak (96.4 vs. 95.1; $p = \text{NS}$).

Ships having outbreaks of AGE had pre-outbreak inspection scores that were higher than the industry-wide mean for the 12 months leading up to the outbreak in 64% of cases. In 72% of cases the outbreak ships belonged to cruise lines with a mean inspection score that was greater than the industry-wide mean over the 12 months prior to the outbreak. Thus, outbreaks occurred more often on the better scoring ships and on ships belonging to the better scoring cruise lines.

Scoring highly on VSP sanitation inspection audit, even a perfect score of 100, did not confer less likelihood of future outbreak. In one case an outbreak voyage began the same day that an audit inspection had scored the ship 100 for sanitation standards. Overall, 15% of ships having outbreaks scored 100 in their most recent inspection, a rate similar to that found for all inspections (16%).

Failing a VSP audit (a score below 86 out of 100) was an uncommon outcome and happened in only 3% of inspections. However, failing an inspection was not associated with greater likelihood of AGE outbreak. Of the ships found to have sub-standard levels of on-board sanitation, 15% had an outbreak of AGE during the study interval. In comparison, an outbreak occurred in 22% of ships that passed every inspection.

Nine ships in the study had an outbreak on more than one non-consecutive voyage. These multi-outbreak ships might logically be suspected of having questionable standards of food hygiene and environmental sanitation. However, this study found that in 73% of cases, these ships had pre-outbreak inspection scores that exceeded the in-

dustry-wide mean score for the 12 months leading up to each outbreak.

Norovirus is the leading cause of acute gastroenteritis outbreaks worldwide [8–10] with a known greater prevalence in winter months [9–11], such that it is sometimes referred to as “winter vomiting disease” [12–14]. Accordingly, this study found that norovirus was the agent partly or totally responsible in 93% (43/46) of cruise ship outbreaks where a cause was identified and that the overwhelming majority of outbreaks occurred in the months of winter and early spring.

Transmission of norovirus is faeco-oral or through exposure to infectious vomitus [8, 15]. Infected food workers transferring virus onto food by means of unhygienic food preparation methods has been said to be a frequent source of outbreak [15]. Whether this is applicable on-board cruise ships is unclear. Outbreaks of acute gastroenteritis in this study arose within the passenger population in 100% of instances but in only 8% of cases was there a concurrent outbreak within the crew population. It is difficult to imagine that the food preparation methods used in crew dining areas are of a higher standard than those in the galleys where meals for passengers are prepared, suggesting that on cruise ships factors other than unhygienic food preparation are responsible.

This study is not the first to describe a relative rarity of gastroenteritis outbreaks amongst crew members. Previous authors have commented that the earlier reporting of gastrointestinal symptoms by crew members and enforced hand washing in their dining areas may be contributory factors to the unexpectedly low prevalence of crew outbreaks [1]. These proposals lend support to a hypothesis of transmission primarily via contact with contaminated surfaces rather than through the ingestion of contaminated food.

If the chief mode of transmission in AGE outbreaks on cruise ships really is by means of contact with contaminated surfaces, then the relative stability of the crew population may to some extent explain the lower incidence of outbreak within this group. Replenishment of the passenger population at the end of each voyage generally approaches 100% whereas the proportion of new crew members joining the ship is often in the order of only 5–10%. Accordingly, there is a greater likelihood that new persons harbouring infectious disease will board within the passenger group than there is within the crew population, leading to more surfaces being affected in public areas than in the crew-only areas on-board.

The VSP seeks to address the prevention and management of communicable disease on-board passenger ships. The VSP operations manual is extensive and detailed; it focuses chiefly on the management of potable and rec-

reational water, food storage and preparation as well as disease surveillance and reporting [2]. The number of outbreaks and individual gastroenteritis cases that over the years have been avoided by the implementation of the VSP operations manual procedures are incalculable. However, relatively little space within the manual is given over to general housekeeping measures, thus drawing attention away from what may well be the main mechanism of norovirus transmission on-board cruise ships.

For each inspection audit within the VSP a fee is charged to the cruise line, in accordance with a sliding scale of charges based on the size of the vessel being inspected [16]. With around 250 inspections per year, the annual cost to the cruise lines is in the region of 3 million dollars. This paper has shown that the scores generated by these inspection audits have no prognostic value in terms of future AGE outbreaks. Identifying the specific aspects of the VSP Operations Manual that truly influence AGE outbreaks and focussing the scoring of audit inspections on those key areas might result in scores that do have a predictive value. In the current format, however, VSP sanitation scores cannot be considered at all indicative of the future risk of AGE outbreak on a cruise ship.

CONCLUSIONS

This study has shown that the scores generated by the food hygiene and environmental sanitation inspection audits carried out under the VSP over the most recently completed 5-year interval had no prognostic value in regard to which ships and which cruise lines were likely to have future outbreaks of acute gastroenteritis on board.

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