Infections on Cruise Ships

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ABSTRACT The modern cruise ship is a small city on the seas, with populations as large as 5,000 seen on large ships. The growth of the cruise ship industry has continued in the twenty-first century, and it was estimated that nearly 21.3 million passengers traveled on cruise ships in 2013, with the majority of these sailing from North America. The presence of large numbers of individuals in close proximity to each other facilitates transmission of infectious diseases, often through person-to-person spread or via contaminated food or water. An infectious agent introduced into the environment of a cruise ship has the potential to be distributed widely across the ship and to cause significant morbidity. The median cruise ship passenger is over 45 years old and often has chronic medical problems, so it is important that, to have a safe cruise ship experience, any potential for the introduction of an infecting agent as well as its transmission be minimized. The majority of cruise ship infections involve respiratory and gastrointestinal infections. This article discusses infectious outbreaks on cruise ships and suggests preventative measures for passengers who plan to travel on cruise ships.

INTRODUCTION

The spread of humanity across the Earth involved travel across the high seas, and until the advent of air travel, ships were the only way to cross the seas. The migration of humans also led to the spread of new diseases into nonimmune populations, with the introduction of pathogenic organisms or their vectors into these populations from ships and their crew. At the same time the presence of large groups of people on ships with limited sanitation, as well as poor food supplies, led to an increased risk of infectious diseases such as typhus and diseases of deficiency such as scurvy. With the advent of air travel, the number of people traveling by sea decreased until the recent resurgence of the cruise ship industry. The popularity of cruise ships for vacation travel has grown rapidly in recent years, and the Cruise Line International Association estimated that 21.3 million passengers traveled on cruise ships in 2013, and this number was forecast to be 21.7 million in 2014. The cruise industry has responded to these increasing passenger loads by increasing the size and capacity of cruise ships, with large “mega ships” that often carry over 5,000 passengers. While the most common cruise destination is the Caribbean, cruise ships are expanding their areas of operation and include river cruises and other destinations such as Antarctica, which are often inaccessible by other means of travel.

A modern cruise ship is a traveling city with its common food and water supply, shared sanitation and air-conditioning systems, and a large number of individuals traveling together. The individuals are often from different cultures, with different immunization backgrounds and health statuses. The proximity of passengers as well as crew members in semi-enclosed spaces, with interactions in the dining halls and recreational rooms, spas, and pools increases the possibility of organisms being transmitted among them. At the same time, an infecting agent has the potential to enter the food or water supply or the sanitation systems in these ships, to be distributed widely across the ship, and to cause significant morbidity and/or mortality. The typical cruise passenger is often an elderly individual and may have chronic illnesses, which can make him or her more susceptible to infection and its complications. It is thus vital for the safety of passengers that any potential for...
the introduction of an infecting agent as well as its transmission be minimized on cruise ships.

HEALTH REGULATIONS

The occurrence of typhoid fever and shigellosis on cruise liners in the early 1970s led to the establishment of the Vessel Sanitation Program (VSP) by the Centers for Disease Control and Prevention (CDC) in 1975. The aim of this cooperative program is to minimize the risk of gastrointestinal disease on cruise ships by maintaining a high degree of sanitation. The mission of VSP is to prevent transmission of acute gastroenteritis to U.S. ports by ships sailing from foreign ports. The program conducts random unannounced twice-yearly inspections of cruise ships carrying 13 or more passengers docking at U.S. ports. The aim of the inspection is to determine the presence of vermin, contaminated food or water, or other unsanitary conditions that may lead to the introduction, spread, or transmission of infectious diseases. The ships are rated on various factors that can impact this such as (i) water sanitation, (ii) food handling and preparation, (iii) personal hygiene and sanitation practices by the ship staff, (iv) pool and spa sanitation, (v) potential for food and water contamination and disinfection, and (vi) general cleanliness. The ships are given a score, which is published and is available on the Internet at www.cdc.gov/nceh/vsp/default.htm. A score of 86 or higher (out of 100) denotes an acceptable level of sanitation, but a study in 2009 that evaluated disinfection cleaning in public restrooms on cruise ships showed no correlation between CDC VSP scores and thorough cleaning of public restrooms on cruise ships.

U.S. public health regulations also authorize the Public Health Service to take measures to prevent the introduction into the United States of “any communicable disease by securing the best sanitary condition of such vessels, their cargoes, passengers, and crews.” The cruise vessels are required to notify public health authorities about cases of diarrhea as well as onboard deaths. The VSP thus receives notification of significant illnesses on board cruise ships traveling in North America and often leads epidemiological as well as environmental investigations of significant diarrheal diseases on cruise ships. The CDC’s quarantine stations respond to these reports and provide recommendations to limit the introduction of infectious diseases into the United States and prevent their spread.

The World Health Organization’s International Health Regulations also provide international standards for ship and port sanitation and provide a core framework for most countries to detect, assess, notify, and respond to public health threats at ports as well as airports and certain ground crossings.

GASTROINTESTINAL INFECTIONS

The development of acute gastroenteritis on ships led to the development of the VSP, and these infections are still the most reported of cruise ship infections. Numerous outbreaks of gastroenteritis on cruise ships have gained widespread media attention. A World Health Organization review of sanitation on ships listed over 100 outbreaks of gastroenteritis on cruise ships from 1970 to 2000, affecting over 16,000 individuals. The CDC’s VSP web page lists over 60 outbreaks of gastroenteritis between 2010 and 2015, suggesting that this continues to be an ongoing problem, though the number of outbreaks has decreased in the second decade of this century. The presence of a common food and water supply, along with the semi-enclosed setting of the ship, easily lends itself to the development of outbreaks of diarrheal diseases. The presentation of the illness generally involves a sudden onset of diarrhea, with persistent loose bowel movements accompanied by vomiting. There may be associated symptoms of abdominal cramps, headache, myalgia, or fever. Patients may occasionally complain of tenesmus and/or blood with their bowel movements, suggesting dysentery, though these symptoms are generally rare.

The vast majority of outbreaks of gastroenteritis acquired on cruise ships are due to noroviruses, formerly known as Norwalk-like viruses (Fig. 1). This group of viruses is notorious for causing diarrheal diseases in closed settings such as nursing homes. There have been multiple outbreaks of these infections on multiple cruise ships over the past years. These infections are often facilitated by the close living quarters, common food supplies, and intermingling of individuals that occur on cruise ships. Several routes, including fecal-oral transmission, aerosolization during vomiting, food and water as vehicles, and environmental contamination by symptomatic patients or asymptomatic carriers, can spread these viruses. The reports in the literature have implicated water supplies, various food items, and poor food-handling techniques, along with person-to-person spread, as methods of transmission of the virus to passengers on cruise ships. The incubation period for noroviral gastroenteritis in humans is usually less than 2 days, though cases can occur within 12 hours after exposure. Noroviral gastroenteritis presents as an acute onset of vomiting, with watery nonbloody diarrhea accompanied by nausea.
and abdominal cramps. Among children, vomiting tends to be more pronounced, but high-grade fever is usually not a feature of this condition and should suggest an alternative etiology. This is a self-limiting condition and usually requires medical attention only for dehydration.

The widespread use of reverse transcription-PCR techniques has led to improvement in the diagnosis of this infection and an increased appreciation of the role of this virus in causing widespread epidemics of diarrhea on cruise ships. The control of an outbreak is often very difficult and should involve aggressive infection control, with active disinfection, isolation of sick individuals, strict hand-washing techniques, and training of food handlers in proper food-handling procedures. A recent study of the behaviors of passengers on cruise ships during noroviral diarrheal outbreaks suggested that passengers often had diarrhea before embarking on the cruise and, once on the cruise, often did not report their symptoms to the ship’s infirmary. They also were less likely to wash their hands or to isolate themselves if they were sick. These behaviors often perpetuate and amplify an illness in the ship’s closed environment.

Though less common than noroviral outbreaks, bacterial gastroenteritis outbreaks have occurred on cruise ships. The bacterial pathogens implicated in cruise ship outbreaks of gastroenteritis include enterotoxigenic Escherichia coli, Salmonella species including Salmonella enterica serovar Typhi, Shigella species, Vibrio species, Clostridium perfringens, Campylobacter jejuni, and Staphylococcus aureus. These infections tend to be more severe than those caused by noroviruses and have led to some deaths of cruise ship passengers. The majority of these outbreaks were caused by contamination of the ship’s water supply by sewage.

The parasitic causes of diarrhea reported on cruise ships include Cyclospora species, which have been implicated in large outbreaks on multiple cruise ships. The acquisition of these organism is often from fresh produce which may have been sourced from countries where Cyclospora is endemic. There have been sporadic outbreaks of diarrhea on ships due to Cryptosporidium species and Trichinella spiralis.

Other food-borne pathogens that can be acquired on board cruise ships include hepatitis E. There also was an outbreak of hepatitis E on a cruise ship thought to be related to eating shellfish, where the majority of the patients developed asymptomatic disease.

According to one study, the probability of contracting a diarrheal disease on a 7-day cruise is less than 1%. The majority of the diarrheal outbreaks on cruise ships involve the introduction of the pathogen into the food and water supply, with the subsequent breakdown of the food and water sanitation chain. The factors implicated in various outbreaks of food-borne disease on cruise ships include the use of contaminated food or water, inadequate food storage and temperature control, cross-contamination of food and contaminated raw ingredients, infected food handlers, and onshore excursions. The food most commonly implicated in cruise ship diarrheal outbreaks is seafood.
The prevention of gastrointestinal infections on cruise ships involves controlling potential deficiencies in food and water handling as well as in cooking and catering, preventing sewage contamination of the water supply, and isolating sick people. In the absence of effective vaccines for the prevention of infections by the majority of the above-mentioned organisms, with the exception of S. enterica serovar Typhi, these efforts are the primary preventive methods to decrease the burden of gastrointestinal illnesses on cruise ships. The prevention of these diseases may also be enhanced by routine screening of departing passengers, especially if they are sick, education of passengers and staff about gastrointestinal illness, and an enhanced focus on improving hand-washing practices and disinfection of public restrooms on cruise ships.

**RESPIRATORY INFECTIONS**

The isolated environment of a cruise ship, with close interaction between a vast cohort of individuals, increases the risk of a passenger being exposed to various respiratory secretions and, potentially, to infectious respiratory viruses. The presentation of these infections is nonspecific and can range from an upper respiratory tract infection to life-threatening pneumonia. A study of the epidemiology of injuries and illnesses among passengers on cruise ships revealed that respiratory tract infections were the most common cause for seeking medical attention by passengers and crew members. There have been well-documented reports of both influenza A and influenza B outbreaks on cruise ships. These infections tend to have a high attack rate, with a large number of individuals being infected before the epidemic is contained. These outbreaks can occur year long on cruise ships, because individuals from different hemispheres introduce the virus into the cruise ship population. The prevention of influenza outbreaks on cruise ships involves a multipronged approach. It should involve procedures to minimize introduction of the influenza or other respiratory virus into the cruise ship population by screening passengers and crew for influenza and influenza-like illness at the time of embarkation. Individuals with symptoms such as fevers, chills, cough, sore throat, runny nose, and myalgias should be advised not to travel until at least 24 hours after resolution of fever. These individuals, if they decide to board, as well as any passengers who become ill with similar symptoms on the cruise, should be medically evaluated and remain isolated in their cabins or quarters until at least 24 hours after resolution of fever (100°F) without the use of fever-reducing medications. The CDC does recommend the use of early antiviral treatment with neuraminidase inhibitors (oral oseltamivir or inhaled zanamivir) in people with suspected or confirmed influenza who have severe illness or who are at a high risk of developing influenza complications.

The prevention of influenza on cruise ships involves annual vaccination of all passengers and crew. The vaccination of passengers should occur at least two weeks before travel, especially if they are a high risk of complications from influenza. In addition, antiviral chemoprophylaxis should be considered for prevention of infection in exposed people who are at high risk for complications or for controlling influenza outbreaks on cruise ships, especially if the cruise has a high proportion of passengers who may have a high risk of influenza complications. The CDC does recommend that cruise ships carry adequate supplies of personal protective equipment to use to manage these infections and that they keep stocks of oral oseltamivir and inhaled zanamivir for antiviral treatment or chemoprophylaxis of influenza virus. The CDC mandates that cruise ships report cases of influenza-like illness on each voyage and provides guidance for management of influenza outbreaks and for patients with severe influenza.

The other respiratory viruses that have caused outbreaks among cruise ships include cases of rubella, though the list is probably underreported, because most respiratory viruses can be transmitted efficiently in the close environments of a cruise ship. It is important that adults traveling with children ensure that all vaccinations are up to date, especially measles.

Among the bacterial pathogens that cause respiratory infections on cruise ships, the most common infections reported have been due to Legionella species (Fig. 2). The symptoms of the disease often include fevers, chills, and a cough with expectoration, and individuals with chronic medical problems or older age (>65) have a higher risk of developing disease. There have been multiple incidents of Legionnaires’ disease associated with cruise ships, with the largest confirmed cluster involving 50 cases spread over 9 cruises of a single ship. The true incidence of this disease may be under-appreciated since the symptoms generally occur 2 to 10 days after exposure and the average length of a cruise is one week; most patients may present to their treating physicians after the cruise. The factors contributing to these outbreaks often involve contamination of the ship’s water supply, the spas or pools, or the air-conditioning system. The prevention of Legionella infections on cruise ships involves treatment of contaminated water by using proper disinfection and
filtration as well as properly cleaning and disinfecting spas and other devices which can disseminate bacteria.

There have also been multiple reported cases of vaccine-preventable infections, such as diphtheria and rubella, acquired on cruise ships. The presence of individuals, especially crew members and passengers from different countries, with differing immunization statuses can lead to transmission of vaccine-preventable diseases such as measles and rubella on cruise ships. It is thus of utmost importance that prior to a cruise, passengers update their immunization status and get appropriate vaccinations.

**VARICELLA**

The most common infection on cruise ships reported to the CDC is varicella, other than in 2009 when H1N1 influenza A was the most reported disease. Varicella causes frequent outbreaks aboard cruise ships, and because varicella complications occur more frequently in adults, cruise ship outbreaks have the potential to involve serious illness since most cruise ship passengers and all the crew are adults. The crew members on a cruise ship are more likely to be susceptible to varicella than the general North American passenger because they often are from the tropics, where varicella infection typically occurs at a later age compared to temperate areas. They also have overall lower immunization rates compared to the North American passengers. The travelers at highest risk for severe disease are immunocompromised people or pregnant women without a history of varicella disease or vaccination.

The clinical presentation of varicella in unvaccinated individuals includes fever and a rash. The pruritic rash progresses rapidly from macules to vesicles and is most concentrated on the trunk. In contrast to children, adults tend to have more severe disease and can develop severe complications such as encephalitis or pneumonia. Passengers or crew members who develop varicella on a cruise should be medically evaluated and remain isolated in their cabins until all lesions have crusted over or no new lesions appear within a 24-hour period (usually 4 to 6 days after rash onset). Only crew members with evidence of immunity to varicella should care for passengers or other crew members in isolation. The cruise ship personnel should identify all passengers and crew members who have had exposure to the infected patient. This is defined as direct face-to-face contact with a varicella case during the infectious period, from 1 to 2 days before rash onset until lesions are crusted (generally 4 to 6 days after rash onset). Individuals who have no documented immunity should be offered postexposure prophylaxis with the varicella vaccine. High-risk contacts for whom varicella vaccine is contraindicated (i.e., pregnant women or immunosuppressed people) should be evaluated for administration of varicella zoster immune globulin, which should be administered as soon as possible but may be effective if administered as late as 10 days after exposure. The majority of varicella cases on cruise ships tend to occur among crew members, and documenting varicella immunity of crew before boarding may be a method to decrease the varicella-susceptible population on cruise ships.

**SKIN INFECTIONS**

The presence of hot tubs and spas and the proximity of individuals on cruise ships can lead to the spread of skin infections among the passengers. The presentation of these infections often consists of folliculitis with single or multiple erythematous, tender pustular lesions. The author has seen a case of necrotizing soft tissue infection caused by community-acquired methicillin-resistant *S. aureus* that presented soon after the patient’s return from a cruise. With the widespread dissemination of community-acquired methicillin-resistant *S. aureus* isolates across the country and the proximity...
of individuals who may be carriers of this organism on cruise ships, it is inevitable that more cases of these infections acquired on cruise ships will be reported. The other organisms that may be seen include *Pseudomonas aeruginosa* presenting as hot tub folliculitis. The treatment of these infections often requires appropriate antimicrobial therapy and use of surgical drainage if an abscess develops. The vast majority of these infections can be, and often are, prevented by meticulous care and disinfection of the hot tubs and spas on cruise ships.

**SHORE-ACQUIRED INFECTIONS**

The typical cruise ship passenger often spends time on daytime land excursions as part of the cruise. These excursions may involve overnight stays on shore, so passengers are also at risk for infections that they may acquire while on land. They can also become symptomatic with infections that may have been incubating before the start of the cruise. Thus, infections that are endemic in the ports of call, such as malaria, may appear on board or after return from the cruise. There have been isolated cases of meningitis acquired aboard cruise ships, though these are uncommon.

The health care workers on board cruise ships, as well as physicians seeing passengers after they return from cruises, need to be aware of infections that may be acquired on board or from the ports of call. The American College of Emergency Physicians has published guidelines for the health care facilities on cruise ships. These guidelines give recommendations on appropriate health care facilities on board as well as on staff numbers and qualifications for these facilities. The diagnosis of infectious diseases aboard cruise ships is often limited and involves signs and symptoms–based diagnosis. The development of rapid point-of-care tests can lead to better diagnostic testing of various infectious syndromes on cruise ships. A good cruise ship medical facility, in general, is similar to an urgent care center and can take care of an estimated 95% of cruise ship illnesses; however, for passengers with serious medical problems or those traveling on smaller cruise ships, the facilities may be inadequate for comprehensive medical care.

**SUMMARY**

Cruise ships are an increasingly popular mechanism of travel and leisure. These ships, which vary in size from small vessels to huge mega ships, carry a large population of travelers and crew in close proximity, often for an extended duration. There is a potential infectious risk in these travels (Table 1). This risk may be from introduction of a pathogen in the food and water supply or in the ship’s sanitation system or spas. Passengers and crew may also transmit respiratory or gastrointestinal pathogens because of close contact. Occasionally, individuals may get sick from acquiring an infection while on shore. The prevention of these infections involves meticulous care of the ship’s sanitary conditions, receiving appropriate vaccinations as necessary, and following basic infection control mechanisms, especially hand washing.

**TABLE 1** Infectious pathogens and diseases of potential risk on cruise ships

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<tr>
<th>Gastrointestinal infections</th>
<th>Respiratory infections</th>
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<td>Noroviral infections</td>
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<td>Enterotoxigenic <em>Escherichia coli</em></td>
<td>Rubella</td>
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<td><em>Salmonella</em> gastroenteritis</td>
<td>Measles</td>
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<tr>
<td><em>Shigella</em> species</td>
<td><em>Legionella</em> species</td>
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<td><em>Vibrio</em> species</td>
<td>Diphtheria</td>
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<td><em>Clostridium perfringens</em></td>
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<td><em>Campylobacter jejuni</em></td>
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<tr>
<td><em>Staphylococcus aureus</em> enteritis</td>
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<tr>
<td><em>Cryptosporidium</em> species</td>
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<tr>
<td><em>Trichinella spiralis</em></td>
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<tr>
<td>Hepatitis E</td>
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<td>Hepatitis A</td>
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<tr>
<th>Skin infections</th>
<th>Infections that may be acquired at ports of call</th>
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<td>Varicella</td>
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<td>Hot tub folliculitis</td>
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<td>Community-acquired methicillin-resistant <em>S. aureus</em> folliculitis</td>
<td>Yellow fever</td>
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<td>Typhoid</td>
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**PRACTICAL TIPS**

- Before booking a vacation on a particular cruise ship, passengers should visit the website [www.cdc.gov/nceh/vsp/default.htm](http://www.cdc.gov/nceh/vsp/default.htm) and check the ship’s inspection score. A score of 85 or lower is unacceptable.
- Check the entire cruise ship itinerary, especially for any land excursion and for any overnight stays on shore.
• Travelers should update their immunization status, especially influenza vaccinations; diphtheria, pertussis, and tetanus vaccination; and varicella vaccination if they have not had the disease.
• Get vaccinations against food-borne diseases such as typhoid and hepatitis A and other vaccinations based on the area of the cruise.
• All children accompanying adults should also have had the measles vaccine in addition to the above vaccines.
• Passengers should be counseled about risk factors and symptoms of gastrointestinal illnesses and respiratory infections and be asked to report their symptoms to the ship’s infirmary as soon as possible if they become sick.
• The importance of quarantine should be explained to passengers, especially if they get sick. They should remain in their cabins if sick to prevent spreading the illness to the rest of the ship.
• The importance of standard infection control measures, especially hand washing, should be emphasized.

RECOMMENDED READINGS