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EU SHIPSAN ACT Joint Action

Public Health Risks of International Concern According to Cargo Ship Types

Work Package 9 Report

Authors: Tanoey J.[1], von Münster T.[1], Dirksen-Fischer M.[2], Oldenburg M.[1], Harth V.[1]

[1] Institute for Maritime and Occupational Medicine (ZfAM), University Medical Center Hamburg-Eppendorf (UKE), Germany

[2] Hamburg Port Health Authority

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Introduction

Ease of transport of goods by waterways has been ever-increasing with advances in navigation technology and logistics. Globalization and world trade have been driving these improvements, as demands of masses of goods in combination with sustainable development rise. Major sea ports around the world record handling billions of tonnes of goods; in Europe alone nearly 4 billion tonnes (gross weight) of sea-transported goods have been handled in the last decade (1, 2).

International transportation of goods by any means, including sea, has been markedly noted to bring about certain hazards to the public and environment. These hazards may originate from a physical source (i.e. ships, packaging and delivery containers, and fires), biological source (i.e. infectious microorganisms and food poisoning), chemical source (i.e. fuel and chemical goods/waste), and nuclear and radiological source (i.e. nuclear goods).

Many incidents that resulted in injuries, loss of lives and property, as well as extensive contamination of the environment have been reported. Some of the most notable ones were caused by dangerous cargo being transported. For example, a recent review on studies of maritime accidents involving chemicals has found records of numerous incidents around the globe where hazardous chemicals from ships and port installations were spilt into the water. The review went on to suggest that smaller amount of spills nearer to the coast or within port cities can cause greater damage to the public health and the environment (3).

Other goods may also carry risks through the chemicals used to preserve them in their packaging/container during transport. All substances that are deemed dangerous, including their proper handling and transportation, are regulated under the International Maritime Organization (IMO) Dangerous Goods Code (4).

However, one of the main causes of concern for public health in cargo shipping is the health hazards resulted in the operation of shipment. These hazards are usually in the form of pollutants or waste that is harmful to the environment and humans. In acknowledgment of these threats, many countries have adopted the MARPOL convention under the auspices of the IMO. The convention include regulations to prevent pollution from oil, noxious liquid substances in bulk, harmful substances in packaged forms, sewage, garbage and air pollution from ships (5). The World Health Organization (WHO) in its Ship Sanitation's Guide also provided a procedure to treat various types of water on board to minimize contamination in biological, chemical or other forms to drinking water on board, as well as into open waters or rivers (6).

In addition, WHO has also revised the International Health Regulations (IHR) and put them into force in 2007. These regulations are placed to globally synchronize the effort to detect, assess, report, and respond to public health emergencies of international concern in a timely manner to

contain their devastating consequences. The mostly addressed hazard in these regulations is that of biological nature, although other forms are also acknowledged. Events that constitute a public health risk of international concern and requiring a coordinated international response is determined by a set of criteria in IHR and assessed by a competent authority (7).

This report aims to bridge the concept of public health risks of international concern with hazards and incidents involving cargo transport by ship. The results are presented according to cargo ship types.

Public health risks of international concern

Human history has been repeatedly marred by catastrophic events that resulted in tremendous loss of lives, as well as other physical and psychological damages. These catastrophes may be natural or man-made, and nations around the globe have been attempting fervently to contain the consequences. The gravity of the damages is worsened when they spread uncontrollably. One of the facilitators of this spread is human and goods travel.

Very well-known calamities in history were caused by pandemics which are known or suspected to have resulted in such dire results because of its transmission across regions and oceans. A historical attempt to prevent importation of diseases into coastal regions has resulted in what is now known as *quarantine*. However, in modern times with the emergence of other communicable diseases of public health importance and aspects of globalization this practice alone has become neither adequate nor appropriate.

The modern era has catapulted the world into new public health challenges. Revolutionary advances in technology have made world travel virtually border-free. This 'openness' has created opportunities for potential public health hazards to enter other regions relatively easily. Moreover, developments in many fields have also come with 'side-effects', which pose new dangers to the public. Passengers and goods can now reach nearly any place on earth within relatively short periods on any means of transport. They have, and may yet, take whatever type of hazard along with them, including those potentially harmful to the public.

Recognizing this possibility, many international organizations and initiatives have promoted the importance of international cooperation to thwart this threat. The World Health Organization as a global health institution has united the cooperation of nearly all countries in this endeavor by publishing the International Health Regulations. The regulations were first introduced in 1969, then revised in 2005 and have been into force since 2007 (7).

In IHR 2005, addressing the health hazards of our time, a public health emergency may be caused not only by specific diseases, but other hazards that are somehow detrimental to health as well. They can be grouped as the following (7, 8):

Biological risks

Hazards in the form of contamination of food and of zoonotic source are included as potential biological risks. A number of communicable diseases are known to have potential public health ramifications. They include viral hemorrhagic diseases such as Ebola, Lassa and Marburg diseases, and other infections such as SARS, Cholera, Yellow fever, West Nile fever and region specific diseases (i.e. dengue fever and meningococcal disease).

Ballast water poses another biological risk, as it is often loaded in coastal waters and discharged in coastal waters of another ecosystem. Ballast water contains a variety of biological materials (e.g., aquatic plants and animals, viruses, and bacteria. Spread of species into other ecosystems may cause extensive ecological and economic damage to aquatic ecosystems. Spread of bacteria and viruses pathogen to humans (Hepatitis A, Cholera) may pose a public health threat for the recipient area.

Chemical risks

Chemicals risks derive from transported goods, operating supplies, ships coating, maintenance products and fumigation substances used to eradicate pests. Inappropriate packing, storage, and handling as well as casualties may cause release of toxic substances and unexpected chemical reactions.

Nuclear and radiological risks

Inappropriate packaging or damage of the containment of radioactive goods may result in the release of nuclear substances or exposure of humans to radioactivity . Another source of contamination is the transportation of nuclear or radioactive goods which are undeclared. Nuclear material has repeatedly been detected in scrap metal. Major accidents can lead to contamination of ports and the environment. Radioactive effects have been documented to present minor to disastrous health damages, in short and long term depending on the type of substance. In contrast to irritative substances, nuclear impacts are likely underreported and underestimated due to its long latency of chronic health effects.

Cargo shipping

Types of cargo

In general, goods transported by ship can be divided into two groups: liquid and dry cargo. Some goods dominate the majority of those being transported by sea. Compiled data from the UNCTAD show the popular goods in the last decades. The main liquid cargo is crude oil, followed by petroleum products and liquid gas. Two thirds of the maritime trade is of dry cargo. This includes bulk goods of mainly iron ore, coal, grain, phosphate rock and bauxite/alumina (main bulk cargo) (9).

Table 1. Development in international seaborne trade, selected years (millions of tonnes loaded) (9)

Year	Oil and gas	Main bulk cargo	Other dry cargo	Total (all cargoes)
1970	1,440	448	717	2,605
1980	1,871	608	1,225	3,704
1990	1,755	988	1,265	4,008
2000	2,163	1,295	2,526	5,984
2005	2,422	1,709	2,978	7,109
2006	2,698	1,814	3,188	7,700
2007	2,747	1,953	3,334	8,034
2008	2,742	2,065	3,422	8,229
2009	2,642	2,085	3,131	7,858
2010	2,772	2,335	3,302	8,409
2011	2,794	2,486	3,505	8,784
2012	2,836	2,665	3,664	9,165

Source: UNCTAD *Review of Maritime Transport 2013*

Transported goods are stored in specific ways. Recent advancements in marine technology have allowed for these goods to be transported in specialized vessels. For example, tankers for oil, petroleum products, liquid gas, chemicals and other large quantity liquids, bulk carriers for dry bulk cargo such as iron ore and coal, refrigerated vessels for fruit products, and container ships. When specialized vessels are not available or suitable, goods are transported on general cargo vessels (10).

Goods can also be categorized as non-dangerous goods and dangerous goods. Dangerous goods are those substances, or made of substances, that have detrimental impact to human health and or the environment (4). Some substances are prominent cause for caution in protection of the environment, for example cargoes that have acute or chronic water toxicity or contain amounts of synthetic plastic, plastic feedstock, polymer, or rubber (11). Another possible marine pollutant is containers and their potentially toxic paint substances. A recent study on lost containers, which were spilled in a shipping accident in 2004, revealed strongly suggestive

results that their 7-year presence in the deep-sea have affected the nearby marine ecosystem (12). The hazardous impacts from dangerous substances may be immediate and short term, but may also take time to manifest and long-lasting. Such goods have to be transported with special precautions following existing regulations.

Market and Conventions

International trade shapes the ups and downs of the world economy, including the shipping industry. In the beginning of the 21st century the global economy had been growing, with a slump in 2008. An analysis on the global market of cargo shipping has revealed that some routes are travelled more than others and some ports are central to those routes. The map below shows the frequency of travels of all cargo ships bigger than 10,000 GT (Gross Tonne) during 2007, with the assumption that they sail along the shortest (geodesic) paths on water (13).

Figure1. Frequency of global cargo shipping journeys and the 20 most central ports/canals within their routes.

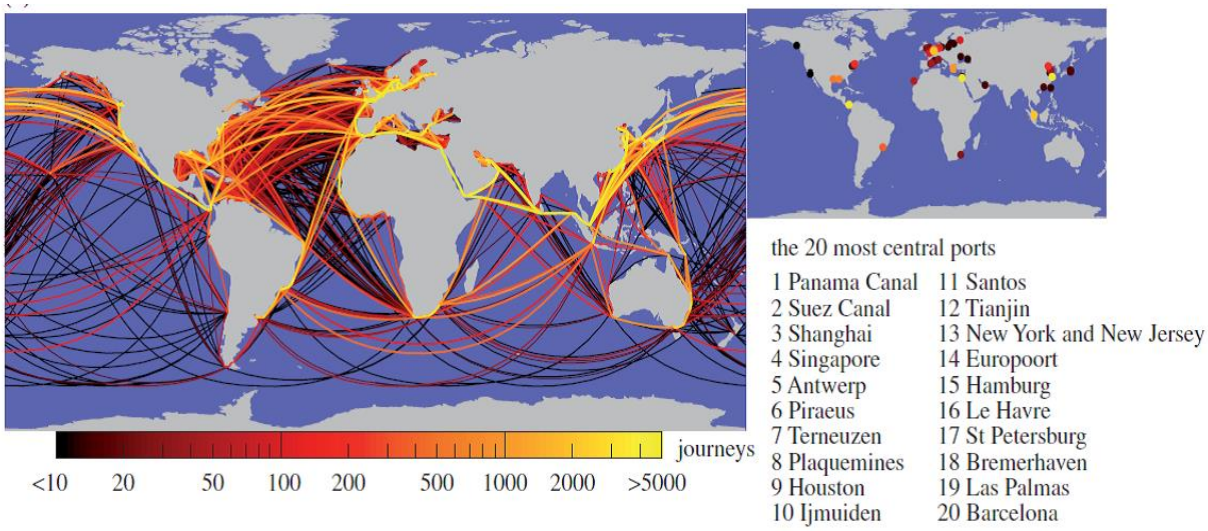


Figure 1. Routes, ports and betweenness centralities in the GCSN. (*a*) The trajectories of all cargo ships bigger than 10 000 GT during 2007. The colour scale indicates the number of journeys along each route. Ships are assumed to travel along the shortest (geodesic) paths on water. (*b*) A map of a ranked list of the 20 most central ports.

Source: *Kaluza, P, et al. The complex network of ship movements, 2010 (13).*

Since the global economic crisis in 2008 global trade has been regaining its momentum and international cargo shipping follows (1, 9, 14). In 2012, however, the global economy demonstrated a slowing growth while international maritime trade increased in performance. The United Nations (UN) noted that this was due to the fact that while there was growth in the international market in Asia, it was also significantly affected by the economic crisis in Europe and decelerating economic growth in large developing countries (namely China and India) (9).

The magnitude of world maritime trade that needs to safely travel between different countries with diverse regulations dictates a need for common regulations. There are a number of prominent international conventions to ensure maritime safety and security developed within

the last century. The most widely applied are the International Convention for the Prevention of Pollution from Ships (MARPOL) (15), the International Convention of Safety of Life at Sea (SOLAS) (16) and the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) (17). The ratification and amendments of these conventions, as well as others on maritime safety and security, marine pollution prevention, and liability and compensation are managed by the International Maritime Organization (IMO) of the United Nations (18).

Recognizing the need for safety transport of dangerous goods, regulations in SOLAS were extended to address this issue. However, it proved to be overly extensive. Therefore, in 1965 the IMO published the International Maritime Dangerous Goods Code (IMDG Code) as another safety reference, and since then, its amendments (4, 19). The Code includes a list of substances that are regarded as hazardous to humans as well as marine pollutants, their individual UN code and distinctive labels or other signs, as well as how to handle, package, store and transport these goods appropriately. Dangerous goods are grouped into 9 classes (4):

1. Explosives
2. Gases
3. Flammable liquids
4. Flammable solids or substances
5. Oxidizing substances and organic peroxides
6. Toxic and infectious substances
7. Radioactive materials
8. Corrosives
9. Miscellaneous dangerous substances and articles.

The Code also provided recommendations on safe packing of cargo in freight containers or vehicles, safe use of pesticides on board and handling of dangerous cargoes in ports. In case of accidents and emergency situations, there are guidelines on the procedure to respond to emergency on vessels with dangerous goods on board and on medical first aid for accidents involving dangerous goods (4). These two guidelines are especially important for the safety of the vessel crew as they are the first ones to be exposed should accidents occur on board involving dangerous cargoes.

International events involving cargo shipping

Seaborne transport with its movements in short or long distances is a potential vector for any matter that may harm human health. Present dangers come in ways that can be grouped into: (1) biological (epidemics and zoonotic infestations), (2) chemical, (3) radiological and (4) accidental.

In spite all safety measures in place incidents resulting in biological, chemical, radiological and physical damages still occur. Various factors may play a role in an incident, namely technical and human factors, in addition to extreme weather conditions. For the purpose of this report, only incidents pertaining to cargo ships are discussed.

Cargo ship incidents involving biological substances often manifest in a relatively small disease outbreak, either on board or at port. Few reports on infectious diseases outbreaks affecting cargo ship crew and port workers have identified Legionnaire's disease, Malaria, influenza or influenza-like diseases and gastrointestinal infections as the culprit (20-22). This does not signify that outbreaks on cargo ships are only caused by the identified biological agents and that it is limited to the crew and port workers, but rather emphasizes the potential for other diseases to affect cargo ship crew or a ship carries a disease or vector agent that allows for the disease to be transmitted outside the confines of the ship.

Shipping incidents may result in chemical, radiological, and physical damages. They vary from spillage of cargo to fires and explosions and are often caused by structural damages, extreme weather, collisions or grounding (3, 23). Numerous accidents have been recorded with minor or major impacts and short or long term consequences to humans and the environment, usually involving dangerous goods. When such incidents occur, they often concern bi-national or multinational parties, including at least the country where the vessel is owned and the country where the incident happens or affects.

A case in point, in July 2012 a container ship MSC Flaminia suffered extensive damages from fire and explosion and was abandoned in the Atlantic Ocean. The ship was carrying nearly 2,900 containers, 149 of which stored dangerous goods. The difficult process of putting out the fire, towing the vessel and finding a port suitable to carry out the investigation took 8 weeks and the efforts of 3 different countries, and it took several more months to safely unload the remaining cargo and clearing up the debris and pollutants before the vessel can be transported for repair. The accident claimed 2 lives, one missing person and 2 injured casualties and has been classified as a very serious marine casualty by the German Federal Bureau of Maritime Casualty Investigation (24, 25).

Many accidents causing oil and other petroleum product spills have also occurred, which is not entirely improbable as crude oil and petroleum products represent more than half of

international seaborne trade. Various websites listed dozens of incidents where such spillages result in not only economic but also environmental damages (i.e. sea water pollution, marine habitat endangerment) (26-28). Damages caused by petroleum spills depend on multiple factors, namely the exact chemical form of the substance, the location and the water and weather conditions. Regardless, works to remove petroleum spillage require significant resources and pose health risks to the workers and the public in the vicinity of the location (29).

A review on studies regarding ship accidents involving chemical substances also found many reports of incidents in the last few decades. The review concluded that the dangers posed by chemical substance release into the sea depend on how they react once they come into contact with air, water or other substances and how toxic they are (3). In addition, it was highlighted that the analyses in the reviewed studies found some of the chemicals were not only carcinogenic, but also formed flammable and or explosive toxic gas clouds. Such toxic gas clouds may present a major concern if it occurs on the coastline (3).

Accidents involving radioactive substances have also occurred. An inventory of accidents involving potential radioactive materials release at sea was published by the IAEA in 2001. A part of the report provided information on marine nuclear cargo transport accidents where release of radioactive materials did or potentially occurred. Based on available information, the report concluded that the radiation exposure impacts were insignificant (30). Another risk analysis performed by the International Atom Energy Agency (IAEA) showed that the estimated radiological consequences should breach of the INF-3 flask (used to transport highly radioactive materials) are very small as to cause major concern (31). However, taking into account the general amount of ship accidents, the overall probability of an incident with radioactive goods is likely not nil.

The presence of radioactive materials might be unknown, as in bulk cargo of scrap metals. In such situations there is danger to anyone within radiation exposure. The IAEA published an information booklet to raise awareness of the dangers of radioactive substances in sealed sources. In the booklet the agency noted an unknown source of radiation in products shipped from India to Belgium. The radioactive material was suspected to have been obtained in the form of scrap metal and later melted and used in production of the good (32). An international collaboration named Megaports Initiative, active under the US National Nuclear Security Administration, has been working to prevent radioactive materials to enter and leave major ports undetected. Under this initiative, more than 40 major international ports worldwide now have radioactivity detection equipment that censors containerized cargo (33).

Public health risks posed by specific cargo ship types

Hazards originating from a ship's operation

The main public health hazard caused by cargo shipping is from the products used and produced by the ship's operation. Damages can be caused by air pollutants from the ship's fuel, water pollutants from the ship's water treatment, sewage management, waste and other harmful substances from chemicals used to maintain the ship, especially ballast water discharge, or other purposes. These pollutants are not exclusive to cargo ships, but the volume and expanse of global cargo shipping makes it one of the major pollutant contributors in transportation. This factor also creates higher necessity for areas where cargo shipping traffic is more congested to acknowledge the generated potential hazards.

In addition, most of these substances are highly detrimental to the environment. This issue is undeniably relevant to cargo shipping and may ultimately affect humans; however, it is not within the scope of this report. Therefore, only hazardous by- or waste products that are known to have impact on human health are discussed.

Air pollutants

In their 2012 report, WHO projected that more than 3.7 million deaths globally are attributable to outdoor air pollution (34). The pollutants that are deemed most dangerous are Particulate Matters (PM) and a mixture of exhaust gases from fuel combustion, which are included in the list of green-house gas emissions (GHG). This gas mixture comprises of Nitrogen Oxide (NO_x), Sulfur Oxide (SO_x), Carbon Oxide (CO_x). They are common products of fossil-fuel combustion process, most notably diesel fuel. Ocean-going vessels contribute to the deterioration of air quality in areas along the coast or surrounding harbors (35-37). Diesel exhaust from vessels contains toxic air contaminants (sulfur dioxide (SO2), nitrogen oxides (NOx)) as well as particulate components which include diesel soot and aerosols such as ash particulates and metallic abrasion compounds.

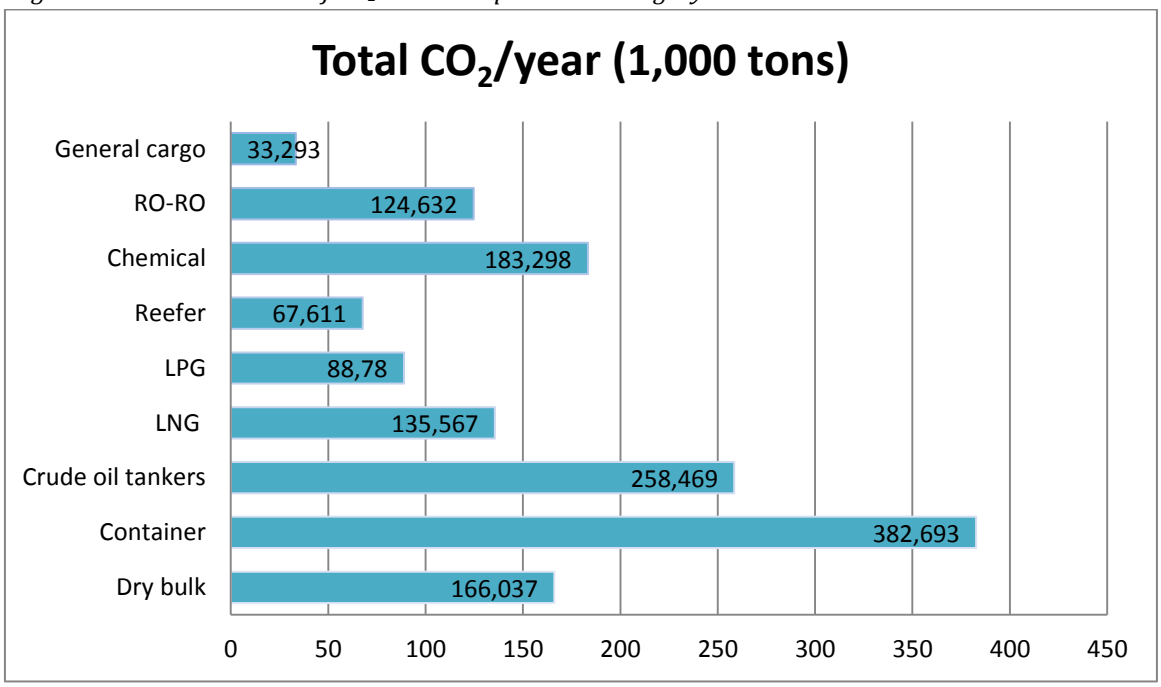
These pollutants can cause a variety of symptoms in children and adults due to their toxic effects, from respiratory, cardiovascular and neurological symptoms to potential deaths (38-42). Short-term exposure of high levels of these pollutants is associated with higher risks of heart attacks (38). Reactions to inhaling Nitro Dioxide (NO_2), for example, can acutely manifest in coughs, difficulty of breathing and asthma attacks, among others. Delayed reactions can show in a wide range of symptoms such as fever, fatigue, nausea, heart palpitations and pain while breathing (43). Small size particulate matter ($PM_{\leq 10}$) can cause multi-organ adverse reactions, most notably cardiovascular and respiratory effects, along with increased emergency room visits and hospital admissions (39, 40).

Long-term exposures are associated with serious chronic health problems such as cardiovascular or cardiopulmonary disease, and lung cancer (39, 44). Diesel exhaust and PM have been listed as a carcinogen for humans by the International Agency for Research on Cancer [IARC 2012] (45, 46).

The sources of outdoor air pollutants are multifaceted; however, the shipping industry as part of the transportation sector significantly contributes to the production of these air pollutants. A ship's engine operation produces substances into the air that endanger the health of the workers and communities residing in the vicinity of busy shipping lanes and ports. Among all types of gas emissions, CO_2 emission factor is considered to provide the best estimate (47). A recent IMO report on GHG emissions from shipping estimated that 2.7% of global CO_2 emission in 2007 came from international shipping, while domestic shipping and fishing contributed 0.6% (total 3.3%). This percentage translates to approximately 1.05 billion tons in that year worldwide (48). The same report also estimated that shipping also generated a 0.03 million tons of NO_2 gas, which is equivalent to 9 million tons of CO_2. The total NO_x emission from international shipping is estimated to be 20 million tons (48).

An analysis on cargo ships gas emissions based on a 2007 international ship registry of merchant fleet estimated the amount of CO_2 emitted per cargo ship type (36,538 vessels). The following figure illustrates the estimated amounts (49).

Figure 2. Absolute amount of CO_2 emissions per vessel category.



Source: Adapted from Psaraftis, H.N. and Kontovas, C.A. CO_2 Emission Statistics for the World Commercial Fleet (2009) (49).

Maritime organizations and governments have been trying to reduce and control the consequences of this thriving sea transport business. The IMO 2nd GHG emission study projected that in 2050 there will be an increase by a factor of 2 to 3 from the 2007 estimation if nothing is done, as a result of the expected growth in the industry. Current policy on energy efficient ships could only help reduce pollution from newly designed ships. The regulations in MARPOL Annex VI also limit emissions of NO_x and PM, prohibit deliberate Ozone depleting substance emissions, as well as limit the sulfur content in a ship's fuel. The revised regulations came into force in 2010 (50). The IMO study also expects that when policies are in place, lower NO_x, SO_x and PM in the long term is foreseen. More significant reductions are expected if a strict sulfur limitation is adapted globally, and not only in Sulphur Emission Control Areas (SECA) (48).

With the restrictions on SO_x fuel content and NO_x emission imposed by the IMO, companies with ships registered in the MARPOL Annex VI ratifying countries have to comply by applying changes to their ships. Some alternatives are available, and a recent review analyzed the options on whether they change the fuel or they apply scrubbers to clean their fuel waste. One of the viable proposed options is the use of LNG (Liquefied Natural Gas) as fuel. Applying this alternative energy source promises lower GHG emissions, but its adoption by shipping companies is not without challenges, least of all its availability (including price) (48, 51).

However, outside the European SECA (North Sea, Baltic Sea and the English Channel), the projection of health cost remain high due to the expected rise in international shipping trade. A study estimating the health impact and its consequent external costs of air pollution in Europe projected approximately 64.1 billion € of costs based on the estimated years of life loss (caused by premature deaths) due to illnesses related to air pollutants in 2020. This estimate shows an increase of 12% compared to the year 2000 due to the projected increase of international ship traffic in Europe and absent a stricter regulation on NO_x emissions. However, the study, which was published in 2013, highlighted the fact that when the imminent stricter NO_x regulations are imposed in addition to the introduction of SECA, they will result in in a significant reduction of air pollution (52).

Moreover, compliance to regulations is key to the best scenario in air pollution control efforts. A review by the Seafarers International Research Center revealed that a small percentage of violations still occur. However, the scope and method of available studies were deemed insufficient to measure the overall compliance in Emission Controlled Areas (ECA) (53).

In short, the shipping industry, particularly cargo transport, has an impact on the public health by contributing to air pollution. Efforts to mitigate the GHG and PM emissions are ongoing and if they should succeed, less subsequent cost from this waste is then imposed on the public health.

Water pollutants

Pollution prevention regulations and health and safety guidelines minimize this risk by regulating how waste should be treated and disposed of. The MARPOL convention, for instance, Ballast Water Convention, the London Convention and Protocol and the WHO Ship Sanitation Guideline aim to protect not only the marine environment but, to an extent, also the public health (6).

Ships generate waste that can pollute the water which can be in the form of oily discharge and accidental oil spills, exotic marine biological species, and garbage. Such pollutants are known for threatening the marine environment and habitat (54) and, ultimately, also the public health. Ballast water essential for a ship's operation is taken and pumped out wherever needed, causing introduction of exotic species into foreign marine habitat that are hazardous to the local marine habitat and humans. Studies recorded numerous species, including a strain of cholera being transported through ballast water exchange (55-59). Stricter regulations on ballast water was adopted by the IMO in 2004 and has been ratified by 43 member states although they have yet entered into force as of November 2014 (60). The IMO Ballast Water Convention 2004 includes specified standards on how many viable organisms are allowed to be discharged in ballast water (61).

Oil discharged through a ship's operation, which could be present in bilge water among others, or oil spills are known to have hazardous effects. This oil may poison the marine creatures that live in such polluted water, and in turn, they may endanger humans who consume them (56, 62, 63). Oil may also cause adverse reactions in humans who come into contact with it by inhalation or skin (26, 64, 65). Other pollutants also enter the water from the bilge water, non-potable water, garbage and waste treatment or maintenance processes on board (54, 62, 66, 67).

With conventions and guidelines in place, pollution in this manner usually occurs when there is a breach of such protocols, intentionally or accidentally (23). Some known recorded incidents, however, have resulted in bans of aquatic agriculture in an effort to mitigate the ensuing public health consequences otherwise and, in case of oil spills, measures to collect the oil out of the sea are executed and later, testing to ensure its safety for access and cultivation (65, 68, 69).

Hazards originating from other sources

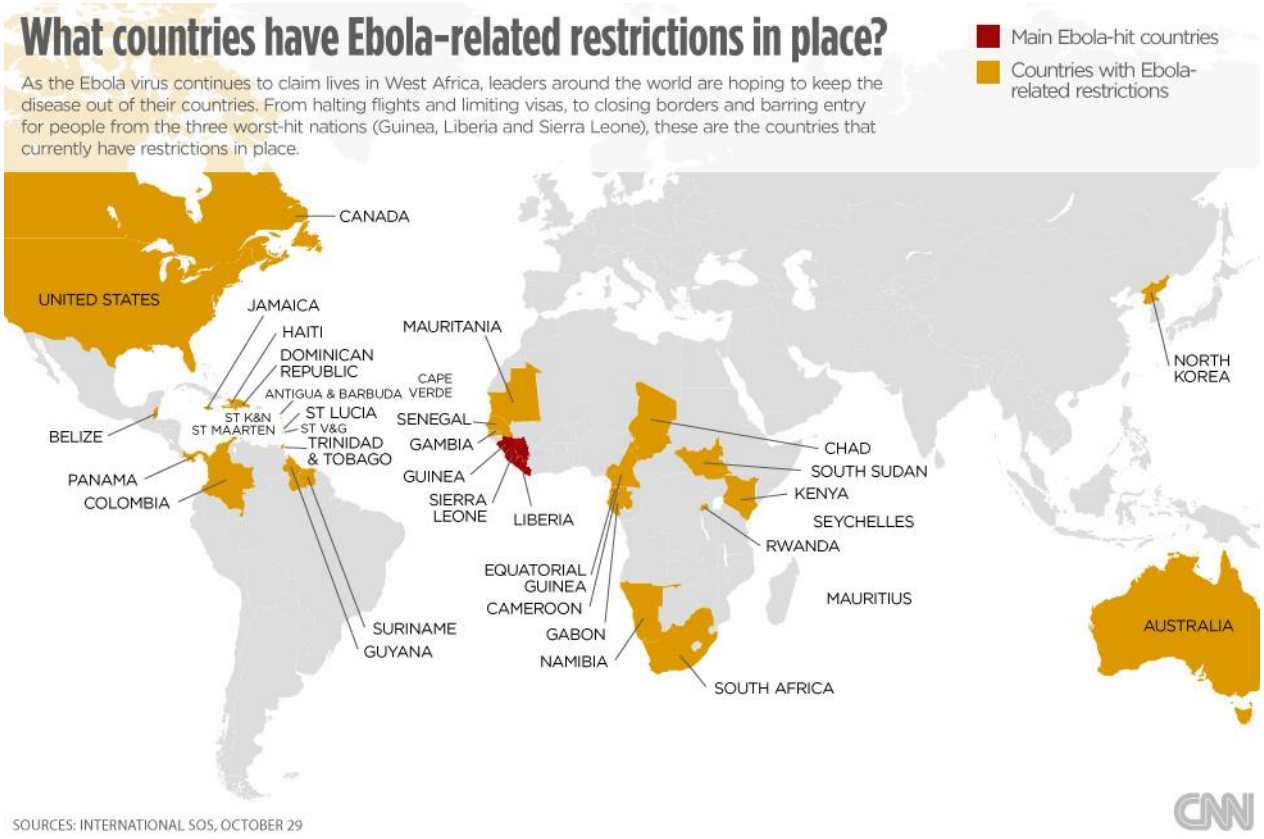
When addressing public health hazards posed by cargo ships, we should not only focus on only the cargo they transport, but also the crew and sometimes passengers on board. Obviously they are also at risk for any danger present on board, but they may also become transmission vessels in case of communicable diseases. As mentioned before, there has been studies reporting disease outbreaks on cargo ships and one Legionnaire disease event that claimed the lives of 2 port workers (21). This particular event warranted a thorough epidemiological investigation as the workers were staying in hotels. The nature of the disease transmission, which is by air,

presented a potential wider spread in the hotel or even more extensively should any of the hotel workers or other guests were infected. Fortunately this did not occur at the time. However, other biological threats, especially communicable disease that are transmitted person to person remain relevant.

The ongoing Ebola outbreak in West Africa has caused much fear in the world community. Reports of cargo and cruise ships being denied entry or being subject to stringent inspection because they have crew members or passengers with suspicious symptoms and they were recently in one of the infected countries are ubiquitous (70, 71). One ship proved to have malaria-infected crew members instead of Ebola as suspected earlier from the patients' 'mild symptoms' and the ship's travel itinerary (72).

The potential risk of Ebola spread in such situations has yet to be proven and effective control measures are still under controversy. The WHO have issued a statement that it does not recommend general bans on travel and trade, including general quarantine on all travelers coming from infected areas, and renowned organizations and associations in trade, transport and travel sectors are in agreement. Exit screening as a strategy to limit the number of travelers leaving infected areas are recommended instead, and the advantage of entry screening acknowledged although it requires considerable resources (73). That said, governments around the world remain on alert and a number of them have even adopted very strict policies regarding allowing entry of anyone from the known outbreak regions (74).

Below is a map taken from CNN.com depicting countries that have travel restrictions or screening measures concerning individuals travelling from current Ebola affected countries (75).



Despite the current Ebola pandemic, world maritime trade proceed, albeit with more caution and copious resources poured into preventing Ebola entry in this method. Needless to say, transport of cargo continues and the potential risks from other hazards remain.

Hazards specific to cargo ship types

As mentioned earlier, cargo shipping vessels have become more specialized. Now there are specific cargo ship types that only load its determined cargo. Therefore, when discussing the public health risks which are posed by the dangerous cargo, this report will approach the issue per cargo ship type.

Oil tankers

Oil tanker accidents have occurred resulting in a multitude of losses. Spills have been recorded to reach tens and hundreds of kilometers when thousands of tons of oil flew into the sea contaminating it with various toxic chemicals (27, 69, 76). The main concern in the event of oil spills is first the marine environment contamination and the exposure of the people who clean them out of the water. Oil can be dangerous to health though skin contact and inhalation of the vapors (29, 77). Less immediate and potentially further-reaching effects to humans are presumably poisoning through ingestion of contaminated fisheries and other aquaculture products. However, it has been argued that oil contamination of these products is noticeable in the taste, therefore preventing them from being consumed (29, 62). Moreover, aquaculture and

consumption of seafood from the contaminated area are usually suspended and it may take years and careful examination before cultivation of the area is permitted again (63, 68).

Bulk cargo ships

Bulk cargo can be categorized into 2 forms, dry (solid) and liquid cargo. Solid bulk cargoes are transported in bulk carriers, bulk liquids and gasses in specific carriers, while liquid bulk cargo of petroleum products is transported in oil tanker ships. Dry bulk cargo ship incidents may result in damages of which the extent depends on the exact substance, the loading (faulty loading may lead to shifting of cargo) or unloading procedure. It is recognized that some cargoes are potentially hazardous when transported in bulk. They are considered dangerous if they could either liquefy or possess chemical hazards. Examples of such products are Direct Reduced Iron (DRI), iron ore fines and nickel ore (78). In addition, some dangerous goods may also be transported in bulk and need special precautions when handled at port (79).

As part of maritime safety procedures, IMO adopted regulations of the transport of bulk cargoes (excluding liquid and gasses) in the SOLAS Convention and published the International Maritime Solid Bulk Cargoes Code (adopted in 2008), in addition to the resolution on safe practice for solid bulk cargoes in 2004 (16, 80). Recommendations for safe operations in loading or unloading bulk goods (solid, liquid and gas) at port have also been developed by the IMO (79, 80).

Container cargo ships

As with bulk cargo ships, container ship accidents usually result in loss of goods and also a threat to the people on board. However, containers are also used to transfer dangerous goods or it is fumigated with hazardous chemicals. Scenarios where accidents result in the opening of a container or the fumigation documents of a container is falsely declared or not declared at all, the presence of any dangerous substance inside may endanger everyone in its vicinity (81-83).

In addition, incompliances to the IMO Dangerous Goods Code have been known to cause extensive damages to ships and loss of lives. Incorrectly labeled cargo, among other faults, may result in misplacement of a dangerous cargo, thereby increasing the risk or resulting in accidents such as explosions and fires - for instance, in the case of the MSC Flaminia in which incomplete documentation of dangerous goods contributed to the fire and explosion on board. The unloading and cleaning up process following the incident may also have had endangered the rescue teams, as this incompliance was only discovered after the fact (25, 84).

LNG Carriers

Specially designed LNG carriers are becoming more frequently seen in international maritime trade as demands are expected to rise for the next decade (85). It is therefore of interest to give attention to the potential public health hazards posed by shipping incidents that result in LNG spills.

An analysis conducted to estimate the likely impacts of a breach to LNG carriers near shore and off shore LNG operations discussed that danger to the public health results from thermal hazard from LNG spill pool fire and the vapor cloud that may form. In their analysis of potential hazards from large LNG carriers (up to 265,000 m^3 of LNG carriers) they estimated that significant public consequences from the thermal hazard (major structural damage within 10 minutes) of a near shore operation incident can most likely reach up to 500 m of a spill, while less impact (causing second degree burns after skin is exposed for 30 seconds) may be seen within 1600 m. Threat from the vapor cloud dispersion in a similar scenario may reach 3km. For offshore operations the threats are estimated to have a larger coverage. However, it was noted that most of these operations are located well away from urban populations as to cause significant damage to the public (86).

Nuclear and radioactive cargo ships

Nuclear and radioactive materials (RAM) are known to cause serious short and long term medical ailments. The severity depends on the substance, amount and duration of exposure. Accidents involving ships carrying radioactive substances have been reported, for instance, the Atlantic Cartier fire in the port of Hamburg in 2014 and the Kapitan Lus collision in the North Sea in 2009. However, significant public health exposures in these accidents have not occurred as the safety precautions and regulations in place together with effective rescue efforts managed to avoid breach of the packaged substances (87).

The IAEA have conducted a study to estimate the risks and severity of various shipping accidents, such as collision and fire to their recommended RAM flasks for Irradiated Nuclear Fuel (INF) 3. These flasks are used to transport irradiated fuels, high level wastes, Plutonium wastes and mixed Oxide fuels with potentially unlimited radioactivity. The scenarios applied in the hypothetical study consider real-life situations commonly occurring in shipping accidents. It was concluded in the study that the tested safety requirements applied to the INF flasks and the IMO regulations for ships (INF Code) are effective in lowering the probability of accidental exposure. Furthermore, it also stipulated that should an accidental exposure occur, the health effects would not be disastrous (31).

Despite no records of significant radioactive consequences in the aftermath of shipping incidents and the assurances that necessary precautions and response measures are in place, concerns of potential accidents that results in public health and environmental effects remain. An analysis performed in the UK in light of the Atlantic Cartier incident in 2014 has raised several issues regarding the possibility that the IAEA and IMO safety precautions have not considered a number of aspects that may indeed result in public health RAM exposure. It also highlighted the fact that many rescue missions have just managed to secure the RAM cargo in time, as in the case of Atlantic Cartier, indicating the probability that similar missions could fail in more severe incidents. Considering the frequency of the transport of RAM and the proximity

of past and potential incidents to coastal settlements, the lack of stricter safety requirements and regulation on any ship that are permitted to carry RAM may increase the contamination risks to the marine environment and public health (87).

As far as unintentional incidents, public health risk from dangerous goods may not be cause for major concern. However, recent acts of terrorism have raised concerns over the possibility of terrorism hijacking of ships with dangerous cargo. Review studies have revealed that such acts may result in disastrous catastrophes, and the protection of the public against such threats cannot be emphasized enough (88).

Since the terrorist attack in the US in 2001 the IAEA has initiated an action plan to protect countries from the risk of terrorist nuclear attacks in 2002. Since then the plan has been continued in 3 year periods. The 2011 Fukushima nuclear reactor incident further emphasizes the need for vigilance in preventing the possibility of the misuse of nuclear power or radioactive materials. The lessons learned following the incident also led to the continued efforts of the IAEA nuclear security plan (89, 90).

Public health emergency response

In response to an international public health emergency, timely international coordinated cooperation is crucial. To that end, the WHO has published a list of core capacities for national surveillance, response and core capacities that must be available at designated ports at all times and in times of events that may constitute an international public health emergency. A coordination plan is also proposed in the IHR 2005, which countries may adopt and adjust to establish their communication and response plan (7, 91).

Vigilance of all health sectors in detecting and assessing, as well as reporting, coordinating, and responding to health authorities and between local, national and international health authorities is essential. Communication and coordination between multiple sectors, in addition to the public, is also of high importance. Any delays or unnecessary panic due to miscommunication may just prove costly.

Other incidents involving cargo ships also require immediate reporting and response. According to IMO pollution convention, ships are required to report pollution incidents to coastal authorities and oil carriers must have oil pollution emergency plan on board. Response measures and cooperation of coastal authorities are also described in the Oil Pollution Preparedness, Response and Co-operation convention (OPRC) by the IMO. This convention also includes protocols in incidents involving hazardous and noxious substances (92).

International response to nuclear or radioactive material incidents are coordinated by Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE). The committee's task is to ensure that relevant international organizations and trade associations are prepared and able to respond adequately to radiological emergencies or incidents. Such incidents are, however, not limited to sea-transport of radioactive substances. A Joint Radiation Emergency Management Plan has been published to support the successful coordination of such events (93).

Other international response associations for oil, chemical and radioactive material emergencies exist because effective management measures to any public health emergency require preparedness and cooperation of competent authorities, and at times of more than 1 country. Furthermore, in terms of shipping, the risks posed by cargo ships may not be limited to only one type of cargo. International organizations, governmental organizations, as well as cargo trading companies and associations all play significant roles in preventing and alleviating the consequences of cargo ship incidents.

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