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Title: **Passenger behaviors during norovirus outbreaks on cruise ships**

Intent: Original article

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Prior publication: Individual cruise ship investigations have been posted on the CDC Vessel Sanitation Program's website www.cdc.gov/nceh/vsp

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Abstract

Background

Norovirus causes a majority of outbreaks of gastrointestinal illness on cruise ships calling on the United States. Control measures include patient isolation, hand washing, and facility closure. Little is known about the behaviors and practices of people who have become ill with norovirus gastrointestinal illness compared to those who remained well during an outbreak.

Methods

Passenger surveys were distributed during three cruise ship outbreaks caused by norovirus. Surveys inquired about illness symptoms, ill contacts, illness reporting status, hand sanitation beliefs and practices, and availability of public hand sanitizer. A case was a passenger reporting ≥ 3 episodes of loose stool in a 24-hour period, ≥ 3 episodes of vomiting in a 24-hour period, or ≥ 1 episodes each of loose stool and vomiting in a 24-hour period. Controls reported they were not ill during the cruise.

Results

In total, 1,323 responses were compared. All ships had passengers who were ill prior to embarkation. Most cases delayed or did not report their illness to the ship's infirmary because they did not believe it was serious (43%–70% of responses). Cases were less likely to believe isolation was effective in preventing disease spread (Mann-Whitney-Wilcoxon (MWW) P value <0.0001). Cases were less likely to believe that hand-washing or hand sanitizer are effective means of preventing disease spread (MWW P values 0.002 and 0.04 respectively), wash their hands after restroom use (MWW P value 0.02), or believe that hand sanitizer was available for public use prior to / after knowing about an outbreak (MWW P values 0.002 and 0.03 respectively).

Conclusions

Prevention and control of norovirus gastrointestinal illness may be improved by routine screening of embarking passengers, education about gastrointestinal illness and its impact on public health, a focus on improving hand washing practices, and identification of public hand sanitizer dispensing locations.

Background

The Centers for Disease Control and Prevention's (CDC) Vessel Sanitation Program (VSP) works with the commercial cruise ship industry to prevent, detect, and respond to outbreaks of gastrointestinal (GI) illness on cruise ships calling on U.S. ports. [1] This program has had marked success in preventing outbreaks of GI illness caused by bacteria, but less success in preventing outbreaks of GI illness caused by viruses.

Between 1990 and 2000, the incidence of GI illness per 100,000 cruise ship passenger days decreased from 29.2 to 16.3. Yet, between 2001 and 2005, the overall incidence increased to 25.6, an increase that has largely been attributed to norovirus. [2] Norovirus has become the most common cause of acute gastrointestinal illness outbreaks in commercial cruise ships calling on U.S. ports. [3] Land-based outbreaks of norovirus are similarly prevalent. In 2004, 57% of 239 nationally reported restaurant outbreaks were caused by norovirus. [4] The infectious dose of this virus is less than 100 particles, and it is resistant to many common control mechanisms. [5] Norovirus can be spread through food, water, fomites, or from person to person. [6]

Moderately effective norovirus outbreak control measures include isolation of ill patients, hand-washing, contact precautions, minimizing staff exposure to ill persons, and facility closure. [7,8] Hand washing is the most effective way to reduce norovirus burden on the hands, while hand sanitizer remains an effective adjunct. [9,10] Most recent studies about hand washing are descriptive, mainly in health care workers, and they do not attempt to link behaviors with health outcomes. [11,12,13] This paper reports the findings relating to the knowledge, attitudes, and practices of people who have become ill with norovirus GI illness compared to those who remained well during an outbreak.

Methods

Between January and April 2006, CDC responded to 12 commercial cruise ship outbreaks of gastrointestinal illness on ships calling on U.S. ports. On three of these investigations, a paper-based survey was administered to passengers prior to disembarkation. Passengers were asked to provide information about illness symptoms, ill contacts, reasons for delaying or not reporting illness, dining and entertainment locations visited during the outbreak, beliefs and practices regarding hand sanitation, and prevalence of public hand sanitizer stations before and after knowing an outbreak was occurring. Table 1 indicates which behavior or practice questions were asked on each ship. A case was defined as a passenger sailing on the ship during the outbreak who had three or more loose stools in a 24-hour period, or three or more vomiting episodes in a 24-hour period, or at least one episode each of loose stools and vomiting. The etiologic agent of the outbreak was confirmed using real-time reverse-transcriptase polymerase chain reaction (RT-PCR). In some cases, the crew also completed a survey but the results are not reported here.

Surveys were entered into Microsoft Access databases and analyzed using SAS v9.1.3. The statistical tests used were odds-ratios (OR) in case-control studies, risk-ratios (RR) in cohort studies, and the Mann-Whitney-Wilcoxon rank-sum test (MWW) for non-parametrically distributed values. Because the survey on ship A was a cohort design and the other two were case-control studies, some results are reported as Odds Ratios / Risk Ratios (OR/RR).

Each ship had a unique itinerary. Their characteristics are as follows:
Ship A was sailing on a 9-day tour of the Caribbean with 1,888 passengers and 814 crew. Surveys were distributed to the entire passenger cohort. All returned surveys were analyzed as a cohort study.

Ship B was sailing on an 8-day tour of the Caribbean with 3,245 passengers and 1,184 crew. Surveys were distributed to the first 30 people to have reported their GI illness to the infirmary as well as to 3 randomly selected controls from the ship's manifest (60 total). One extra survey was mistakenly distributed to the control population and collected. In total, 91 surveys were distributed. All returned surveys were analyzed as a case-control study.

Ship C was sailing on an 11-day tour of the Mexican ports along the Baja Peninsula with 1,904 passengers and 840 crew. Surveys were distributed to all passengers, and a case-cohort study was performed on the returned surveys. A power calculation was used to determine the number of controls needed to detect an odds-ratio of 2.0 or greater with 95% confidence, a beta of 80%, prevalence of exposure of 50%. [14]

Results

Ship A—The epidemic curve exhibited a peak of passengers reporting illness on the 3rd day of the cruise, with a secondary peak on the 5th day. Fifty-four percent of the surveys distributed were returned. In total, 829 surveys were available for comparison. The overall passenger attack rate, obtained from the ship's infirmary logs, was 5.3% (101/1,888). Norovirus RNA was detected by real-time RT-PCR in both of the two passenger stool specimens collected.

Ship B—The epidemic curve exhibited a peak of cases on the 2nd day of the cruise that gradually tapered over the next 5 days. The overall passenger attack rate, obtained from the ship's infirmary logs, was 7.8% (252/3,245). The survey response rate was 100%. 41 cases were compared to 32 controls. Norovirus RNA was detected by real-time RT-PCR in 3 of 8 (38%) passenger stool specimens collected.

Ship C—The epidemic curve exhibited a peak of cases on the 4th day of the cruise, with a secondary peak on the 6th day. The overall passenger attack rate, obtained from the ship's infirmary logs, was 5.6% (112/1,986). The survey response rate was 65%, and 87 cases were compared to 314 controls. Norovirus RNA was detected by real time RT-PCR in 12 of 34 (35%) passenger stool specimens collected.

All ships had passengers who indicated that they were ill prior to boarding (range 5–12 passengers). The mean age for passengers in the studies ranged from 42.6 to 59.4, there were no differences between cases and controls in regard to age or gender for any study. All investigations showed significantly elevated odds / risk-ratio point estimates for having an ill cabin mate (OR/RR range 3.3–∞), ill social contact (OR/RR range 2.1–5.0), and exposure to another's vomitus or diarrhea (OR/RR range 8.4–∞). On ship A, cases were significantly more likely to have eaten the lunch buffet on embarkation, but no specific food item was consistently identified in the case-cohort or cohort study. Use of any other dining locations during specific meals did not differ between cases and controls for ships B and C.

The two most common reasons passengers delayed or did not report their illness to the ship's infirmary were, believing that the illness was not serious and indicating that they treated themselves. (Table 2) On ship C, cases were less likely to believe that hand-washing or hand sanitizer were effective ways to prevent spread of diseases that cause gastrointestinal disease (MWW P values 0.002 and 0.04 respectively) and less likely to wash their hands after restroom use (MWW P value 0.02). Cases on ship C were also significantly less likely than controls to believe that isolation was an effective measure to prevent the spread of disease (MWW P value < 0.0001). On ships B and C, hand sanitizer distribution stations were present throughout the ship for the duration of the cruise. Cases on ship B were significantly less likely than controls to report that hand sanitizer was present before knowing about an outbreak (MWW P value 0.002). Cases on ship C were less likely to report that hand sanitizer was present after knowing about an outbreak (MWW P value 0.03).

The study on ship C found no difference between the cases and controls in relation to smoking status, frequency of touching the face with the hand, or biting their nails / chewing on non-food objects. All of these practices potentially increase hand-face contact and may increase the risk for contracting a person to person spread disease.

Conclusions

Norovirus outbreaks are common, difficult to prevent, and complex to control. This case-series presents some insight into practices that may help prevent spread of norovirus from person to person. Each investigation identified passengers who reported GI illness prior to boarding the ship. Given the low infectious dose and rapid spread of norovirus, it is possible that these people were the source of the outbreak. Although some cruise lines already routinely screen for ill passengers prior to boarding, most do not. Routine pre-embarkation screening may help reduce the burden of imported disease.

These were some of the first CDC investigations to look at reasons for not reporting GI illness on a cruise ship. The most common reasons that people delayed or did not report their illness was because they did not believe that it was serious, or else they self-treated. In addition, ill passengers did not believe isolation was an effective measure to prevent spread of disease. These findings indicate that passengers may not understand the disease, the risk factors involved in contracting it, its mechanism of spread, or procedures used to prevent the propagation. Better passenger education regarding the signs, symptoms, and public health impact of GI illness may encourage reporting and allow for earlier implementation of outbreak protocols.

Incentives for reporting illness and remaining in isolation for an appropriate period of time may facilitate reporting.

Another focus area for preventing norovirus outbreaks on cruise ships should center on hand washing and hand sanitizer use. Ill passengers were less likely to believe that hand washing or hand sanitizer were effective means to prevent spread of pathogens that cause GI illness. In addition, cases in the studies on ship B and C were less likely to know that hand sanitizer was present before or after learning about an outbreak. Hand sanitizers vary in their efficacy against feline caliciviruses (a proxy for norovirus) but do appear to be an effective adjunct to hand washing. [9,10] In addition, the presence of properly formulated hand sanitizer in public locations has been shown to decrease overall disease burden in that population. [15,16] Informing passengers of hand sanitizer efficacy and location using ship tours, signage, newsletter articles, and in-room television may have helped to prevent some outbreaks from occurring.

An overarching goal for preventing outbreaks of norovirus and controlling ones that do occur is education of the potentially exposed population. Adequate knowledge about hand hygiene is fundamental to changing the attitudes and practices of people before and during norovirus outbreaks. Investigators, primarily looking at healthcare workers, have indicated that beliefs about hand-washing, peer modeling, and peer pressure all play approximately equal roles in changing practices. [17,18,19] Kampf has published an excellent article regarding possible interventions in preventing the spread of disease in hospitals, and would likely be of use in any location prone to norovirus outbreaks.

This article focuses on providing appropriate, easily accessible hand sanitization facilities, proper education, adequate funding for a prevention program, having peers set a proper example, and providing a low-stress work environment. [20] Future studies pertaining to norovirus outbreaks should evaluate the effect of interventions on improving the beliefs and practices of people in environments prone to norovirus outbreaks.

These studies have some limitations. Although a power analysis was performed for the study on ship C, it was not performed retrospectively in others, a fact that may indicate that the other ship studies are underpowered. Yet, the study on ship A had more cases and controls than ship C, which likely indicates sufficient power. A significant under-reporting of illness to the infirmary led to more cases than controls on ship B. Although this may indicate an underpowered study in comparison to the other two, the MWW test (used in all the behavioral questions) should still be a valid test of association. All studies were paper-based and relied upon passenger recall; they are thus subject to recall bias. Two studies had response rates of 54% and 65%. People who chose not to fill out the survey may have differed from those who did in their knowledge, attitudes, and practices during these outbreaks. All studies took place on cruise ships with passengers of a specific age range, lifestyle, and socioeconomic class; these characteristics may not be generalizable to other populations.

CDC's Vessel Sanitation Program continues to work with the cruise ship industry through ship construction consultations, educational seminars, regular inspections, providing guidance on standard operating procedures and gastrointestinal illness outbreak prevention plans, monitoring all cruise ships from foreign ports for GI illness through an electronic reporting system, and outbreak investigation. The VSP is actively engaged in education and research programs that make commercial cruise ships healthy places to live, work, and play.

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Table 1. Behavioral questions asked by ship investigation

Question	Ship A	Ship B	Ship C
Reasons for delaying or not reporting illness to ship's infirmary	X		X
Belief in the efficacy of hand washing and hand sanitizer			X
Frequency of hand washing / hand sanitizer use			X
Belief in isolation as a means of stopping spread of disease			X
Extent to which hand sanitizer stations were present before or after knowing about an outbreak		X	X

Table 2. Most common reasons for passengers delaying or not reporting illness

Reason	**Percent of all responses** (some selected multiple responses)	
	Ship A n = 44	Ship C n = 40
Did not believe serious / thought it would pass	43%	70%
Self isolated / knew what to do	23%	2%
Self-treated	18%	35%
Did not want to be isolated	*	23%
Did not want to pay to see physician	*	25%

* Only ship C studied these specific reasons