

Varicella at sea: a two-year study on cruise ships

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ABSTRACT

Background. Being highly contagious by person-to-person transmission, varicella can easily spread within the multinational population of a cruise ship and into communities ashore. The aim of the study was to report the prevalence of varicella infections in a fleet of cruise ships during a two-year period and to discuss measures to prevent and contain shipboard outbreaks.

Material and methods. All probable varicella cases among passengers and crew on 34 cruise ships were registered for 2 years by the medical facilities onboard. Patients remained isolated until 6 days after rash onset. Susceptible contacts were identified and offered post-exposure prophylaxis. Crew nationality, number of vaccinated contacts, and direct vaccination costs were registered.

Results. During two years 187 varicella cases (36 passengers, 151 crew) were registered and 2,685 varicella vaccinations were administered at an estimated direct vaccination cost of US \$ 283,832. Of the 34 ships, only 3 reported no cases of varicella. There were 8 clusters ('outbreaks') of ≥ 5 varicella cases presenting less than 42 days apart, comprising a total of 89 patients. While > 130 nations were represented among the crew, the 151 crew cases came from 26 countries, and 88 (58%) of them came from 5 sub-tropical/tropical countries.

Conclusions. All cruise vessels must expect to encounter varicella cases or outbreaks onboard every few years. Every varicella case can start an outbreak and thus trigger several time-consuming and expensive containment measures, including isolation and mass vaccination of susceptible contacts. Mandatory pre-contract evidence of varicella immunity from all seafarers or from subgroups according to position or nationality might be worth considering. Seafarers known to be immune to varicella should always carry valid documentation while traveling.

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Key words: varicella, outbreak control, maritime medicine, crew, passengers

INTRODUCTION

Varicella (chickenpox) is a mostly mild and self-limiting acute viral illness with worldwide distribution. Adults may have more severe disease and have a higher incidence of complications. Varicella may have serious consequences in pregnant women and in immuno-compromised persons [1]. Being highly contagious by person-to-person transmission and spreading quickly throughout enclosed environments, varicella is particularly worrisome on cruise ships because the recom-

mended control measures, including patient isolation, may influence safety and service aboard by reducing the work force and keeping key personnel off duty. Crew and passengers come from all over the world, and port health authorities are concerned about varicella from ships spreading into communities ashore.

Our aim is to report varicella in a fleet of cruise ships during a two-year period and to describe and discuss measures to prevent and contain future shipboard outbreaks.

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MATERIAL AND METHODS

The study comprised passengers and crew on a fleet of cruise ships involving three separate corporate brands under one corporate owner and one medical department. The fleet increased ranging from 30 to 34 ships during the study period. The ships sailed mostly 7-day cruises (range: 2–25 days) all over the world. Total passenger capacity ranged from 694 to 6,300 per ship. The complement of crew ranged from 400 to 2,160 per ship. The multinational crew served contracts onboard from 3 to 9 months. Most crew below officer rank shared a cabin.

The medical facilities on all the ships offered regular consultation hours twice per day for passengers and crew, as well as medical emergency service around the clock (24/7). The medical staff on each vessel included 1–3 physicians and 2–5 nurses, depending on ship size.

All probable varicella cases among passengers and crew reported to the ship medical facilities in 2009 and 2010 were registered and followed up by the medical teams onboard and by the corporate medical department. The diagnosis was clinical; serological testing was not performed. The study was part of a corporate quality assurance program, and, to ensure confidentiality of protected health information, most patient data, with the exception of crew nationality, were not made available for evaluation. Although the number of crew onboard remained relatively constant (approximately 35,000 crew members at the close of 2010), the number of different seafarers working on these ships during the two years was higher owing to factors such as vacation, end of contract, and new hires. Crew nationality statistics were therefore based on the company's updated August 2011 crew list, comprising 53,258 seagoing employees from 134 nations. The 8 largest crew groups came from the Philippines (21.4%), India (12.7%), Indonesia (7.6%), Jamaica (6.0%), the USA (4.2%), the United Kingdom (3.1%), Romania (2.6%), and St. Vincent (2.5%).

The number of vaccinated contacts and direct vaccination costs were registered for each ship. A ship was considered 'varicella-free' if more than 42 days (2 incubation periods) had passed since the last symptomatic patient.

VARICELLA DEFINITIONS [2]:

- **Case classification:** a) **Probable** – A case that meets the clinical definition, is not laboratory confirmed, and not epidemiologically linked to another probable or confirmed case. b) **Confirmed**
 - A case that is laboratory confirmed **or** a case that meets the clinical case definition and is epidemiologically linked to a confirmed or a probable case.
 - **Case contact:** A persons with ≥ 5 minutes of direct face-to-face contact with a confirmed varicella case during the infectious period.
 - **Clinical case definition:** An illness of diffuse (generalized) maculo-papulo-vesicular rash without other apparent cause.
 - **Incubation period:** The period between virus exposure and onset of rash: Average 14–16 days, with a range of 10–21 days.
 - **Index case:** The first person with varicella identified in a chain of transmission.
 - **Infectious period:** Virus shedding period: From 2 days before rash onset until all lesions are crusted over or until no new lesions appear within a 24-hour period (average range: 4–7 days).
 - **'Evidence of immunity to varicella'** includes:
 - a) Written documentation of receipt of two doses of varicella-containing vaccine; **or**
 - b) Serologic evidence of immunity or confirmed disease; **or**
 - c) Birth in the United States before 1980; **or**
 - d) A diagnosis or history of varicella or herpes zoster verified by a health-care provider or by the cruise ship clinician based on the patient's description of the illness.
 - **High-risk person/contact:** Someone at increased risk for complications from varicella because of age or an underlying condition (e.g., immuno-compromised person, cancer patients, pregnant women, neonates whose mothers are not immune).
 - **Outbreak:** The occurrence of ≥ 5 varicella cases that are related in place and epidemiologically linked.

PROTOCOL FOR VARICELLA MANAGEMENT ABOARD

Table 1 shows outbreak containment measures implemented when three in a 24-hour period or four or more varicella cases in a single incubation period occurred on a cruise ship during the study, based on guidance from The U.S. Centers for Disease Control and Prevention (CDC) [1]. Further details from the instructions sent by the medical department of the fleet to the vessels:

- **Case finding:** Conduct a review of all crew and passenger medical logs for the previous 42 days in search of cases of rash illness suggestive of varicella whenever a probable varicella case is reported.

Table 1. Outbreak containment measures implemented when three in a 24-hour period or four or more varicella cases in a single incubation period occurred on a cruise ship

<ul style="list-style-type: none"> • Report cases to port health authorities and company headquarters • Isolate the case(s) until 6 days after rash onset • Ensure that only immune crew members care for isolated persons • Conduct an all-crew survey to determine the number of susceptible individuals • Identify high-risk persons to provide proper post-exposure prophylaxis • Acquire a sufficient number of vaccines through company headquarters • Identify and vaccinate susceptible contacts among passengers and crew • Notify onboard and embarking passengers and port visitors about the exposure risk • Arrange for pre-sea vaccination of crew scheduled to join the ship • Cancel transfer of non-immune crew to other vessels for 42 days after the last reported case • Implement active daily surveillance for symptoms among the crew for 21 days after the last case • Isolate all crew with fever within 21 days after the last case and observe for rash onset for the next 2 days • Monitor clinic visits for rashes (passive surveillance) for 21 days after the last case

- **Case management:** Isolate all cases in their cabins using standard, contact, and airborne precautions until all lesions have crusted or 6 days have elapsed since rash onset. Crew patients may return to work after 6 days have elapsed since rash onset. Crew members needing to be in contact with passengers or crew under isolation must supply evidence of immunity to varicella.
- **Identification of contacts:** Identify all contacts of each case, including intimate partners, cabin mates, bathroom mates, dining mates, work mates, social contacts, and any other person with whom the case had direct contact during the case's infectious period. Assess all contacts for signs of varicella and for evidence of immunity to varicella, and identify high-risk contacts. Ask all contacts to report fever or rash to the shipboard medical facility immediately.
- **Post-exposure prophylaxis of contacts:** Provide a first dose of varicella vaccine to all susceptible contacts (except high-risk persons) within 3–5 days of exposure. Give a second dose at least 4 weeks later to adults. Evaluate high-risk contacts for administration of varicella zoster immune globulin within 96 hours of exposure.
- **Surveillance and management of contacts:** Susceptible crew members who received the first dose of varicella vaccine may return to work immediately after vaccination but are placed under active surveillance and monitored **daily** for symptoms of varicella for up to 21 days after their last exposure to an active varicella case. Susceptible crew members who do not receive varicella vaccine should, from the 8th through the 21st day after last exposure to the case, have no passenger contact, minimal contact with other crew members, and be placed under active surveillance for symptoms of varicella. Only persons who are immune to varicella are permitted to have contact with susceptible, exposed crew members, and the amount of contact with other crew members should be limited. Anyone with a new fever should be isolated and monitored for 2 days for the onset of rash. If a rash develops, then continue isolation as for an active varicella case. If a rash does not develop within 2 days of fever onset, the crew member may be released from isolation but instructed to minimize contact with others, while active surveillance is continued until a total of 21 days has elapsed since exposure. Conduct passive surveillance aboard the ship until 27 days after the rash onset date of the last case by monitoring patient visits for rash illnesses suggestive of varicella.
- **Crew transfer cancellation:** Whenever an outbreak of varicella is declared, transfer of crew without evidence of immunity to other vessels must be immediately cancelled for a period that extends for two incubation periods (42 days) after the last reported case.
- **Reporting:** All clinical varicella cases must be reported immediately to the medical department at corporate headquarters and to local port authorities in every port according to International Health Regulations 2005 ('Maritime Declaration of Health') [3] and to national law. Ships destined for a U.S. port of entry from a foreign country or possession must report varicella cases to the CDC Quarantine Station at or nearest to the next intended U.S. port of arrival [4] and act according

to the CDC's Guidance for Cruise Ships on the Management of Varicella (Chickenpox) [1].

RESULTS

During the two-year study period 187 varicella cases (151 crew, 36 passengers) were registered and 2,685 varicella vaccinations were administered at an estimated direct vaccination cost of US \$ 283,832 (Table 2). No contacts received varicella zoster immune globulin. Of the 34 ships, only 3 reported zero cases of varicella, 5 ships reported zero crew cases, while 19 reported zero passenger cases. There were 8 clusters of 5 or more varicella cases presenting less than 42 days apart from each other, comprising a total of 89 patients (Table 3): Three clusters in 2009 (29, 8, and 6 patients, respectively) and five in 2010 (14, 13, 7, 6, and 6 patients, respectively). Two of these 8 clusters occurred on one ship (Ship C); one in 2009 and one in 2010, and they were more than 6 months apart.

Details from 4 clusters:

- **Cluster 1 (Ship A).** The largest outbreak in 2009 comprised 29 crew cases on a ship with a complement of 860 employees. All presented within 15 days and there were no further cases during the following 42 days.
- **Cluster 2 (Ship D).** The largest outbreak in 2010 comprised 13 patients (10 crew) on a ship with 2400 employees. All presented within 35 days with 16 days being the largest interval between patients (between the 1st and 2nd crew patient).
- **Cluster 3 (Ship E).** The epidemiological linking within a second apparently large outbreak in 2010 was more uncertain (Figure 1): It comprised possibly 11 patients (9 crew) over a period of 4.5 months, but perhaps only 6 crew patients over a 25-day period were interconnected: Five days after the first crew case presented, a passenger presented with typical symptoms. Twenty-seven days later (> 1 incubation period) a second crew case presented, followed 5 days later by a third crew case. After 49 more days (> 2 incubation periods) a 4th crew presented, and during the next 25 days another 5 crew members presented with symptoms, followed by a passenger 28 days after the last (9th) crew case. There were no further cases for the next 6 months.

Table 2. Number of varicella patients among crew and passengers, number of contact vaccinations given, and direct vaccination costs on a fleet of 34 cruise ships during a two-year period

Year	Varicella cases			Vaccinations	Vaccination costs (US\$)
	Crew	Passengers	Total		
2009	82	7	89	762	\$ 107,105
2010	69	29	98	1,923	\$ 176,727
Total	151	36	187	2,685	\$ 283,832

Table 3. Number of varicella patients among crew and passengers and number of contact vaccinations given during 8 outbreaks on 7 cruise ships within a two-year period

Outbreak definition: ≥ 5 possibly interconnected cases

Ships w/outbreaks	Year	Crew	Passengers	Total	Vaccinations
Ship A	2009	29	0	29	400
Ship B	2009	6	2	8	157
Ship C	2009	5	1	6	34
Ship A+B+C	2009	40	3	43	591
Ship D	2010	11	3	14	565
Ship E	2010	10	3	13	447
Ship C	2010	6	1	7	223
Ship F	2010	6	0	6	270
Ship G	2010	6	0	6	118
Ship D+E+C+F+G	2010	39	7	46	1,623
All 8 outbreaks	2009+2010	79	10	89	2,214

– **Cluster 4 (Ship F).** Similar to Cluster 3, there was a gap of 27 days between the 4th and the 5th patients in a cluster of 6 crew patients during a 68-day period in 2010.

During the two-year-period 151 crew members from 26 nations presented with symptoms of varicella. Fifty-eight per cent (88 cases) came from 5 countries: The Philippines, Jamaica, Indonesia, India, and St. Vincent & the Grenadines (Table 4).

DISCUSSION

Varicella is highly contagious by person-to-person transmission. Once a case has occurred in a susceptible population, it is very hard to prevent an

outbreak; secondary attack rates among susceptible household contacts may reach 85–90% [1]. On cruise ships there is a high turnover of passengers and crew from many countries, and the high population density in a semi-closed environment facilitates person-to-person spread [5]. The vessels' rapid movement between ports, with differences in sanitation standards and exposure risks, can also introduce sightseeing and embarking passengers and crew to varicella.

Based on only a few available data per registered varicella patient, the present study has many limitations. Varying research experience and enthusiasm among the ships' medical team members as well as

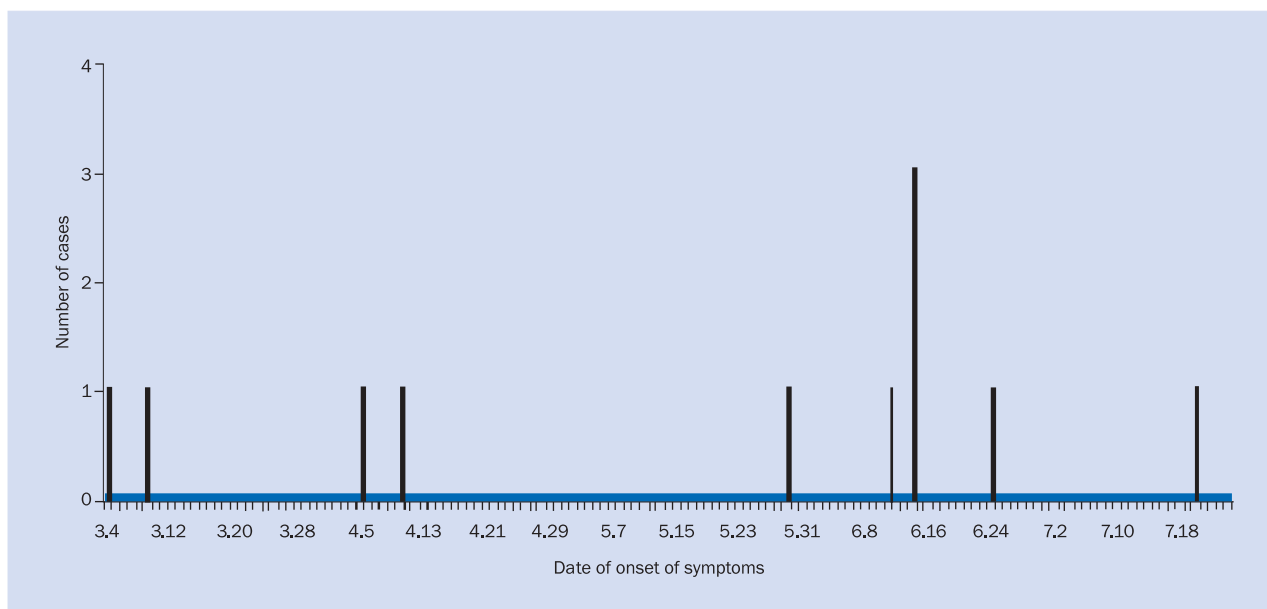


Figure 1. Eleven varicella cases on a cruise ship during 4.5 months. The second and the eleventh patients were passengers. The time intervals between the second and the third patient and between the tenth and the eleventh patient are longer than 1 incubation period, while the 49-day gap between the fourth and the fifth patient is longer than 2 incubation periods

Table 4. Number and percentage of varicella cases among 151 crew members from 26 countries during two years on a fleet of 34 cruise ships, according to nationality

	Number of cases	% of cases	% of crew*
Philippines	24	16	21.4
Jamaica	24	16	6.0
Indonesia	15	10	7.6
India	13	8	12.7
St. Vincent	12	8	2.5
The 5 nations with most cases	88	58	50.2
USA	0	0	4.2
United Kingdom	2	1	3.1

*Percentage of crew from the various nations, according to company employee statistics 2011

ship-to-shore communication challenges may have resulted in underreporting of single cases, while it is unlikely that patient clusters have not been registered. In total, 187 varicella cases were found, and most of the ships had occasional varicella cases among passengers and crew during the two years. Every one of the 187 diagnosed cases could become an index case for another outbreak and was regarded as such, but in only 8 instances 5 or more cases seemed to be interconnected or 'epidemiologically linked'. These 8 outbreaks involved 89 (48%) of the 187 varicella cases and lead to 2,214 (82%) of 2,685 contact vaccinations. On the other hand, more than 50% of these highly contagious cases were not involved or did not result in outbreaks.

The relative low number of outbreaks and the limited number of cases in each patient cluster may primarily be attributed to factors such as:

- a high percentage of immune passengers and crew;
- readily available medical care for new passengers and crew members on board, with heightened awareness to report fever and rash;
- an active screening and identification program and a strict isolation policy for symptomatic patients, and
- an active screening, identification, immunization, and follow-up program for close contacts.

In temperate climates, most varicella cases occur before the age of 10, with near-universal seroconversion by late childhood [6]. The epidemiology is less well understood in tropical areas, where a relatively large proportion of adults in some countries are seronegative [6]. In the present study, most cruise passengers were born in the United States before 1980 and therefore were considered immune [7]. Since the introduction of varicella vaccine in 1995, the incidence of varicella in USA has decreased as vaccination coverage has increased. Nevertheless, varicella outbreaks continue to occur, even among populations with high vaccination coverage [8]. Varicella vaccine is routinely used to vaccinate healthy children only in some countries, including the United States, Australia, Canada, Costa Rica, the Dominican Republic, Germany, Mexico, Qatar, Spain, South Korea, Switzerland, the United Arab Emirates, and Uruguay [7].

No passenger was the likely index case in any of the 8 outbreaks. The majority of varicella patients (81%) were crew members, and the typical index case was a crew member from a sub-tropical or tropical country who had signed on the ship less than 21

days before presenting with a typical skin rash. In 6 of the clusters all cases seemed interconnected with intervals of less than one incubation period between two presentations. However, in Cluster # 3, which appeared to last 4.5 months, there were 2 gaps longer than one incubation period and 1 gap slightly longer than two incubation periods between cases, and in Cluster # 4 there was a 27-day gap between the 4th and the 5th patients, suggesting new index cases or unreported missing links.

Since turnover of passengers and crew was high, a new varicella case presenting more (or even less) than 21 days after the last one might just as well represent a new index case from ashore. However, there are also several explanations for possible missing links: contagious patients may have left the ship before the rash appeared or without reporting it, the rash could have been misdiagnosed, fear of isolation may have scared patients from reporting, or the symptoms could have been so mild that the patient was not bothered enough to report. Varicella vaccine is 70–90% effective in preventing all varicella, but modified varicella infections (breakthrough) can occur in vaccinated people [2]. The rash is then often atypical (mostly maculopapular lesions with less than 50 vesicles), and fever is less common or of shorter duration. Although less infectious than varicella in unvaccinated people, breakthrough varicella cases should still be isolated for as long as lesions persist [1]. In the present study, breakthrough varicella was not diagnosed, but cases which were not reported roaming the ships during the > 21-day gaps between reported patients could represent contagious missing links within 2 of the clusters (Cluster # 3 and # 4). This possible phenomenon has contributed to cruise line policies extending control measures to 2 incubation periods (42 days) after the last varicella case.

Most crew members came from developing countries, some of which have low immunization rates. In an Indian study, antibody testing showed that 26% of 78 nursing and medical students were found to be susceptible to varicella [9]. Serological testing revealed that 17% of 121 Indian seafarers heading to cruise ships were susceptible to varicella, while the remainder might have had varicella or been vaccinated, but their recollection was uncertain [10]. In a report from two cruise ships in Hamburg, 1 Filipino and 2 Indonesian crew members had varicella [11]. Also in the present study Filipino, Indian, and Indonesian crew members were among the most frequently reported nationalities with varicella. But these na-

tionalities were also among those with the highest number of seagoing employees. However, a disproportionately high number of varicella cases (8%) came from St. Vincent and the Grenadines, a small, densely populated Caribbean island nation of about 104,000 inhabitants, which supplied 2.5% of the crew. In contrast, 4.2% of the crew members but none of the varicella cases among the crew were US citizens.

The 187 varicella cases led to 2,685 contact vaccinations, and more than US\$ 280,000 in direct vaccination costs. The number of vaccinated contacts and the direct vaccination costs show that varicella on cruise ships is time consuming and expensive. Further, these figures only represent 'the tip of the iceberg' regarding the actual time expended and work performed by the medical teams and other staff aboard. This is evident from the fleet protocol for varicella management (Table 1). While indirect costs (loss of productivity, interruption of crew transfers, etc.) were not recorded, they were clearly considerable. Logistically demanding, time-consuming, and costly measures are estimating the need, ordering, obtaining, and transporting vaccines all over the world to ships that are often at sea for days between ports. An additional challenge is the fact that the vaccine should be administered in 2 doses 4–8 weeks apart. The second dose is often due after most passengers and many crew members have left the vessel.

Major cruise lines now require proof of immunity of measles, mumps, and rubella (antibodies or MMR vaccination) before hiring and some have added proof of varicella immunity as well. The CDC recommends that cruise ship passengers should be current on routine vaccinations before travel, and crew members should have documented proof of immunity to vaccine-preventable diseases [7]. Idnani suggests that testing for varicella IgG and IgM antibodies, followed by vaccination when necessary, is a 'cost-effective method to prevent an expensive outbreak in the semi-closed setting of a cruise ship' and recommends this as a mandatory part of the pre-employment medical examination for Indian seafarers [10].

Our results suggest that it makes as much or even more sense to require these measures for selected other nations, too. The percentage of varicella cases from one small island nation was much higher than expected, also when considering the relatively high number of seafarers hired from there. The cruise industry is clearly a major local employer, and easy solutions like an employment ban for seafarers from

some small countries might have national economic and political consequences. Then again, the threat of an employment ban might be a powerful incentive for smaller nations to improve their general immunization situation. Hence, a sensible starting point might be to demand pre-sea proof of immunity for seafarers from nations with a disproportionately high percentage of varicella-susceptible adults.

Would it be a cost-effective way to reduce the risk of varicella outbreaks on cruise ships to demand pre-contract testing of all seafarers without evidence of immunity and subsequent vaccination of the susceptible ones? The present study is not designed to answer that question, but it gives some ideas for consideration. One hundred and fifty-one varicella cases among the crew in two years seem like a lot, and it was certainly expensive. But a corporation with a steady on-board complement of 35,000 crew members will need to obtain proof of immunization from many more, considering crew vacations and high crew turnover. Even if the economic burden of antibody testing and subsequent vaccination is placed on the individual crew member, such a measure may go against the spirit of the Maritime Labour Convention of 2006 [12], and there will still be high costs for companies in connection with policy implementation, immunity control and documentation, follow-up, revocation of job offers, rescheduling of contract dates, and travel arrangements, etc.

At this time most seafarers do not carry evidence of varicella immunity, but in preparation for management of future outbreaks seafarers' physicians and medical examiners should, whenever such proof is available, add such to the seafarer's medical certificate.

In conclusion, all cruise vessels must expect to encounter one or more varicella cases every few years and be prepared to handle outbreaks. All cases must be reported to public health authorities ashore, and respective varicella management guidelines must be followed. Hence, every shipboard varicella case must be considered a potential index case and trigger a number of time-consuming and expensive measures to prevent or control outbreaks, including isolation and mass vaccination. It is not clear whether mandatory pre-contract evidence of varicella immunity from all seafarers is a cost-effective way to reduce the outbreak risk on cruise ships; but pre-contract testing/vaccination of crew members who hold certain positions (medical staff, child care, spa personnel) and from sub-tropical and tropical areas with uncertain or low immunity might be worth consider-

ing. Seafarers with known varicella immunity should be encouraged to obtain valid documentation and always carry it while travelling.

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