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State of the art: public health and passenger ships

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Abstract

Background*. The purpose of this report is to describe issues relevant to public health and to review all passenger ship associated diseases and outbreaks. Moreover, legislation and practices on sanitation and diseases surveillance related to ships internationally were also reviewed. Some relevant historical information about infections on merchant ships is provided as well.*

Material and methods*. The methods used to develop the state-of-the-art report included a scientific literature review and an extensive and thorough search of the websites of organisations and government departments. A considerable effort was made to capitalise on previous experience in the field. In particular, for the literature review, a total of 158 scientific articles were used including 91 full papers and 67 abstracts, 7 guidelines published by the WHO, and 13 guideline documents published by other organisations. Moreover, 5 international conventions relevant to passenger ships were identified.*

Results*. At the international level, public health issues related to ships are regulated by the revised International Health Regulations (2005). Other conventions of the International Maritime Organization regulate safety on board ships and waste and ballast water management, while conventions of the International Labour Organization regulates issues related to working conditions on board ships. Guidelines for preventing and controlling public health threats on board ships can be found in seven Guidelines published by the World Health Organization, including the WHO Guide to Ship Sanitation, which provides a framework for policy making and local decision making. The literature review results revealed that the infections/outbreaks that occur on passenger ships include Norovirus, Legionella spp., Salmonella spp., E. coli, Vibrio spp., and influenza A and B virus. The modes of transmission include person to person, waterborne, foodborne, airborne, and vectorborne, and shore excursions are responsible for some outbreaks.*

Conclusions*. The industry (especially the ferry industry) and sanitary organisations can enhance collaboration in order to implement integrated hygiene programmes and prevent the occurrence of communicable diseases aboard passenger ships.*

Key words: *passenger ship, diseases surveillance, prevention*

Executive summary

During 2008, the industry carried an estimated 13.05 million passengers on cruises around the globe (Cruise Lines International Association, 2009). The worldwide population of seafarers serving on internationally trading merchant ships was estimated to be about 466,000 officers and 721,000 ratings in 2005 (IMO, 2009).

Ships are closely related to public health in many ways: they may provide the place for disease transmission from person to person; they may be the source of infection (e.g. contaminated food, surfaces, water), or they may act as a means through which infections or vectors may be transmitted internationally. While travelling on a cruise ship or ferry may be associated with some specific infection risks (e.g. Norovirus), the overall rate of foodborne outbreaks (for example) on such ships may be lower than equivalent shore based facilities. However, comparisons of ship and shore related infections and outbreaks are difficult because of differences in surveillance between ship and shore and because ascertainment differs between countries. In particular, the larger cruise ship operators usually maintain information on reported passenger ill health that is not commonly held for shore based holidays. As a result, some outbreaks will be detected on ships that would not be detected on land. Some outbreaks on ships may be due to shore visits while others are due to specific bad management on board an individual ship.

The scope of this report is to review all passenger ship associated diseases and outbreaks and to describe legislation and practices on sanitation and disease surveillance related to ships internationally. Some relevant historical information about infections on merchant ships is provided as well.

The methods used to develop the state-of-the-art report included a scientific literature review, and an extensive and thorough search of the websites of organisations and government departments. A considerable effort was made to capitalise on previous experience in the field. In particular, for the literature review, a total of 158 scientific articles were used including 91 full papers and 67 abstracts, 7 guidelines published by the WHO, and 13 guideline documents published by other organizations. A total of 14 main websites are referenced in this report. Moreover, 5 international conventions relevant to passenger ships were identified.

The results revealed that the infections/outbreaks occurring on passenger ships included: cholera, cyclosporiasis, diphtheria, E. coli *infection, Hepatitis A, influenza, Legionnaires' disease, measles, meningococcal meningitis, rubella, salmonellosis, scabies, shigellosis, sexually transmitted diseases, trichinosis, tuberculosis, varicella, and viral gastroenteritis. The pathogens that most often caused outbreaks were: Norovirus,* Legionella *spp.,* Salmonella *spp.,* E. coli, Vibrio *spp., and influenza A and B virus. The modes of transmission included person to person, waterborne, foodborne, airborne, and vectorborne, and shore excursions were responsible for some of the outbreaks. The factors which contribute to such outbreaks are often preventable, or can be reduced by means of sanitation measures, training the crew members, and advising passengers.*

At the international level, public health issues related to ships are regulated by the revised International Health Regulations (2005). These regulations have changed ship sanitation certification, disease surveillance, and response to public health threats that may constitute an emergency of international concern. Other conventions of the International Maritime Organization regulate safety onboard ships and waste and ballast water management, while conventions of the International Labour Organization regulates issues related to working conditions onboard ships.

European legislation directly applied to ships includes safety rules and standards for passenger ships, border measures for public health purposes, and the welfare of animals in

transit. Except for a few exceptions in food safety issues, there is no legislation exclusively or directly applied to passenger ships regarding potable water safety, recreational water safety (pools), and communicable disease surveillance, although there is industry guidance. These issues are covered by legislation applicable in land-based establishments, although issues such as potable water management present different risks onboard ships and need special regulation.

Guidelines for preventing and controlling public health threats on board ships can be found in seven guidelines published by the World Health Organization. The WHO Guide to Ship Sanitation covers preventive environmental health management, disease surveillance, outbreak investigation, and routine inspection and audit. It provides a framework for policy making and local decision making.

Among the integrated sanitation and surveillance programmes identified throughout the world, the United States Vessel Sanitation Program has the longest experience in gastrointestinal disease surveillance, outbreak investigation, and environmental health inspections. The Surveillance Programme for the port of Sydney covers a broader range of diseases and includes surveillance for prescribed symptoms.

A passenger ship can be considered a leisure or accommodation place or a means of transport. There are a number of aspects with public health significance that can influence the health of passengers and crew members including quality of food, water, and air, the presence of vectors, waste produced and carried on board, and even travellers behaviour. Hazards that may arise from those factors should be effectively managed in order to prevent disease occurrence. Scientific published papers that describe outbreaks and diseases related to ships contain useful information that can be used in planning preventive measures. Useful international guidance has been published by international and national organisations and authorities relevant to public health on ships.

1. BACKGROUND

Travelling by ship is tightly interwoven with human history. Ships have been used by explorers, merchants, pirates, war fleets, refugees, missionaries, pilgrims, and tourists to cross waters back and forth for different purposes. Life threats or health threats on ships have varied according to the era. Drowning, injuries, and attacks by sea creatures were probably the most relevant life threats aboard the earliest types of ships. It was only after ships sailed for more than a day or two that questions of food and water supply, sanitation, ventilation, care of the sick and injured on board, the spread of plagues, and the transmission of infectious diseases began to arise (Minooee and Rickman, 1999). Even nowadays, in modern ships of all sizes and types, diseases can threaten the health of passengers or crew members, and can still occasionally be fatal.

Generally, a ship is categorised according to what it carries. The main categories include passenger ships and cargo ships (IMO, 2007) although there are a variety of other ship types including military and work ships (e.g. tugs, fishing vessels). This state-of-the-art paper deals with ferries and cruise ships, which are passenger ships.

Nowadays, there are different sizes of ships which carry passengers and crew members, from just a few to a few thousand. During 2008, the industry carried an estimated 13.05 million passengers on cruises around the globe (Cruise Lines International Association, 2009). The worldwide population of seafarers serving on internationally trading merchant ships was estimated in the BIMCO/ISF Manpower update of 2005 to be in the order of 466,000 officers and 721,000 ratings (IMO, 2009).

Disease outbreaks have occurred aboard passenger ships throughout the world and within European waters. Results have shown that infections/outbreaks that have occurred on passenger ships have included: cholera, cyclosporiasis, diphtheria, *E. coli* infection, Hepatitis A, influenza, Legionnaires' disease, measles, meningococcal meningitis, rubella, salmonellosis, scabies, shigellosis, sexually transmitted diseases, trichinosis, tuberculosis, varicella, and viral gastroenteritis. The pathogens that most often caused outbreaks were: Norovirus, *Legionella* spp., *Salmonella* spp., *E. coli*, *Vibrio* spp., and influenza A and B virus. The modes of transmission included person to person, waterborne, foodborne, airborne, and vectorborne, and shore excursions were responsible for some of the outbreaks. The factors which contribute to such outbreaks are often preventable, or can be drastically reduced through sanitation measures, the training of the crew members, and advising passengers. Furthermore, ships can have an impact on public health in ways other than their role in ship-acquired infection. For example, they can transport infected humans and vectors, such as mosquitoes and rats, between ports and, therefore, act as a means by which infections can be transmitted internationally.

The phenomenon of globalisation in the twenty-first century has altered the traditional distinction between national and international health. Very few, if any, urgent public health risks are solely within the jurisdiction of national authorities (WHO, 2002b). Ships move rapidly from one country to another where different standards of sanitation are required, while disease surveillance practices vary. These cause administrative difficulties to competent authorities of countries, as well as ship operators, when trying to deal with the prevention and control of diseases aboard ships. In 2006, the European Union project SHIPSAN (http://www.shipsan.eu) was established and funded by the Directorate General for Health and Consumers of the European Commission in order to assess the usefulness of an integrated common programme for communicable disease surveillance and hygiene inspection in Europe. In the frame of this project, public health risks that potentially occur on passenger ships were assessed, and a review of the relevant legislation and literature on communicable diseases outbreaks was conducted. It was developed to explore inefficiencies within Europe and to provide evidence-based recommendations to the European Commission in order to rectify them. Ship itineraries often include many different ports in European countries, and therefore there is a need for European standards to regulate health related issues which can be adopted and accepted by all.

European legislation directly applied to ships includes safety rules and standards for passenger ships, border measures for public health purposes, and welfare of animals in transit. Except for a few exceptions in food safety issues, there is no legislation exclusively or directly applied to passenger ships regarding potable water safety, recreational water safety (pools), and communicable disease surveillance, although there is industry guidance. These issues are covered by legislation applicable in land-based establishments, although issues such as potable water management present different risks onboard ships and need special regulation.

The World Health Organization (WHO), which is the United Nations specialised agency for health, updated the International Health Regulations (IHR) in 2005. The purpose of the IHR is to provide maximum protection against the international spread of diseases with minimum interference to world traffic.

This paper reviews the current situation in terms of regulation and practice internationally. More specifically, it aims a) to describe issues related to public health aboard ferries and cruise ships, b) to review the scientific literature regarding illnesses that have occurred among passengers and crew members, or have been introduced to a country through any type of ship, c) to present the international and European action, in terms of regulations, taken in order to protect public health, and d) to gather information on practices developed internationally to protect people's health aboard ships, as well as the prevention of the introduction of diseases into a country.

2. METHODOLOGY

The methodology used to develop this state-of-the-art report included a scientific literature review, searching the websites of organisations and governmental departments, and communication with experts. Every effort was made to capitalise on previous experience in the field. The literature review was based on Medline (PubMed) with references held in Reference Manager Version 10 software to create the bibliography.

In particular, for the literature review, a total of 158 scientific articles were used including 91 full papers and 67 abstracts, 7 guidelines published by the WHO, and 13 guideline documents published by other organisations. A total of 14 websites were visited. Moreover, 95 EU legislation documents (directives, regulations) and 5 international conventions were identified to be relevant to ships.

3. ISSUES OF PUBLIC HEALTH SIGNIFICANCE ON SHIPS

Ships, when they sail, transport humans, animals, vectors, plants, water, food, and much more (Table 1). Each of these factors can be important in ensuring the health of passengers aboard a ship. Today's passenger ships can be considered a gathering place for the global community, where opportunities for interpersonal interactions and sharing common activities and food and beverages are plentiful. As a result, ships may be sites where diseases occur, they may provide the milieu for person-to-person transmission, they may be the source of an outbreak, or they may act as a courier of ill persons, vectors, or microbes from one place to another. The public health significance of each aspect that might influence human health aboard ships is described below. Finally, proposals on how these aspects could be used in assessing the public health risk of a ship are provided in this chapter.

HUMANS

Persons from multiple geographical origins gather on cruise ships and spend a few to many days together, and then disperse to multiple locations, often via long flights on large commercial aircraft. Cruise ships may pick up and drop off passengers at multiple locations, so there may be new people regularly joining the cruise. A cruise ship may stop at multiple ports, and travellers may disembark and spend hours to days visiting a local population and the local environment. Although sailing may suggest an outdoor experience, many of the activities on cruise ships take place in a closed environment: in dining rooms, movie theatres, dancing halls, or in cabins (Wilson, 2003). The closed or semi-closed environment of passenger ships and the close contact between passengers and crew provide opportunities for transmission of communicable diseases.

When people travel, they carry their genetic make-up, their accumulated immunological experience,

Table 1. What a passenger ship transfers from a public health perspective

1.	Humans
2.	Air
3.	Potable water
4.	Food
5.	Recreational water (spas, swimming pools)
6.	Ballast water
7.	Sea water
8.	Vectors (insects, rodents etc)
9.	Animals
10.	Plants
11.	Luggage
12.	Cargo
13.	Vehicles
14.	Waste

pathogens in or on their bodies, and may also transport disease vectors, such as lice. Their technology (agricultural and industrial), methods for treating disease, cultural traditions, and behavioural patterns may influence their risk for infection in a new environment and their capacity to introduce disease into the new region (Wilson, 1995).

Cruise ships may draw staff from countries where vaccine use differs from that in North America and parts of Europe. For example, an investigation of an outbreak of rubella on a cruise ship found that many of the staff came from countries where rubella vaccine is not routinely given (Anon, 1998).

Because of the ease of travel and the availability of on-site medical care, cruise ships may attract older, less mobile travellers. Some cruise ships are equipped to provide renal dialysis. On one cruise ship that was the site of an outbreak of influenza, an investigation revealed that 77.4% of the 1448 passengers were 65 years of age or older and 26.2% had chronic medical problems (Anon, 1997b).

AIR

During a voyage, passengers and crew members spend most of the time indoors. Shipboard ventilation systems supply and remove air to/from spaces throughout the ship, and treat air to maintain the proper temperature and humidity. Some spaces of a ship present different needs in air quality such as the galleys, the car decks and the accommodation areas. Effective ventilation design and maintenance reduce considerably the possibility of air contamination.

FOOD

There are a number of factors which influence the standards of food safety and the likelihood of foodborne illness on passenger ships. On ships a large number of people eat from the same food supply. The sources of food supplied to ships may vary depending on the previous ports of call of the ship, although many ships routinely store provisions in designated ports from controlled sources.

Food handlers on ships come from a variety of countries, and their experience and understanding of food safety, together with the levels of hygiene training and expertise on the ship, can vary considerably. Extensive menus with many dishes are often offered to passengers, many of whom eat on board for the majority of their voyage. As on land, the preparation of a wide variety of foods at the same time for a large number of people can increase the risk of mishandling or cross contamination. Most ship companies seek to reduce such risks by good design — in particular the installation of adequately sized, fully equipped food rooms and the separation of ‘low risk’ and ‘high risk’ food processes. Other factors that influence the standards of food safety may include: a) the effective implementation and maintenance of food safety management systems including HACCP, b) the overall design of the food production, storage, and service areas including logical work flows, adequate sizes, and the separation of ‘low risk’ and ‘high risk’ food processes, c) the standard of food facilities and equipment including durability and ease of cleaning, d) the age of food production facilities may also be a factor, and e) the effective repair, maintenance, and conditioning of food handling facilities and equipment.

Passengers and crew may also take trips ashore at different ports where food- or waterborne (or person-to-person) infections could be acquired and then subsequently be spread on board.

POTABLE WATER

At a very basic level, water is an essential load aboard ships for daily consumption and hygiene of passengers and crew members, as well as for food production, cleaning, and recreational use. The potable water quality used aboard ships has a significant impact on human health. It is well documented that water supplies aboard ships have been identified as a vehicle for diseases.

Water supply and management aboard ships can lead to known health risks. Port authorities use special arrangements for managing the water after it has entered the port. Water is delivered to ships by hoses or transferred to the ship via water boats or barges. Transfer of water from shore to ship can provide possibilities for microbial or chemical contamination. Different piping systems carrying potable water, seawater, sewage, and fuel are fitted into a relatively confined space and can increase the possibility for cross contamination. Piping systems are normally extensive and complex, making them difficult to inspect, repair, and maintain. During distribution, it may be difficult to prevent water quality deterioration due to stagnant water and “dead ends”. Moreover, loaded water may be mixed with water generated on board by reverse osmosis or distillation. Water distribution on ships may also provide opportunities for contamination to occur because ship movement increases the possibility of surge and backflow (Rooney et al., 2004b).

Many passenger ships now have extensive water safety management systems including halogen treatment and continuous monitoring. Cross connection control programmes comprising checks and testing are employed on many passenger ships. Moreover, backflow prevention systems (such as reduced pressure principle assemblies) are now usually built into items of equipment. On board, ultra violet and chlorine dosing systems are used to ensure the safety of potable water, and some passenger ship companies have routine microbiological and chemical testing regimes. Modern passenger ships are designed to minimise any 'dead ends' or 'deadlegs'. Other controls in place include programmes for routine superhalogenation of tanks and distribution systems, water tank cleaning, and the routine maintenance programmes for water systems.

Chemical water poisoning, while rare, can also occur on ships. For example, one outbreak of acute chemical poisoning implicated hydroquinone, an ingredient of photo developer, as the disease-causing agent in the ship's potable water supply. Chronic chemical poisoning on a ship could also occur if crew or passengers were exposed to small doses of harmful chemicals over long periods of time (WHO, 2006a).

RECREATIONAL WATER (SPA, SWIMMING POOLS)

In modern ships, water is used as a means of recreation. Some cruise ships include more than five recreational pools. Spa pools are becoming increasingly popular, providing health benefits through massage, relaxation, and pain relief. It is well documented that swimming pool water has been identified as a vehicle for diseases. Similarly to on land, infectious agents can be easily introduced to a pool via bathers, from dirt entering the pool, or from the water source itself. Once in the spa pool, suitable conditions often exist for these infectious agents to grow and proliferate. There have been several examples of people contracting infections from spa pools, for example Legionnaires' disease (Health Protection Agency, 2006). Flow-through seawater swimming pools on cruise ships and ferries may present additional risks if the source sea water is polluted (WHO, 2006b).

Passenger ships often have extensive management and maintenance systems in place for the safe control of recreational water on board, such as automatic dosing of pool/spa water with halogen disinfectants. They can also have extensive systems for the control and monitoring of parameters such as halogen (chlorine and bromine) levels, temperature, pH, and alkalinity, as well as routine backwashing, pool/spa cleaning systems, water filter checks, and the regular sampling of water quality.

BALLAST WATER

Ships have used ballast water for stability since the nineteenth century, discharging water at ports of call and en route. Ballast tanks carry a diverse community of organisms, resulting in many biological invasions. Pathogens, including those affecting humans, are common in coastal waters and can also be transferred in ballast water (Ruiz et al., 2000). Organisms discharged with ballast water can potentially affect human health. In the early 1990s, *V. cholerae* O1 Inaba, biotype El Tor was cultured from the ballast, bilge, and sewage from five cargo ships docked in ports in the US Gulf of Mexico (McCarthy and Khambaty, 1994). The isolates were indistinguishable by pulsed-field gel electrophoresis from the strain causing the cholera epidemic in South America. A later study of vessels arriving in Chesapeake Bay from foreign ports found *V. cholerae* in ballast from all ships studied. Investigators found both *V. cholerae* O1 and O139 (Ruiz et al., 2000).

The problem of invasive species is largely due to the expanded trade and traffic volume over the last few decades. The effects in many areas of the world have been devastating. Quantitative data show the rate of bio-invasions is continuing to increase at an alarming rate, in many cases exponentially, and new areas are being invaded all the time. Volumes of seaborne trade continue to increase overall and the problem may not yet have reached its peak (IMO, 2007).

VECTORS (INSECTS, RODENTS, ETC)

Some injurious and unwanted organisms such as flies, cockroaches, mosquitoes, flees, lice, and others may enter a ship either directly from the ship's open spaces, including ramps, portholes, and scuttles, they may be carried in food supplies, cargo, luggage, and vehicles, or may be human or animal ectoparasites. Vectors onboard ships can cause harm in different ways. They may be introduced, established, and spread diseases in areas in which they have not previously been found. Vectors may cause an illness onboard a ship, and this may be due to the consumption of food containing human enteropathogens mechanically transmitted by flies or cockroaches, particularly within kitchens. Finally, insects may infest food products and cause considerable damage to stored products. Faeces, odours, webbing, cast skins, and live or dead insects can contaminate stored food (Mouchtouri et al., 2008b).

Many passenger ships have well developed Integrated Pest Management (IPM) systems in place to minimise such risks and to help prevent and control pests. These tend to include staff training and written guidance/manuals, the use of pest monitoring stations, electronic fly control units, routine inspection of all incoming food supplies and ship areas for pests, and, where required, the use of specific pesticides and pest treatment programmes.

ANIMALS

Live animals including dogs, cats, and any other pets, fish, shellfish, horses, poultry, captive birds, bovine, porcine, ovine, and caprine, can be transferred by ferries. Cruise ships may carry pet animals. Anthropozoonosis may be transmitted to passengers and crew members from animals carried aboard ships. Special measures during transportation are required to ensure the welfare of animals in transit and to prevent the transmission of diseases among animals and between animals and humans. Specific measures should be taken for the control of imported live animals and pets carried aboard ships.

VEHICLES, LUGGAGE, CARGOS

Vehicles, luggage, and any type of cargo aboard ships may be contaminated by pathogenic microbes or may be infested by vectors. Shipments of used tires have been implicated as the primary dispersal of *Aedes albopictus* in Italy, California (Madon et al., 2002), and other places through the worldwide shipping transport. International Health Regulations 2005 regulate public health measures that are required for public health purposes to be applied to goods, containers, and other inanimate objects aboard ships on international voyages.

WASTE

Almost all types of waste can be found aboard ships: medical waste from the ship's hospital, hazardous waste from the photographic studio of a cruise ship, liquid waste from the toilets, solid waste from the galleys, international catering waste which contains animal by-products, and much more. Waste can contain pathogenic microbes and chemical or physical hazardous agents. Unsafe management and disposal of ship waste may lead to adverse health consequences. The risk of exposure may be direct, e.g. penetration of skin by used syringes, or indirect by contaminated environmental surfaces, or through mechanical transmission of infectious agents by insects.

RISK ASSESSMENT OF SHIPS

Conducting a risk assessment of a ship is a complicated procedure and a variety of factors can be used for that purpose. The issues of public health importance aboard ships, which were described in this chapter, could be utilised to assess the health risk of a passenger ship. Hazards that may be present should be identified first. To categorise a ship, the shipping industry usually uses the ship size, which is measured in gross tonnage. From the public health perspective a variety of factors including the passenger and crew capacity, the age of the ship, the ship itineraries, the duration of travel, and the facilities of public health interest aboard the ship can be used to categorise a ship according to the health related risks (Table 2). Effective preventive measures that may be in place to control the occurrence of a hazard should also be taken into consideration. Previous inspection results can be used in the assessment of the effectiveness of preventive measures.

Ships with more passengers should be considered of higher risk than those with few passengers, since the number of persons exposed to a possible health hazard is bigger and the interaction of factors that people carry are more complicated.

The factors of ship age and ship size have been analysed and were shown to be significantly associated with sanitation inspection scores (Cramer et al., 2006), with potable water microbiological quality (Grenfell et al., 2008), and with *Legionella* contamination of ship water distribution systems (Goutziana et al., 2008). Generally, older ships could be considered of higher risk than newer ones.

Ship itineraries also play an important role in the exposure of passengers and crew members to health risks. Ships which visit ports with poor potable water quality and inefficient protection of potable water bunkering facilities, or those which visit countries in which infectious diseases are endemic (e.g. malaria), should be considered of high risk if preventive measures are not taken. The duration of travel determines the time of exposure to a possible risk.

The presence and the number of potable water tanks, food preparation and service areas, swimming and spa pools, and cabins should be used in the risk assessment of a ship.

4. DISEASES ASSOCIATED WITH SHIPS

4.1. HISTORY OF DISEASE TRANSMISSION BY SHIPS

Throughout history, ships have been involved in disease transmission in many ways. Ill persons travelling by ship spread epidemics in new areas. After the discovery of the New World in 1492, Old World diseases such as smallpox, measles, influenza, and typhus annihilated most of the American native po-

Table 2. Suggested criteria and examples for risk analysis and categorisation of ships and facilities of public health interest aboard ships

Criteria for categorization													
Ship size (gross tonnage)	**Score**	**Ship age**	**Score**	**No of passengers**	**Score**	**No of crew members**	**Score**	**Travel duration**	**Score**	**No of facilities of public health interest**	**Score**	**Previous inspection results**	**Score**
< 3,000		1–5		12–100		1–50		> 12 hours		Potable water tanks			
3,001–15,000		6–10		101–500		51–100		13–23 hours		Restaurants			
										Canteens			
										Bars			
15,001–30,000		11–15		501–1,000		101–500		1–7 days		Swimming pools			
30,001–60,000		16–20		1,001–2,000		501–1,000		8–15 days		Spa pools			
60,001–120,000		21–30		2,001–3,000		1,001–1,500		16 days to 1 month		Cabins			
> 120,000		> 30		> 3,000		> 1,500		> 1 month		WC			
Total score													

pulations (Bianchine and Russo, 1992). Vector dispersal by ships from one country to another happened many times throughout history. Infected food or water supplies consumed aboard ships were another source of disease. Person-to-person transmission of diseases aboard ships is another example. When Christopher Columbus and his men embarked on the second Colombian expedition in 1493, the crew suffered from fever, respiratory symptoms, and malaise. It is generally accepted that the disease was influenza (Munoz-Sanz, 2006). Finally, the lack of food with essential nutrients during long sea voyages led to the discovery of scurvy.

Furthermore, ships have been used as facilities for medical treatment or isolation of ill persons during operations of military forces of navies of various countries around the world. An early example of a hospital ship was the Red Rover in the 1860s, which aided the wounded soldiers of both sides during the American Civil War (US Naval Historical Centre, 2007). During World War I and World War II, some passenger liners were converted for use as hospital ships. The Britannic was such a ship which served in this capacity (Greenberg, 2006) as was the Canberra, which was used in the Falklands war. Some representative examples of disease transmission by ships are described below.

Plague

At various times in the last two millennia, plagues became widespread, affecting a large number of countries on most continents during several pandemics. The first evidence for the contribution of ships to the spread of plague can be found during the second plague pandemic of the fourteenth century, which is well known as the “Black Death”. The Old Icelandic annals show that the Black Death came to Bergen, Norway, in 1349 via a ship from England. The epidemic must have started by infected black rats and rat fleas in the grain cargo of the ship (Oeding, 1990).

In 1377, in the busy Mediterranean seaport of Ragusa (modern Dubrovnik, Croatia), a new law was passed establishing a “trentino”, or thirty-day isolation period. The law indicated that citizens or visitors (including passengers of the arriving ships) from plague-endemic areas would not be admitted into Ragusa until they had first remained in isolation for 1 month. During the next 80 years, similar laws were introduced in Marseilles, Venice, Pisa, and Genoa. Moreover, during this time the isolation period was extended from 30 to 40 days, thus changing the name “trentino” to “quarantino”, a term derived from the Italian word *quaranta*, which means “forty” (Sehdev, 2002).

The third plague pandemic began in Canton and Hong Kong in 1894 and spread rapidly throughout the world, carried by rats aboard the swifter steamships that replaced the slow-moving sailing vessels in merchant fleets. Within 10 years (1894–1903) plague had entered 77 ports on five continents: Asia (31 ports), Europe (12), Africa (8), North America (4), South America (15), and Australia (7) (World Health Organization, 1999).

Plague (infection by *Yersinia pestis*) was presented in Hawaii for the period 1899–1957 and caused at least 370 fatalities. The first infections came from immigrant commensal rats, probably *Rattus rattus* and *Rattus norvegicus*, on ships from the Orient. The flea *Xenopsylla vexabilis* arrived with *R. exulans*, and its close relative *Xenopsylla cheopis* accompanied the ship rats. Following each introduction to port cities, plague subsided after a few years but remained active in rural areas of two islands for nearly 50 years (Tomich et al., 1984).

Yellow fever

The slave trade of the seventeenth century formed a close connection between West Africa and Spanish-Portuguese America. "Yellow Jack" was one of the most dreaded of the diseases of the Atlantic trade routes; the legend of the "Flying Dutchman", a vessel doomed to haunt the seas around the Cape of Good Hope because yellow fever broke out and no port would give it harbourage and all the crew perished, as described by Sir Walter Scott, was inspired by stories of this disease (Hobson, 1963; Vainio and Cutts, 1998).

James Lind's account (1792) of fever aboard a vessel off the coast of Senegal in 1768 is usually accepted as the first in which one can definitely recognise yellow fever in Africa. No clinical description of the fever was given, but the evidence for its being yellow fever was its occurrence first in men who had been ashore, and its apparent propagation aboard ship (Vainio and Cutts, 1998).

Yellow fever reached New York in 1668, Boston in 1691, and Charleston in 1699 by ship. During the 19th century, ships arrived at European ports with yellow fever onboard and caused several epidemics: Brest in 1802, 1839, and 1856, St. Nazaire in 1865, Swansea in 1843, 1851, 1864, and 1865, and Southampton in 1852, 1866, and 1867 (Vainio and Cutts, 1998).

Cholera

Cholera pandemics in the 19th century spread mainly along trade routes, facilitated by merchant shipping (Taylor, 1997). In the 1830s, the waves of emigration reaching North America coincided with cholera epidemics, and fears rose that there was some connection between the emigrant traffic and Asiatic cholera. A quarantine station was established in Quebec, where the sick could be housed and passengers and ships could be cleaned after the ocean crossing. All ships had to stop for inspection by the Health Officers. A ship which had had cholera on board was subject to fifteen-day quarantine and all steerage and hold passengers were landed to clean themselves and their baggage while the ship was cleaned. If a ship arrived with cholera aboard, the victims were to be taken ashore to the hospital and the remaining passengers landed while their ship was cleaned and served thirty days quarantine. Convalescent passengers were to be kept apart from the healthy for twenty days after their recovery (Bilson, 1977).

Typhus fever

Typhus fever is a disease which occurs due to bad sanitation and is caused by *Rickettsia prowazekii*. It has come under many headings, including "ship fever". Overcrowding, bad hygiene, and lack of ventilation made ships the ideal environment for typhus, which was passed on by lice. Sailors infected with typhus could start an epidemic on board a ship in a matter of days. Typhus fever was one of the diseases responsible for the high death rate among the crowded prison ships in New York harbour during the American Revolution. Preventive measures such as quarantine, delousing, and maintaining personal cleanliness by the use of soap were gradually adopted, and the incidence of typhus fever decreased (Minooee and Rickman, 1999).

Other diseases

Dengue fever vectors are thought to have spread to new countries by sailing ships. As the global shipping industry expanded in the 18th and 19th centuries, port cities grew and became more urbanised creating ideal conditions for the principal mosquito vector *Aedes aegypti* (Gubler, 2006).

There are some other recent historical examples showing the implication of ships in the spread of diseases. It is thought that *Anopheles gambiae*, a major vector of malaria, was probably introduced into Brazil in 1930 from Senegal by means of a French naval vessel (Gratz et al., 2000).

Influenza was also introduced in some countries via ships during the 1918 pandemic. From October 1918 to May 1919 a total of 79 "infected vessels" containing 2,795 patients, 48,072 passengers, and 10,456 crew and 149 "uninfected vessels" containing 7,075 passengers and 7,941 crew arrived at Australian ports (Bell, 2006). Some island countries enforced maritime quarantines which delayed or prevented the introduction of pandemic influenza. On the African mainland, quarantine was introduced in 1918 in some port cities in, for example Liberia, Gabon, and Ghana (formerly known as the Gold Coast). In October 1918, Australia began to quarantine arriving ships upon which cases of influenza had occurred during the voyage.

Outbreaks of infectious diseases have also been reported on board cruise ships and ferries in recent years. The period people stay on passenger ships ranges from a few hours in ferries to one or more weeks for cruise ships. This limits the evidence for linking such cases to the source of infection. A passenger may have left the ship before symptoms begin or become serious enough to warrant medical attention. Furthermore, offshore activities contributing to disease may become evident during a cruise (Minooee and Rickman, 1999), and passengers might be exposed to sources of infection such as hotels before or after the cruise. Therefore, it can prove quite difficult to clearly identify the ship as the source of an infection (Rowbotham, 1998).

In this chapter, a review of infectious diseases aboard passenger ships has been made, and the identified diseases have been divided into six categories: foodborne, waterborne, respiratory, vector-borne, and other diseases. Norovirus outbreaks have been described separately. The diseases that have occurred aboard passenger ships are summarised in Table 3.

Table 3. Infectious diseases that have occurred on passenger ships in recent years

Cholera	(Boyce et al., 1995)
Cyclosporiasis	(Anon, 1997c)
Diphtheria	(Anon, 1997a)
Escherichia coli	(Adkins et al., 1990; Berkelman et al., 1983; Daniels et al., 2000; Koo et al., 1996; Snyder et al., 1984)
Hepatitis A	(CDC, 2007a)
Influenza	(Anon, 1993; Uyeki et al., 2003)
Legionnaires' disease	(Rowbotham, 1998)
Malaria	(Raju et al., 2000)
Measles	(Centes for Disease Control and Prevention, 2005)
Meningococcal meningitis	(CDC, 2007a; DiGiovanna et al., 1992)
Rubella	(Hoey, 1998)
Salmonellosis	(Berkelman et al., 1983; Koo et al., 1996)
Scabies	(Ellyson et al., 1996)
Shigellosis	(Anon, 1994b; Berkelman et al., 1983; Finch et al., 1986; Koo et al., 1996; Kunert and Rzepecka, 1966; Lew et al., 1991; Merson et al., 1975b)
Sexually transmitted diseases	(Centes for Disease Control and Prevention, 2005)
Trichinosis	(Singal et al., 1976)
Varicella	(Minooee and Rickman, 1999)
Viral gastroenteritis	(Anon, 2002; Anon, 2003a; Anon, 2003b; Bohnker and Thornton, 2003; Enserink, 2006; Rooney et al., 2004b; Rooney et al., 2004a)

4.2. DISEASES TRANSMITTED FROM PERSON TO PERSON IN RECENT YEARS

Respiratory illnesses including the common cold and influenza (flu) are some of the most common infections affecting human beings (Eccles, 2005).

Ships provide an isolated environment that may increase the passenger's risk of infection if exposed to respiratory pathogens. The contemporary epidemiology of injuries and illnesses among passengers on four recreational cruise vessels originating from the United States in 1991 revealed that the most common diagnosis for passengers and crew seeking care in the ship's infirmary was respiratory tract infection (Peake et al., 1999). This diagnosis constituted 29.1% of all visits. Antibiotics also made up 7 of the top 15 oral prescriptions dispensed (Minooee and Rickman, 1999).

Illnesses such as diphtheria (Anon, 1997a), rubella (Hoey, 1998), and influenza (Anon, 1994a; Anon, 1999) have been reported on cruise ships, while cases of tuberculosis have been reported to occur among crew members of non-passenger ships (Suzuki et al., 1997). Pandemic influenza spread and Severe Acute Respiratory Syndrome (SARS) could be considered possible risks aboard ships as well as on land.

The microbiology and epidemiology of respiratory diseases which have been associated with ships are described below. A more detailed description is given for influenza A and B, due to its more frequent occurrence among passengers than other respiratory diseases.

4.2.1. Influenza

Infectious agent

The currently circulating influenza viruses that cause human disease are divided into two groups: A and B. Influenza A has 2 subtypes which are important for humans: A(H3N2) and A(H1N1), of which the former is currently associated with the most deaths. Influenza viruses are defined by 2 different protein surface antigens called haemagglutinin (H) and neuraminidase (N) components.

The genetic makeup of influenza viruses allows frequent minor genetic changes, known as antigenic drift, and these changes require annual reformulation of influenza vaccines (WHO, 2003).

Clinical features

The onset of illness is sudden; fever usually over 39°C, headache, and myalgia tend to become prominent. Other signs include fatigue, sore throat, nasal congestion, and red eyes. A cough is a very important symptom, which starts as dry and progresses to wet with thick mucous (Turkulov and Madle-Samardzija, 2000).

Epidaemiology

Influenza rapidly spreads around the world in seasonal epidemics and imposes a considerable economic burden on governments in the form of hospital and other health care costs and lost productivity. In annual influenza epidemics, 5–15% of the population are affected with upper respiratory tract infections. Hospitalisation and deaths mainly occur in high-risk groups (elderly, chronically ill). Although difficult to assess, these annual epidemics are thought to result in between 3 and 5 million cases of severe illness and between 250,000 and 500,000 deaths every year throughout the world. Most deaths currently associated with influenza in industrialised countries occur among people over 65 years of age (WHO, 2003).

Reservoir

Humans are the only known reservoir of influenza types B and C. Influenza A may infect both humans and animals. There is no chronic carrier state.

Mode of transmission

The virus is easily passed from person to person through the air by droplets and small particles excreted when infected individuals cough or sneeze. The influenza virus enters the body through the nose or throat. It then takes between one and four days for the person to develop symptoms. Someone suffering from influenza can be infectious from the day before they develop symptoms until seven days afterwards.

The disease spreads very rapidly among the population, especially in crowded environments. Cold and dry weather enables the virus to survive longer outside the body than in other conditions and, as a consequence, seasonal epidemics in temperate areas appear in winter (WHO, 2003).

Incubation period

The incubation period varies from one to four days.

Influenza outbreaks aboard ships

From 1997 to 2005, nine confirmed outbreaks of influenza linked to ships were published in the scientific literature. The infectious agent in 7 out of 9 cases was the Influenza A virus and in one case Influenza B. A total of 898 cases were reported including passengers and crew members, and two of them were fatal. The attack rate ranged between 0.5 and 37%.

High attack rates of influenza are typically seen in closed settings such as cruises (Minooee and Rickman, 1999). During a cruise, passengers and crew from several nations intermingle for extended periods in semi-enclosed compartments. Shipboard activities such as dining, games, and movies increase the likelihood of contact between passengers and crew. Approximately one-third of cruise passengers are senior citizens. Elderly travellers and other persons with underlying health problems have an increased risk of complications following influenza virus infection (Miller et al., 2000).

Prevention and control

Influenza outbreaks among passengers and crew members on cruise ships suggest that travelling in large groups can pose a risk for exposure to influenza viruses, even when the group is travelling in regions where influenza is not in seasonal circulation. Both passengers and crew members can serve as potential sources of influenza infection (Anon, 2001).

The WHO recommend that elderly persons, and persons of any age who are considered to be at "high risk" of influenza-related complications due to underlying health conditions, should be vaccinated. Among the elderly, vaccination is thought to reduce influenza-related morbidity by 60% and influenza-related mortality by 70–80%. Among healthy adults the vaccine is very effective (70–90%) in terms of reducing influenza morbidity, and vaccination has been shown to have substantial health-related and economic benefits in this age group (WHO, 2003).

Recommendations for the prevention of influenza aboard ships have been published by several authors: Travellers at high risk for complications of influenza (e.g. persons aged more than 50 years, immunocompromised persons, and persons with chronic disorders of the pulmonary or cardiovascular systems) who were not vaccinated with influenza vaccine during the preceding fall or winter should consider receiving influenza vaccine before travel (Anon, 2001). Cruise lines should attempt to reach at least an 80% vaccination rate among crew members on each ship each year. Early suspicion of a potential influenza outbreak among crew members and rapid implementation of a respiratory illness control protocol can probably limit the size of outbreaks. Key elements of the protocol included (1) implementation of active and passive surveillance using standard case definitions; (2) use of targeted rapid influenza diagnostic testing and viral cultures to confirm cases of influenza virus infection; (3) isolation of all crew members meeting the Influenza-Like Illness (ILI) case definition or those with confirmed influenza; (4) use of antiviral agents for treatment and, if indicated, for prophylaxis; and (5) monitoring of intervention results. Because influenza viruses are usually spread by droplets and aerosols produced by an infected person who is coughing or sneezing, isolation can limit the spread of infection in semi-enclosed environments such as cruise ships (Miller et al., 2000). Although the number of days crew members with ILI were isolated from non-infected crew members and passengers was not reported, isolation measures ideally should have covered the first five days of illness, a period based on the duration of influenza virus shedding in adults (Bodnar et al., 1999).

A cost-effectiveness analysis for vaccination of crews on cruise ships showed that it is not only cost-effective but it is also cost saving (Ruben and Ehreth, 2002). Screening and quarantining entering travellers at international borders did not substantially delay virus introduction in past pandemics, except in some island countries, and will likely be even less effective in the modern era. Instead, the WHO recommends providing information to international travellers and possibly screening travellers departing countries with transmissible human infection (Bell, 2006).

More detailed guidelines for the prevention of influenza aboard ships are given in the: CDC Preliminary Guidelines for the Prevention and Control of Influenza-Like Illness Among Passengers and Crew Members on Cruise Ships, August 1999.

Pandemic influenza

The influenza virus is characterised by its great antigenic variability. Major modifications, called antigenic shifts or type changes, occur approximately three times per century and result in worldwide epidemics–pandemics. Pandemics and epidemics caused by influenza virus, such as the “Spanish Flu”, the “Asian Flu”, and the “Hong Kong Flu” killed many people worldwide (Turkulov and Madle-Samardzija, 2000). Pandemic influenza spreading via ships has been documented historically. Quarantine measures at ports only delayed the onset of influenza pandemic in many countries (Bell, 2006).

Most recently, the WHO declared influenza A (H1N1) a 2009 pandemic, and cases of the new virus have occurred on passenger ships (Russell, 2009). There is good guidance available to ships’ companies, medical officers, and masters (CDC, 1999; CDC, 2009; Mouchtouri et al., 2009; WHO, 2009).

Limited outbreaks of a new influenza subtype A (H5N1) directly transmitted from birds to humans have occurred in Hong Kong Special Administrative Region of China in 1997 and 2003 (WHO, 2003), and this was followed by the transmission of the bird infection to many parts of the world through bird migration, with sporadic cases in areas where close human contact with chickens is common.

4.2.2. Severe Acute Respiratory Syndrome

Recently, severe acute respiratory syndrome has been noted as a disease that probably originated from an animal host, and can spread within hospitals and the community, but might also be spread by travellers or on ships (WHO, 2007). This disease, caused by a coronavirus, is associated with a respiratory tract infection and flu-like symptoms. However, although initially presenting rather like influenza, complications can include severe pneumonia and respiratory system failure, which can be fatal.

4.2.3. Other respiratory diseases associated with ships

Other respiratory diseases such as tuberculosis, diphtheria, and rubella have been reported on ships. In 1997 a case of diphtheria was confirmed in an unimmunised 72-year-old woman who developed a sore throat during a cruise on the Baltic Sea (Anon, 1997a). In the same year, on a ship sailing between Florida and the Bahamas, CDC investigators found rubella infection in 16 crew members (4%), eight of whom had no symptoms. An additional 25 crew members (7%) had no rubella antibodies and were susceptible to infection. On another ship cruising a similar route, seven crew members experienced a rash (Hoey, 1998).

Transmission of tuberculosis is airborne, most often occurring by coughing or sneezing. Frequent overcrowding in a confined environment such as on a cruise or during air travel may increase the risk of infection. There are no published reports on the transmission of tuberculosis on board cruise ships

(Minooee and Rickman, 1999). Outbreaks involving crew members of other types of vessels which present conditions similar to those of cruises have been documented (DiStasio and Trump, 1990; Suzuki et al., 1997).

4.3. WATERBORNE DISEASES

Waterborne diseases result either from ingestion of contaminated water or ice, contact with water (e.g. bathing, wading, swimming, ocular exposure), or inhalation of aerosols generated from water that contains aetiological agents.

Diseases acquired by ingestion are classified as:

- intoxications caused either by chemical substances or preformed toxins produced by microorganisms; these may affect the gastrointestinal tract or other organs;
- infections caused by microorganisms that produce enterotoxins (i.e. toxins that affect tissues of intestinal mucosa, usually by interfering with salt and water transport) during their growth in the intestinal tract;
- infections caused by microorganisms that invade the intestinal tract and may travel to and affect other tissues (Rooney et al., 2004a).

There are a number of reported waterborne outbreaks on passenger ships (Daniels et al., 2000; Khan et al., 1994; Mintz et al., 1998; O'Mahony et al., 1986). A WHO review of over 100 outbreaks associated with ships found that one fifth of the outbreaks reported were attributed to a waterborne route (WHO, 2001).

4.3.1. Legionellosis

Infectious agent

Legionellae are poorly staining, Gram-negative bacilli. Internationally, about 90% of the cases of Legionnaires' disease are due to *L. pneumophila*, and the predominant serogroup 1 of *L. pneumophila* accounts for 84% of cases (Yu et al., 2002).

Most ship-associated cases have been ascribed to infection by *L. pneumophila* sg 1 (Rowbotham, 1998). However, *L. pneumophila* serogroups 5 (Kobayashi et al., 2004; Kura et al., 2006), 4, and *L. longbeachae* sg1 have been isolated from clinical specimens from passengers with Legionnaires' disease (Rowbotham, 1998).

Clinical features and severity of Legionellosis

Legionellosis is an acute bacterial disease with two currently recognised, distinct clinical and epidemiological manifestations: Legionnaires' disease and Pontiac fever. Both are characterised initially by anorexia, malaise, myalgia, and headache. Within a day, there is usually a rapidly rising fever associated with chills. Temperatures commonly reach 39–40.5°C. A non-productive cough, abdominal pain, and diarrhoea are common. In Legionnaires' disease, a chest radiograph may show patchy or focal areas of consolidation that may progress to bilateral involvement and ultimately to respiratory failure.

Pontiac fever is not associated with pneumonia or death; patients recover spontaneously in 2–5 days without treatment; this clinical syndrome may represent reaction to an inhaled antigen rather than bacterial invasion.

Diagnosis depends on isolating the causative organism on special media, its demonstration in tissue or respiratory secretions by direct IF stain, or detection of antigens of *Legionella pneumophila* serogroup 1 in urine by RIA or by a four-fold or greater titre.

Epidemiology and severity

Legionellosis is neither new nor localised, since the earliest documented case occurred in 1947 and the earliest documented outbreak in 1957 in Minnesota. Since then, the disease has been identified throughout North America, as well as in Australia, Africa, South America, and Europe. Although cases occur throughout the year, both sporadic cases and outbreaks are recognised more commonly in summer and autumn. Serological surveys suggest a prevalence of antibodies to *L. pneumophila* serogroup 1 at a titer of 1:128 or greater in 1–20% of the general population in the few locations studied. The proportion of cases of community acquired pneumonias that are due to *Legionella* ranges between 0.5% and 5.0% (American Public Health Association, 2000).

Outbreaks of legionellosis usually occur at low attack rates (0.1–5%) in the population at risk. Pontiac fever outbreaks have frequently had high attack rates (about 95%).

Inhalation of contaminated aerosols may result in pneumonia, with a high mortality rate 20% (Gaillot, 2004). The case fatality rate has been as high as 39% in hospitalised cases and it is generally higher in those with compromised immunity.

Underdiagnosis and underreporting are common. Only 2–10% of estimated cases are reported (Sabria and Campins, 2003).

Reservoir

Legionella is commonly found in warm aquatic environments. Hot water systems (showers), air conditioning cooling towers, evaporative condensers, humidifiers, whirlpool spas, respiratory therapy devices, and decorative fountains have been implicated epidemiologically. The organism has been isolated from water in these, as well as from hot and cold water taps and showers, hot tubs, and from creeks and ponds and the soil from their banks. The organism survives for months in tap and distilled water. An association of Legionnaires' disease with soil disturbances or excavation has not been clearly established.

Mode of transmission

Legionnaires' disease is normally contracted by inhaling *Legionella* bacteria, either in tiny droplets of water (aerosols), in droplet nuclei (the particles left after the water has evaporated) contaminated with *Legionella* spp., or in *Legionella* infected amoebae through inhalation deep into the lungs. There is evidence that the disease may also be contracted by inhaling *Legionella* spp. bacteria following ingestion of contaminated water by susceptible individuals. Person to person transmission has not been documented.

Duration

Legionnaires' disease lasts 2–10 days, most often 5–6 days; Pontiac fever 5–66 hours, most often 24–48 hours.

Susceptibility and resistance

Illness occurs most frequently with increasing age (most cases are at least 50 years of age), especially in patients who smoke and in those with diabetes mellitus, chronic lung disease, renal disease, or malignancy; and in the immunocompromised, particularly those who are receiving corticosteroids or who have had an organ transplant. The male to female ratio is about 2.5:1. The disease is extremely rare in those under 20 years of age. Several outbreaks have occurred among hospitalised patients.

Legionnaires' disease aboard ships

Incidents of Legionnaires' disease have been associated with ships. The World Health Organization compendium published in 2001, showed that from 1970 to 2000, 51 incidents of Legionnaires' disease (LD) were reported to be associated with ships, involving almost 200 cases, while 10 fatalities were recorded (WHO, 2001).

Environmental investigation

Environmental studies that have investigated *Legionellae* contamination of water systems aboard ships have revealed a high prevalence of *Legionella* spp. The following described studies were not conducted to associate outbreaks with environmental investigation findings. A study carried out on nine ships docked at the seaports of northern Sardinia in 2004 found that 42% (38/90) of the water samples examined were contaminated by *Legionella* spp. *L. pneumophila* was isolated in 42/44 samples (95.5%), followed by *L. micdadei* (4.5%). Strains were identified as *L. pneumophila* serogroup 6 (45.2%; 19 samples), 2–14 (42.9%), 5 (7.1%), and 3 (4.8%). *Legionella* spp. load was high; 77.8% of the water samples contained > 10^4 CFU/L (Azara et al., 2006).

Another study was carried out on 21 ferries and 10 cruise ships in Greece in 2004. The 133 samples collected from the 10 cruise ships' water distribution systems, air conditioning systems, and pools were negative for *Legionella* spp. Of the 21 ferries' water distribution systems examined, 14 (66.7%) were legionellae-positive. A total of 276 samples were collected from water distribution systems and air conditioning systems. *Legionella* spp. was isolated from 37.8% of the hot water samples and 17.5% of the cold water samples. Of the total 96 positive isolates, 87 (90.6%) were *L. pneumophila* (Goutziana et al., 2008).

Prevention and control

Epidemiological data and environmental investigation findings suggest that Legionnaires' disease is an important public health problem aboard ships and measures for the prevention and control of the disease should be taken. The lack of specific guidelines and policy aboard ships have been highlighted (Breyrer et al., 2006).

Enforcement of health and safety on ships is made difficult because cruise ships are in dock for relatively short periods, often move from country to country, and sail under foreign flags. Ideally, there would be an internationally accepted programme of certification of vessels to agreed sanitation standards. Breyrer et al. suggest that a practical approach in the short term might involve tour operators only commissioning cruises when they are satisfied that the ship has up-to-date risk assessment, an ongoing *Legionella* control programme with appropriate temperature-monitoring records, and medical staff trained in recognition of LD on board (Breyrer et al., 2006).

Specific measures for the prevention and control of *Legionella* spp. aboard ships can be found in the following guidelines:

1. World Health Organization. Rolling Revision of the WHO Guidelines for Drinking-Water Quality. Draft for review and comments (not for citation). Guide to Ship Sanitation. WHO, Geneva. October 2004.
2. World Health Organization. Sustainable Development and Healthy Environments. Sanitation on ships: compendium of outbreaks of foodborne and waterborne disease and Legionnaires' disease associated with ships, 1970–2000 WHO/SDE/WSH/01.4.
3. European Surveillance Scheme for Travel Associated Legionnaires' disease and the European Working Group for Legionella Infections European Guidelines for Control and Prevention of Travel Associated Legionnaires' Disease. London 2005.

4. Centres for Disease Control and Prevention. Final recommendation to minimize transmission of Legionnaires' disease from Whirlpool Spas on cruise ship. Atlanta, Georgia. CDC, 1997.
5. Health Protection Agency. Management of Spa Pools — Controlling the Risks of Infection. Health Protection Agency 2006.
6. Centres for Disease Control and Prevention. Vessel Sanitation Programme Operations Manual 2005.

4.3.2. Other waterborne diseases

A review on the outbreaks of waterborne diseases associated with ships, within the framework of a World Health Organization project on setting guidelines for ship sanitation, showed that from January 1970 to June 2003 there were a total of 21 reported waterborne outbreaks associated with ships of all types. Out of the 21 water-related outbreaks only 12 were identified as having water or ice as a source. In seven outbreaks (33%), water or ice was the probable or possible source, and in two outbreaks it was the suspected source. The majority of outbreaks were found to be associated with passenger ships (18/ /21; 86%) (Rooney et al., 2004a).

Enterotoxigenic Escherichia coli (ETEC) was the principal pathogen and was involved in one third of the outbreaks. Other pathogens included noroviruses (formally Norwalk-like viruses), *Salmonella* spp., *Shigella* sp., *Cryptosporidium* sp., and *Giardia* sp. One outbreak of chemical water poisoning was caused by hydroquinone. The aetiological agent was not identified in one-quarter (25%) of the outbreaks (Rooney et al., 2004a).

Information on mortality and morbidity was available in 20 outbreak reports. A total of 6,405 people were affected, with two deaths reported from two different outbreaks. The organisms associated with these deaths were *Salmonella typhi* and *Shigella flexneri 2a*.

The number of passenger days spent on ferries worldwide is likely to be at least equal to that spent on cruise ships, and the risk factors and exposures for cruise ships and ferries are likely to be similar. The complete absence of ferries from reported outbreaks is probably due to the short duration of time on board relative to the incubation period of the disease. Thus, if an outbreak was to occur, the affected individuals would likely arrive at a destination port and disperse before symptoms developed (Rooney et al., 2004a).

Prevention and control

The review by Rooney et al. identified that the factors which contributed to outbreaks included contaminated port water loaded onto the ship, defective storage tanks, cross connections at loading, inadequate residual disinfection, and defective backflow preventers (Rooney et al., 2004a).

The revised draft of the WHO Guide to Ship Sanitation includes guidelines on the prevention of waterborne diseases. In particular, the guidelines cover the following topics: water system risk assessment, hazard analysis, management plan, control measures, monitoring, and corrective actions. Different guidance is given per water management stage: water source, water production, storage, and distribution.

The WHO Guidelines for drinking water quality include details of the health risks from ship potable water, issues that should be taken into consideration when undertaking risk assessment of the ship's drinking water system, operational monitoring, management of potable water, and surveillance to ensure drinking water safety on ships (WHO, 2006a).

Reference should be made to two important standards in relation to sanitary design and construction of ship water supplies (http://www.iso.org/iso/ /en/ISOOnline.frontpage):

- ISO 15748–1: 2002 — Ships and marine technology — Potable water supply on ships and marine structures — Part 1: Planning and design; and
- ISO 15748–2: 2002 — Ships and marine technology — Potable water supply on ships and marine structures — Part 2: Method of calculation.

It is worth noting that the majority of the reported outbreaks should have been prevented by simple chlorination of the water.

4.4. FOODBORNE DISEASES

Foodborne diseases occur daily in all countries in multiple settings such as restaurants, nursing homes, and hotels, attract media attention, and raise consumer concern. Several foodborne outbreaks have been reported aboard passenger ships.

Foodborne diseases have been defined by the WHO as any diseases, usually either infectious or toxic in nature, caused by agents that enter the body through the ingestion of food. Every person is at risk of foodborne illness (WHO, 2002a).

Foodborne biological hazards include bacteria, viruses, fungi, and parasites. Chemical hazards may be naturally occurring or may be added during the processing of food (U.S. Department of Health and Human Services, 2005).

Foodborne outbreaks can have potentially serious health consequences for passengers and crew. In economic terms, foodborne diseases aboard passenger ships can be very costly for the passenger liners and can harm their reputation.

Foodborne outbreaks aboard ships

There are a number of reported outbreaks of ship-related foodborne diseases (Berkelman et al., 1983; Boyce et al., 1995; Hobbs et al., 1976; Koo et al., 1996; Lawrence et al., 1979; Lew et al., 1991; Merson et al., 1975a; Snyder et al., 1984b; Waterman et al., 1987). The WHO review of over 100 outbreaks associated with ships found that two fifths of the outbreaks reported were attributed to a foodborne route (WHO, 2001).

A review of outbreaks of foodborne diseases associated with passenger ships within the framework of a World Health Organization project on setting guidelines for ship sanitation showed that from January 1970 to June 2003 a total of 50 foodborne outbreaks occurred (Rooney et al., 2004b). The majority of outbreaks 44 (88%) were associated with ocean cruise ships, four outbreaks were associated with ferries, and two were associated with river cruises. Five outbreaks were associated with on-shore excursions and two with packed lunches.

Forty-one outbreaks (82%) were due to bacterial pathogens, and the rest were due to viruses, parasites, or agents of unknown aetiology. *Salmonella* spp. were the pathogens most frequently associated with outbreaks. Other agents included enterotoxigenic *E. coli*, *Shigella* spp., *Vibrio* spp., *Staphylococcus aureus*, *Clostridium perfringens*, *Trichinella*, and *Cyclospora*.

Almost 10,000 people were affected, and 33 people were hospitalised. One death was reported, which was associated with an outbreak of *Shigella flexneri 2*.

One or more contributing factors were reported for 20 (40%) of the outbreaks. These factors included inadequate temperature control, infected food handlers, contaminated raw ingredients, cross contamination, and inadequate heat treatment. Contributing factors were identified for 15 (30%) outbreaks with a confirmed or presumptive food vehicle.

Seafood was implicated in almost one third of the outbreaks; other vehicles included salads, eggs, poultry, and red meat. The pathogens and toxins linked to outbreaks of foodborne disease were identified in the review of Rooney et al. (2004).

The 50 reported foodborne disease outbreaks identified in this review most likely underestimate the true number. This is because some outbreaks do not come to the attention of the health authorities, few reports are published, and it is likely that many outbreaks remain undetected. Outbreaks are infrequently detected on ferries. Although large numbers of passengers travel on ferries on each sailing, the short duration of these trips and the rapid dispersal of passengers afterwards make it very difficult to detect outbreaks (Rooney et al., 2004b).

Prevention and control

The review by Rooney et al. (2004) identified that factors contributing to outbreaks included inadequate temperature control, infected food handlers, contaminated raw ingredients, cross contamination, and inadequate heat treatment. Many of the outbreaks could have been prevented if measures had been taken.

The revised draft of the WHO Guide to Ship Sanitation includes details on food safety issues including the construction of food establishments, display and layout, equipment and utensils, facilities (water, cleaning and disinfecting, ventilation, lighting, storage), operational management (sources of food, hygiene control systems), and HACCP principles.

The International Labour Organization (ILO, 1976) has developed labour standards that include consideration of food and catering requirements and competencies for merchant ships.

The Codex Alimentarius Commission (CAC) implements the joint FAO/WHO Food Standards Programme, the purpose of which is to protect the health of consumers and to ensure fair practices in the food trade. The Codex Alimentarius is a collection of internationally adopted food standards presented in a uniform manner. It also includes provisions of an advisory nature in the form of codes of practice, guidelines, and other recommended measures to assist in achieving the purposes of the Codex Alimentarius. The CAC guidance provides important information on basic food safety http:////www.codexalimentarius.net. See also Chapters 5 and 6.

4.5. NOROVIRUS INFECTION

Noroviruses are now recognised as the most common cause of sporadic cases of diarrhoea in the community (Rockx et al., 2002). These viruses have previously been referred to as small-round-structured viruses, Noroviruses, or human caliciviruses. The first recognised norovirus (NoV) gained its name from an outbreak of ‘winter vomiting disease’ in 1968 at an elementary school in Norwalk, Ohio, USA (Adler and Zickl, 1969). At that time there was no conclusive evidence that viruses were agents of acute gastroenteritis (Hutson et al., 2004). In 1972, however, it was demonstrated that the unidentified Norwalk agent was indeed a virus (Kapikian et al., 1972).

4.5.1. The virus

NoV is the prototype strain of genetically and antigenically diverse single-stranded RNA (ribonucleic acid) viruses, which are classified in the genus Noroviruses (NoVs) in the family Caliciviridae (Parashar et al., 2001). NoVs can be classified into at least five genetic groups. Two of these genetic groups, called genogroups I and II (GI and GII), contain the majority of the human NoVs (Hutson et al., 2004). GIII infect pigs and cows. Phylogenetic analysis places at least two human NoVs within a proposed GIV: strains Alphatron and Fort Lauderdale (Fankhauser et al., 2002). The recently described murine norovirus forms a proposed GV genetic group (Hutson et al., 2004). NoVs in GI and GII can be further subdivided into genetic clusters, designated I.1 to I.8 and II.1 to II.17, respectively (Atmar and Estes, 2006). The GII.4 NoVs have been the predominant circulating strains detected in the population since the 1990s (Fankhauser et al., 2002).

4.5.2. Clinical feature — Epidemiology — Mode of transmission

Clinical feature

Human volunteer NoV infection studies revealed that approximately 82% of inoculated volunteers became infected. Of the latter, 68% were symptomatic and 32% had trivial or no symptoms (Graham et al., 1994). Through RT-PCR NoV, gastroenteritis was diagnosed among patients who presented to their primary care doctors with acute gastroenteritis (Rockx et al., 2002). All ages were indiscriminately affected. Symptoms included diarrhoea (87%), vomiting (74%), abdominal pain (51%), abdominal cramps (44%), nausea (49%), fever (32%), and mucus in stool (19%), but none had bloody stools. Vomiting occurred during the first days of illness. Symptoms lasted for a median of 5 days. Diarrhoea lasted a median of 4 days, but occasionally up to 28 days. Symptoms persisted for longer periods in older patients. This clinical description of the spectrum of illness seen in NoV gastroenteritis fits well with what is seen in outbreaks although a shorter duration of illness is frequently seen in outbreaks (Goodgame, 2006).

Almost all patients with NoV gastroenteritis recovered completely and rapidly without sequelae. Increased morbidity has been associated with certain strains, settings, and certain at-risk groups (Goodgame, 2006).

Epidemiology of gastrointestinal infections on cruise ships

Cruise ships were found to be the third most common setting (16%) of NoV outbreaks in the US, during the period 1996 to 2004 (Goodgame, 2006). A recently published paper by Cramer et al. (2006) evaluated incidence rates of gastroenteritis on cruise ships calling on U.S. ports and carrying 13 or more passengers, using Gastrointestinal Illness Surveillance System data. The following data concern gastrointestinal diseases and not exclusively NoV gastroenteritis. However, NoVs are currently recognised as the cause of almost all (96%) outbreaks of non-bacterial gastroenteritis (Mead et al., 1999), and the majority of the reported outbreaks to the VSP CDC were attributed to NoV infection, according to the website database (http://www.cdc.gov/nceh/vsp//surv/GIlist.htm#2001). The potential burden of NoV disease can be understood by examining the disease burden of gastroenteritis of all causes in cruise ships.

From 2001 to 2004, the background (non-outbreak) case incidence was 3.25 passengers with acute gastroenteritis (AGE) per cruise (48,206//14,842). The outbreak associated case incidence was 85 passengers with AGE per cruise (6,747 outbreak associated cases per 79 outbreak associated cruises).

The combined outbreak and non-outbreak incidence rates of gastroenteritis per 100,000 passenger days among 14,842 cruises were higher on cruises longer than 7 days than on cruises lasting 3 to 7 days. AGE incidence rates per 100,000 passenger days varied by reporting region.

Among the 71 outbreak-associated cruises, the overall incidence rate was 4.8 outbreaks per 1,000 cruises and 3.8 outbreaks per 10,000,000 passenger days (Cramer et al., 2006).

Available reviews of infirmary data have shown that gastrointestinal illnesses account for less than 10% of all visits by passengers to ships' infirmaries (Peake et al., 1999).

The likelihood of contracting gastroenteritis on an average 7-day cruise at sea is less than 1% (Cramer et al., 2006).

Mode of transmission

NoVs are transmitted through the faecal-oral route, by consumption of faecally contaminated food or water, direct person-to-person spread, or environmental and aerosolised droplet contamination (Goodgame, 2006).

Frequently, during an outbreak, primary cases result from exposure to a faecally contaminated vehicle (e.g. food or water), whereas secondary and tertiary cases among contacts of primary cases result from person-to-person transmission (Becker et al., 2000).

During a 1994 study of 50 volunteers exposed to NoV, 82% became infected; of these infections, 68%

resulted in illness, whereas the remaining 32% were asymptomatic (Graham et al., 1994). Viral shedding in stools began 15 hours after virus administration and peaked 25 to 72 hours after virus administration. Unexpectedly, viral antigen could be detected by ELISA in stool specimens collected 7 days after inoculation in both symptomatic and asymptomatic persons. In a later study on infected volunteers, viral antigen in stools was detected ≤ 2 weeks after administration of virus (Okhuysen et al., 1995). New, more sensitive molecular assays revealed that many infected persons have the virus in their stools for several weeks after the resolution of symptoms (Atmar and Estes, 2006).

The low infectious dose of NoVs (expert opinions have placed the infectious dose at < 10–100 virons [Atmar and Estes, 2006]), readily allows spread by droplets, fomites, person-to-person transmission, and environmental contamination, as evidenced by the enhanced rate of secondary and tertiary spread among contacts and family members. The prolonged duration of viral shedding that can occur among asymptomatic persons increases the risk for secondary spread and is of concern in food handler-related transmission. The ability of the virus to survive at relatively high levels of chlorine (Keswick et al., 1985) and varying temperatures (i.e. from freezing to 60°C) facilitates its spreading through recreational and drinking water and food items, including steamed oysters (McDonnell et al., 1997). Because of the diversity of NoV strains, lack of complete cross protection, and lack of long-term immunity, repeated infections can occur throughout life (Parashar et al., 2001).

Transmission on cruise ships

Investigations on cruise ships have confirmed that outbreaks can be transmitted by multiple modes and can recur on subsequent cruises. Isakbaeva et al. (2004) reported a large outbreak of NoV-related gastroenteritis that affected six consecutive cruises and recurred despite thorough sanitisation after the second cruise. Epidemiological analysis suggested an initial foodborne source of infection with subsequent secondary spread from person to person, while molecular analysis provided several new insights into disease transmission. Several introductions of new strains aboard were confirmed (Isakbaeva et al., 2005). The arrival of new and susceptible passengers every 1 or 2 weeks on affected cruise ships provides an opportunity for sustained transmission during successive cruises. NoV outbreaks extending beyond 12 successive cruises have been reported (Ho et al., 1989).

Other published investigations of NoV outbreaks have confirmed an association between illnesses on cruise ships and shared bathrooms with ill cabin mates who vomit (Lawrence, 2004), and on land, an association between illness and transmission associated with fomites such as contaminated carpets (Cheesbrough et al., 1997) and soft furnishings (Evans et al., 2002).

4.5.3. Norovirus outbreaks aboard ships in Europe and the US

Europe

A large number of Norovirus outbreaks are reported in Europe every year in different settings, including healthcare facilities, food establishments, and vacation venues. Between 1st January and 5th July 2006, 42 reported outbreaks of gastroenteritis on 13 different cruise ships sailing in European waters were confirmed or suspected to be caused by NoV. Almost 1,500 cases of gastroenteritis were reported among passengers and crew, but no common source was determined (Lopman et al., 2004). Details of the NoV outbreaks that have been reported in the European Member States authorities are presented in Table 4.

The NoV GII.4 variant “2006b” was found to be circulating widely, causing these outbreaks of NoV illness in cruise ships across Europe (Koopmans et al., 2006; Kroneman et al., 2006). Based on previous years’ experience, an ECDC expert panel considered it likely that the emergence of new NoV strains coincided with increased reports of outbreaks in European countries, which was reflected by increased activity on cruise ships (Depoortere and Takkinen, 2006). In 2002 and 2003, a previously undescribed NoV, GII.4/Farmington Hills, caused a dramatic increase in the number of US NoV outbreaks in 10 different states and on cruise ships (Widdowson et al., 2004). Moreover, Lopman et al. found that in 2002, a striking increase and unusual seasonal pattern of NoV gastroenteritis occurred with the emergence of a novel genetic variant. They suggested that the new strains of NoVs that took over might be more virulent or more environmentally stable, or fewer people may have had resistance to it, leading to more widespread disease (Lopman et al., 2004).

United States

The incidence of diarrhoeal disease among cruise ship passengers declined from 29.2 cases per 100,000 passenger days in 1990, to 16.3 per 100,000 passenger days in 2000 (Cramer et al., 2003).

Table 4. Norovirus outbreaks in Europe in 2006 (Takkinen, 2006)

Date	Route	Country reported	Cases	Morbidity and mortality	Mode of trans-mission	Infectious agent	Comments
April 2006	Zutphen (Netherlands) —Antwerp (Belgium)	The Nether-lands		15		Swab samples from door handles, toilets, and a reception counter positive for NoV. Sequences determined: GGII.4. A stool sample was collected from one of the patients and tested negative for NoV.	At the time of reporting, some hygiene measures had been taken. The ship was thoroughly cleaned before the arrival of a new group of passengers. No new cases have been reported
May and June 2006	Kiel (Germany), Nijmegen (Netherlands), Vienna (Austria)	The Nether-lands	Several				2 outbreaks. During the second out were break, patient samples collected in Germany and sent to RIVM in Bilthoven for NoV testing. No further information available at this time.
May and June 2006	Harwich (UK), Bergen (Norway), Flam (Norway), Gudangan (Norway), Rosendal (Norway), Harwich	England	May: 70 pass-engers and 15 crew members June: 28 pass-engers		Both trips included an excursion to a fish market where passengers ate various fish and shellfish. Therefore this market is a potential source of infection.		During the 1st outbreak, stool samples from passengers were ex-amined for NoV at a laboratory in Trondheim, Norway. Due to mis-communication, no patient or environmental samples were taken during the 2nd outbreak.

In 2002, the Vessel Sanitation Programme of the Centres for Disease Control and Prevention reported 29 outbreaks (3% or more passengers ill) of acute gastroenteritis on cruise ships, an increase from 3 the previous year (Cramer et al., 2006).

Surveillance data of the US VSP from 2001 to 2004 indicated that 79 cruises were associated with outbreaks. Seventy-one were considered unique outbreaks; eight were excluded because they were associated with an outbreak on the same ship during the previous contiguous cruise and were associated with either the same or an unidentified pathogen. Among the remaining 71 outbreak-associated cruises, the overall incidence rate was 4.8 outbreaks per 1,000 cruises and 3.8 outbreaks per 10,000,000 passenger days. The outbreaks per 1,000 cruises increased from 0.65 in 2001 to 6.45 in 2002, and then dropped down to 5.73 in 2003 and to 5.46 in 2004.

In 2005, 14 outbreaks were reported to the US VSP from the ship's medical staff.

In 2006, 32 NoV outbreaks were reported, involving 4,527 passenger cases (6.70% Attack Rate) and 557 crew members' cases (2.00% Attack Rate). Two "Not sail recommendations" were issued because the number of ill passengers and crew were higher than expected in subsequent cruises.

4.5.4. European Centre for Disease Prevention and Control actions

The ECDC expert panel, with expertise in the fields of NoV epidemiology and microbiology, including experts from the EU funded project and the CDC Vessel Sanitation Program (VSP), met in September 2006 with the following objectives (ECDC, 2006):

- to review current NoV epidemiology in Europe;
- to assess the actions needed to prevent and control future outbreaks in cruise ships;
- to review the existing guidelines for prevention and control measures in cruise ships and other public settings.

The need for guidance and legal framework was clearly identified.

The main challenges determined with relation to the current NoV prevention and control strategies were:

- The two new NoV strains have been identified over a vast geographic region (Australia, Hong Kong, and Europe). Transmission via members of a ship's crew, over and above the usual transmission, may account for such a wide dissemination of new variants, given that they often come from different countries and travel widely.
- The implementations of hygiene measures and the reporting of outbreaks vary considerably depending on whether or not the ships call at US ports. Regulations in the US are stricter and the occurrence of outbreaks is reported on the internet in a transparent way. The US CDC publishes scores based on sanitation inspections of the affected ships, and outbreaks are published within a voluntary VSP activity. In Europe, analysis of Hazard Analysis Critical Control Point (HACCP) in cruise ships could be carried out.
- Collaboration by the public health agencies with and among the ship owning companies is recommended. Good cooperation between the medical staff would be a good start. In the US, sanitary inspections are paid for by the companies themselves, bearing in mind the benefits of not having outbreaks on their cruises.
- In Europe, it is not clear whether and where reports of epidemics in the cruise ships are registered. While some ships keep their own logs for outbreak episodes, there is a strong need for an international registry for cruise ship outbreaks.
- There is also a need to identify ground rules with regard to exactly what the response to an NoV outbreak on a cruise ship should entail, how rapidly the response should be triggered, and how the activities should be coordinated on an international level when necessary.

The panel concluded that practical and standardised guidelines for the implementation of prevention and control measures, based on best practices identified from previous experience, should be developed. The cruise ship industry has a major interest in limiting and containing NoV outbreaks, so there is an opportunity for a close and mutually beneficial collaboration between public health authorities and industry.

4.5.5. Prevention and control

A large number of guidelines have been published for NoV environmental cleaning in various settings and mainly hospitals. Specific guidelines for cruise ships are going to be published by the UK Health Protection Agency. Other recommendations for the prevention and control of NoV infection can be found in scientific papers.

Foodborne transmission

Good food handling practices should be applied because any food item can potentially be infected with NoVs. However, certain foods are implicated more often than others in outbreaks of NoV gastroenteritis. Shellfish (e.g. oysters or clams) tend to accumulate NoVs in their tissues by filtering them out of contaminated waters from which they are harvested (Shieh et al., 2000), and shellfish meeting bacteriologic standards of hygiene can contain NoVs. Moreover, cooking (e.g. steaming) might not completely inactivate NoVs. Raw shellfish consumption is recommended to be avoided.

Food contamination by infectious food handlers is another possible cause of NoV gastroenteritis outbreaks. In view of the low infectious dose of NoVs and the high concentration of virus in stools, even a limited contamination can result in substantial outbreaks. Ready-to-eat foods that require handling but no subsequent cooking (e.g. salads and deli sandwiches) represent a high risk. In the past, the exclusion of ill food handlers for 48–72 hours after resolution of illness was recommended to prevent outbreaks caused by food handlers (Parashar et al., 2001).

Waterborne transmission

In three NoV waterborne outbreaks occurring aboard ships the contributing factors identified included: a) defective backflow preventers on ice machines, b) bilge water cross connection, and c) contaminated loaded water (Rooney et al., 2004a). Measures such as safe and reliable source of water, treatment of loaded water, regular inspection and maintenance of backflow preventers, and proper handling of ice should be taken.

Swimming pools have been implicated in NoV outbreaks and should not be used by infected persons (Podewils et al., 2007). Chemical water disinfection and frequent control of the residual levels is recommended.

Detailed guidelines for drinking and recreational water safety are provided in the revised WHO Guide to Ship Sanitation, while specific requirements can be found in the US CDC Vessel Sanitation Programme Manual. See also waterborne disease prevention and control (see Chapter 6).

Person-to-person transmission

Frequent hand washing with soap and water is an effective means of prevention. The recommended procedure is to rub all surfaces of lathered hands together vigorously for ≤ 10 seconds and then thoroughly rinse the hands under a stream of water. Since spattering or aerosols of infectious material might be involved in disease transmission, wearing masks should be considered for persons who clean areas substantially contaminated by faeces or vomitus (e.g. hospital or nursing home personnel). Soiled linen and clothes should be handled as little as possible and with minimum agitation. They should be laundered with detergent at the maximum available cycle length and then machine dried (Parashar et al., 2001).

Isolation of ill persons, provision of paid sick leave for ill crew, and the development of strategies and incentives to dissuade symptomatic passengers from boarding may minimise the risk of person-to-person transmission and the opportunities to introduce infected persons aboard ship (Isakbaeva et al., 2005).

Environmental surfaces

Cleaning and disinfecting are strongly recommended for preventing spread from environmental surfaces. Specific procedures should be applied and effective detergents and disinfectants should be used for NoV inactivation. Appropriate agents should be used for different types of surface (hard surfaces, curtains, furniture, etc.). Not many commercial disinfectants are effective against NoVs. NoVs cannot be cultivated *in vitro*. However, feline calicivirus can be used as a surrogate to determine disinfectant efficacy against NoVs (Jimenez and Chiang, 2006). Ingredients used as disinfectants include sodium hypochlorite, chlorine dioxide, hydrogen peroxide, and others.

Conclusion — recommendations

Foodborne and waterborne transmission of pathogens including NoV have been effectively prevented and controlled aboard ships in recent years. There are effective guidelines and adequate legislation for the prevention of contamination of food and water. However, the prevention and control of the transmission of these pathogens from one person to another, or through the air or from environmental surfaces, have not been adequately described and specific legislation has not been developed yet. Therefore, guidance or legislation for controlling and preventing the transmission of NoV through these modes is required. Specific strategies for the actions of governmental agencies and the ship industry should be put in place. Guidance for the management of Norovirus infection on cruise ships has been developed by the Health Protection Agency (Norovirus Working Group, 2007).

Science-driven plans of action based on the principles of the preventative control system “Hazard Analysis Critical Control Point” have been recommended by professional bodies (USDA, FDA). The NoV chain of infection is considered as a system. Systematic analysis of the chain of infection reveals important information and makes it possible to determine how to stop infection most effectively. A link in the chain that must be broken is designated as a “critical control point” or “CCP”. The links in the chain that are not deemed critical are still important, but emphasis from a management standpoint rests with the CCPs (Environ Health Associates, Inc. Technical Report 1: Norovirus Contamination and Control http://www.safefoods.tv/9.html).

4.6. VECTORBORNE DISEASES

Ships have been implicated in the transmission of vectorborne diseases worldwide. They may play a role as the courier of a vector, or may transfer an infected passenger. The introduction in a region of potential vectors of disease may result in the transmission of diseases not previously endemic. However, the invasion and establishment of a new vector in an area depends mainly on biological, social, and environmental factors (Wilson, 1995; Wilson, 2003).

Surveillance, vaccination, and control measures against vectorborne diseases, as well as deratting and disinsection aboard ships are regulated by the International Health Regulation (WHO, 2005). Nowadays, cruise ships sail in exotic and remote parts of the world such as the Amazon and African rivers. Travellers cruising in some tropical and subtropical countries are at great risk of exposure to vectorborne diseases. Travelling in European countries does not present a risk for vectorborne diseases such as Yellow fever, Malaria, or Dengue fever.

The role of some synanthropic insects such as flies and cockroaches in human infections is very important since they are considered as efficient vectors and transmitters of human enteric protozoan parasites (Majewska, 1986) and they can both be present in passenger ships.

4.6.1. Vector dispersal by ships

The historical evidence for the role of ship travel and trade routes in the spread of microbes and their vectors between countries was described in detail in Chapter 4.1. In this part, recently reported incidences of vector dispersal and vectorborne disease transmission via ships are presented.

Successive waves of invasion of the vector mosquitoes *Aedes aegypti*, the *Culex pipiens Complex*, and, most recently, *Aedes albopictus* have been facilitated by worldwide ship transport (Lounibos, 2002). The first major discovery of a large population and subsequent establishment of *Aedes albopictus* in the U.S. was reported in 1986 in Houston, TX, in a shipment of used tires from Japan. In early June 2001, infestations of this species associated with containerised oceanic shipments of "lucky bamboo" (*Dracaena* spp.) packaged in standing water were introduced into southern California from mainland south China (Madon et al., 2002).

Tatem et al. used a comprehensive database of international ship and aircraft traffic movements, combined with climatic information, to remap the global transportation network in terms of disease vector suitability and accessibility. The expansion of the range of *Aedes albopictus* proved to be surprisingly predictable using this combination of climate and traffic data. Traffic volumes were more than twice as high on shipping routes running from the historical distribution of *Ae. albopictus* to ports where it had established in comparison with routes to climatically similar ports where it was yet to invade. In contrast, *An. gambiae* has rarely spread from Africa, which they suggest is partly due to the low volume of sea traffic from the continent (Tatem et al., 2006).

Rodents and arthropods including mosquitoes, cockroaches, mites, flies, fleas, ticks, and other pests may enter a ship through the ship's gates, or might be carried in humans' or animals' bodies, in luggage, vehicles, or in ships loads. Cockroaches and flies are often found aboard passenger ships and their presence indicates poor sanitation standards and threatens food safety. The house fly, *Musca domestica*, has long been considered a potential agent for disease transmission ever since its existence (Nazni et al., 2005), while cockroaches represent an important reservoir for infectious pathogens (Tatfeng et al., 2005).

Historically, rodents aboard ships have played a major role in the transmission of plague and nowadays they are present in non passenger ships and occasionally in ports worldwide. A quarter of ships arriving in Chinese seaports have rodent infestations. The surveys conducted in those ports showed that the percentages of incoming vessels carrying mosquitoes, flies, and cockroaches were 20%, 15%, and 50%, respectively (Song et al., 2003).

Cruise ship inspection reports by US Vessel Sanitation Programme personnel have described the presence of cockroaches, drain flies, house flies, and fruit flies aboard some cruise ships (http://wwwn.cdc.gov/vsp/ /InspectionQueryTool/Forms/InspectionSearch.aspx).

A survey carried out in 21 Greek ferries revealed that neither rats nor mice were trapped onboard, but three of the ferries had been infested with rats or mice in the past. Eighteen ferries were infested with flies (85.7%), 11 with cockroaches (52.3%), three with bedbugs, and one with fleas. Other species found on board were ants, spiders, butterflies, beetles, and a lizard. A total of 431 *Blattella germanica* species were captured in 28 (9.96%) traps, and 84.2% of them were nymphs. Only one ship was found to be highly infested (Mouchtouri et al., 2008).

4.6.2. Vectorborne diseases associated with ships

Malaria

Malaria is a common and life-threatening disease in many tropical and subtropical areas. It is currently endemic in over 100 countries which are visited by more than 125 million international travellers annually. It is estimated that annually over 10,000 international travellers fall ill with malaria after returning home from countries where the disease is endemic. Due to under-reporting, the real figure may be up to 30,000 (CDC, 2007b). International travellers are at high malaria risk because they are non-immune and are frequently diagnosed late or misdiagnosed when returning to their home country. Human malaria is caused by four different species of the protozoan parasite Plasmodium: *Plasmodium falciparum, P. vivax, P. Ovale*, and *P. malariae*. The malaria parasite is transmitted by various species of *Anopheles* mosquitoes, which bite mainly between sunset and sunrise. The time between the infective bite and the appearance of clinical symptoms is approximately 7–14 days for *P. falciparum*, 8–14 days for *P. vivax* and *P. oval*, and 7–30 days for *P. malariae*. For some strains of *P. vivax*, mostly from temperate areas, there may be a protracted incubation period of up to 10 months.

The practice of ocean-going cruise ships sailing at night and being in port during the day lessens the passengers' exposure to land-based mosquitoes. There is no malaria risk on European cruises, but some cruises which call in to European ports include destinations in Algeria, Egypt, and Morocco, where a limited risk of malaria exists in some parts of these countries. Even though malaria is a problem in many areas of Turkey, there is no malaria risk on typical cruise itineraries along the coast with Greece. Antimalarial prophylaxis is not recommended for cruises on the Mediterranean Sea, nor on Nile River cruises (CDC, 2007b).

Table 5. Cases of Malaria probably transmitted through live mosquitoes imported by ships in non-endemic areas

Year	Country (port)	Cases*	Infectious agent	Reference	Comments
1993	Marseille, France	2	*P. falciparum*	(Delmont et al., 1994; Delmont et al., 1995)	One hypothesis is vectorial transmission following introduction of one or several anopheles mosquito species from a ship coming from tropical Africa.
1995	Northwest, Italy	1	*P. falciparum*	(Anselmo et al., 1996)	The possible means of transmission was through a live vector imported from an endemic area in a port terminal near a resort area.
1997	Evergem, Belgium	1	*P. falciparum*	(Peleman et al., 2000)	It was assumed that a malaria infected mosquito derived from a foreign port was released from a ship docking at the Fruit Terminal of Ghent main port. The patient's home was about 3.5 km from the harbour and was therefore in the catchment area for potentially infected mosquitoes carried in the cargo load or in luggage.
2004	Haifa, Israel	1	*P. vivax*	(Rubin et al., 2005)	The patient's work in the port included opening ship containers from countries all over the world, including the Far East and Africa. He recalled an incident in late June in which he had opened a container originating in the Far East and a swarm of mosquitoes had flown out.

*All cases had no recent travel history to endemic areas and had not received blood products

However, some risk probably exists on cruises along the west coast of South America (Ecuador and Peru north of Lima). Except for Haiti, the Dominican Republic, and most recently Jamaica, there is no known risk of malaria on Caribbean cruises. However, there is risk of malaria on Amazon cruises and those on African rivers in malaria-endemic areas (Anon, 2005).

Transmission of malaria onboard passenger ships is apparently uncommon, but clinical manifestation of the disease may become evident during the cruise (Minooee and Rickman, 1999). Four tourists who were passengers on merchant ships and arrived in Croatia were reported to have developed malaria from 1990 to 1993. Furthermore, one tourist who contracted malaria while embarking on a merchant ship was treated in a Clinic of Infectious diseases in Croatia (Raju et al., 2000).

Malaria risk is very high for sailors (Raju et al., 2000). The estimated number of malaria cases in international seafarers may vary between 500 and 1,000 each year, and fatalities among them have been reported (Tomaszunas, 1998).

Mosquitoes transferred aboard ships are imported in new areas thereby spreading the disease. There are at least five reported cases of malaria among people who work or live close to harbours in Italy, France, Belgium, and Israel (Anselmo et al., 1996; Delmont et al., 1994; Delmont et al., 1995; Peleman et al., 2000; Rubin et al., 2005). None of the patients had a history of blood transfusion or recent foreign travel (Table 5).

Yellow fever

Yellow fever is a mosquito-borne (*Aedes aegypti*) viral illness, endemic in tropical South America and Africa. Although there is no risk in Asia, on Caribbean cruises, or in the Panama Canal Zone, there is some risk on Amazon cruises, on river cruises in endemic areas in Africa, and in some urban areas in endemic zones of Africa and South America. Yellow fever vaccination is the only immunisation that may be demanded by a country under the World Health Organization's International Health Regulations. Yellow fever vaccination must be considered in both medical and regulatory contexts (Anon, 2005).

Dengue fever

Dengue fever is a cosmopolitan, viral illness transmitted by day-biting mosquitoes (*Aedes aegypti* and *Aedes albopictus*). Although it is widespread in tropical and subtropical climates, there are no data on cruise-associated infections.

Protection involves onboard mosquito control and, at an individual level, personal protective measures. Travellers should be advised to use personal protective measures on land-based tours should the local disease situation warrant it (Anon, 2005).

Prevention and control

Travelling in European countries does not present a risk for malaria. However, cruises in the Mediterranean Sea include destinations to regions of Morocco, Egypt, and Algeria, where a limited risk of malaria exists in some parts of these countries. Although malaria is endemic in some parts of Turkey, there is no risk on typical cruise itineraries along the coast with Greece (CDC, 2007b).

European ports are visited by various types of ships coming from places all over the world. Moreover, cruise ships that call on European ports include destinations in tropical parts of the world where vector-borne disease might be endemic. Additionally, ferries often carry loads which come from other continents of the world together with passengers. Measures for preventing the entry of vectors onto passenger ships should be taken.

Integrated pest management programmes should be implemented for the elimination of insects which mechanically transmit pathogens, such as cockroaches and flies (see also Chapter 6).

4.7. OTHER DISEASES

As well as the infectious diseases that have been thoroughly described in this chapter, other diseases such as cyclosporiasis and varicella (Minooee and Rickman, 1999), meningococcal meningitis, sexually transmitted diseases, Hepatitis A, and measles (CDC, 2005) have also been reported on passenger ships.

5. INTERNATIONAL AND EUROPEAN UNION LEGISLATION FOR SHIPS

Ships sail between different jurisdictions worldwide, and many different countries may be involved in the ownership and management of a ship. Therefore, the establishment of unanimously accepted and adopted international standards is required to regulate issues related to ships. There are four international organisations which represent the interests of Member States and are linked to the United Nations (UN) through special agreements, and are responsible for publishing international guidelines, conventions, or legislation related to ships:

5.1. INTERNATIONAL LEGISLATION

World Health Organization

Coordinates programmes aimed at solving health problems and the attainment by all people of the highest possible level of health. It works in such areas as immunisation, health education, and the provision of essential drugs and has been responsible for drawing up the International Health Regulations.

Food and Agriculture Organization (FAO) of the UN

The FAO works to improve agricultural productivity and food safety, and to better the living standards of rural populations.

International Maritime Organization (IMO)

The IMO works to improve international shipping procedures, raise standards in marine safety, and reduce marine pollution by ships.

International Labour Organization (ILO)

The ILO formulates policies and programmes to improve working conditions and employment opportunities, and sets labour standards used by countries around the world.

5.1.1. International Health Regulations (IHR)

The World Health Organization, which is the United Nations specialised agency for health, updated its International Health Regulations (IHR) in 2005. The purpose of the IHR is to provide maximum protection against the international spread of diseases with minimum interference to world traffic. The World Health Assembly, which is the supreme decision-making body of the WHO and is attended by delegations from all WHO’s 193 member states, calls upon the Member States to implement fully the IHR 2005. In this part of the State-of-the-Art Report, a brief summary of the IHR, the parts of the IHR applicable to cruise ships and ferries, and the relationship between the EU ship sanitation programme and the IHR, are included.

Summary of the International Health Regulations 2005

On 23 May 2005, the fifty-eighth World Health Assembly adopted the revised International Health Regulations that are referred to as the “International Health Regulations (2005)”. The IHR contains provisions and measures relating to travellers, conveyances or other inanimate objects, points of entry, or other authorities related to international voyages. Individual countries are required to develop, strengthen, and maintain core surveillance and response capacities to detect, assess, notify, and report public health events to the WHO, and respond to public health risks and public health emergencies. The

WHO, in turn, is to collaborate with individual countries to evaluate their public health capacities, facilitate technical cooperation, logistical support, and the mobilisation of financial resources for building capacity in surveillance and response. The IHR document contains ten (10) parts and nine (9) annexes.

Part 1 includes the definitions, the purpose, and the scope of the Regulations, the principles that should be adopted, and the authorities of individual countries involved in the implementation of the IHR.

The purpose and scope of these Regulations are to prevent, protect, control, and provide a public health response to the international spread of disease in ways that are commensurate with and restricted to public health risks, and which avoid unnecessary interference with international traffic and trade.

Each country is required to designate or establish a National Focal Point to communicate with WHO Contact Points and to expedite information regarding the implementation of the IHR. Furthermore, the National Focal Point is required to be the link among the WHO Contact Points and the government departments of the individual country by exchanging available information. Government departments are those responsible for surveillance, reporting, points of entry, public health services, clinics and hospitals, etc.

Part 2 involves the requirements for surveillance, notification, and information verification of events that may constitute a public health emergency. Information-sharing and cooperation between the WHO and any individual country, all countries, and intergovernmental organisations, as well as consultation with the WHO during unexpected or unusual public health events are also included in this part of the Regulations. Moreover, the criteria and procedures that the Director-General applies to determine a public health emergency of international concern, and the procedures regarding collaboration and response to public health risks and other events of individual countries and the WHO are also included.

Part 3 includes the temporary and standing recommendations that are issued by the WHO and might be applied to persons, baggage, cargo, containers, conveyances, goods, and postal parcels in order to prevent or reduce the international spread of disease and avoid unnecessary interference with international traffic, and promptly detect its recurrence. The criteria used by the Director-General for issuing, modifying, or terminating these recommendations are also included. Recommendations involve health measures, reviews of documents, implementation of quarantine, isolation, inspection, and refusal of entry or departure.

Part 4 includes the obligations of each country regarding the capacities that have to be developed at the points of entry (ports, airports, ground crossings), identification of the competent authorities in each point of entry, provision to the WHO of information on sources of contamination or infection in response to public health risks, and lists including authorised ports to offer Sanitation Certificates. It also includes the obligations of the authorities responsible for the implementation and application of health measures at points of entry.

Part 5 includes the public health measures that are required for public health purposes to be applied to travellers and conveyance operators, or conveyances (ships, aeroplanes, trains, coaches, civilian lorries) and goods, containers, and container loading areas. Public health measures regarding travellers include information on destinations, itineraries, and health documents), vaccination or other prophylaxis, isolation, quarantine, public health observation, and medical examination and treatment. Public health measures regarding conveyances or other inanimate objects include decontamination, deratting, disinsection, etc.

Part 6 includes the health documents that travellers and conveyances are required to possess, and the procedures that have to be followed to issue them. These documents are: certificates of vaccination or other prophylaxis for travellers, the Maritime Declaration of Health and Ship Sanitation Certificates for ships, and the Health Part of the Aircraft General Declaration for Aircrafts.

Part 7 includes proposals and restriction on the charges that should or should not be made for health measures undertaken to travellers and conveyances or other inanimate objects.

Part 8 includes the criteria that have to be used by individual countries to implement health measures and the obligations for information sharing between the WHO and individual countries regarding implemented health measures. Furthermore, this includes guidelines on collaboration and assistance among the countries, the WHO, and other organisations regarding the development of capacities and the implementation of the IHR. Rules on the treatment of personal data and transport and handling of biological substances, reagents, and materials for diagnostic purposes are included in this Part.

Part 9 includes the procedures of establishment, the constitution, the duties, and the working rules of the IHR Roster of Experts, the Emergency Committee, and the Review Committee.

The last Part of the Regulations, Part 10, describes provisions regarding review, correction, and reporting rules on the implementation of the IHR. Furthermore, it includes arrangement procedures in case of debates between individual countries, determines the relationship of IHR implementation and other international agreements, appoints which provisions of other previous international sanitary agreements and regulations are replaced by the revised IHR, and provides the timeframes and the procedures for the application, withdrawal, rejection, or reservation of the IHR by countries.

In IHR Annex 1, the core capacity requirements per country for surveillance and response at a local community level are specified, at an intermediate public health level and at a national level. These capacities include the ability to detect and report events involving disease or death above expected levels for the particular time, to implement control measures immediately, to confirm and assess reported events, and if necessary to notify the event to the WHO. Moreover, each country has to be able to determine, implement, and report to the WHO any public health response in the case of events that may constitute a public health emergency of international concern. This Annex also includes the capacity requirements for points of entry at all times and in case of events.

IHR Annex 2 presents the decision instrument for the assessment and notification of events that may constitute a public health emergency of international concern. This instrument provides three ways to make a decision: the first determines four specific diseases that have to be immediately notified; the second determines diseases that must always lead to the utilisation of the decision instrument, and the third refers to any event of potential international public health concern. Some representative examples are also provided in this Annex.

IHR Annexes 4, 5, and 7 include obligations of conveyance operators and requirements regarding conveyances, specific measures for vectorborne diseases, and requirements regarding vaccination or prophylaxis for specific diseases, respectively.

IHR Annexes 3, 6, 8, and 9 provide sample forms of the Ship Sanitation Control Exemption Certificate/ /Ship Sanitation Control Certificate, the International Certificate of Vaccination or Prophylaxis, the Maritime Declaration of Health, and the Health Part of the Aircraft General Declaration, respectively.

5.1.2. International Convention for the Safety of Life at Sea

The International Convention for the Safety of Life at Sea (SOLAS) is the most important treaty to protect the safety of merchant ships. The main objective of the SOLAS Convention is to establish minimum standards for the construction, equipment, and operation of ships, in compliance with their safety. Flag States are responsible for ensuring that ships under their flag comply with its requirements, and a number of certificates are prescribed in the Convention as proof that this has been done. Control provisions also allow Contracting Governments to inspect ships of other Contracting States if there are clear grounds for belief that the ship and its equipment do not substantially conform to the requirements of the Convention — this procedure is known as port State control. The current SOLAS Convention includes Articles setting out general obligations, amendment procedures, and so on, followed by an Annex divided into 12 Chapters.

Requirements for the construction of accommodation spaces are clearly described in Chapter II — 2 of the SOLAS Convention (IMO, 2007).

5.1.3. International Convention for the Prevention of Pollution from Ships

The MARPOL Convention is the main international convention covering the prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978, respectively, and updated by amendments over the years. The Convention includes regulations aimed at preventing and minimising pollution from ships — both accidental pollution and that from routine operations — and currently includes six technical Annexes:

Annex I Regulations for the Prevention of Pollution by Oil

Annex II Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk

Annex III Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form

Annex IV Prevention of Pollution by Sewage from Ships

Annex V Prevention of Pollution by Garbage from Ships

Annex VI Prevention of Air Pollution from Ships

5.1.4. Conventions of the International Labour Organization (ILO) and International Maritime Organization (IMO) on seafarer's occupational health

The Maritime Labour Convention 186 (ILO, 2009)

The ILO formulates policies and programmes to improve working conditions and employment opportunities, and sets the labour standards used by countries around the world. Since 1919, the ILO has maintained and developed a system of international labour standards aimed at promoting opportunities for women and men to obtain decent and productive work, in terms of freedom, equity, security, and dignity.

The Maritime Labour Convention 186, which was adopted in 2006, includes a modernised management-based approach to occupational health and safety. The Convention comprises Articles, Regulations, and a Code (Part A: mandatory standards, Part B: non mandatory guidelines). The new labour standard consolidates and updates more than 65 international labour standards related to seafarers, adopted over the last 80 years.

Regulations 3.1 and 3.2 of the ILO's Maritime Labour Convention 2006 include requirements for accommodation, sanitary and recreational facilities, food, catering, and drinking water aboard ships (ILO, 2006).

Regulation 4.1 deals with issues of medical care on board ships and ashore, this is also the case for guideline B4.1.

Standard A1.2 of the Convention is related to the medical certification of fitness for work in seafarers. Guideline B3.1.12 deals with prevention of physical hazards of noise and vibration. Standard A4.2 is related to ship owner's liability for health protection and the medical care of seafarers.

Regulation 4.3 ("Health and safety protection and accident prevention") has the function of ensuring that seafarers' work environment on board promotes occupational health and safety in a hygienic and safe environment. Standard A4.3 ("Health and safety protection and accident prevention") aims at promoting the adoption of laws and regulations related to the adoption and effective implementation of various occupational health policies and programmes on ships, including risk evaluation as well as training and instruction of seafarers. Moreover, on board programmes for the prevention of occupational accidents and diseases have to be implemented, taking into account preventive measures, including engineering and design control, substitution of processes and procedures for collective and individual tasks, and the use of personal protective equipment. It is the responsibility of a competent authority to ensure that occupational accidents and diseases are adequately reported, and that comprehensive statistics of occupational accidents and diseases are kept, analysed, and published, and where appropriate followed up by research into general trends and identified hazards. The reporting and investigation of occupational health and safety matters shall take into account the need to ensure the protection of seafarer's personal data. According to guideline B4.3.1 ("Provisions on occupational accidents, injuries, and diseases"), the competent authority should ensure that the national guidelines for the management of occupational health and safety address issues like general and basic provisions, structural features of the ship, including means of access and asbestos related risks, the effects of physical occupational hazards like extremely low or high temperatures, and noise and vibrations; the physical and mental effects of fatigue; the effects of drug and alcohol dependency; and AIDS/HIV prevention and protection. According to guideline B4.3.6, all occupational accidents and diseases should be investigated — the subjects of the investigation could be: the working environment; the incidence of occupational accidents and diseases in different age groups; physiological and psychological problems created by the shipboard environment; or problems arising from physical stress on board a ship, in particular as a consequence of increased workload. Guideline B4.3.7 emphasises the need for the provision of a sound basis for the execution of measures to promote occupational safety and health protection; this provision could be made by the implementation of programmes for the promotion of occupational health and safety. These programmes should be based on the general trends of occupational hazards as they are revealed by proper statistics. In these programmes ship owners, seafarers, and the competent authority have to be involved. Furthermore, Guideline B4.3.8 describes the content of prevention and protection programmes. The main axes of this content are: the preparation of national guidelines and policies for occupational health and safety; the organisation of occupational health and safety protection and accident prevention training and programmes; the organisation of publicity on occupational health and safety protection and accident prevention, including films, posters, and brochures; and the distribution of bibliography and information on occupational health and safety so that it reaches seafarers on board ships. Guideline B4.3.10 describes the aspects of health and safety education of young seafarers, and the last Guideline, B4.3.11, focuses on the importance of international cooperation for the promotion of occupational health and safety.

Convention 073 of the ILO concerning medical examinations of seafarers (ILO, 1946)

Convention 073 of the ILO concerning the medical examination of seafarers was adopted in 1946.

According to this convention: "No person to whom this Convention applies shall be engaged for employment in a vessel to which this Convention applies unless he produces a certificate attesting to his fitness for the work for which he is to be employed at sea signed by a medical practitioner or, in the case of a certificate solely concerning his sight, by a person authorised by the competent authority to issue such a certificate". The medical certificate shall attest that the person recorded satisfactory levels of hearing, sight, and colour vision, and that the person is not suffering from any disease likely to be aggravated by, or to render him unfit for, service at sea or likely to endanger the health of other persons on board.

Recommendation 105 of the ILO concerning the contents of Medicine Chests on board ships (ILO, 1958)

Recommendation 105 of the ILO concerning the contents of Medicine Chests on board ships was adopted in 1958. An annex described the minimum list of Medical Equipment, and medications on board. Moreover, all medicine chests should contain a medical guide approved by the competent authority, which explains fully how the contents of the medicine chest have to be used. The guide should be sufficiently detailed in order to enable persons on ship, other than a ship's doctor, to administer the needs of sick or injured persons on board both with and without supplementary medical advice from the radio. Regular inspection of the proper maintenance and care of medicine chests should be performed at intervals normally not exceeding 12 months.

Convention 164 of the ILO concerning health promotion and medical care for seafarers (ILO, 1987)

Convention 164 of the ILO concerning health promotion and medical care for seafarers was adopted in 1987. It includes 21 articles. The Convention deals with issues related to emergency treatment of seafarers, and the provision to the seafarers of special curative and preventive services in port. Regarding emergency treatment and medical cure on board, persons who are not doctors should have satisfactorily completed a course approved by the competent authority of theoretical and applied training in medical skills. The content of the training programme depends on the type of ship: For ships of less than 1,600 gross tonnage which are capable of reaching qualified medical care and medical facilities within eight hours, elementary instruction will enable trained persons to take immediate and effective action in case of accidents or illnesses occurred on board the ship, and to make use of medical advice provided by radio or satellite communication. For all other ships, more advanced medical training is required, including practical training in the emergency/casualty department of a hospital and training in life saving techniques, which will enable the persons concerned to participate effectively in co-ordinated schemes for medical assistance to ships at sea, and to provide the injured or sick with a satisfactory standard of medical care. Persons involved in training programmes shall undergo refresher courses at five years intervals to enable them to maintain and increase their knowledge and skills. Article 13 describes the cooperation activities which should be undertaken by the member states for which this Convention is in force.

According to this article, countries having ratified this convention should collaborate in order to: "collect and evaluate statistics concerning occupational accidents, diseases, and fatalities to seafarers and integrate and harmonise them with any existing national system of statistics on occupational accidents, diseases, and fatalities covering other categories of workers".

Other regulations — recommendations of the International Maritime Organization

The international convention of the IMO on standards of training, certification, and watch keeping for seafarers (STCW) (IMO, 1995)

Regarding conventions of IMO, the international convention on standards of training, certification, and watch keeping for seafarers (STCW) was adopted in 1978 and has been revised in 1995. It covers the following aspects related to occupational health: medical fitness for work among seafarers, prerequisites and requirements for seafarers designated to provide first aid on board, educational activities on work related health hazards on board (various types of ships), minimum requirements for the provision of first aid and medical care on board, and guidelines on evaluation of fitness for work of seafarers.

IMO guidelines on the basic elements of a shipboard occupational health and safety programme (IMO, 2003)

The IMO, recognising the need to provide guidance to personnel or consultants who are implementing, improving, or auditing the effectiveness of shipboard health and safety programmes, approved guidelines related to the basic elements of a shipboard occupational health and safety programme. The basic elements are: 1. executive management commitment and leadership, 2. employee participation, 3. hazard anticipation, identification, evaluation, and control, 4. training, 5. record keeping, 6. contract of third party personnel, 7. fatality injury, and 8. systematic programme evaluation and continuous improvement.

International Convention for the Control and Management of Ships' Ballast Water and Sediments

The purpose of the Convention is to prevent, minimise, and ultimately eliminate the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast water and sediments (IMO, 2007).

Recommendations on the Safe Use of Pesticides in Ships (IMO)

The purpose of this guidance note is to provide advice on:

(1) the importance of safe and proper procedures when pesticides are used on board ships;
(2) the appropriate application of the IMO Recommendations on the Safe Use of Pesticides in Ships, both to cargo and to cargo spaces; and
(3) the likely application of other related requirements or guidance on the use of, handling, or transport of pesticides (IMO, 1996).

5.2. EUROPEAN UNION LEGISLATION FOR SHIPS

In an attempt to identify EU legislation related to ship sanitation and control of communicable diseases, the EU Directory of Community legislation that remains in force (as at 1.11.2006) was reviewed using the Eurlex system (http://eur-lex.europa.eu/en/ /index.htm).

Legislation relating to ships covers:

- binding secondary legislation (regulations, decisions, ECSC general decisions and recommendations, EEC/EC/Euratom directives) under the Treaties establishing the EU and the European Communities, with the exception of day-to-day administrative acts;
- certain non-binding acts.

The "secondary legislation" is the third major source of Community law after the treaties (primary legislation) and international agreements. It can be defined as the totality of the legislative instruments adopted by the European institutions pursuant to the provisions of the treaties. Secondary legislation comprises the binding legal instruments (regulations, directives, and decisions) and non-binding instruments (resolutions, opinions) provided for within the frame of the EC Treaty, together with a whole series of other instruments such as the institutions' internal regulations and Community action programmes.

5.2.1. Definitions

Regulation

Adopted by the Council in conjunction with the European Parliament or by the Commission alone, a regulation is a general measure and is binding in all its parts. Unlike directives, which are addressed to the Member States, and decisions, which are for specified recipients, regulations are addressed to everyone.

A regulation is directly applicable, which means that it creates a law which takes immediate effect in all the Member States in the same way as a national instrument, without requiring any further action on the part of the national authorities.

Directive

Adopted by the Council in conjunction with the European Parliament or by the Commission alone, a directive is addressed to the Member States. Its main purpose is to align national legislation.

A directive is binding on the Member States with regard to the achieved results but leaves them the choice of the form and method they adopt to realise the Community objectives within the framework of their internal legal order.

If a directive has not been transposed into national legislation in a Member State, if it has been transposed incompletely, or if there is a delay in transposing it, citizens can directly invoke the directive in question before the national courts.

Decision

Adopted either by the Council, or by the Council in conjunction with the European Parliament, or by the Commission, a decision is the instrument by which the Community institutions give a ruling on a particular matter. By means of a decision, the institutions can require a Member State or a citizen of the Union to take or refrain from taking a particular action, or confer rights or impose obligations on a Member State or a citizen.

A decision is:

- an individual measure, and the persons to whom it is addressed must be specified individually, which distinguishes a decision from a regulation,
- binding in its entirety.

Recommendation

A recommendation allows the institutions to make their views known and to suggest a line of action without imposing any legal obligation on those to whom it is addressed (the Member States, other institutions, or in certain cases the citizens of the EU).

Resolution

The European Parliament is involved in a number of stages in any legislative procedure (cooperation procedure and co-decision procedure): the documents adopted by Parliament at each stage in the procedure are generally resolutions and may contain instruments of various types, such as opinions or amendments to the Council's common position. Legislative procedures are referred, depending on the subject matter, to a Parliamentary committee, which prepares a report containing a draft resolution for adoption by Parliament in its plenary session.

5.2.2. EU Regulations and Directives

Food safety

Legislation concerning maximum permitted levels in foodstuffs

A. EU Directives focused on pesticide contamination
B. EU Regulations dealing with radioactive contamination

Regulation (EC) No 737/90 Conditions governing imports of agricultural products originating in third countries following the accident at the Chernobyl nuclear power station

C. Regulation for setting maximum levels for certain contaminants in foodstuffs

Legislation related to certain substances in food-stuffs

A. EU Directives for contamination from substances with hormonal action and other substances
B. EU Directives/Regulations dealing with food additives and flavourings

Legislation related to HACCP

Other food safety legislation

A. EU Directives for freezing — ionisation
B. EU Directives and Regulations for Genetically Modified Organisms
C. EU Directives and Regulations related to labelling
D. EU Directive and Regulations with regard to oils — fats

Legislation dealing with packaging

Legislation on controls and food hygiene rules

Legislation related to imports from third countries and intra-Community trade

Legislation dealing with specific provisions for animals

A. EU Directives dealing with specific provisions: bovine and porcine animals
B. EU Directives related to specific provision: ovine and caprine animals
C. EU Directives with regard to specific provisions — poultry
D. EU Directives for specific provisions: meat and meat-based production
E. EU Directives focused on specific provisions: fish and fishery products

Potable water safety

Although there are many differences between the water supply systems of land establishments and ships, there is no specific legislation for ships. The following EU directive deals with potable water: Directive 98/83/EC on the quality of water intended for human consumption

Waste

Regulation (EC) No 1774/2002 Laying down health rules concerning animal by-products not intended for human consumption.

Directive 2000/59/EC Port reception facilities for ship-generated waste and cargo residues.

Welfare of animals in transit

Directive 91/628/EEC Protection of animals during transport and amending Directives 90/425/EEC and 91/496/EEC (91/628/EEC).

Directive 95/29/EC Protection of animals during transport.

Safety rules and standards for passenger ships

Directive 2002/25/EC on safety rules and standards for passenger ships.

Directive 98/18/EC on safety rules and standards for passenger ships.

Directive 2001/106/EC The enforcement, in respect of shipping using Community ports and sailing in waters under the jurisdiction of the Member States, of international standards for ship safety, pollution prevention, and shipboard living and working conditions (port State control).

Directive 1999/97/EC The enforcement, in respect of shipping using Community ports and sailing in waters under the jurisdiction of the Member States, of international standards for ship safety, pollution prevention, and shipboard living and working conditions (port State control).

Directive 98/42/EC The enforcement, in respect of shipping using Community ports and sailing in waters under the jurisdiction of the Member States, of international standards for ship safety, pollution prevention, and shipboard living and working conditions (port State control).

Directive 98/25/EC of 27 April 1998 amending Directive 95/21/EC concerning the enforcement, in respect of shipping using Community ports and sailing in waters under the jurisdiction of the Member States, of international standards for ship safety, pollution prevention, and shipboard living and working conditions (port State control).

Directive 95/21/EC of 19 June 1995 concerning the enforcement, with respect to shipping using Community ports and sailing in the waters under the jurisdiction of Member States, of international standards for ship safety, pollution prevention, and shipboard living and working conditions (port State control)

Communicable disease surveillance

Regulation (EC) No 851/2004 of the European Parliament and of the Council of 21 April 2004 establishing a European centre for disease prevention and control.

Decision No 2119/98/EC of the European Parliament and of the Council of 24 September 1998 setting up a network for the epidemiological surveillance and control of communicable diseases in the Community

Resolution of the Council and the Ministers for health of the Member States meeting within the Council of 13 November 1992 on the monitoring and surveillance of communicable diseases

Decision 2000/57/EC of 22 December 1999 on the early warning and response system for the prevention and control of communicable diseases under Decision No 2119/98/EC of the European Parliament and of the Council

Decision 2009/547/EC of 10 July 2009 amending Decision 2000/57/EC on the early warning and response system for the prevention and control of communicable diseases under Decision No 2119/98/EC of the European Parliament and of the Council

Decision 2008/426/EC of 28 April 2008 amending Decision 2002/253/EC laying down case definitions for reporting communicable diseases to the Community network under Decision No 2119/98//EC of the European Parliament and of the Council

Border measures for public health purposes

Regulation (EC) No 562/2006 of the EP and Council, on the Schengen Borders Code.

Directive 2004/38/EC of the EP and Council, on the right of EU citizens and family members to move and reside freely in the EU.

5.2.3. European treaties for border measures and the IHR

A key objective of the revised IHR, particularly Part V, is to balance the need for restrictions on arbitrary border measures with the right of states to carry out necessary checks on travellers in case of a Public Health Emergency of International Concern, as described in article 12 of the IHR.

European law further restricts unilateral measures: at intra-Community borders, through the Schengen Borders Code; and at all borders, through Directive 2004/38/EC on free movement, and the European Convention on Human Rights (EC, 2006).

IHR Article 31 permits States Parties to require medical examinations, vaccinations or other prophylaxis of travellers as a condition of entry. This is subject to certain conditions, including that any examination is the least invasive and intrusive necessary to achieve the public health objective.

Under Directive 2004/38/EC, MS may deny entry of EU citizens and their family members if they are considered a threat to public health, but only if this is proportionate and meets strict material and procedural safeguards. Under the Schengen Borders Code, third-country nationals may also be refused entry if considered a threat to public health. In order to define the notion of "threat to public health", both documents refer to the relevant instruments of the WHO (EC, 2006).

Furthermore, as set out in the Network Decision No 2119/98/EC, in which MSs intend to adopt measures for the control of communicable diseases, they must inform, and where possible consult, other MSs and the Commission in advance.

6. GUIDELINES FOR SANITATION ON SHIPS

World Health Organization Guidelines

The World Health Organization is the United Nations specialised agency for health. It was established on 7 April 1948. The WHO's objective, as set out in its Constitution, is the attainment by all peoples of the highest possible level of health. Health is defined in the WHO's Constitution as a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity.

The WHO is governed by 193 Member States through the World Health Assembly. The Health Assembly is composed of representatives from the WHO's Member States. The main tasks of the World Health Assembly are to approve the WHO programme and the budget for the following biennium and to decide on major policy questions.

The WHO works on aspects of water, sanitation, and hygiene where the health burden is high, where interventions could make a major difference, and where the present state of knowledge is poor. The work of the WHO in this field covers, among other things, the following topics: water, sanitation and hygiene development, drinking water quality, and bathing waters. Under these activities, the WHO has published or is preparing to publish the books and documents given below, which are related to ship sanitation and communicable disease surveillance and control:

— Guide to ship sanitation (in revision)

The primary aim of the revised Guide to Ship Sanitation is to present the public health significance of ships in terms of disease and to highlight the importance of applying appropriate control measures. The guide is intended to be used as a basis for the development of national approaches to controlling the hazards that may be encountered on ships, as well as providing a framework for policy making and local decision making. The guide may also be used as reference material for regulators, ship operators, and ship builders, as well as a checklist for understanding and assessing the potential health impacts of projects involving the design of ships.

— Guidelines for Drinking-Water Quality, 3rd (current) edition, including the first addendum

The third edition of the Guidelines has been comprehensively updated to take account of developments in risk assessment and risk management since the second edition of the Guidelines for Drinking-water Quality. It describes a "Framework for Drinking-water Safety" and discusses the roles and responsibilities of different stakeholders, including the complementary roles of national regulators, suppliers, communities, and independent "surveillance" agencies.

In particular, paragraph 6.8 of Chapter 6 entitled "Application of the Guidelines in specific circumstances" includes details on health risks from ship potable water, issues that should be taken into consideration in undertaking risk assessment of the ship's drinking water system, operational monitoring, management of potable water, and surveillance to ensure drinking water safety on ships (WHO, 2006a).

— Guidelines for safe recreational water environments. Volume 2: Swimming pools and similar environments

This book provides an authoritative referenced review and assessment of the health hazards associated with recreational waters of this type; their monitoring and assessment; and activities available for their control through education of users, good design and construction, and good operation and management. The Guidelines include both specific guideline values and good practices. It addresses a wide range of types of hazards, including hazards leading to drowning and injury, water quality, contamination of associated facilities, and air quality.

In Chapter 6, Tables 6.2 and 6.4 summarise the health risks and design construction issues, and health risks and operation and management actions, associated with flow-through seawater swimming pools on cruise ships and ferries, respectively (WHO, 2006b).

Furthermore, the book entitled International Travel and Health 2005 is a WHO publication that provides guidance on the full range of health risks likely to be encountered at specific destinations and associated with different types of travel — from business, humanitarian, and leisure travel to backpacking and adventure tours.

In 1988, the WHO published the International Medical Guide for Ships, which provides complete information and advice for non-medical seafarers faced with injury or disease on board ship (WHO, 1988).

Codex Alimentarius

The Codex Alimentarius Commission was set up in 1963 by the FAO and WHO to develop food standards, guidelines, and related texts such as codes of practice under the Joint FAO/WHO Food Standards Programme. The main purposes of this Programme are protecting the health of the consumers and ensuring fair trade practices in the food trade, and promoting coordination of all food standards work undertaken by international governmental and non-governmental organisations (Codex Alimentarius Commission, 2007). Standards for food establishments are available in guidelines, codes of practice, and other recommendation documents of the Codex Alimentarius Commission. Moreover, details for the application of the Hazard Analysis Critical Control Point system in food establishments have been thoroughly described by the WHO/FAO (FAO, 2007).

6.1. OTHER GUIDELINES

There are many published Guidelines of national organisations worldwide regarding the prevention and control of communicable diseases aboard cruise ships and ferries. These guidelines concern: gastrointestinal diseases and respiratory diseases including Legionnaires' disease, SARS, and influenza. Other guidelines regarding potable water aboard passenger ships and spa pools have been published.

Guidelines on Gastrointestinal (GI) diseases

The following guidelines are relevant to the prevention of gastrointestinal diseases.

1. ECDC Meeting Report. Consultation on Norovirus prevention and control. Stockholm, 12 September 2006 (ECDC, 2006). The objective of the consultation was to review the Norovirus epidemiological situation in Europe, to assess the actions needed to prevent consecutive outbreaks in cruise ships, and to review the prevention and control measures for cruise ships and other settings.
2. Health Protection Agency. Guidelines for the management of Norovirus infection in cruise ships. July 2007 (Health Protection Agency, 2007).

3. Centres for Disease Control and Prevention. Management of Acute Gastroenteritis Outbreaks on Cruise Ships — OPRP Guidelines. The purpose of this document is to assist cruise ships and their respective corporate offices in the development of new Outbreak Prevention and Response Protocols (OPRPs) or the refinement of existing ones. (http://www.cdc.gov/nceh/vsp/cruiselines/ /detailed_outline.htm).

Guidelines on Respiratory diseases

Legionnaires' disease

1. European Surveillance Scheme for Travel Associated Legionnaires' Disease and the European Working Group for Legionella Infections European Guidelines for the Control and Prevention of Travel Associated Legionnaires' Disease. London. 2005. These guidelines apply to the control of *Legionella* bacteria in any undertaking involving a work activity and to premises controlled in connection with a trade, business, or other undertaking where water is used or stored, such as cruise ships (EWGLI, 2005).
2. Centres for Disease Control and Prevention. Final recommendation to minimise transmission of Legionnaires' disease from Whirlpool Spas on cruise ships. Atlanta, Georgia. CDC, 1997 (CDC, 1997).

Influenza

1. Preliminary Guidelines for the Prevention and Control of Influenza-like Illnesses Among Passengers and Crew Members on Cruise Ships, August 1999.

This document includes recommendations for eliminating influenza outbreaks on cruise ships and guidelines for successful management and effective control of influenza outbreaks. Data forms and threshold levels are included as well (CDC, 1999).

SARS

1. CDC. Interim Guidelines about Severe Acute Respiratory Syndrome (SARS) For Cruise Ship Passengers and Crew Members.
2. CDC. Prevention, Identification, and Management of Suspect & Probable Cases of Severe Acute Respiratory Syndrome on Cruise Ships

The US CDC released these documents in May 2003, but since they are not relevant to the current situation, they are not posted on the CDC website. However, if the situation changes, the document will be posted on this site, along with any other pertinent information

http://www.cdc.gov/ncidod/sars/cruiseship-guidelines.htm.

3. Public Health Agency of Canada. Interim Protocol prevention and management of suspect or probable cases of severe acute respiratory syndrome (SARS) on cruise ships (Public Health Agency of Canada, 2003).

Guidelines on Potable water

1. Health Protection Agency. Guidelines for Water Quality On Board Merchant Ships Including Passengers Vessels (Health Protection Agency 2003). The purpose of this document is to ensure the microbiological quality of water on board vessels. It provides guidance to ship owners and operators, responsible officers, port health officers, and environmental health officers. In addition, the guidelines encourage consistency of laboratory testing and interpretation or reporting of microbiological results for water samples taken from vessels (Health Protection Agency, 2003).

Guidelines on spa pools

1. Health Protection Agency. Management of Spa Pools — Controlling the Risks of Infection (Health Protection Agency 2006). This guidance is of use to all who have anything to do with spa pools from the designer to the user. It is useful for people who manage and/or operate spa pools to control the risks from infection to their staff, the users, and anyone else potentially exposed to the spa pool water or aerosols from it. This guidance is applicable to spa pools onboard cruise ships (Health Protection Agency, 2006).

7. INTEGRATED COMMUNICABLE DISEASE SURVEILLANCE AND SANITATION PROGRAMMES FOR SHIPS WORLDWIDE

Sanitation problems aboard ships and disease incidents among crew members and passengers have led national authorities and international and intergovernmental organisations to stipulate laws and develop different systems in order to prevent or control diseases and to improve the living conditions aboard ships. Most countries worldwide have developed Communicable Disease Surveillance systems and conduct inspections aboard ships according to national laws or the International Health Regulations. Although many of them already have significant experience, it was decided to describe and include in the State-of-the-Art report only the Integrated Programmes for which scientific papers have been published.

US CENTRES FOR DISEASE CONTROL AND PREVENTION VESSEL SANITATION PROGRAMME

The Centres for Disease Control and Prevention (CDC) established the Vessel Sanitation Programme (VSP) in the 1970s as a cooperative activity with the cruise ship industry. The programme assists the cruise ship industry in fulfilling its responsibility for developing and implementing comprehensive sanitation programmes in order to minimise the risk of gastrointestinal diseases (http://www.cdc.gov/nceh/vsp//default.htm).

The programme fosters cooperation between the cruise ship industry and government to define and reduce health risks associated with vessels and to ensure a healthful and clean environment for vessels' passengers and crews (CDC VSP, 2005).

The VSP responsibilities are:

- A comprehensive food safety and environmental sanitation inspection on vessels that have a foreign itinerary, call on a U.S. port, and carry 13 or more passengers;
- Ongoing surveillance of gastrointestinal illness and coordinates/conducts outbreak investigations on vessels;
- Construction inspections at the shipyard and when the vessel makes its initial call at a U.S. port (CDC, 2005);
- Other activities such as: investigating disease outbreaks; checking a specific condition such as residual halogen in the potable water distribution system; or investigating complaints of unsanitary conditions on a vessel.

Furthermore, VSP provides:

- Food safety and environmental sanitation training seminars for vessel and shore operations management personnel;
- Consultative services for reviewing plans for renovations and new construction;
- The programme disseminates information to the public (CDC VSP, 2005).

The VSP has been evaluated in descriptive epidemiological studies from 1975 to 2006. Several reports describe the impact of the US VSP on gastrointestinal diseases amongst passengers and crew members aboard cruise ships.

The first study of Addiss et al. (1989) reported that on cruises lasting 3–15 days and having at least 100 passengers, diarrhoeal disease outbreaks investigated by the CDC had decreased from 8.1 to 3.0 per 10 million passenger days between 1975–1979 and 1980–1985. The proportion of outbreaks due to bacterial pathogens (36%) had not changed during the same periods. When the programme began (in the mid-1970s) none of the cruise ships passed periodic VSP sanitation inspections, while from 1978 to 1985 more than 50% of ships met the standard annually (Addiss et al., 1989). Another study of Cramer et al. (2003) indicated that from 1990 to 2000 inspection scores gradually increased from a median of 89 in 1990 to 93 in 2000 ($p < 0.001$), with an associated statistically significant 21% increase in likelihood of passing. The total baseline level of diarrhoea among passengers was 2.0 cases per cruise (13,243//6,485), or 23.6 cases per 100,000 passenger-days (13,243/56,129,096). The latter rate declined significantly from 29.2 in 1990 down to 16.3 in 2000 ($p < 0.0001$). Diarrhoeal disease incidence rates among passengers sailing on ships that passed environmental inspections were significantly lower than rates among passengers sailing on ships that failed inspections (21.7 vs. 30.1; RR = 1.39; 95% CI: 1.31–1.47). Diarrhoeal disease outbreak-related illnesses decreased from 4.2 to 3.5 per 100,000 passenger-days from 1990–1995 to 1996–2000 (Cramer et al., 2003).

In 2002, the Vessel Sanitation Programme of the Centres for Disease Control and Prevention reported 29 outbreaks (3% or more passengers ill) of acute gastroenteritis on cruise ships, an increase from 3 the previous year (Anon, 2003a).

A recent study reported that from 2001 to 2004 the background and outbreak-associated incidence rates of passengers with acute gastroenteritis per cruise were 25.6 and 85, respectively. Acute gastroenteritis outbreaks per 1,000 cruises increased overall from 0.65 in 2001 to 5.46 in 2004; outbreaks increased from 2 in 2001 to a median of 15 per year in 2002–2004. Median ship inspection scores remained relatively constant during the study period (median 95 on a 100-point scale), and were not significantly associated with either gastroenteritis incidence rates (risk ratio, 1.00; 95% confidence interval, 0.98–1.02) or outbreak frequency (Spearman's coefficient, 0.01, $p = 0.84$) (Cramer et al., 2006).

As indicated by the authors of these reports, since the implementation of the VSP, the risk of diarrhoeal disease outbreaks on cruise ships decreased until 2000. From 2001 to 2004, despite good performance on environmental health sanitation inspections by cruise ships, the expectation of passenger cases of gastroenteritis on an average 7-day cruise increased from two cases during 1990–2000 to three cases during 2001–2004. This increase, probably attributable to noroviruses, highlights the inability of this environmental programme to fully predict and prevent disease related to risk factors common to person-to-person and fomite spread.

Koo et al. (1996) studied the epidemiology of diarrhoeal disease outbreaks on cruise ships from 1986 to 1993 and concluded that the observance of two simple precautions could have prevented almost one third (5/16, or 31%) of the investigated outbreaks on cruise ships. Cruise lines have been repeatedly reminded to cook seafood thoroughly and to use pasteurised eggs for menu items calling for pooled eggs. Preventing food handlers from working while ill and not using onshore caterers for shore excursions might have prevented at least an additional one third (5/16) of these outbreaks (Koo et al., 1996).

Flemmer and Oldfield (2003), after summarising data of 21 gastroenteritis outbreaks, concluded that in addition to emphasising basic food and water sanitation measures, control efforts should include thorough and prompt disinfection of ships during cruises and isolation of ill crew members and passengers for 72 hours.

In another paper of Lawrence (2004), the importance of the modes of transmission was highlighted. Although norovirus outbreaks may begin as foodborne or waterborne disease, easy person-to-person transmission occurs through faecal- or vomitus-splattered surfaces, other items, clothing, and especially hands. Control of person-to-person spread of illness among crew and passengers becomes the major objective. Rigorous hand washing, environmental disinfection, and other food service job-related restrictions are required to prevent multiple outbreaks on the same ship. Clinicians providing pre-travel health advice and post-travel diagnoses and care can benefit from and contribute to epidemiological investigations and thereby enhance the health of cruise passengers individually and collectively.

The VSP is an integrated programme focusing in the prevention and control of gastrointestinal diseases. It includes sanitation inspections, construction consultation inspections, gastrointestinal disease surveillance and outbreak investigation, and provision of training. Environmental inspection is the main approach adopted to prevent gastrointestinal diseases. Often, during an outbreak, VSP staff board ships and sail the remainder of the voyage. They carry out an onboard investigation, distribute and analyse passenger and crew surveys, interview ill people, conduct environmental health inspections, and make recommendations.

It is the only integrated sanitation programme that has been implemented for more than 30 years worldwide, and its experience in sanitation inspections and gastrointestinal disease surveillance is significant. A future EU Ship Sanitation Programme would benefit considerably from their experience in inspection and disease surveillance.

According to the previously mentioned published scientific studies, the VSP seems to have contributed to the improvement of the sanitation conditions aboard cruise ships and the reduction of gastrointestinal diseases since its implementation.

Health Canada Cruise Ship Inspection Programme

Through consultation with the cruise ship industry, Health Canada Workplace Health and Public Safety Programme has implemented a voluntary compliance inspection programme for cruise ships that visit Canadian ports, to prevent the introduction, transmission, and/or spread of communicable diseases into Canada. This proactive and collaborative approach between the cruise ship industry and Health Canada has been exemplified in the past by a high level of compliance from the cruise ship industry to Health Canada's guidelines (http://www.hc-sc.gc.ca/hl-vs/travel-voyage/general/inspection/cruise_ship-navires_croissieres_e.html).

In keeping up with the harmonisation process between the United States Centres for Disease Control and Prevention, Vessel Sanitation Programme (CDC/VSP), and Health Canada Workplace Health and Public Safety Programme (HC/WHPSP), HC/WHPSP has adopted the CDC/VSP administrative guidelines and technical criteria for inspections, with the required jurisdictional changes where necessary (CDC VSP, 2005).

The Health Canada conducts:

- Unannounced comprehensive food safety and environmental sanitation inspections on vessels that have a foreign itinerary, call on a Canadian port, and carry 13 or more passengers. The definition of a cruise ship includes "expedition vessels" that travel in northern Canada;
- Ongoing surveillance of gastrointestinal illness and coordinates/conducts outbreak investigations on vessels;
- Other activities such as: investigating disease outbreaks; checking specific conditions such as residual halogen in potable water distribution systems; or investigating complaints of unsanitary conditions on a vessel;
- Furthermore, the programme disseminates information to the public (Health Canada, 2007).

New South Wales Public health surveillance and response in the Port of Sydney

In New South Wales the Port of Sydney, comprising Sydney Harbour and Port Botany, falls within the jurisdiction of the South Eastern Sydney Public Health Unit (PHU). Over the past decade, but particularly since 1998, staff of the PHU have worked with Sydney-based shipping lines operating international cruises to improve health surveillance on cruise ships. The major change has been from reporting quarantinable diseases only when a case occurs, to routine reporting of all infectious diseases of public health interest for every cruise, even when there are no cases (Ferson and Ressler, 2005).

During the 2000 Olympic Games, ten cruise ships were berthed in Sydney, acting as floating hotels. In accordance with New South Wales law, cruise ship doctors were required to advise the health department of cases of notifiable diseases. Additionally, they completed a daily medical report on the number of people presenting with influenza-like illness, suspected pneumonia or gastroenteritis, hospital admissions, and deaths. The vessel inspection programme for the 2000 Olympic Games was built upon the existing programme, which was modelled on the US Centres for Disease Control and Prevention (CDC) Vessel Sanitation Programme. Environmental officers conducted inspections of each cruise ship upon arrival and regularly thereafter, focusing on food buffet services (in particular, food temperatures), water supply, waste disposal, air conditioning systems, and swimming pool and spa maintenance. Information on cruise ship health and environmental issues was faxed daily to the health department (Banwell et al., 2000; Jorm et al., 2003; Waples et al., 2000).

The South Eastern Sydney Public Health Unit activities include:

- Diseases surveillance on quarantinable diseases and all infectious diseases;
- Outbreak investigation.

Although this reporting is voluntary, it is consistent with the requirements of the Public Health Act 1991 (NSW), the Quarantine Act 1908 (Cwlth), and the International Health Regulations.

In New South Wales, the Public Health Act 1991 includes provisions for statutory notification of infectious diseases. Public health units receive notifications from pathology laboratories, public and private hospitals, and registered medical practitioners. State legislation applies to vessels within state coastal waters. It is unclear whether this jurisdiction covers ships' doctors, who may be registered outside the state, or the vessels, which are generally registered in other countries.

The Australian Quarantine Act 1908 requires mandatory reporting of specified quarantinable and infectious diseases using the "Quarantine Pre-arrival Report for Vessels (Pratique)". This Act is administered by the Australian Quarantine and Inspection Service (AQIS). Senior disease control staff in each state health department are authorised human quarantine officers, linking the quarantine service and state-based disease control personnel.

The International Health Regulations require all ships' masters to report the presence of quarantinable diseases on the vessel before they enter port. However, ships' doctors, who report on behalf of ships' masters, have often not been aware of the Quarantine Act requirements to report other infectious diseases.

The most important input of the South Eastern Sydney Public Health Unit surveillance programme has been to educate ships' doctors and masters regarding the need to report all required diseases (Ferson and Ressler, 2005).

Conditions reported under the Quarantine Act 1908

Prescribed symptoms:

- Temperature > 38°C
- Skin rashes or lesions thought to be caused by an infection or toxin
- Persistent or severe vomiting (other than that caused by inebriation or motion sickness)
- Persistent, watery, or profuse diarrhoea
- Bleeding from skin or mucosa
- Axillary or cervical lymphadenopathy
- Prolonged loss of consciousness
- Persistent cough or dyspnoea (other than chronic respiratory or cardiac disease)
- Inability to disembark (except in a person with restricted mobility or an otherwise healthy young child)

Prescribed diseases

- Cholera
- Dengue fever
- Influenza
- Malaria
- Measles
- Plague
- Polio
- Rabies
- Severe acute respiratory syndrome (SARS)
- Smallpox
- Tuberculosis
- Typhoid fever
- Viral haemorrhagic fever
- Yellow fever

An "end-of-voyage medical report" is sent in the 24 hours before a ship berths in Sydney, and provides information on the vessel, cruise details, and crew and passenger complement; presentations to the medical centre for acute respiratory illness (ARI), influenza-like illness, pneumonia and gastroenteritis; hospitalisations; medical disembarkations; and deaths. This report used to be sent by fax to the PHU via the shipping agent's Sydney office; it is now sent by email directly to designated PHU staff. With the advent of ready email communication from ship to shore, it has become routine for ships' doctors to forward a series of progress reports during a cruise whenever there is concern about cases of disease or an outbreak (Ferson and Ressler, 2005).

An article by Fenson et al. published in 2005, indicates the following:

Over the past decade, the South Eastern Sydney PHU cruise ship health surveillance programme has provided a focal point for coordinated data gathering and response to public health concerns on Sydney-based cruise ships. The evolution of the programme has led to a strengthening of relationships and communication protocols among the PHU, Sydney-based operators of cruise ships and the medical personnel that support them, the Sydney Ports Corporation, and the AQIS. The expertise obtained by staff was passed on to the personnel involved in the cruise ship vessel inspection and surveillance programme.

In practice, more open and earlier reporting of potential or actual public health issues on vessels has meant that the public health response may be more timely and effective. Moreover, public health staff have worked with vessel operators to:

- Educate ships' doctors and masters of the need to report any case of infectious disease scheduled under the Quarantine Act;
- Strengthen the role of the medical clinic as the ship's "surveillance office", where data are routinely collected on illness and questionnaires are issued to patients if an outbreak is suspected;
- Advocate for improved preventive measures and messages, such as influenza vaccination of crew and inclusion of more comprehensive pre-travel vaccination advice to passengers in cruise brochures;
- Promote risk communication by the operators in the form of advisory letters to passengers during outbreaks and "pillow letters" advising incoming passengers of public health problems on the previous cruise;
- Encourage the waiving of professional medical fees by major operators during outbreaks to remove this financial barrier to passengers' use of the clinic (and thus to establishing the real extent of the outbreak); and
- Support the use in the medical clinic of rapid diagnostic kits for influenza, legionella, and norovirus for earlier confirmation of the cause of outbreaks.

Finally, it is planned to negotiate with other operators of cruise ships using Sydney (and other Australian ports) to provide standardised end-of-voyage medical reports. A similar programme has recently been initiated in Queensland, and discussions are underway towards a coordinated, national cruise ship surveillance programme modelled on the Sydney programme (Ferson and Ressler, 2005).

Hellenic Vessel Sanitation Program for the 2004 Olympic Games

During the Athens 2004 Olympic Games, ten cruise ships were contracted by the Athens 2004 Olympic Organising Committee to be used as floating hotels in the Piraeus Harbour. The Ministry of Health and Social Solidarity identified a lack of a standardised or coordinated response to a potential public health threat for passengers and crew members. Many different authorities were involved with similar but not clearly assigned responsibilities. Thus, a coordinated approach on ship sanitation and communicable disease surveillance was required (Hadjichristodoulou et al., 2005a; Hadjichristodoulou et al., 2005b). The National School of Public Health developed the Hellenic Vessel Sanitation Program, which was closely modelled on the US VSP (NSPH, 2004). A specific law was enacted for the application of the Hellenic Vessel Sanitation Program exclusively during the Olympic Games.

The requirements for disease surveillance were specified by the Hellenic Disease Surveillance Centre in order to harmonise with the National Surveillance System. Reporting of diseases included all infectious diseases, quarantinable diseases, and specific syndromes.

8. ASSOCIATIONS AND ORGANISATIONS RELEVANT TO SHIPS

8.1. INTERNATIONAL HEALTH ASSOCIATIONS

International Maritime Health Association (IMHA)

The IMHA was founded to ensure that sound concepts of health protection and treatment are developed and disseminated. It aims at promoting and advancing scientific research and the quality of maritime medicine worldwide, and creating a forum for people, ideas, data, research efforts, and queries regarding maritime health.

International Society of Travel Medicine (ISTM)

The International Society of Travel Medicine (ISTM) is committed to the promotion of healthy and safe travel. In cooperation with national and international health care providers, academic centres, the travel industry, and the media, ISTM advocates and facilitates education, service, and research activities in the field of travel medicine. This includes preventive and curative medicine within many specialties such as tropical medicine, infectious diseases, high altitude physiology, travel related obstetrics, psychiatry, occupational health, military and migration medicine, and environmental health (http://www.istm.org/).

8.2. INTERNATIONAL ORGANISATIONS

International Maritime Organization

The IMO is a specialised agency of the United Nations with 167 Member States and three Associate Members. The IMO's specialised committees and sub-committees are the focus for the technical work to update existing legislation or develop and adopt new regulations, with meetings attended by maritime experts from Member Governments, together with those from interested intergovernmental and non-governmental organisations (http://www.imo.org).

International Shipping Federation (ISF)

The ISF represents the employers' voice regarding industrial relations issues, proactively explaining and justifying employers' activities to the media. To others, the ISF is an authority on the STCW Convention and assists with advice on its detailed technical requirements (http://www.marisec.org/index.htm).

Cruise Lines International Association

The Cruise Lines International Association is a marketing and training organisation composed of the major cruise lines serving North America. The CLIA was formed in 1975 in response to the need for an association to promote the special benefits of cruising. The CLIA exists to educate, train, promote, and explain the value, desirability, and affordability of the cruise vacation experience.

The CLIA became the principal external marketing organisation for its member lines in 1984 following the consolidation of several other industry organisations into the CLIA. Currently, nearly 17,000 travel agencies are affiliated with the CLIA and display the CLIA seal, which identifies them as authorities on selling cruise vacations (http://www.cruising.org/Index.cfm).

The International Chamber of Shipping (ICS)

The International Chamber of Shipping (ICS) is the international trade association for merchant ship operators and represents the collective views of the international industry from different nations, sectors, and trades. ICS membership comprises national ship owners' associations representing over half of the world's merchant fleet (http://www.marisec.org/ics/ /icswhat.htm).

International Transport Workers' Federation

The International Transport Workers' Federation (ITF) is an international trade union federation of transport workers' unions. Any independent trade union with members in the transport industry is eligible for membership of the ITF (http://www.itfglobal.org/).

8.3. EUROPEAN ORGANISATIONS

European Cruise Council

The European Cruise Council represents the leading cruise companies operating in Europe and has the following two-fold aims: firstly, to promote the interests of cruise operators with the EU Institutions in all matters of shipping policy and ship operations and secondly, to promote cruising by the European public and encourage expansion of the European cruise market (http://www.europeancruisecouncil.com/default.html).

European Community Ship owners' Association

The ECSA was initially formed in 1965 under the name Comité des Associations d'Armateurs des Communautés Européennes (CAACE) and took its present name in 1990. The ECSA comprises the national ship owners' associations of the EU and Norway. The ECSA works through a permanent secretariat in Brussels and a Board of Directors, as well as a number of specialised committees. Its aim is to promote the interests of European shipping so that the industry can best serve European and international trade and commerce in a competitive free enterprise environment to the benefit of both shippers and consumers (http://www.ecsa.be/).

9. OCCUPATIONAL HEALTH

9.1. INTRODUCTION

The world merchant fleet comprises 1.4 million seafarers, of whom two thirds work within multi-ethnic crews. In general, the crew composition reflects the pattern of global economic order; none of the seafarers from organisations for Economic Cooperation and Development (OECD) are employed under seafarers from non OECD nations (Lane et al., 2002).

It is widely accepted that seafaring is considered a high risk job in terms of health and safety at work, while provision of health care aboard is a very complex question (ILO, 1996). Seafarers, by the nature of their work, are exposed to a variety of hazards which can cause them illness, injury, or even death.

9.2. NON-BIOLOGICAL HAZARDS OF SEAFARING OCCUPATIONS

Occupational injuries are, especially on smaller vessels, frequent and often serious (Hansen et al., 2002). Seafarers are exposed to a variety of chemical hazards, including carcinogenic substances (Moen et al., 1996). Asbestos, which in previous years was widely used on board ships, has been shown to increase lung cancer risk among seafarers (Greenberg, 1991). Exposure to substances like benzene, styrene, and vinyl chloride could be associated with an increased risk of leukaemia, renal cancer, and bladder cancer (Moen et al., 1996; Nilsson et al., 1988; Saarni et al., 2002). Moreover, paints, pigments, and cutting oils used in ship maintenance represent a possible risk factor for bladder cancer (Dolin and Cook-Mozaffari, 1992). There is some evidence that seafarers display higher cancer mortality compared with the population on shore (Andersen et al., 1999). The excess was attributable to lung cancer and alcohol associated cancers. It has been reported that some cancer types occur more often among the sailing population, for example, cancers related to sun exposure, and mesothelioma. Male deck officers had an increased risk of cancer of the kidneys, and male deck crew of cancer of the pancreas. Deck and engine officers had an enhanced risk of old-age brain cancer (Pukkala and Saarni, 1996). Merchant seafaring is an occupation which differs from many occupations in many aspects, but especially in terms of work organisation: Seafarers live in their workplace for extended periods of time, they usually work long hours, and usually in rotating shift working schedules. This could be associated with an increased risk of cardiovascular disease, and psychiatric disorders (Filikowski et al., 2003; Leka, 2004; Nitka, 1990). Work-related fatigue is associated with sickness absence and mental and physical health problems, and may increase the risk of accidents and injuries at work (Wadsworth et al., 2006). The specific environmental working conditions of seafarers (e.g. isolated working and living conditions with restricted recreational activities during free time) are associated with their unhealthy profile regarding lifestyle. It is reported that seafarers recorded higher prevalence of smoking, alcohol consumption, and obesity compared to a reference group ashore (Hansen et al., 1994b; Hoeyer and Hansen, 2005; Plant, 1974). Seafarers belong to these occupational groups, which more than others are prone to alcohol dependence. Numerous stress factors often lead them to “escape through alcohol drinking”. Furthermore, the Maritime occupation is associated with occupational exposure to hazards such as vibrations, noise, and musculoskeletal strain (Goethe et al., 1984).

9.3. BIOLOGICAL HAZARDS; INFECTIOUS DISEASES OF SEAFARERS

Seafarers, due to their occupation, can travel to different geographical areas, far from their own countries. Consequently, they are at risk of contracting infectious diseases at ports of call in various countries (Wickramatillake, 1998a). Seafarers can transmit biological agents to other people, thus the question of infectious diseases among seafarers could have a public health impact.

Some studies have demonstrated concern regarding some infectious diseases in seafarers. In 1993 the common committee of the International Labour Organization (ILO) and World Health Organization (WHO) identified Hepatitis B infection, and Human Immunodeficiency Virus infection (HIV) and Acquired Immunodeficiency Syndrome (AIDS) as infectious diseases against which there should be provisions for guidance on prevention (ILO, 1994). Furthermore, it seems that other infectious diseases like Hepatitis A, B, and C, tuberculosis, influenza, and malaria could be related to seafarer’s health.

9.3.1. Sexually transmitted, and bloodborne infectious diseases

9.3.1.1. Hepatitis B

Seafarers have a potential for contracting Hepatitis B Virus Infection (HBV) via various routes like sexual contacts at ports of call or on board, intravenous drug use, during the handling of biomedical waste, and when they are treated by infected medical attendants. However, original research work on HBV among seafarers is extremely limited. The results vary from country to country. This is the case regarding both prevalence and seroconversion rates (Bellis et al., 1996; Cerdeiras and et al., 1990; Duc Lung N, 1997; Hansen et al., 1996; Hawkins et al., 1992; Hooper et al., 1988; Siebke et al., 1989).

Further analysis has documented that duration of employment as a seafarer, and casual sex abroad, were independently associated with the presence of serological markers of HBV infection (Siebke et al., 1989). Sailors from Asia had a higher prevalence of seropositivity when compared with their colleagues from Western Europe and North America (Bellis et al., 1996). Vaccination of seafarers against HBV could be an effective preventive measure.

9.3.1.2. HIV

HIV infection and AIDS in seafarers is not a new phenomenon. In the late '50s, an English seafarer died of HIV infection. This also was the case in the late '60s for a Norwegian seafarer and his family (Hansen et al., 1994a). There are a limited number of studies aimed at investigating HIV infection among seafarers. Some studies did find an increased risk of HIV infection among seafarers (Hansen, 1996; Van Damme and Van Damme, 1989; Verhaert, 1993). However, a large study conducted in the USSR did not find an association between HIV infection and seafaring occupation (Wickramatillake, 1998a). Certain characteristics of seafaring result in seafarers often being at high risk. Due to the nature of their work they spend long periods of time away from their families, which provides opportunities for uncontrolled and casual sexual behaviour, often in areas with high endemicity of HIV infection. A survey did demonstrate that the knowledge of ratings on HIV virus transmission among seafarers was inadequate. In addition, the majority of seafarers had not used condoms for protection against HIV infection (Sesar et al., 1995). Moreover, it has been documented that seafarers have inadequate knowledge about the routes of HIV transmission, and they rarely used condoms for protection against HIV infection. It should be stressed that there is a lack of a surveillance system, and thus the majority of the studies are conducted on samples of volunteering seafarers at ports of call. This material could provide biased results, because seafarers involved in casual sex may be reluctant to participate in surveillance studies. Consecutively, an underestimation of the risk of seafarers to acquire HIV infection can occur. Despite the limitations of the studies carried out, the scientific community has been convinced that HIV infection in seafarers' should be seriously considered. As mentioned above, the potential for transmission of the infection to the public reveals the public health dimensions of HIV infection among seafarers.

Educational interventions on knowledge on modes and routes of transmission of HIV infection, and sexual behaviour, could considerably decrease the risk of acquiring HIV infection among seafarers.

9.3.1.3. Hepatitis C infection

Information about the prevalence of HCV among seafarers is sparse (Hansen et al., 1995; Hawkins et al., 1992; Ollero et al., 1992). The studies were of cross-sectional nature. Former intravenous drug use and tattooing were found to be independent risk factors. On the basis of the data available it is difficult to identify a clear association between seafaring occupation and occurrence of HCV infection. In view of the lack of a preventive vaccine, educational interventions are essential for the prevention of the disease.

9.3.2. Waterborne and foodborne infections

9.3.2.1. Hepatitis A infection

Cross sectional studies from different countries (mainly Denmark, Norway, and the United States) have shown a varied prevalence of antibodies against hepatitis A virus (Hansen et al., 1995; Siebke et al., 1989).

Furthermore, it was found that the prevalence of anti-HAV antibodies increased with years in foreign trade, and was independently associated with prior Caribbean deployment.

Another study from the US showed an increased seroconvertion rate attributed to an epidemic aboard one of the ships under study (Hooper et al., 1988).

Seafarers deployed routinely outside North West European waters should be considered for immunisation with hepatitis A vaccines (Zuckerman, 2003).

9.3.2.2. Other foodborne and waterborne infections

The most common aetiological agents are *E coli, Salmonella, Campylobacter,* and *Shigella* as bacterial causes, as well as Norwalk and small round viruses, and protozoal agents such as *Entamoebahistoytica* and *Giardia lamblia*. Seafarers may be exposed through the consumption of contaminated food and water, contaminated either at source, e.g. polluted water or by food handlers, or as a result of direct contact through person-to-person transmission. Personal hygiene and good food handling practices in kitchen galleys is essential to avoid outbreaks of food and waterborne disease (Zuckerman, 2003).

9.3.3. Person-to-person transmitted infection – Airborne

9.3.3.1. Tuberculosis

Hansen et al. (1996) in their study conducted in Denmark found that the Standardised Incidence Ratio (SIR) of tuberculosis among male seafarers did not increase (Hansen et al., 1996). However, the opposite was true for Indian seafarers (Wickramatillake, 1998b). A new study from Denmark found that the risk of tuberculosis among male seafarers was significantly higher compared with the general population (Hansen et al., 2006). The increase of tuberculosis incidence on a global scale, and the recruitment of seafarers from endemic countries, reveal TB as a notable hazard for seafarers (Wickramatillake, 1998b).

9.3.3.2. Influenza

There is some evidence that influenza viruses represent an occupational biological hazard for seafarers. High rates of influenza have been reported among crew members on cruises. Vaccination of seafarers (cruises lines) against influenza viruses is an effective preventive measure (Ruben and Ehreth, 2002). Pandemic influenza could be a serious occupational hazard for seafarers. This is also the case for Severe Acute Respiratory Syndrome (SARS).

9.3.4. Vectorborne infections

9.3.4.1. Malaria

Numerous studies have investigated malaria among seafarers. A varied incidence rate from 3 to 12/1,000 seafarers per year was reported (Herrador, 1996; Mohr W, 1971; Tomaszunas, 1984; Wickramatillake HD, 1998; Wickramatillake, 1998b). In Italy, seafarers and airline personnel represented 21% of malaria cases (Majori et al., 1989). Tomaszunas estimated the number of malaria cases among the international seafarers workforce ranged from 500 to 1,000 per year (Wickramatillake, 1998b). Health education and chemical prophylaxis are essential for the prevention of the disease among seafarers.

10. PUBLIC HEALTH CRISIS MANAGEMENT AND PASSENGER SHIPS

Public health crisis management on board passenger ships can be defined as the procedures followed after the occurrence of a public health threat. These threats may include serious events such as those covered by the International Health Regulations 2005 and are defined as “any event which might constitute a public health emergency of international concern”, or other diseases such as Norovirus outbreaks, which require the implementation of less strict procedures.

Guidance for managing diseases associated with pandemic threats on board passenger ships is given in the International Health Regulations 2005. Various procedures and measures should be followed depending on the public health threat.

The procedures usually followed when trying to deal with high-burden diseases on board ships are categorised as pre-departure, during the voyage, and upon arrival in the port.

In a public health crisis it is very important to define in advance the roles and the responsibilities of all the involved individuals and authorities. Therefore, response plans should be in place and drilling can be carried out on different levels (ship, local, national, international).

Management responsibility of serious events, under the IHR, belongs to many authorities at different levels. Some representative examples are:

- the crew members and ship operators;
- the National IHR Focal Point;
- the authorities responsible for surveillance and reporting, points of entry, public health services, clinics and hospitals, and other government departments;
- the European Early Warning and Response System (according to the EU legislation, Decision 2119/1998) and the WHO are involved in the European and international levels, respectively.

The following procedures are an example of general guidelines and can be adopted in accordance with the specific event, which might constitute a public health emergency of international concern.

Pre-departure screening of passengers and crew for suspect or probable cases

Before boarding the ship, all passengers and crew members should receive a pre-departure screening form. The form reviews travel history to affected areas (the duration of history depends on the duration of the incubation period of the disease), contact with a suspect or probable case, and the presence of any symptoms related to the disease.

Passengers can be classified as follows:

- Asymptomatic passengers or crew members having no contact with infected person and/or having not visited affected areas.
- Asymptomatic passengers or asymptomatic crew members having close contact with a person meeting the probable case definition.
- Asymptomatic passengers or asymptomatic crew members who are in close contact with suspect cases because they live with, care for, or have a strong suspicion of contact with secretions from a suspect case.
- Passengers and crew with any symptoms (i.e. “symptomatic”) and history of travel to an affected area or contact with a case.

Different public health measures can be taken per category, and WHO recommendations under the IHR can be taken into consideration.

Pre-departure medical management of symptomatic passengers and crew members

If a symptomatic passenger or crew member is identified before departure, the following procedures can be followed onboard:

- isolation of the person who is a suspect or probable case, to the extent possible;
- notification to public health officials only if the person is thought to be a case;
- the suspect or probable case should be referred to a health care facility;
- contact tracing and management.

Before the ill person is transported, the health care facility and transporting agency should be alerted to the need for appropriate precautions. The Port Authority will make these arrangements.

Identification of a suspect or probable case during the voyage

The following procedures can be applied:

- isolation of the suspect or probable case to the extent possible;
- notification to the nearest Port Authority;
- contact tracing and management;
- disinfection of materials possibly contaminated.

Arrival in the port with a suspect or probable case among passenger or crew

In the event of a death or ill person on board, the master of a ship is required to report the occurrence to the nearest Port Authority. If the next port is not equipped for undertaking appropriate actions, the ship may be ordered to proceed to the nearest suitable point of entry.

Point of entry

The designated port authority should be able to take the following actions

- apply the public health emergency response plan;
- provide isolation and treatment of affected travellers or animals;
- provide quarantine of suspected travellers;
- disinsect, de-rat, disinfect, or decontaminate baggage, cargo, containers, etc;
- apply entry or exit controls;
- carry sampling and send samples to laboratories;
- undertake inspection of the ship and, if required, respond, investigate, and provide advice (to confirm the status of reported events and to support or implement additional control measures);

Procedures on National Level

The IHR National Focal point should be informed, which will then assess the event and notify (or not) the EWRS and the WHO Contact Point.

11. CONCLUSIONS

A passenger ship can be considered a leisure or accommodation place or a means of transport. There are a number of aspects with public health significance that can influence the health of passengers and crew members including quality of food, water and air, the presence of vectors, waste produced and carried on board, and even travellers' behaviour. Hazards that may arise from these factors should be effectively managed in order to prevent diseases occurrence. Published scientific papers relating to ships, which have described outbreaks and diseases, contain useful information that can be used in planning preventive measures. There is guidance published by international and national organisations and authorities relevant to public health on ships. These include preventive measures for food-borne and waterborne diseases, and diseases transmitted from person to person. International, European Union, and national legislation covers issues related to ship hygiene and the health of passengers and crew on board passenger ships.

The provision of health care and occupational health services to seafarers is a complex issue given the nature of maritime occupation. The European Union, ILO, and IMO are trying to deal with this problem and suggest the most promising and applicable solutions. Seafarers are exposed to a variety of work-related hazards. However, seafarers' exposure to biological hazards and infections could have public health implications, and thus requires further investigation. The lack of proper statistics and a registration system on seafarer health in general, and in particular on infectious diseases among seafarers, is a serious limiting factor for prevention initiatives. International collaborative training programmes on health and safety at work targeting seafarers are anticipated to further promote prevention against seafarers' occupational risk.

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