



Estimating the Risk of Communicable Diseases aboard Cargo Ships

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Background. International travel and trade are known to be associated with the risk of spreading communicable diseases across borders. No international surveillance system for infectious diseases on ships exists. Outbreak reports and systematic studies mainly focus on disease activity on cruise ships. The study aims to assess the relevance of communicable disease occurrence on cargo ships.

Methods. Retrospective analysis of all documented entries to 49 medical log books from seagoing cargo ships under German flag between 2000 and 2008. Incidence rates were calculated per 100 person-years at sea. Case series of acute respiratory illness, influenza-like illness, and infectious gastrointestinal illness affecting more than two persons within 1 successive week were classified as an outbreak. Attack rates were calculated based on number of entries to the medical log book in comparison to the average shipboard population during outbreak periods.

Results. During more than 1.5 million person-days of observation, 21% of the visits to the ship's infirmary were due to presumably communicable diseases (45.8 consultations per 100 person-years). As many as 33.9 patients per 100 person-years sought medical attention for acute respiratory symptoms. Of the 68 outbreaks that met predefined criteria, 66 were caused by acute respiratory illness with a subset of 12 outbreaks caused by influenza-like illness. Attack rates ranged between 3 and 10 affected seafarers per ship (12.5%–41.6% of the crew). Two outbreaks of gastrointestinal illness were detected.

Discussion. Respiratory illness is the most common cause of presumably communicable diseases aboard cargo ships and may cause outbreaks of considerable morbidity. Although the validity of the data is limited due to the use of nonprofessional diagnoses, missing or illegible entries, and restriction of the study population to German ships, the results provide guidance to ship owners and to Port Health Authorities to allocate resources and build capacities under International Health Regulations 2005.

Seafaring has always been a dangerous occupation, with infections and accidents being important health hazards.¹ The ship constitutes an environment in which communicable disease spread is favored: Crew members with different susceptibility to infection share living quarters, common food and water supplies, sanitation, and air-conditioning systems.²

Under the International Health Regulations 2005 shipmasters are required to notify Port Health Authorities about “*any cases of illness indicative of a disease of an infectious nature or evidence of a public health risk on board.*”³ Despite these notification requirements, the magnitude of disease transmission on board international ships is mostly unknown. Often, shipmasters are not aware of notification requirements

or fear that notification will cause retardations or penalties.

With the exception of specific international networks dedicated to agents of infectious diseases with significance to travel-related activities⁴ no international surveillance specifically related to shipping exists as of now. Public health surveillance and response in ports differ substantially between nations and do not—with a few exceptions^{5,6}—result in a systematic evaluation and publication of data. A literature research performed by using the PubMed database and the Maritime Library of Hamburg Port Health Center using combinations of MeSH terms revealed that publications on the risk of communicable diseases associated with the transport sector mainly focus on the passenger industry.^{7,8,9} Descriptive epidemiology of disease transmission on cargo ships is rare.

The transferability of study results from cruise line to merchant seafaring is limited: On cruise ships a large number of passengers from many countries of all ages—many of them with comorbidities—and a large crew gather on a ship for a relatively short period of time. Often they consume high-risk food in common spaces on board and have access to local food markets

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and restaurants in ports.^{10,11} Common recreational facilities are used. Cruise ships do have medical facilities and perform routine surveillance of disease and other preventative activities. Most cruise companies require crew to provide evidence of immunity against vaccine-preventable diseases before embarking. In contrast, on a cargo ship a multicultural crew of 30 or less persons are living in a common space for months. Due to regular obligatory health checks, chronic diseases are mostly ruled out. There is generally a lack of opportunity for merchant seafarers to visit local food markets or restaurants and for person-to-person contact in port cities. Medical care is performed by the second officer who is a nonmedical person. If needed, medical advice is given by telemedical services that use satellite technology to allow direct contact with an emergency physician.¹² No routine disease surveillance is in place and food hygiene is highly variable. A current study revealed cockroach infestation on more than 10% of investigated seagoing ships in Hamburg.¹³

The study aims to describe the epidemiology of communicable diseases aboard a sample of cargo ships and to assess the magnitude of disease transmission among the crew by means of determining the background incidences and frequencies of outbreaks.

Methods

Data Collection

Medical log books are archived by the competent authority of the ship's home port for at least 10 years, as required under German law.¹⁴ They contain information about the name of the vessel, dates of first and last entry to the medical log book, dates the patients were seen, their rank, ailment or complaint, action taken by the ship officer in charge including medical treatment, and additional remarks and queries. Information is entered by the ship officer in charge of medical care aboard referring to a single textbook.¹⁵

Using a retrospective study design, all 49 medical log books of international cargo ships under German flag between the years 2000 and 2008, which were available to the Hamburg Port Health Center due to the legal requirements, were analyzed. All visits to the ships' infirmaries were included. Entries on date of birth were too fragmentary, and names—because of privacy protection reasons—were not included into the analysis. Data on the individual ship characteristics (eg, type of vessel, number of crew members) were obtained from the ship database of the Hamburg Port Health Center. The Federal Commissioner for Data Protection and Freedom of Information permitted the study, August 30, 2007 (Ref.-No. IV-521-2/001#0001).

Case Definitions

According to the scientific literature, case definitions for common infectious disease categories were set. There are internationally agreed definitions for acute

respiratory illness in outbreak investigations on board cruise ships.⁹ In this study, a case of acute respiratory illness was defined as any symptom of the upper respiratory tract such as nasal congestion, cough, sore throat, or documented "cold." Influenza-like illness, a subset of acute respiratory illness cases, was defined as documented "influenza," "flu," or symptoms of acute respiratory illness with fever or self-reported feverishness.¹⁶ Infectious gastrointestinal illness was defined as any type of gastroenteritis, diarrhea, or documented "stomach flu."¹⁷ Nausea, although a common symptom of gastrointestinal illness, is specifically excluded from this definition to avoid misclassifying seasickness (nausea and vomiting) as gastroenteritis.

Furthermore, it was investigated whether the dates of onset of illness appeared to cluster. Based on principles of infectious disease epidemiology,¹⁸ case series of acute respiratory illness, influenza-like illness, and infectious gastrointestinal illness affecting more than two persons within 1 successive week were considered as an outbreak.

Additionally, it was explored, what proportion of initial treatments by the medical officer resulted in external consultation defined as a doctor's visit in the next port of call or via telemedical assistance.

Statistics

The primary outcome, incidence rates per 100 person-years at sea were estimated for all ships.¹⁹ Based on the review of the above-mentioned ship database, the average crew size was 24. Taking into account the reporting period of each medical log book, it was possible to control for variations in length of journey and crew size. Using the number of encounters (excluding revisits for the same complaint within 1 wk) as the numerator, and the 100 person-years underway as the denominator, illness incidence rates by disease category and total illness incidence (number of new cases per 100 person-years) were determined. Due to missing information, the calculation of person-years at risk did not take into account crew turnover and boarding or disembarkment of single crew members. Outbreak incidence rates were calculated using the number of case series occurring within temporal relation of 1 week as the numerator, and 1,000 ship-weeks underway as the denominator.^{5,20} Attack rates were calculated with the number of initial visits as nominator and the average shipboard population during possible outbreak periods as denominator. EpiInfo (version 3.5) and Microsoft Excel (version 2.3) software were used.

Results

Forty-nine medical log books with entries from January 2000 to April 2008 were included in the analysis. The acquisition period varied between 51 and 2,439 days, with an average reporting period of 1,291 days. Review of the Hamburg Port Health Center's ship database

displayed crew sizes between 20 and 38. Based on the average crew number of 24, 1.52 million person-days of observation were included in the analysis. A total of 8,918 entries to the medical log books had been recorded during the study period (214.4 entries per 100 person-years). A pilot study showed the following ranking order regarding the recorded frequency of disease: respiratory diseases, gastrointestinal diseases, skin diseases, conjunctivitis, dental problems, problems of the musculoskeletal system, cuts, lacerations and contused wounds, traumata, scalds, and burns.

In our study, 1,880 (21.1%) visits to the ship's infirmary were due to presumably communicable diseases (Table 1). The case incidence varied between ships with a range from 8.8 to 149.1 cases per 100 person-years, but 87.7% of the data ranged within 20 to 80 cases per 100 person-years. Averaged over the study period, the overall case incidence was 45.8 consultations per 100 person-years due to presumably communicable diseases. The total number of presumably communicable diseases consists of 1,635 initial visits and 245 follow-up visits for the same condition.

With 1,410 cases (33.9 cases per 100 person-years) acute respiratory illness accounted for 75% of the total number of presumably communicable diseases occurring in the study population. Influenza-like illness was suspected in 19.4% (6.6 cases per 100 person-years) of the cases of acute respiratory illness. The documented symptoms ranged from nonspecific nasal discharge and congestion to pharyngitis with fever to pneumonia. As many as 141 cases (3.4 cases per 100 person-years) of presumably infectious gastrointestinal illness were observed during the study period. Further diagnoses categorized as infectious diseases included conjunctivitis, ear infection, genitourinary tract infection, varicella, herpes zoster, scabies, ringworm infection, and minor skin infections. Sexually transmitted diseases (gonorrhoea) were reported in four

Table 1 Entries to the ship's medical log books by disease category

	Total number of cases (<i>n</i>)	Percentage of communicable diseases (%)	Incidence (per 100 person-years)
All entries	8,918		214.4
All communicable diseases	1,880	100.0	45.8
Acute respiratory illness	1,410	75.0	33.9
Influenza-like illness (subset of ARI)	273	14.5	6.6
Infectious gastrointestinal illness	141	7.5	3.4
Others	329	17.5	7.9

Table 2 Impact of detected outbreaks by disease category

	Frequency of outbreaks	Total number of outbreak-related cases	Attack rate (%)	Outbreak duration in days
Acute respiratory illness	66	3–10	12.5–41.6	1–20
Influenza-like illness (subset of ARI)	12	3–10	12.5–41.6	1–10
Infectious gastrointestinal illness	2	3	12.5	1–11

cases. A doctor's visit in the next port of call or via telemedical assistance was needed in 123 (6.5%) cases.

Outbreaks were only included in the analysis when acute respiratory illness, influenza-like illness, or infectious gastrointestinal illness was suspected and more than two cases occurred within temporal relation of 1 successive week. During the study period, 68 outbreaks (7.5 per 1,000 ship-weeks) that met predefined criteria were detected; 66 were caused by acute respiratory illness with a subset of 12 by influenza-like illness (Table 2). Two outbreaks of infectious gastrointestinal illness occurred within the study population. The average attack rate for acute respiratory illness was 17% (range between 12.5 and 33.3% of the crew aboard affected ships). Attack rates for influenza-like illness followed a similar pattern and ranged between 12.5 and 41.2% with a cluster size of 3 up to 10 persons being affected. The two outbreaks of infectious gastrointestinal illness affected three persons (attack rate 12.5%). Mean outbreak duration was 9 days for acute respiratory illness and 6 days for the subcategory influenza-like illness. One outbreak of infectious gastrointestinal illness lasted 1 day, the other 11 days.

Of all cases, 93.5% of patients have been treated under the sole responsibility of the officer in charge with no port doctor or telemedical advice being involved.

Discussion

This study provides an assessment on baseline disease activity on board cargo ships under German flag. Nearly one-fourth of the visits to the ship's infirmary were due to a presumably communicable disease with 75% of those being classified as respiratory disease. With an analysis of a large number of person-days at risk accumulated during the study period, this is the first study to estimate the frequency of communicable disease outbreaks aboard cargo ships.

The retrospective study design and the method used to identify outbreaks have several limitations which may influence the validity of the results. In our study the diagnosis was established by medical lay-persons; therefore, misclassifications of cases are possible (eg, classifying a skin rash as either skin infection or allergy).

Our calculations did not take into account the possible interdependencies for the risk of disease by the seafarers' country of origin, duration of voyage, preceding events of sickness, and type of cargo. However, results did not differ substantially between ships indicating that the establishment of the lay-diagnosis follows a common pattern which may be caused by the fact that there are statutory requirements for medical training and equipment of the medical chest including a single textbook¹⁴ as a reference to the medical officer.

The presence of one statistical outlier of only 8.8 cases within a reporting period of more than 5 years probably leads to an underestimation of the total case incidence. The reason for the low case incidence on one ship remains unknown (eg, insufficient reporting procedures or the ship was in repair for a longer period of time). Further studies need to predefine the exclusion criteria.

All crew members of German flagged ships undergo a mandatory health check ruling out chronic or severe diseases, but this will not exclude the occurrence of acute infectious diseases. Acute respiratory illness is one of the leading causes of death from any infectious disease.¹⁸ Among cruise line passengers, respiratory illnesses have been shown to cause significant morbidity.^{21,22,23} Our study indicates that respiratory diseases are the most common infections in crews from cargo ships as well. Closed ventilation systems, the sharing of living quarters by persons with different levels of susceptibility, international travel, change of climate, and others may be considered to have an impact on respiratory disease incidence in seafarers.^{24,25} Our data indicate that most illnesses were self-limited with symptomatic treatment from the ship's medical chest only. Preventative measures such as vaccination of crew, allocation of seafarers in single cabins, early treatment, and isolation of respiratory diseases may be useful tools to safeguard ship operation and contain outbreaks.

There had been well-documented reports of influenza outbreaks on cruise and military ships,^{9,16} which tend to have high attack rates. Ferson and colleagues⁶ showed from surveillance data in the port of Sydney that in a 4-year period 8 out of 14 outbreaks on cruise ships were caused by respiratory infections. Awareness and prevention of common respiratory infections will help to prevent the occurrence of seasonal or pandemic influenza, emerging diseases, and other respiratory diseases associated with ships such as tuberculosis, rubella,²⁶ or chicken pox.

Outbreaks of infectious gastrointestinal diseases occurred only twice during the study period (1.6 per 1,000 ship-weeks). An epidemiological study published on outbreaks among vacation cruise ships (median cruise duration of 1 wk) found an outbreak frequency of 6.3 outbreaks for infectious gastrointestinal illness per 1,000 ship-weeks.⁵ As described in the introduction, cruise ships and cargo ships do represent two different environments concerning risk for outbreaks of infectious gastrointestinal diseases. Although the

transferability to ships under international flags might be limited due to different standards of food and living hygiene, our study findings suggest that infectious gastrointestinal illness does have a moderate impact on the health of the crew on cargo ships.

Sexually transmitted diseases have been rarely recorded in the medical log books of our study, although transport workers are generally regarded as being a risk group.²⁷ In consideration of the fact that the medical officer on board is a colleague and superior, it may be assumed that underreporting and misclassification (eg, sexual transmitted disease as urinary tract infection) bias the results to an underestimation.

Global travel and transport had been identified for centuries to be connected with the spread of infection and led to international sanitary agreements. The International Health Regulations³ oblige ship operators to undergo a sanitary inspection of their ship every 6 months and to notify any occurrence of infectious disease to Port Health Authorities. Beside national approaches,⁶ no international surveillance for the occurrence of infectious disease exists on board ships. Therefore, baseline activity of infections is unknown on board. The data presented in this study will aid ship operators and health authorities to allocate resources and assess the relevance of disease occurrence on board cargo ships. Thus, competent authorities may be able to use the detection of unusual or increased occurrence of sickness as an early warning system for international health threats.

Declaration of Interests

The authors state they have no conflicts of interest to declare.

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