Management and Control of Varicella on Cruise Ships:
A Collaborative Approach to Promoting Public Health

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Background. In most years varicella is the vaccine-preventable disease most frequently reported to Centers for Disease Control and Prevention (CDC) by cruise ships. Since 2005, CDC has received numerous isolated case reports of varicella among crew members and has investigated varicella outbreaks aboard vessels sailing into and from US seaports.

Methods. CDC investigators reviewed electronic varicella case reports from 2005 to 2009 and outbreak reports from 2009 to characterize the response and control efforts implemented by cruise ships in accordance with CDC protocols. Outbreak reports from 2009 were manually reviewed for details of case identification, contact investigations, isolation and restriction of cases and contacts, respectively, and number of contacts administered varicella vaccine post-exposure by cruise lines.

Results. During 2005 to 2009, cruise ships reported 278 cases of varicella to CDC among predominantly male (80%) crew members, three-quarters of whom were residents of Caribbean countries, Indonesia, the Philippines, or India, and whose median age was 29 years. Cases were more commonly reported during spring and winter months. During 2009, cruise ships reported 94 varicella cases among crew members of which 66 (70%) were associated with 18 reported varicella outbreaks. Outbreak response included isolation of 66 (100%) of 66 cases, restriction of 66 (26%) of 255 crew-contacts, and administration of post-exposure vaccine to 522 close contacts and other susceptible crew members per standard CDC recommendations.

Discussion. Most cases reported to CDC during 2005 to 2009 were among non-US resident crew members. Overall, cruise lines sailing into North America have the onboard capability to manage varicella cases and outbreaks and appear responsive to CDC recommendations. Cruise lines should continue to implement CDC-recommended response protocols to curtail outbreaks rapidly and should consider whether pre-placement varicella immunity screening and vaccination of crew members is a cost-effective option for their respective fleet operations.

In 2009, an estimated 10,198,000 passengers embarked on cruise ships in North American seaports, with an estimated 13,442,000 passenger embarkations worldwide. The cruise ship industry continues to burgeon, with a reported growth rate during 1990 to 2009 of 7.2% annually, characterized by larger fleet sizes; larger, more complex vessels; more annual voyages; and larger passenger and crew cohorts. Of the reported 118 ships representing 4,212 voyages that originated in the United States during 2008, 54% of passengers embarked at seaports in Florida. The cruise ship environment is home to thousands of crew members who live and work at sea, most of whom were born outside the United States.

Crew members may originate from countries where endemic disease incidence and prevalence rates can differ markedly from those in the United States and with diverse national vaccine strategies. Crew members’ living quarters, activities, galleys, and eating areas are separate from those of passengers, may vary by job duties, and may facilitate the introduction and spread of disease among crew who work and live closely for prolonged periods of time.

Communicable diseases associated with cruise ship passengers and crew are well documented. During a single 106-day cruise ship voyage, dermatologic and respiratory symptoms were the most common presenting complaints to the ship’s dispensary. Reports of disease epidemics of public health importance aboard cruise ships include influenza A and B, Legionella pneumophila, rubella, and food-borne and water-borne outbreaks. Except during 2009, a pandemic influenza year, varicella (isolated cases and outbreaks)
was the vaccine-preventable disease most frequently reported to the Centers for Disease Control and Prevention (CDC) since 2005 by cruise ships sailing in US waters [CDC Division of Global Migration and Quarantine (DGMQ) Quarantine Activity Reporting System (QARS), unpublished data]. In the context of ongoing challenges associated with communicable diseases affecting cruise travelers, an extensive collaboration has developed between the cruise industry and the CDC. Since 2005, the CDC DGMQ has received numerous isolated case reports of varicella among crew members and has investigated outbreaks aboard vessels sailing into and from US seaports. Although the median age of passengers on cruise ships varies by cruise line, susceptibility to varicella of US passengers who sail on cruise ships from North America will be low due to naturally acquired immunity in older age groups and vaccination in younger people. Epidemics of varicella among foreign-born crew members, however, have been associated with susceptibility among unvaccinated Southeast Asian, African, and European seafarers.55

Compared with children, infection with varicella in adults is associated with more severe clinical symptoms and more frequent complications.36,37 Varicella vaccine is highly effective for the prevention of varicella infection.38

US Quarantine Stations are located at 20 US ports of entry where international travelers arrive. Medical and public health officers at CDC Quarantine Stations respond to reports of illness on cruise ships, monitor reported disease activity, collect medical and public health information relating to ill crew members and passengers, and coordinate guidance for isolated case management and outbreak response. Quarantine personnel collaborate with cruise industry and federal partners, local and state health departments, and infectious disease subject-matter experts at CDC to respond to public health threats. When necessary, CDC conducts active surveillance by screening embarking and disembarking passengers and distributing Travel Health Alert Notices. When indicated, CDC collaborates with industry to conduct a spectrum of clinical, epidemiological, and environmental activities to inform response and recommendations.

On cruise ships, clinical varicella is diagnosed by shipboard medical personnel or land-based cruise line-contracted medical facilities, and managed according to cruise line-specific protocols based on CDC recommendations.39,40 Presumptive and laboratory-confirmed cases are reported by cruise line-designated staff to CDC Quarantine Stations. Quarantine station personnel may assist with case identification, contact investigation and management, make recommendations for isolation of cases and monitoring of contacts, and provide guidance for post-exposure prophylaxis (Table 1). Although passenger cases are identified by infirmary personnel, extensive contact tracing is typically limited to crew.

The purpose of this analysis was to review 5 years of varicella reports to CDC from cruise ships, focusing on varicella case reports among crew members during 2005 to 2009 and varicella outbreaks on cruise ships during 2009. This article also details the cooperation between the federal government and the cruise ship industry in the identification of and response to varicella cases and implementation of CDC-recommended response protocols in the control of varicella disease on cruise ships.

Methods

Definitions

A clinical case of varicella was defined using criteria established by the Council of State and Territorial Epidemiologists (CSTE)41 as an illness characterized by acute onset of generalized papulovesicular rash with no other apparent cause. Laboratory-confirmed cases or two epidemiologically linked clinical cases were classified as confirmed cases. Epidemiologically linked cases were in known or suspected contacts of a primary case or cases among individuals who had common risk factors (shipboard exposures) for infection. A probable case was defined as a clinical case that was not laboratory confirmed or epidemiologically linked to another probable or confirmed case. Also, cases labeled as “presumptive” in the CDC QARS database were considered probable cases of varicella. A single varicella case without epidemiologic linkage to at least one other case was considered an isolated case; an outbreak was defined as two or more epidemiologically linked cases. A crew contact was defined as a crew member (or officer) sailing on a cruise ship during the period of infectivity of a probable or confirmed case of varicella and who shared living quarters, toilet facilities, food, cigarettes, beverages, or work duties, or had intimate contact with the ill person. Contacts were identified and assessed for evidence of immunity to varicella39 by medical personnel aboard the vessel.

Data Collection and Analysis

Since June 2005, clinical, epidemiological, and ship- and voyage-specific information relating to reports to DGMQ of illness and death have been recorded in the electronically secure QARS database. CDC investigators queried the QARS database for data variables associated with cruise ship reports with the presumptive diagnosis of “varicella” or “chickenpox.” All single case reports in QARS of “varicella” or “chickenpox” during 2005 to 2009 were extracted, including the following variables: report number, date of report, patient’s gender and age, vessel identification number, cruise line, ship name, voyage departure date (embarkation date), reporting quarantine station, and vessel disembarkation date for each report. Data were extracted using SAS software and exported into a Microsoft Excel spreadsheet. Extracted case data were sorted by cruise
Reporting to CDC

• Post-exposure prophylaxis
  • Evidence of immunity to varicella
  • Incubation period
  • Laboratory testing (not required for diagnosis)
  • Clinical signs and symptoms (in unvaccinated people)

| Clinical case definition of varicella | An illness with acute onset of diffuse (generalized) maculopapulovesicular rash, without other apparent cause |
| Clinical signs and symptoms (in unvaccinated people) | • Mild fever may precede rash onset
• Pruritic rash occurring usually 14–16 d after exposure
• Progresses rapidly (within 24 h) from macules and papules to vesicular lesions
• Skin lesions are present simultaneously (vesicles contain clear fluid and are superficial and delicate)
• Rash spreads from head to trunk and extremities |
| Incubation period | 10–21 d (average 14–16 d) |
| Communicability | 1–2 d before rash onset until all lesions have crusted (usually 4–6 d after rash onset) |
| Transmission | Person to person by direct contact with vesicular fluid or inhalation of aerosolized fluid from skin lesions from persons with acute varicella or herpes zoster |
| Case isolation | • Follow standard contact and airborne precautions
• Crew member may return to work when no longer infectious |
| Surveillance for additional varicella cases | • Surveillance period from start of the infectious period (2 d before rash onset of first varicella case) until 21 d after the end of the infectious period (6 d after rash onset of last case)
• Review crew and passenger medical logs to search for cases of rash (maculopapular with few or no vesicles) suggestive of varicella
• Review logs 42 d prior to first case’s rash onset date through 27 d after rash onset date of last case |
| Laboratory testing (not required for diagnosis) | Isolation of varicella virus from a clinical specimen, or direct fluorescent antibody (DFA), or polymerase chain reaction (PCR), or significant rise in serum varicella immunoglobulin G (IgG) level by any standard serologic assay |
| Contacts | • Identify all contacts of each case
• Crew-contacts include intimate partners, cabin mates, bathroom mates, dining mates, workmates, social contacts, and other persons with whom the ill person had direct contact (face-to-face contact for ≥5 min) during the communicable period
• Passenger-contacts include those with whom ill crew member had direct contact (face-to-face contact for ≥5 min) during the communicable period if the crew member is a waiter, day care attendant, or personal service assistant (eg, masseuse, hairdresser) |
| Evidence of immunity to varicella | • Written documentation of recipients’ age-appropriate vaccination or
• Serologic evidence of immunity or confirmed disease or
• Birth in the United States before 1980 (unless pregnant, health care personnel, or immunosuppressed)
• A diagnosis or history of varicella or herpes zoster verified by a health care provider |
| Post-exposure prophylaxis with vaccine or varicella zoster immune globulin (VZIG) | • Provide first dose of varicella vaccine to all susceptible contacts within 3 d (may be effective up to 5 d) after exposure to case for those without evidence of immunity
• Do not use vaccine for those who are pregnant or immunosuppressed
• Vaccination is recommended beyond 5 d to prevent future exposures and further spread
• Second dose may be provided to susceptible contacts with written documentation of having received first dose of vaccine within appropriate time interval between doses (except those who are pregnant or immunosuppressed)
• High-risk persons for whom varicella vaccine is contraindicated (ie, pregnant women or immunosuppressed persons) should be evaluated for administration of VZIG. VZIG should be administered as soon as possible but may be effective if administered as late as 10 d after exposure |
| Monitoring and restriction of susceptible crew-contacts | • Susceptible crew members who receive the first dose of varicella vaccine or VZIG may return to work immediately after vaccination.
• Persons receiving the first dose of varicella vaccine should be placed under active surveillance and monitored daily for symptoms of varicella for up to 21 d after their last exposure to an active varicella case.
• Susceptible crew members who do not receive varicella vaccine should have no passenger contact, minimize contact with other crew members, and be placed under active surveillance for signs and symptoms of varicella, from the 8th through the 21st d after last exposure to the case. For persons receiving VZIG this period is extended to 28 d after exposure
• Isolate any crew member who develops a fever within 21 d after contact with a varicella case and observe for rash onset. |
| Reporting to CDC | • Inform CDC Quarantine Station of high-risk individuals who may experience complications from varicella vaccine
• Report management of susceptible contacts, and new cases identified through medical log review or surveillance
• Notify the CDC Quarantine Station with local seaport jurisdiction of passenger contacts aboard vessel. CDC to notify passengers before disembarkation http://www.cdc.gov/quarantine/QuarantineStations.html |

Table 1 CDC guidance for management, response, and control of varicella aboard cruise ships sailing in North American waters, Division of Global Migration and Quarantine, CDC


Investigators performed a more detailed manual review (including free-text fields) of all varicella case reports received by DGMQ during 2009. Outbreaks were identified by using the case and outbreak definitions to link related cases. Variables reviewed included: time (in days) from the onset of illness in the index case to the date of report to a CDC Quarantine Station; the number of other first-generation cases
identified (occurring $\leq 21$ d from the onset of the index case); the number of second-generation cases (occurring $22–42$ d from the onset of the index case, epidemiologically linked to a primary case) and additional (occurring $>42$ d from the onset of the index case) generations of cases identified; the number of total contacts identified by the cruise line; the number of susceptible contacts to whom post-exposure prophylaxis [with vaccine or varicella-zoster immune globulin (VZIG)] was administered; the number of crew members isolated or restricted (required to have no passenger contact and to minimize contact with other crew members); and the presence of qualified medical staff or an infirmary onboard conducting follow-up and performing management and case follow-up.

Once the records had been reviewed, all unique identifiers associated with outbreaks and case reports were removed, including names, dates of birth, gender, countries of origin, job titles and duties on the vessel, vessel names, and cruise line names.

Analysis was limited to varicella reports among crew members on cruise ships. Reports from cargo ships were not included since they do not carry trained medical personnel and follow different CDC recommendations than those given to cruise ships. Passenger varicella cases and contacts were not included, since secondary cases associated with the index case would not be readily identified and only contact management information up to the time of disembarkation would be available. Categorical variables were described using frequencies and percentages, and continuous variables were described using ranges, means, and medians.

This investigation was approved as non-research by the CDC Institutional Review Board.

Results

During 2005 to 2009, varicella reports comprised 357 (15%) of the total 2,305 maritime illness reports submitted to CDC during that period. Of the varicella reports, 278 (78%) were among cruise ship crew members. They were predominantly male (80%), their median age was 29 years (range 20–66), and three-quarters of the ill crew members were residents of Caribbean countries, Indonesia, the Philippines, or India. Excluding 2005, a partial reporting year, varicella was reported more commonly in the spring (28%) and winter (27%) months.

During 2009, 94 cases of varicella among cruise ship crew members were reported to CDC Quarantine Stations. By manual review of each case report, 22 varicella clusters were identified. Four of the clusters were excluded because the cases were not considered epidemiologically linked. Therefore, after exclusion, 66/94 (70%) cases among crew members were associated with 18 outbreaks. The remaining 28 cases were considered isolated case reports.

Outbreak response by cruise ships reporting the 18 varicella outbreaks during 2009 included isolation of 66 (100%) of 66 cases, restriction of 66 (26%) of 255 close crew-contacts, and administration of post-exposure vaccine to 522 close contacts and other susceptible crew members (Table 2). No contacts received VZIG. The number of cases per outbreak ranged from 2 to 9. There were a total of 45 first-generation cases (range 1–6 per outbreak), 16 second-generation cases (range 0–4), and five additional-generation cases (range 0–2) (Figure 1). There was a slight but nonsignificant positive correlation between time to reporting and number of second- and additional-generation cases.

Discussion

Our results demonstrate that case identification and contact management has in most situations been successful as a strategy for controlling varicella disease on cruise ships. On average, the first generation of cases was reported to CDC within 2 days of identification, and 100% of ill crew members were isolated at diagnosis. Only 5 (8%) of 66 reported cases occurred beyond 42 days from the onset of the index case, indicating more than two generations of cases. Although the data suggested a positive correlation between the time to reporting and number of follow-on cases, the 18 outbreaks provided insufficient statistical power to

| Table 2 | Characteristics of 18 varicella outbreaks and intervention and control measures implemented by cruise ships reporting varicella cases to CDC, 2009 |
|-----------------|------------------------|------------------------|
| Outbreak characteristics | Median no. per varicella outbreak | Range | Total for all varicella outbreaks (%) |
| Cases | 3 | 2–9 | 66 |
| Contacts | 17.5 | 3–28 | 255 |
| Isolated | 3 | 2–9 | 66/66 (100) |
| Primary cases | 2 | 1–6 | 45/66 (68) |
| Secondary cases | 1 | 0–4 | 16/66 (24) |
| Additional cases | 0 | 0–2 | 5 (8) |
| Median ages (y) | 29 | 22–45 | n/a |
| Days between onset of first case and report of outbreak to CDC | 2 | 0–19 | n/a |
| Contacts administered post-exposure varicella vaccine | 6 | 0–250 | 522 |

definitively test this relationship. The proportion (74%) of close contacts who were not restricted may in some cases reflect non-adherence to CDC guidelines but also includes crew members with evidence of immunity and those who received timely post-exposure prophylaxis. The 522 crew members who received post-exposure vaccination includes those who were vaccinated as part of a wider (mass) immunization campaign in response to an outbreak.

Varicella response protocols developed by CDC and followed by the cruise industry include reporting illness, case finding, identifying contacts, managing crew illness through timely diagnosis and isolation, and managing susceptible crew-contacts through post-exposure prophylaxis with vaccination or VZIG, and monitoring for symptoms and restriction as needed (Table 1). Because of active contact identification and case finding among crew and rapid isolation of cases and use of post-exposure prophylaxis, cruise lines have been very effective at identification and containment of outbreaks, as evidenced by the low numbers of second and additional generations of cases.

Overall, cruise lines sailing into North America have the onboard capability to manage varicella cases and outbreaks and appear responsive to CDC recommendations. Many cruise lines have been proactive in implementing early environmental control measures to mitigate both vaccine-preventable diseases and other communicable diseases through fleet-wide outbreak prevention protocols and extensive crew training programs.24

Most varicella cases reported to CDC during 2005 to 2009 were among foreign-born crew members who were residents of tropical countries. In tropical regions, varicella infection is common in adolescents and adults, and seroconversion occurs at a later age than in countries with temperate climates.42 Non-immune crew members may become infected with varicella while visiting or traveling to varicella-endemic countries or may be exposed to illness by other crew members or infected passengers.35 Varicella reporting to CDC showed a seasonal pattern typical of incidence in temperate areas, with most cases reported during winter and early spring.43

In principle, primary prevention of communicable disease is a preferred strategy, and there is evidence in published reports to suggest that “screen for immunity, then vaccinate” strategies in certain populations may be cost-effective for prevention of varicella.44 One study of Southeast Asian crew members recommended serologic testing followed by vaccination, when necessary, as a cost-effective part of pre-employment medical screening in that population of seafarers.45 However, cruise lines are not legally required to offer pre-placement vaccination as part of their occupational health programs and may not choose to incur the cost and administrative responsibilities associated with varicella immunity screening and vaccine procurement, maintenance, and administration. Further, providing prompt case management and vaccinating those exposed has been an effective response strategy, given the rapid access to the entire cohort of crew, the availability of the vaccine in the United States, and the ability to enforce standards and conduct follow-up among all potentially exposed. However, this strategy is time-consuming and takes crew members out of the workforce. In addition,

Figure 1  Reported varicella outbreaks on cruise ships sailing in US waters, 2009 (n = 18 outbreaks), CDC. Frequency distribution of varicella outbreaks, by number of cases and generation of illness, reported by cruise ships sailing in North American waters during 2009, Division of Global Migration and Quarantine, CDC (stacked bar graph with numbers of first-, second-, third-generation cases).
it leaves a large proportion of susceptible crew members at risk for future infection with the potential for spread among passengers, including immunocompromised persons and pregnant women who are at higher risk for complications.

Our investigation has several limitations. Although febrile rash illnesses are reportable to CDC under federal regulations, the reporting system is passive and subject to underreporting. Other limitations included possible misclassification of cases and the inability to identify secondary cases among passengers due to short voyage lengths (average 7 d). By law, ships can be requested but not required to provide susceptibility status and other contact tracing data. Since this information was not systematically collected, analyses using the total number of susceptible contacts as a denominator could not be carried out.

Cruise lines should continue to implement CDC-recommended response protocols to rapidly curtail varicella outbreaks, including timely clinical and public health management and infection control measures such as case isolation and contact monitoring and restriction as needed. Cases and outbreaks of diseases of public health interest should be reported to the CDC and foreign ministries of health in accordance with international reporting standards. While cruise lines, for the most part, have the medical capability to effectively manage cases and outbreaks of varicella, CDC will continue to maintain industry-directed Web-based guidance and provide support for outbreak investigation and response. To reduce the logistical burden of responding to varicella outbreaks and to minimize the health risk to crew and passengers from varicella illness, cruise lines should consider whether pre-placement varicella-immunity screening and vaccination of crew members is a cost-effective option for their respective fleet operations.

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Disclaimer
The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Declaration of Interests
The authors state that they have no conflicts of interest.

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