Sick Ships – A Call For Improved Surveillance and Alert Systems

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Abstract

In the 14th century, a fleet of Genoese ships carried black plague from the Black Sea to a small port city in Sicily. Inability to contain the disease started a pandemic in Western Europe known as "Black Death". Within 5 years, over one third of Europe's population was utterly destroyed. Pandemics occur in the world every 30-40 years. The last pandemic occurred in 1969, so we must prepare for another. Passenger ships historically have been the means by which pandemics move swiftly from one region of the world to another. Small towns in Alaska, with less than 10,000 residents, are deluged annually with over 750,000 cruise ship passengers and crew. A highly infectious, lethal disease, uncontained on a cruise ship, and unleashed upon an unsuspecting community without timely alert to public health and safety officials, is a scenario of disastrous proportions. This paper examines several recent outbreaks of disease associated with cruise ships in SE Alaska where off-season Type A influenza epidemics infected 40,000 people annually in 1998-1999. It recognizes efforts of the cruise ship industry to get a better program of surveillance instituted on their ships in cooperation with the Center of Disease Control and Prevention. It critiques some of the slowness in the current process of surveillance and alerting public health and safety officials in the United States, especially when an outbreak of influenza is detected on a cruise ship. It calls for systems that promote accelerated outbreak detection, effective intervention and rapid public notice of outbreak alerts.

Introduction - Pandemics

Disclaimer: This paper solely presents opinions and recommendations of the author and not necessarily the official position of the Commandant, U.S. Coast Guard.

Starting in the 14th century, the origin of the Black Death pandemic in Western Europe is traced by historians to the arrival of a small fleet of Genoese ships that carried the plague from Constantinople to Messina, Sicily in 1347. Plague had erupted in the early 1330's in China and moved slowly west along land caravan routes. By

1345 it was reported on the lower Volga River and by 1346 it was reported in the Caucasus and the Crimea. The plague broke out with vengeance in Constantinople in early 1347 and leap-frogged into the Black Sea / Mediterranean trade aboard ships. While it took four years for the plague to get from China to Constantinople, once it was introduced aboard ships, it accelerated its spread throughout the port cities of the Mediterranean Basin within a few months. It hit Alexandria, Egypt in early summer and Messina in early fall of 1347.

When the ships docked in Messina, Sicily, many of the crew and passengers on board were already dying of the disease. Port officials were not notified of the sickness until several days of commercial intercourse had occurred among the ships' complement and the tradesmen and entrepreneurs ashore. Port officials only had a system of disease surveillance ashore triggering alerts based upon reports from inns-keepers and gravediggers.

The disease could not be contained. Within days it spread to several adjacent cities and the surrounding countryside. By January 1348, arriving by sea, the plague reached Marseilles. Following river trade routes, it reached Paris in spring of 1348 and jumped the English Channel by September 1348. In general, the plague outbreaks rapidly followed high seas trade routes and concentrated in port cities along coasts and river-ways. After five years, one third of Europe's population fell prey to the "Black Death", a total number of 25 million casualties. Plague continued to claim lives worldwide in several waves of epidemic and pandemic proportions, typically initially presenting itself as outbreaks from ships in major port cities, the last in 1866-1869 in Europe and the last in the Western United States by the end of the 19th century. Plague has been only one of several diseases that over the centuries have terrorized populations with the threat of pandemic. Pandemics outbreaks occurred where, for various reasons, war, drought, natural disasters, famine or epidemics themselves created the momentum of a global or regional mass migration of people, often with weakened immune systems.

Though there were several pandemics in the 20th century, the best known was the "Spanish Flu", an influenza pandemic that occurred near the end of World War I. While it was believed to have originated in China and entered the United States from ships passing through west coast ports, it first appeared in massive proportions in the military recruit boot camps of FT Riley, Kansas. The US government failed to contain the disease and as US soldiers and sailors joined each other on transports and passenger liners enroute to the battlefields, a mutant and killer strain of influenza traveled with them. The disease spread through European ports and grossly affected the health of all warring parties to the conflict and the war weary civilian populations. Of all the US soldiers, who died in the WWI European theater, half died of the influenza virus, not the enemy. The influenza pandemic of 1918-1919 was a global disaster of epic proportions. Over a fifth of the world's population was infected and 28% of all Americans were infected. 675,000 Americans died of the disease, ten times as many Americans as were killed in WWI.. The affect was so severe that the average life span in the United States was depressed by 10 years.

Background – Sick Ships Are A Common Denominator For Pandemics

Passenger ships have almost always been a common factor in the spread of pandemics. They were the major means for moving large numbers of people during and immediately following World War I (WWI), and resulted in close contact among large groups of people for sustained periods of time.

For example, the Spanish Flu spread rapidly following the WWI military logistics and the commercial trading routes of worldwide shipping lines. Despite stringent wartime controls and regulations, the medical infrastructure of the United States was stretched very thin. Political leaders and their health officials simply could not contain the disease as troops returned on transports from the battlefields and carried the disease to their homes in rural and metropolitan America. No corner of the world was spared. Outbreaks swept through North America, Europe, Asia, Africa Brazil and the South Pacific with a focus on port cities. India was particularly hard-hit having a Spanish Flu mortality rate over 50 deaths per 1000 people.. Worldwide deaths of Spanish Flu are estimated somewhere between 20-40 million people, more casualties than died from the Black Death in Europe almost 650 years ago.

The necessary coincident event for a pandemic often has been the simultaneous emergence of a new hybrid or mutant strain of highly communicable disease that can't be contained due to free-flowing worldwide mass transportation without adequately responsive surveillance and alert systems. Today, mass transportation includes high speed jumbo aircraft, railroads and highway transport systems, but large passenger liners or cruise ships still convey a substantial potential of disease transport among nations. They are much larger than ever and virtually comprise floating cities. As floating cities they provide entertainment, food service, sanitation service, public safety and emergency health services. Since the age group of most of today's cruise ship passengers is geriatric, the emergency health services component is vitally important. Unfortunately, there are currently only limited capabilities for emergency health services on most cruise ships, and these services must be depended upon for disease surveillance as first line of defense against pandemics and bio-terrorists.

Discussion

Pandemics only occur in the world on an average of every 30-40 years. The last pandemic officially recorded was 1969. The world should experience the next pandemic within the next ten to fifteen years. Since 1969, the cruise ship industry in Southeast Alaska has grown from its infancy to now, when small towns in Alaska, with less than 10,000 residents, are deluged with over 750,000 cruise ship passengers and crew visiting during a season that starts annually in May and runs through the month of September. A scenario of uncontrolled port calls with sick tourists pouring ashore and infecting tourist trade workers and residents of small Southeast Alaskan towns has devastating potential from a local community's perspective, especially given these communities' sparse medical facilities ashore. Evacuations from such relatively remote communities of a large number of sick passengers with infectious disease would overwhelm existing medical emergency transportation and logistics systems. Existing medical surveillance based upon county health organizations and the Centers for Disease Control and Prevention (CDC) disease surveillance hospitals and medical practitioner "sentinel" volunteers around the country could trigger a national alert eventually, but only after tourists had returned to their points of origin and presented the consequences of their disease to their local physicians. But by that time, a highly dangerous disease could be propagating widely throughout the general population.

The first problem is one of standards. There are no mandatory international medical staffing standards regulating the cruise line industry. (Medical care and services are not covered by United States Coast Guard or Safety Of Life At Sea (SOLAS) regulations. These regulations generally focus on requirements for the safe navigation and design of the cruise ship itself as well as the training and competency of its crew. For instance, the Coast Guard does not require cruise ships to carry a ship's doctor. However, most ocean-going passenger vessels today do provide a doctor and medical facilities in order to offer attractive and competitive service. The quality of the medical care is absolutely not guaranteed by Coast Guard regulations.) Only competitive market forces and self-interest currently drive the quality of medical care and capabilities of cruise ships. While the CDC has the authority of the Public Health Service Act to take measures necessary to prevent the introduction, transmission, or spread of communicable diseases in the United States from a foreign country (42United States Code Section 264(a)), they usually have used their authority only to require routine shipboard surveillance of gastrointestinal diseases through a program run by the Vessel Sanitation Service. Surveillance of the respiratory system diseases such as pneumonia and influenza, which have more potential as pandemic agents, only recently have been voluntarily implemented in surveillance system programs by some of the cruise ship industry in concert with CDC. The CDC relies on the cruise ship companies to independently monitor the health data on their ships and only alert the CDC if they pass certain thresholds of infection percentages of their passengers onboard. Crew standards for outbreak threshold determinations are yet to be developed and the outbreak threshold for passengers and travel industry workers is tentative, at best. Once CDC gets information of a potential outbreak, they are slow to react and share information with other public safety organizations such as the National Response Center and the Coast Guard.

Bio-terrorism raises unique challenges with cruise ships. In addition to making it difficult to isolate and contain disease during early phases of a pandemic, cruise ships may become potentially attractive targets to terrorists bent on releasing a biological agent. There are several reasons why this may be the case: they are control, efficiency and scheduling. Cruise ships provide a highly controlled cohort of individuals for a predetermined amount of time (several days) in close quarters. In addition the cruise ship passengers' average age is relatively high (65-70 years old) with a significant percentage in a potentially high-risk medical category, so the efficiency of the biological agent could be relatively high. Finally, the biological attack could be planned or timed so that the severest symptoms of the disease would not show up until the passengers have gone ashore, dispersed and returned to their homes to spread the disease "like a dandelion gone to seed and blown by the wind".

Over 130 cruise ships currently operate from US ports and this number is projected to grow to 165 cruise ships by 2004. These vessels carry 1000 – 5000 passengers onboard typically with one additional crewperson for every two passengers. Cruise ships usually have limited medical diagnosis capability and their surveillance programs rely upon passengers and crew members presenting their symptoms to the ship's small medical staff. Cruise ships are flagged and subject to the regulations of numerous nations. The ships have a wide variety of onboard accommodations, personnel training and technological constraints. It is virtually impossible to mandate a universal standard of medical capability and care for passengers and crew onboard all cruise ships. Standardization might be achieved more cost effectively by augmenting the limited capabilities of the medical staff onboard with telemedicine and shore-based forensic analysis services. Medical surveillance incorporating early pattern identification techniques employing sophisticated detection algorithms and real time "physician in the loop" telemedical diagnostic and consultation services might be sufficient to catch the early stages an attack or outbreak while it is still retained onboard the cruise ship, to allow more effective intervention and mitigation while reducing the threat of disease propagation ashore.

Who must be included in the surveillance is an issue that depends upon scale, degree of contact and dwell time. Medical surveillance systems on cruise ships must be integrated to include the passengers, crew and travel industry workers. For instance, certain travel industry workers come in direct contact with most of the passengers: when cruise ships integrate their passengers into land tours, passengers generally come in direct contact with tour guides and other cruise line employees, who, coming in close proximity with thousands of passengers over a short period of time, may be hosts for more than just the passengers that they serve for several days on busses. Returning the passengers directly from the land cruises to their ship can periodically reintroduce the disease back onto the cruise ship. Consequently, integrated land transportation staff, who come in direct contact with cruise ship passengers, should be subjected to surveillance for communicable diseases and given prophylaxis. Passengers and certain crew on a cruise ship share variable contact with each other for 5 or more days especially in restaurant food service, maid service and beverage service areas. Same precautions as travel industry workers should be taken for the food service workers aboard the ships who handle food and drinks. They all should be subjected to regularly managed surveillance for communicable diseases and given a chance through vaccination and prophylaxis to protect them from becoming a carrier.

Other crewmembers must also be included in a cruise ship health surveillance system. If not included in the ship's medical surveillance system and provided with prophylaxis, crew-members can provide a reliable pool of infection, passing the disease to the cohort of passengers from cruise to cruise, creating what is called a "Sick Ship" situation. Vaccination of crew members has been used by certain cruise lines in response to several years of influenza outbreaks in the Alaska cruise trade but vaccines are only 70-90 percent effective even if administered in time for crew members to build up an immune reaction before their first exposure. Consequently, crewmembers often are and always should be included in proactive health surveillance. This is absolutely imperative for pandemics or bio-terrorism where a vaccine has not yet been identified or made available.

Technically, surveillance for disease on passenger ships has been required by law for all but the smallest of passenger ships bound for US ports. However, the mandatory regulations have only been developed in some detail for surveillance of diarrheal disease. The Vessel Sanitation Program of the Center for Disease Control and Prevention maintains a surveillance system for diarrheal illness on board passenger ships carrying 13 or more passengers. The Vessel Sanitation Program relies on timely and accurate counts of cases of gastrointestinal illnesses during passenger cruises, which in turn depend on cruise passengers and crew members to report diarrhea to the Master of the ship or the ship's medical staff. Each cruise ship is required to maintain standardized gastrointestinal illness incidence reports for each cruise. These reports contain information on total number of passengers and crewmembers and of passengers and crewmembers who reported diarrhea, including the number of cases of gastrointestinal illnesses by dates of onset. These records are maintained aboard the cruise line vessel. A reportable case is defined by the regulations as a situation where three or more episodes of loose stools in 24 hours are reported by a passenger or crew member to the Master of the ship or the ship's medical staff during an international cruise that includes a US port.

Foreign quarantine regulations, 42 CFR 71.21, require that the Master of the ship destined for a US port must immediately radio the quarantine station at or closest to the port when the ship will arrive and to report any death(s) or any illness among the passengers or crew. Sooner than 24 hours in advance of a US port call, the ship's medical officer is required to report through the Master any incidents (voluntary reports from passengers) of gastrointestinal disease above certain predetermined thresholds to the Center of Disease Control Vessel Sanitation Service. All cases of diarrhea that occur after the 24-hour report must be reported at least 4 hours before the ship's arrival. Reports may be made by telephone or facsimile directly to the Vessel Sanitation Program.

Some particularly nasty outbreaks can, as determined by the Vessel Sanitation Service, result in vessel quarantine and a visit by a special CDC inspection team. If at least 3.0% of the ship's passengers or crew members have gastrointestinal illness, the Vessel Sanitation Program, in consultation with other environmental health and infectious disease programs at the Centers for Disease Control and Prevention may conduct an investigation aboard the ship or from a port call or from Atlanta to determine if an outbreak of gastrointestinal illnesses occurred.

Until recently, there has not been a similar surveillance and inspection system in place for reporting respiratory diseases or other dangerous communicable disease outbreaks. An alarming number of respiratory disease and influenza-like infection outbreaks were reported associated with Alaska trade cruise ships during 1997-1999. These cases often were not detected by the cruise ships before they were picked up from local or county health agencies reporting diseases presented to local physicians by cruise ship passengers only after they had returned home following a short incubation period. In 1997, when Type A influenza was first confirmed during the off-season in the Alaska cruise ship season, Health Canada alerted CDC who then supported aggressive intervention taken by one cruise line to give influenza vaccine and prophylaxis to their crew-members to successfully break the repetitive "Sick Ship" pattern from cruise to cruise. This suggested to CDC and Health Canada that the pool of crewmembers were one of the key mechanisms spreading the disease.

Off-season influenza returned in a different pattern the next year. In 1998 an off-season outbreak of Type A influenza was detected by local health authorities in the Yukon from a cohort of passengers off of several cruise ships that had integrated cruise – land packages. During the 1998 cruise ship season, Health Canada and the CDC and Prevention estimated that over 40,000 passengers and cruise ship – land tour workers suffered from off-season influenza. According to one cruise line executive, cruise ships often didn't experience sick passengers aboard until they reported off the integrated land tours for the return passage from Alaska back to British Columbia. Others apparently contracted the disease from others aboard the cruise ship and expressed it only after they had returned to one of numerous hometowns across the Lower 48 states of the US or other points of origin overseas.

In 1999, the off-season influenza reappeared in a manner that it was directly linked to the integrated cruise-land tours again, but there were less numbers of cases reported. By this time, several of the Alaskan trade cruise line companies had worked with Health Canada and the CDC and deployed more aggressive vaccination and prophylaxis procedures among their crew-members and tour workers and the CDC and Health Canada had widely distributed health alerts and recommended procedures for decreasing the risks to passengers, especially those falling in the high risk health category. Certain members of the international Alaska-trade cruise-line associations were very concerned about the pattern of the disease over several years and its adverse publicity to the Alaska-trade cruise ship industry. They collaborated with Health Canada and the Centers for Disease Control and Prevention and helped design a voluntary outbreak alert and surveillance system for tracking influenza and pneumonia aboard their ships.

Their preliminary guidelines follow: 1) Medical staff onboard ships are routinely educated in clinical, diagnostic and primary care treatment. Three aspects of the strategy to arrest respiratory illness include surveillance, prevention and control. The major focus of the strategy is on pneumonia and influenza. 2) The program includes routine annual vaccination. 3) The program includes passive year-round surveillance – if the cruise is greater than 3 days count the number of passengers presenting to the ship's infirmary with respiratory illness. 4) Provisions should be to carry year round sufficient medical supplies to respond to an outbreak of 50-100 person test kits for influenza and 20 persons for pneumonia / Legionnaires' Disease. Reports are to be submitted regularly to the company's medical surveillance coordinator. Outbreak determinations are to be dependent upon regional specific thresholds with final values to be determined. Interim values for outbreak in the Alaska, British Columbia and Yukon cruise line trade to be based on 1997-1998 baselines. Data to include # of passengers meeting acute respiratory infection or influenza-like illness case definitions, total number of passengers aboard, and duration of cruise. Crew data is yet to be determined. The 1998 incidence rate was used as a "tripwire" resulting in enhanced surveillance methods, intervention and control. Criteria were to apply to those vessels carrying over 600 passengers. Preliminary guidelines were to allow for early recognition of the outbreak, rapid lab diagnosis, and prompt institution of control measures (including provision of anti-viral medications or prophylaxis for influenza Type A). Each ship was recommended to have a plan for performing viral cultures from selected patients if an influenza outbreak is confirmed by rapid viral diagnostic testing or if the disease remains unknown. In response to an outbreak in the administering of anti-viral treatment ships should give priority to ill passengers and crew with highest risk for complications first and then administer the remainder to other ill passengers and crew. Chemo-prophylaxis should be given first to those with close contacts with ill passengers and crew members with increased risk for infection and complications, then to others in close contact with ill persons in group activities such as tour guides, next to passengers and crew members at increased risk but not in close contact with ill persons, all other crew then all other passengers. Specific to the crew: active surveillance of crewmembers by supervisors is highly recommended during the affected cruise and continued during the next cruise (up to 21 days following intervention origin.) Crewmembers should be asked daily if they have any symptoms of respiratory illness. Crewmembers who have symptoms suggestive of respiratory illness should report to the ship's infirmary for medical evaluation. All sick crew members should be isolated from non-infected crew members and passengers: Isolation or cohorting which limits the spread of infection, consists of confinement to a cabin alone for at least 5 days after symptom onset. Contact with infected crew members should be strictly limited to influenza vaccinated or recovered persons (no visitors) including meal services. If isolation on board ship is not feasible, it is recommended that infected crewmembers be moved ashore into hotel facilities and cohorting these. As a target, the cruise line should ensure vaccination of at least 80% of their crewmembers. Crew should be offered 2 weeks of chemoprophylaxis first for those not vaccinated then for those vaccinated. (Keep in mind that vaccination is only about 70% effective) Essential persons who cannot take chemoprophylaxis and who have not been vaccinated should be isolated as much as possible during an outbreak situation. If a variant of influenza Type A not controlled by the vaccine is circulating, crewmembers should NOT be transferred to other ships from a cruise line ship experiencing an influenza outbreak until the crewmembers have completed 2 weeks of anti-viral chemoprophylaxis. Any crewmembers joining the ship for the next cruise should be vaccinated with influenza vaccine and placed on chemoprophylaxis for 2 weeks while they build up their immune systems. Additional recommendations for passengers were as follows: All passengers suspected of infection of influenza should be encouraged to limit their activities to prevent further spread of influenza among passengers and crew. All newly embarked passengers should be fully informed of the outbreak on the previous cruise of the ship. They should be notified of the status of the outbreak and measures taken to prevent transmission and to treat infection. High-risk passengers should always be advised to consult with the ship's medical staff regarding available chemoprophylaxis.

Some of their cruise-line members tested the above system on a voluntary basis in the years 2000-2001. However, the system is not geared to respond to a pandemic or terrorist attack because it relies heavily upon preventing outbreak of a known virus with vaccines and reasonably effective prophylaxis in stock. The World Health Organization said in their contingency plan for the next pandemic (statement is available on their web page), "Should a true influenza pandemic virus again appear that behaved as in 1918, even taking into account the advances in medicine since then, unparalleled tolls of illness and death would be expected…Modern higher speed travel could hasten the spread of a new virus and decrease the time available between Phase 0 and Phase 1, for preparing interventions. (Note: Phase 0 is the pre-outbreak phase of a pandemic.) As an indicator of the time factor necessary today to isolate a new virus and produce a vaccine for general application, in 1997, the occurrence of several cases of Hong Kong influenza (H5N1) raised concern about a potential avian borne pandemic. However, lack of an efficient person-person transmission of the virus prevented pandemic propagation of the disease. However, the 1997 scare had a lesson: preparation of high growth reassortants for the production of H5N1 vaccine was both difficult and time consuming, due to technical problems. More than 12 months elapsed after the occurrence of the index case in May 1997, before such reagents were available for experimental vaccine production. Rapid production of a suitable vaccine effective against a pandemic influenza strain might not be quick.

The current voluntary program also is limited to the somewhat marginal diagnostic and treatment facilities aboard the cruise ship and is not consistently inclusive of crewmembers, tour workers, and passengers. The system incorporates no comprehensive survey mechanism for direct feedback from cruise ship passengers other than the existing local health surveillance networks "back home", that are currently in place for general use of local and state health officials. Given the threat of "sick ships", it is a commendable start for the cruise ship industry, and even more so commendable, in that it was largely voluntary on the part of the international cruise ship companies. Admiral James Loy, the Commandant of the US Coast Guard at the SeaTrade Conference in Miami, March 6, 2001 said the following: "After all, vigilance and risk management are essential to every segment of marine transportation. And ICCL (International Council of Cruise Lines) and its member companies are certainly demonstrating their commitment in this regard. This commitment is reflected in ICCL's leadership in the IMO's work program on large passenger vessel safety . . and by the ICCL's decision to upgrade its voluntary guidelines for medical facilities.

However, it is just a start. The voluntary surveillance system is still substantially inadequate to meet the threat of either a terrorist or a pandemic.

Conclusions

Biological threats come in many sizes and forms. The ability of modern society to cope with such distressful situations is both helped and hindered by technology. Technology and the economic development that has resulted from technology has created a society that takes for granted a higher degree of freedom to travel with much greater mobility. This means that outbreaks of infectious diseases are much more difficult to isolate and contain. On the other hand, advances in remote sensors and diagnostic devices, telemedicine, satellite communications, and Smart Cards can achieve an edge on fast-breaking biological crises. Data mining forensics linked to Smart Card technology can derive plausible sources of infection and take rapid steps for effective intervention. Passenger ships (modern cruise liners) remain one of the most traditional enablers of pandemics and biological vectors, especially in those regions of the world such as Alaska, where the cruise ship industry activity has exploded in size since the last pandemic in 1969. Similarly, in 1969, biological terrorism aboard a cruise ship was simply inconceivable but today is a real threat. Successful design and deployment of a cruise ship "Sick Ship" alert prototype system is a vital first step at protecting our coastal communities from this inevitable menace, and our nation from biological agent attacks or pandemics in general.

Recommendations

Looking towards the future I recommend the following notional proposal: This approach blends Smart Cards, telemedicine with a partner shore-based teaching and consultative medical center like the George Washington University Medical Center, data mining services (with early pattern recognition using clustering, classifying, classifying and regression, and ranking / choosing for multi-criteria decision support), deployment of remote networked and miniaturized biological agent detection and identification devices on the cruise ships for environmental monitoring, and an integrated system of tracking and managing the health trends and requirements of passengers, crewmembers, and tour workers.

Smart cards are key to the system's ability to be used for forensics to rapidly establish the source of the infection on the ship. Smart Cards were initially deployed nationally by the French government as the digital intermediary between citizens and their government. The American Express Blue Card is one of the more recognizable Smart Cards deployed in the US. The Blue Card maps consumers' buying habits and patterns and shares this data with potential suppliers for targeted services. The availability of microminiaturized storage devices allows for significant personal information to be encrypted and stored locally. The Smart Card can therefore become the room key, the credit card, the access to the spa, the bar tab tracker, and the meal tracker with records about the identity of the server in each customer – cruise worker transaction. Initial credits can be implanted on the Smart Card to limit consumption to certain thresholds without surcharges. The card would be read every time the passenger enters and leaves the ship. The card would be downloaded at the end of each cruise, and would be linked with a 10-day follow-up, after-cruise questionnaire. Essential data would be shared with private parties only on a limited transaction basis. For instance, if a passenger was sick, and the surveillance system established that a common facility was used by several other sickened passengers, the Smart Card tracking system could identify others who used the same facility but left the ship 'well" They might be at risk of infection several days after leaving the ship, justifying a follow-up call to their personal physician or local health authorities.

The telemedicine devices would use INMARSAT-C satellite communications to link shipboard medical facilities with a facility like the George Washington University Medical Center's staff of telemedicine consultants. Resolution of graphics would be sufficient for ships to transmit X-rays for expert reading and analysis at the hospital. Smart cards would transfer key identification data about the passenger and their detailed interaction with various staff and facilities on the cruise ship and land-based special tours. Near real time results of diagnostic readings could be stored on the smart card but also would be transmitted to the hospital for such standard tests as breath chemical / biological analysis, EKG, retinal scan and ocular pressure, blood pressure, pulse, temperature and urine test readings. Results from other analysis techniques for sick passengers or crewmembers could be transmitted such as text or graphical data about stool sample contaminants, sputum analysis, and X-rays. For passengers or crewmembers needing a direct consultation with a physician at the hospital, telemedicine would allow for both E-Mail Chat or direct video teleconferencing on an appointment basis. All medical services might be charged against patients' existing health plans including Medicare but would be augmented through subscription to a special premium health maintenance service package provided through an insurance institution like the George Washington University Health Maintenance Organization

By applying and extending ideas from data mining and pattern recognition, a new generation of computational tools and techniques are being developed for the disaster response and mitigation community by the Center for Applied Scientific Computing at the Lawrence Livermore National Laboratory. They are developing scalable algorithms for the interactive exploration of large, complex, multi-dimensional scientific data. This project is called “Project Sapphire”. Access to these tools by academic institutions could be established through the Multi-Sector Crises Response Consortium at the National Science Foundation supported ACCESS center in Ballston, VA. ACCESS is a national capital area supercomputer demonstration center and supports the collaboration of over 50 universities and research institutes on developing applications of Widely Distributed Grid Computational Solutions. On a smaller prototype scale, there are several highly versatile products for data mining and determining multi-dimensional correlations among data streams. For example, one is the Cygron Pte Ltd. Software called “DataScope”. DataScope is designed for non-specialist users and its user-friendly interface requires little training to derive immediate benefits. Its interactive 3-D graphics and data visualization help the user directly discover actionable knowledge and make decisions. Its features include data exploration, what-if analysis, visual querying and drill-down support exploratory analysis and loosely defined objectives such as “find anything valuable hidden in the data”. Powerful prediction and decision modeling techniques can be used to model customer interactions and customer value perceptions. Datascope operates on a desktop PC and its results can be exported to a database, website or integrated into a report. Data mining can be automatically executed on a predefined schedule to detect repeating patterns of seemingly random infection and allow for successful intervention to eliminate the threat of “Sick ships”.

Miniaturized electronic sensors can be developed with simple neural net technology to smell or “sense” tags or indicators of disease producing bacteria such as that associated with the pneumonia called Legionnaires disease. Other devices called MEMS employ simple neural nets to learn or sense tracers from other pathogens. Schemes of automatically and remotely sampling readings of large numbers of such devices are under development at the George Washington University School of Engineering and Applied Science (Ref: David Nagel). Such devices could be used as a forensic intervention or prevention strategy; they might be distributed in passenger accommodations’ ventilation systems or located in high-risk facilities such as saunas, steam baths, spas, or food preparation areas

The proposed surveillance system would address privacy and regulatory needs of passengers, crewmembers, tour workers, cruise line companies and the government. Federal Privacy Act and Federal Medical Records Security regulations would be strictly complied with. Smart Card data would be encrypted and linked with a passenger’s personal identification number (PIN) code. It would seek to augment the basic level of primary care with more emphasis upon geriatric care with corresponding improved levels of medical diagnosis and treatment capabilities. It would include a standardized package of telemedicine, data compilation and data mining / pattern detection services. Data processing and pattern seeking forensics could be accomplished by a new Center for Biological Surveillance (CBS) located as a public-private-academic partnership at a facility like the George Washington University. Another facility like the George Washington University Medical Center and their staff of medical care consultants would provide Telemedicine services. Emergency infectious disease outbreaks with multiple casualties or biological warfare agent attack mitigation consultation and technical support would be provided over the telemedicine link through the National Response Center in Washington, DC and their networks with CDC and the Soldiers Biological & Chemical Command

Health maintenance planning assistance could be a central feature of this system for cruise line companies. For crewmembers, tour workers and passengers, it would have at least two levels of service: the basic would be part of every cruise line experience and would offer routine monitoring with intervention on an exception basis through a Smart Card transaction. Passengers and crew would be prompted by their Smart Card to report to the shipboard medical facilities if they felt ill. Each visit to the ship's medical facilities would update the Smart Card as well as compile results for periodic transmission to the central hospital / records analysis center. The premium service would be offered to all for a higher fee but would be customized for high-risk passengers and would offer individual consultation services using telemedicine. Initial input into the Smart Card would come from a questionnaire filled out by the passenger (perhaps through their private physician) when they booked their cruise. High-risk passengers would be prompted to report to the shipboard medical facility their first day onboard to establish medical baseline data. Certain types of remote diagnostic services could be used to establish medical baselines. Data captured for each participant would be stored on their personalized Smart Card and would include basic identification, cabin number, meals consumed, identification of servers, home address and telephone, specific sea-land tour package, specific travel arrangements, and use of specific athletic facilities such as spas, saunas, and swimming pools. Information would be linked to any medical reports submitted by the health facility onboard. Data from the shipboard health facility would be transmitted periodically using a satellite connection to a facility such as the George Washington University Medical Center. All outbreak alerts would be rapidly disseminated to the cruise line company and all required public health and safety agencies including the CDC and the National Response Center.

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