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Acute Febrile Respiratory Illness Aboard Ships In the US Navy

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Acute Febrile Respiratory Illness Aboard Ships In the US Navy

by

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Dedication

This Capstone Project is dedicated to CAPT Dwight C. Fulton, and CAPT Frank A. Chapman. Each went out of his way to educate me and guide me along this rewarding career path. Both have proven to be a constant inspiration through personal skills, career achievement, and gifted leadership ability. They truly represent the Navy core values of Honor, Courage and Commitment. It has been my honor and privilege to serve with them.

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I would like to acknowledge and thank the outstanding faculty and staff who displayed such dedication and commitment to education and the advancement of knowledge during a year with so much disruption and change. It has been my fortune to receive the benefit of their wisdom and expertise.

I would like to thank my committee members Dr. Laura Rudkin and Dr. Miriam Alter for their dedication and skill as both instructors during the year and advisors in this project. Their help has been greatly appreciated.

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Acute Febrile Respiratory Illness
Aboard Ships In the US Navy

Publication No._____

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Abstract

Acute Febrile Respiratory Illness (A/FRI) is a common but significant category of illness with world wide effect and impact on morbidity and mortality. In the shipboard environment the environmental, susceptibility and exposure factors that favor the spread of A/FRI are augmented. This paper assesses the risk of A/FRI aboard US Navy ships and compares that risk to preparations and policy already in place to reduce the risk of epidemics aboard ships. For ships to have the best chance at avoiding disabling epidemics, improvements are needed in the following five areas: 1) accurate and timely medical intelligence about A/FRI outbreaks worldwide, disseminated to all ships medical departments, as well as aggressive ship board surveillance programs with rapid testing Influenza kits and real time submission up the chain of command, 2) mandated education for all shipboard personnel about proper hygiene, the avoidance of disease, and self reporting of symptoms to facilitate early diagnosis and intervention if needed, 3) facilitation of early detection of outbreaks through the widespread availability and use of point of care rapid testing for influenza A & B with reflex testing to identify Avian Flu or novel strains, 4) early treatment with antiviral medications including keeping supplies aboard for ready use to avoid time delay in procurement, and 5) development of effective respiratory isolation methods and procedures standardized by ship class, established, in place and ready for immediate use. Improvements in these five critical areas are necessary to avoid the potential of an A/FRI epidemic aboard ship and its resultant impact on morbidity, mortality and operational readiness.

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List of Abbreviations

A/FRI	Acute Febrile Respiratory Illness
AFMIC	Armed Forces Medical Intelligence Center
AMAL	Authorized Minimum Medical Allowance
AOR	Area of Responsibility
BSL	Bio Safety Level
CDC	Centers for Disease Control and Prevention
CNO	Chief of Naval Operations
COMPACFLT	Commander Pacific Fleet
COMTHIRDFLT	Commander Third Fleet
CONUS	Continental United States
COTS	Commercial Off the Shelf
CVN	Nuclear powered Aircraft Carrier
DNBI	Disease and Non Battle Injury
DOD	Department of Defense
DON	Department of the Navy
EMF	Expeditionary Medical Force
FHP	Force Health Protection
FLS	Flu Like Syndrome
GI	Gastrointestinal
H	Hemaglutinin
HNS	Host Nation Support

HSC	Homeland Security Council
ICU	Intensive Care Unit
N	Neuraminidase
NEPMU	Navy Environmental and Preventive Medicine Unit
NGO	Non Governmental Organization
NIAID	National Institute of Allergy and Infectious Disease
NMCPHC	Navy and Marine Corps Public Health Center
OPNAVINST	Operational Navy Instruction
OS	Operational Stage
OTUSF	Other than US forces
PACFLT	Pacific Fleet
PI	Pandemic Influenza
PPE	Personal Protective Equipment
PPM	Personal Protective Measures
SARS	Severe Acute Respiratory Syndrome
SMDR	Senior Medical Department Representative
SUPPLAN	Supplemental Plan
TB	Tuberculosis
TST	Tuberculosis Skin Test
UCC	Unified Combatant Command
USFFC	US Fleet Forces Command
USPACOM	US Pacific Command
USPACOMINST	US Pacific Command Instruction
WHO	World Health Organization

Chapter 1 – Introduction

Specific Aims

The purpose of this Capstone project is to do an analysis of a specific public health problem, Acute/Febrile Respiratory Illness (A/FRI) aboard US Navy ships, and produce recommendations on how the US Navy can improve its existing policies and plans to counter this threat.

A/FRI is a serious threat to the military and an even greater threat aboard US Navy ships. During the 1918 pandemic, influenza had a detrimental effect on the ability of the US to prosecute World War 1. An estimated 675,000 Americans died of influenza during the pandemic, ten times as many as in the world war. Of the U.S. soldiers who died in Europe, half of them fell to the influenza virus and not to the enemy.[1] An estimated 43,000 servicemen mobilized for WWI died of influenza.[2] [3] Spread of disease was greatly facilitated by the close quarters troops were subject to during transport overseas. Due to the confined nature of the ship board environment, infectious illness has the potential to easily and rapidly spread, infecting a large percentage of the crew. Aboard US Navy ships, this can seriously degrade their ability to carry out their missions, as well as cause serious morbidity and even mortality among the US service men and women who man them. In light of the recent interest in Influenza, specifically H5N1 Avian flu and its potential to produce an Influenza pandemic, the US government and subsequently the Department of Defense, and Department of the Navy have produced recommendations and policies on how to meet this threat. This capstone project will attempt to examine the threat of A/FRI aboard US Navy Ships as well as assess the policies in place to meet it.

Specific objectives

The specific objectives of this capstone project are the following:

1) Assess the threat of A/FRI such as that caused by pandemic influenza, novel influenza strains or other etiologies aboard U.S. Navy ships and come up with a set of essential vulnerabilities that need to be successfully addressed to mitigate the risk.

2) Review current US policies for addressing the risk of Pandemic Influenza, including the National Strategy and Implementation Plan, as well as policy from the Department of Defense, Department of Navy/Chief of Naval Operations, Unified Combatant Command, Major Fleet Command and numbered Fleet Command, addressing the threat of pandemic influenza or epidemic A/FRI.

3) Compare vulnerabilities in the ship board environment with existing policy and instruction. Identify gaps and produce specific recommendations for A/FRI prevention and control aboard U.S. Navy ships.

Significance

The risk of an epidemic of A/FRI aboard ship is very real. Factors that facilitate the spread of A/FRI, including environmental factors, crew susceptibility and exposure are magnified aboard ship. Ships that are deployed have increased exposures to new illness through crew exposure on port calls and the arrival of new crew members. The environmental and exposure factors make the risk of significant morbidity and mortality from an epidemic aboard ship much higher. Additionally the effect of such an epidemic aboard a ship, out to sea, with a limited number of crew to maintain and manage it, can have a much greater impact on operations, than the effect on shore, with a ready supply of people to fill in for those who are ill. Epidemic A/FRI is a serious threat to any ship's mission capability, but even more so, when it is

deployed. The average nuclear aircraft carrier costs 6.5 billion dollars and over $800,000 per day to operate[4]. A significant epidemic of A/FRI aboard a single ship, could potentially take it out of operations for days costing millions of dollars.

For all of these reasons, it is important to study this problem and facilitate the Navy's development of effective policies to mitigate the risk of serious epidemics, minimize the number of serious illnesses, and effectively counter and the illnesses that do happen.

Chapter 2 – Background and Literature review

Background Information

Acute/Febrile Respiratory Illness (A/FRI), also known as Influenza-like illness (ILI) or Flu-like syndrome (FLS), is a serious U.S. and worldwide health problem, responsible for significant morbidity and mortality. It is estimated that there are between three and five million cases of severe illness each year throughout the world, with approximately 250,000 to 500,000 deaths directly attributed to influenza or its complications.[5] In the U.S. A/FRI is a very common illness, with adults averaging one to three episodes per year and children three to six episodes per year.[6] Mortality and hospitalizations in the U.S. directly attributed to influenza vary considerably due to the length and severity of annual influenza seasons; however, the CDC estimates that in the U.S. about 36,000 people die (range 17,000 to 52,000) and 200,000 people are hospitalized each year as a result of influenza or related complications.[7] The most familiar etiology of A/FRI is influenza, but other etiologies such as adenovirus, respiratory syncytial virus, *Mycoplasma pneumoniae* and *Haemophilus influenzae* are significant as well. In a study done by Amundson et al, the etiology of A/FRI in military recruits was sought. In 47%, no diagnosis could be made, 21% were due to *Mycoplasma pneumoniae*, 16% due to *Haemophilus influenza*, 9% influenza, 7% adenovirus and 5% *Strep pneumoniae* (total greater than 100% as some cases had more than one etiology discovered).[8] In another study during the 2003 joint exercise known as Cobra Gold, cases meeting criteria for A/FRI were evaluated for cause. Of that group, 44% were due to influenza virus, 13% corona virus OC43 (not SARS), 13% respiratory syncytial virus, and 6% rhinovirus.[9]

Symptoms of A/FRI commonly include fever, chills, headache, dry cough, loss of appetite, myalgias, arthralgias and GI symptoms (mostly in children). In most cases, the symptoms are caused by cytokines released by immune system activation. Technically, any diagnosis of influenza based on symptoms or clinical findings, and not on laboratory testing is really a diagnosis of A/FRI, not of influenza. In other words, it is a medical diagnosis of possible influenza or other illness causing a set of common symptoms. This distinction, however, is usually of no great concern since most cases of A/FRI are mild and self-limiting. Studies have shown that most cases of A/FRI are not due to influenza, but rather other non influenza causes. (See Figure 1) Even in times of epidemic seasonal influenza, the percentage of A/FRI that is actually influenza is at most 25%.

In figure 1 (next page), the colored bars represent different types and subtypes of influenza and actual numbers are shown on the scale to the left side of the figure. The solid black line shows the percent of all cases of A/FRI that are caused by influenza with the scale to the right side. During peak periods it shows that about 25% of A/FRI is due to influenza.

Of all the causes of A/FRI however, influenza remains the most significant of A/FRI because of its highly efficient human to human spread, its history of morbidity and mortality in those with underlying medical conditions, and its potential for developing into novel strains through antigenic shift and producing a pandemic.

Since most of the literature is related to influenza, this capstone project will focus primarily on that entity, but will also include other causes of A/FRI wherever possible in an attempt to produce recommendations that are pertinent to all serious causes of A/FRI.

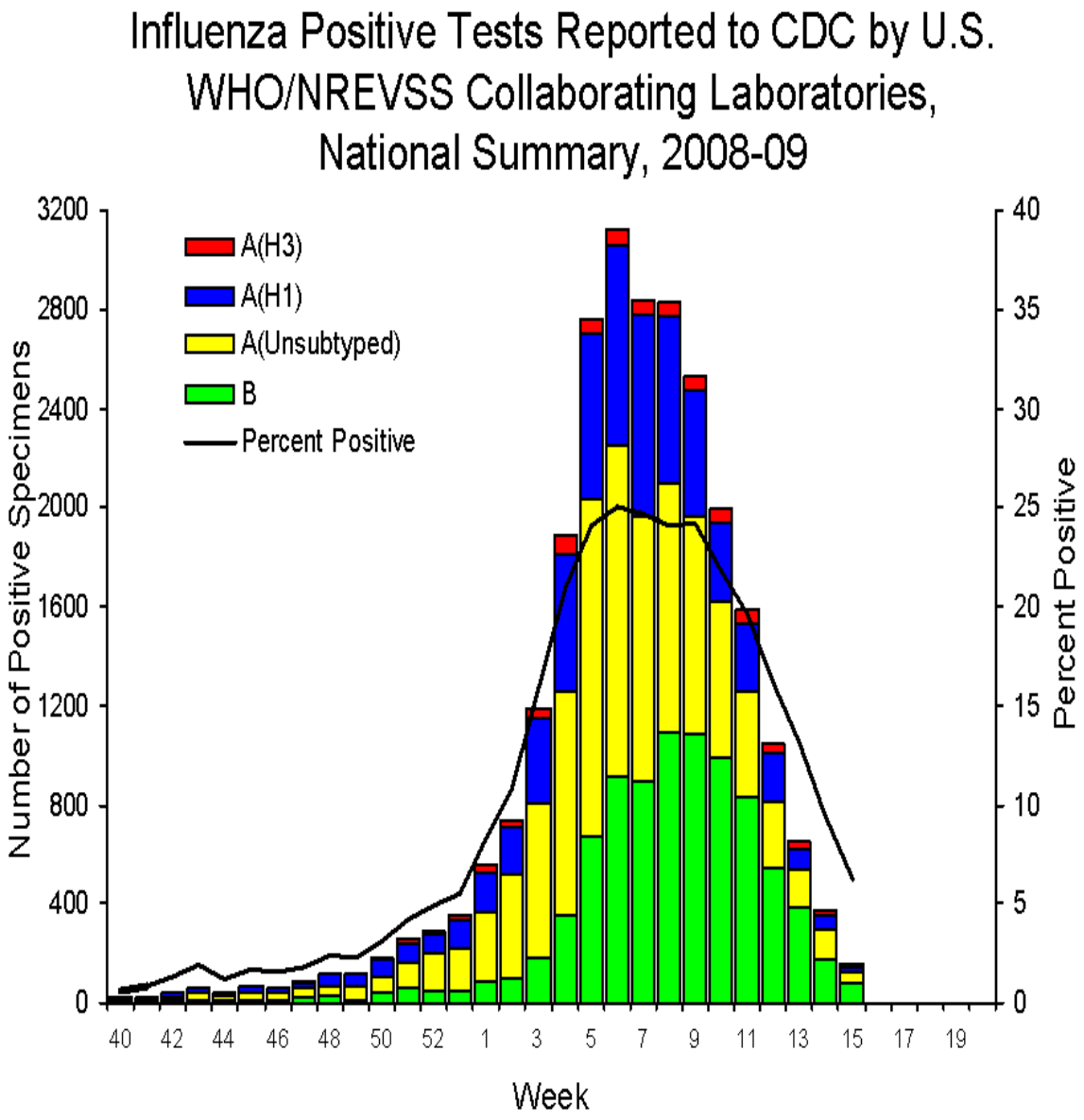

Figure 1: A /FRI diagnosed vs. results of positive test for Influenza graph [10] This work is in the public domain in the United States because it is a work of the United States Federal Government under the terms of Title 17, Chapter 1, Section 105 of the US Code

Chapter 3 – Data and Methods

This study involves a review of existing literature on the subject of Acute/Febrile Respiratory Illness (A/FRI) aboard US Navy ships. As this literature is quite limited, the scope needed to be expanded to include similar illnesses and comparable environments. It also involves a review of existing strategy and implementation plans for pandemic influenza. It starts with the National Strategy and Implementation plan, followed by the Department of Defense Implementation plan. Next, Department of the Navy implementation plans from the Chief of Naval Operation's (CNO) office is reviewed. Review was then conducted at the Unified Combatant Command level, the Major Fleet level and the Numbered Fleet level. Since it is beyond the scope of this capstone project to review and summarize all organizations within the US Navy, one Unified Combatant Command was chosen (PACOM) and in like fashion only one of the two major fleets (PACFLT) and one of the six numbered fleets (Third Fleet) was chosen for review and summarization. This is followed by a discussion and comparison of risk versus existing policy to mitigate that risk, with additions to policy recommendations at the end.

Aim 1- Assessing the Risk

This aim is addressed through a review of the scientific literature using Pub Med. Selection was limited to English language, human studies, from 1950 to present. Key words used in searches included "epidemic", "influenza", "febrile respiratory illness", "acute respiratory illness", "influenza like illness", "military", and "naval ships". Since little is written specifically about this risk aboard US Navy ships, information was cross referenced from similar environments or populations, for example, cruise ships, military recruits, and travelers. Information on deployment related illnesses were accessed from the Naval Environmental and

Preventive Medicine Units (NEPMU) and Navy and Marine Corps Public Health Center (NMCPHC). NEPMU and NMCPHC keep statistics on febrile respiratory illness, outbreaks of other epidemics, and outbreaks in certain geographic areas. Additionally, all military units submit Disease Non-Battle Injury (DNBI) reports to Combatant Commands. While these reports do not specifically identify Influenza, they do count Febrile Respiratory Illness. Armed Forces Medical Intelligence Center (AFMIC) also collects data on geographic disease threats.

This data was used to elucidate the risk of A/FRI in the shipboard environment and determine the A/FRI etiology that represents the greatest threat. It was also used to illustrate those features of shipboard life including environmental factors, susceptibility to illness, and exposure to illness that contribute most to the risk of epidemic A/FRI aboard ships.

Aim 2 – Current Policy Review

Current policies and instructions as they pertain to pandemic influenza (PI) were reviewed. The intent was to start from the National Strategy for Pandemic Influenza and its implementation, and trace its course through typical chains of command, both administrative and operational, leading to shipboard implementation. In this project, we selected the operational and administrative commands that the USS John C Stennis CVN74 would have when deployed to the Western Pacific. The operational chain of command would start with the President of the United States National Strategy and Implementation plan, and proceed to the Department of Defense plan, ultimately to the Unified Combatant Command represented by Pacific Command (PACOM). The Administrative chain of command would again start with the President and Department of Defense, then go through the Department of the Navy policy (Chief of Naval Operations), major fleet command represented by Pacific fleet (PACFLT), and then to a numbered Fleet Command represented by Third Fleet (see table 1).

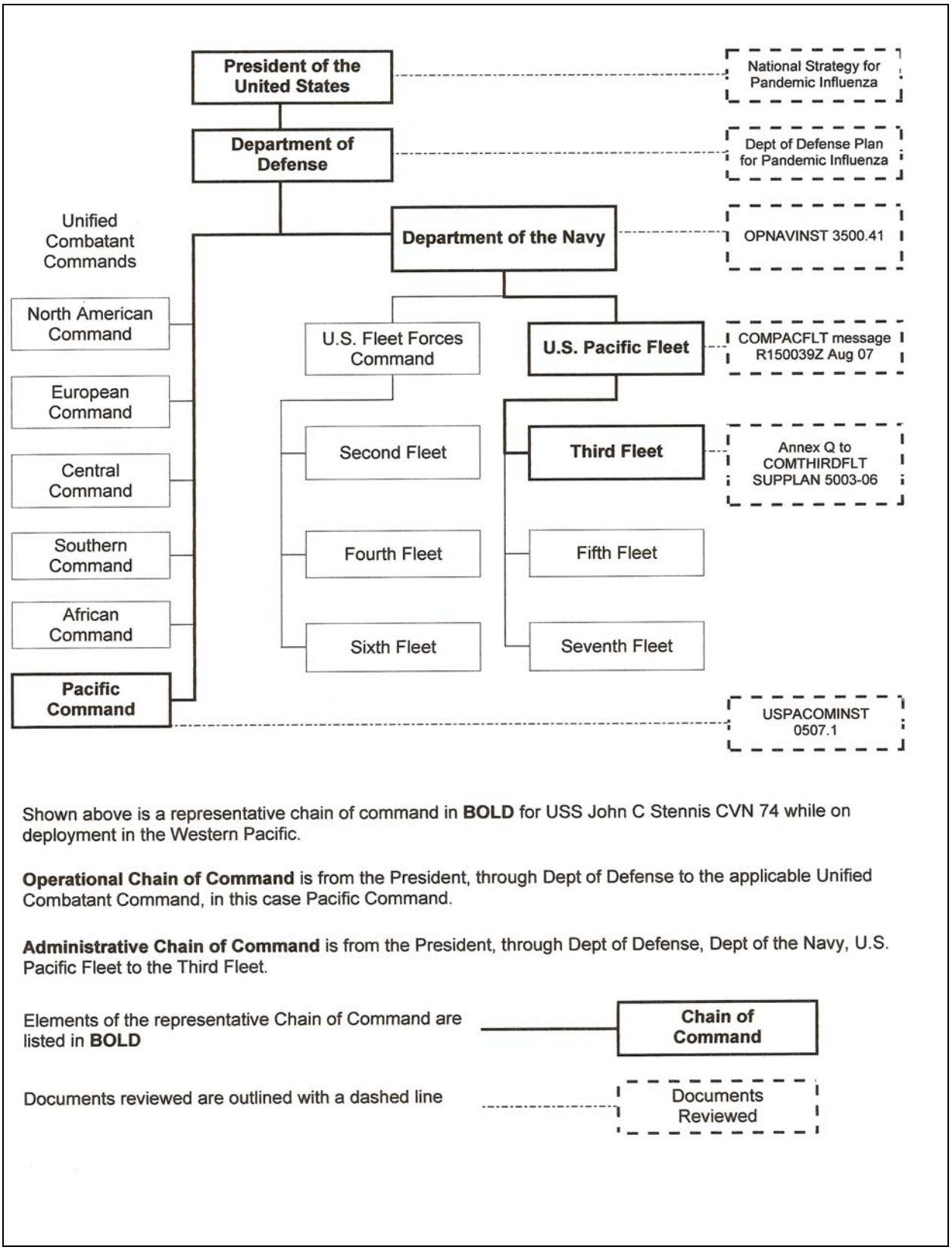

Table 1: Representative Chain of Command

Tasking and responsibilities that seemed to have applicability to shipboard risk of outbreaks were collected and reviewed. This information was available primarily via published instruction from the commands involved. Other information was available from websites maintained by Navy Medicine Online Portal, Navy Environmental and Preventive Medicine Unit (NEPMU) 5 and 6, and through direct contact with the Force Surgeons for Fleet Commands, specifically 3rd Fleet, Military Sealift Command and Commander Naval Air Forces. These command instructions were reviewed to ascertain how they implemented the three basic pillars of the National Strategy for Pandemic Influenza: 1) Preparedness and Communication, 2) Surveillance and Detection, and 3) Response and Containment. To attempt to identify gaps in current Navy planning and instruction, a table was constructed listing responsibilities called for by instruction from the commands noted above. These responsibilities were then organized under the three pillars of response dictated by the National strategy. Finally, this table was reviewed to see how the three pillars of National Strategy were carried through to the fleet level.

Aim 3 – Comparison of Risk vs. Current Policy

Utilizing data from Aim 1, as well as this author's experience on what has been needed in the past to control shipboard epidemics, a list of what measures should be in place at the ship board level was compiled. This list was compared to the responsibilities called for in the command instructions that were categorized in Aim 2. A comparison was made between what is needed and what is already in place. Any deficiencies were noted and highlighted in discussion and recommendations.

Chapter 4 – Results

Aim One – Assessing the Risk

Influenza

Influenza is a highly contagious respiratory illness, characterized by high fever, myalgias, headache, rhinitis, sore throat, and non productive cough. It typically lasts for one to two weeks and most individuals will recover without serious sequelae. It can be severe however, in the very young and the elderly, or those with serious medical conditions, and can lead to severe respiratory complications, pneumonia and death. It is transmitted by coughs or sneezes, creating aerosols containing the virus.[11] Influenza can also be transmitted by saliva and nasal secretions. Infections occur through contact with these aerosols, body fluids, or with contaminated surfaces. Crowded conditions tend to favor the spread of the disease.[12, 13] It is estimated that influenza causes between three and five million cases of severe illness worldwide, with approximately 250,000 to 500,000 deaths directly attributed to influenza or its complications each year.[14] In the US, even with an effective vaccine readily available, there are many serious cases and significant mortality each year. Although the incidence of influenza can vary widely between years, approximately 36,000 deaths and more than 200,000 hospitalizations are directly associated with influenza every year in America.[7]

All human influenza viruses are divided into two major types, A and B. The viruses are further classified by antigens or surface proteins. These antigens fall into two categories, Hemagglutinin (HA) and Neuraminidase (NA) and can vary considerably in their structure and antigenicity (see Figure 2).

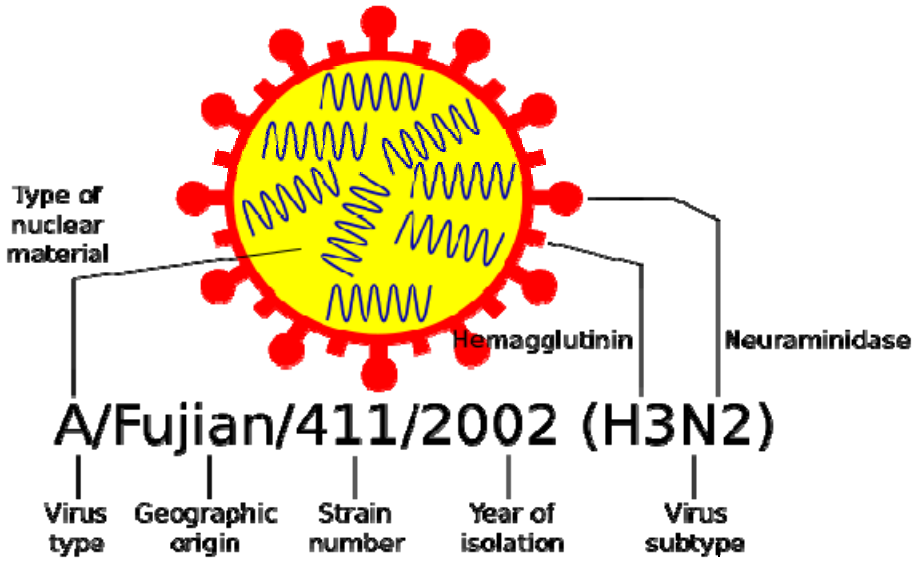

Figure 2: Influenza Virus Nomenclature showing surface antigens used in subtyping [15] Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.2 or any later version published by the Free Software Foundation.

The Hemagglutinin (HA) proteins are essential for viral attachment to cells. Individual viruses attach to cells via bonding of HA to surface proteins containing N-acetylneuraminic acid (NANA). Antibody to the HA protein will prevent viral attachment to host cells and subsequently block infection.

The Neuraminidase protein (NA) has a different function. When a host cell is infected by an influenza virus, the newly formed viruses are released by budding of the plasma membrane of the host cell. Since the host plasma membrane has surface proteins containing NANA, the new virus particles will have these same glycoproteins with NANA. The NA protein is an enzyme that removes the NANA from the newly formed viral particle. If it did not do this, the virus particles would all clump together, HA binding to NANA on other particles, and greatly decrease the number of infectious particles. Antibody to NA then directly affects the virus's ability to avoid clumping, and decreases the number of effective infectious particles created per cellular infection. [16]

How the Influenza Virus Changes – Antigenic Drift vs. Antigenic Shift

Influenza viruses are continually evolving and present considerable challenges to their hosts in the development of natural immunity or immunity from vaccines for prevention of disease. This evolution typically occurs via two mechanisms.

Antigenic Drift - The first is called antigenic drift, and is the result of random mutation of the viral genome. Influenza viruses have single stranded RNA as their genetic material. Unlike double stranded DNA with good repair mechanisms and a second strand to use as a template for repair, single stranded RNA has poor repair mechanisms and no built in template, so change (mutation) is more likely to persist. This tends to produce a gradual but steady change in the virus. Minor changes in the HA or NA proteins can affect their reactivity with previously established host antibodies and make these antibodies less likely to bind and deactivate viral particles. As a result, the host, despite prior infection or vaccination, eventually becomes susceptible again to a gradually changing virus [16] (see Figure 3). Antigenic drift is one of the reasons the influenza vaccine has to be reformulated each year.

Antigenic Shift – The second mechanism, antigenic shift, produces a more significant and less predictable change in the resulting influenza virus genome. It requires that two different strains of influenza virus infect the same host cell. During the process of replicating the eight different segments of viral genome and the reassembling of new viruses, a "reassortment" of these segments of viral genome can occur, producing new viruses with segments of RNA genome from both of the original viruses. These new or novel strains of influenza virus have not been seen before, consequently there is no existing immunity to them. If this new virus strain happens to have a selective advantage over other viruses, it will thrive and produce new infection. Reassortment is considered the most likely basis for the emergence of new subtypes of Influenza A. This is based on sequence analysis of genes of viruses isolated from human and

animal species. [16] There is some thought that human pandemic influenza viruses have derived their HA and NA surface glycoproteins from an avian lineage via reassortment. This reassortment may have occurred in either birds or humans infected with both human and avian virus. However, pigs are quite susceptible to both human and avian viruses, and may be the most likely host for reassortment [16] (see Figure 4). There is currently great concern over the potential for re-assortment of Avian flu (H5N1). Such a virus has pandemic potential because it may be intrinsically pathogenic in humans and have surface antigens against which the human population lacks any significant immunity.[17] Reassortment creating an Avian influenza strain that is human to human transmissible could produce a highly pathogenic, highly infectious influenza virus that could lead to the next pandemic (see Figure 3).

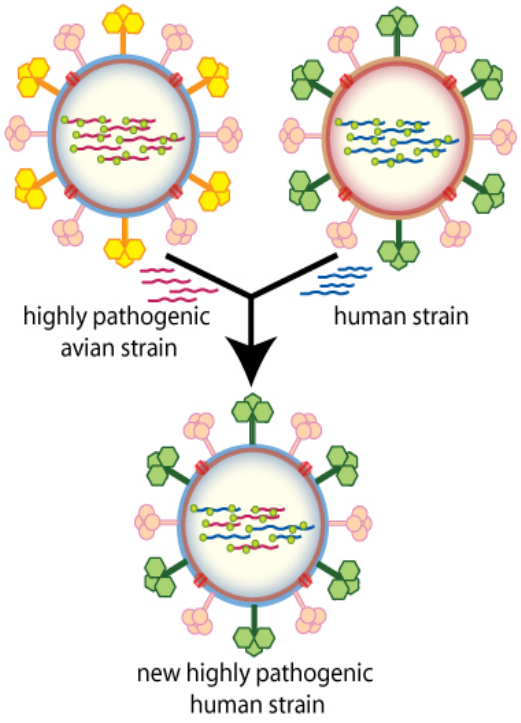

Figure 3: Showing reassortment of the genetic material from a Highly Pathogenic Avian strain plus a Normal Human strain, into a *New* Highly Pathogenic Human Strain[18] Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.2 or any later version published by the Free Software Foundation

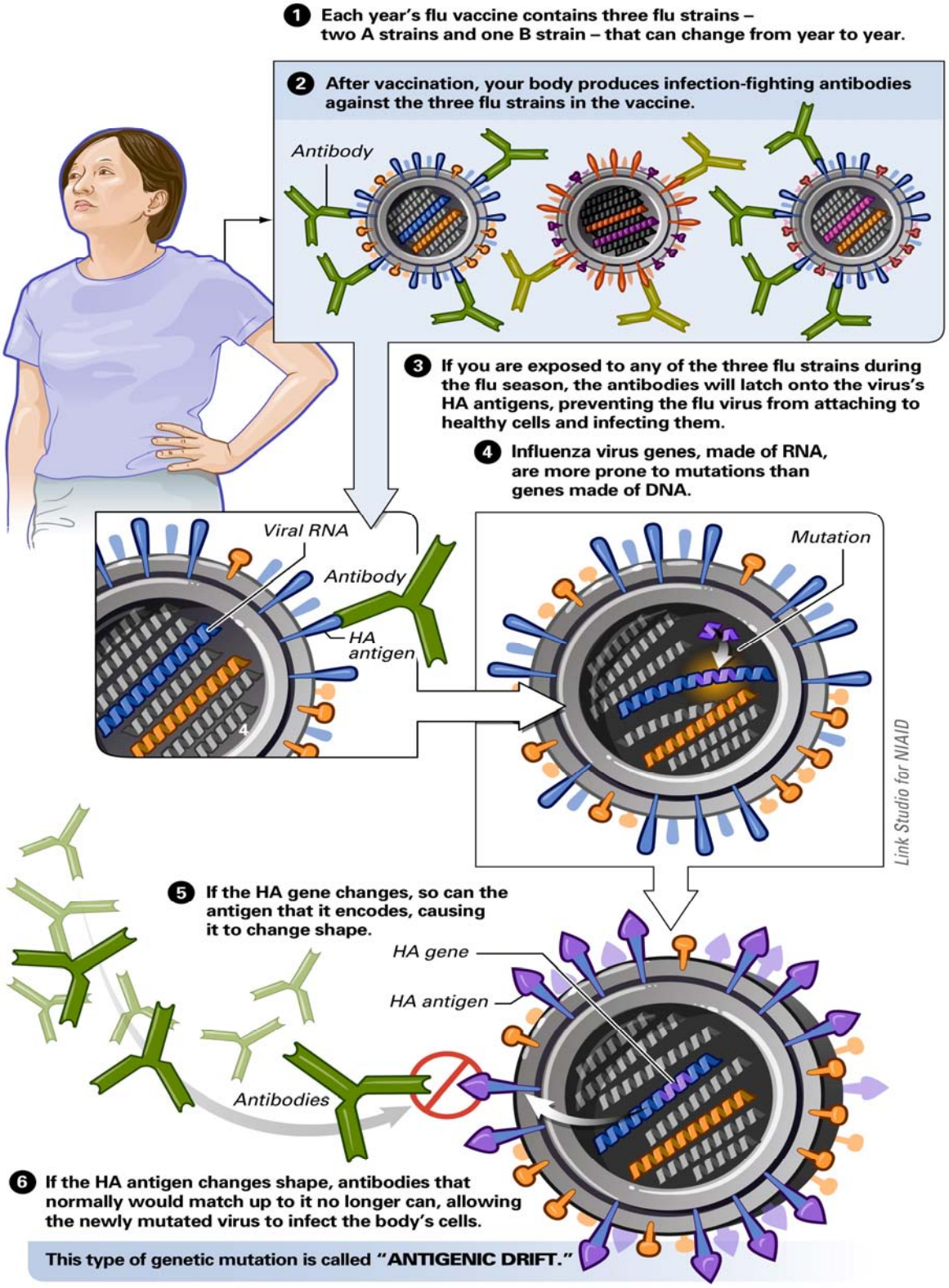

Figure 4: Antigenic Drift[19] This image is in the public domain. Please credit the National Institute of Allergy and Infectious Diseases.

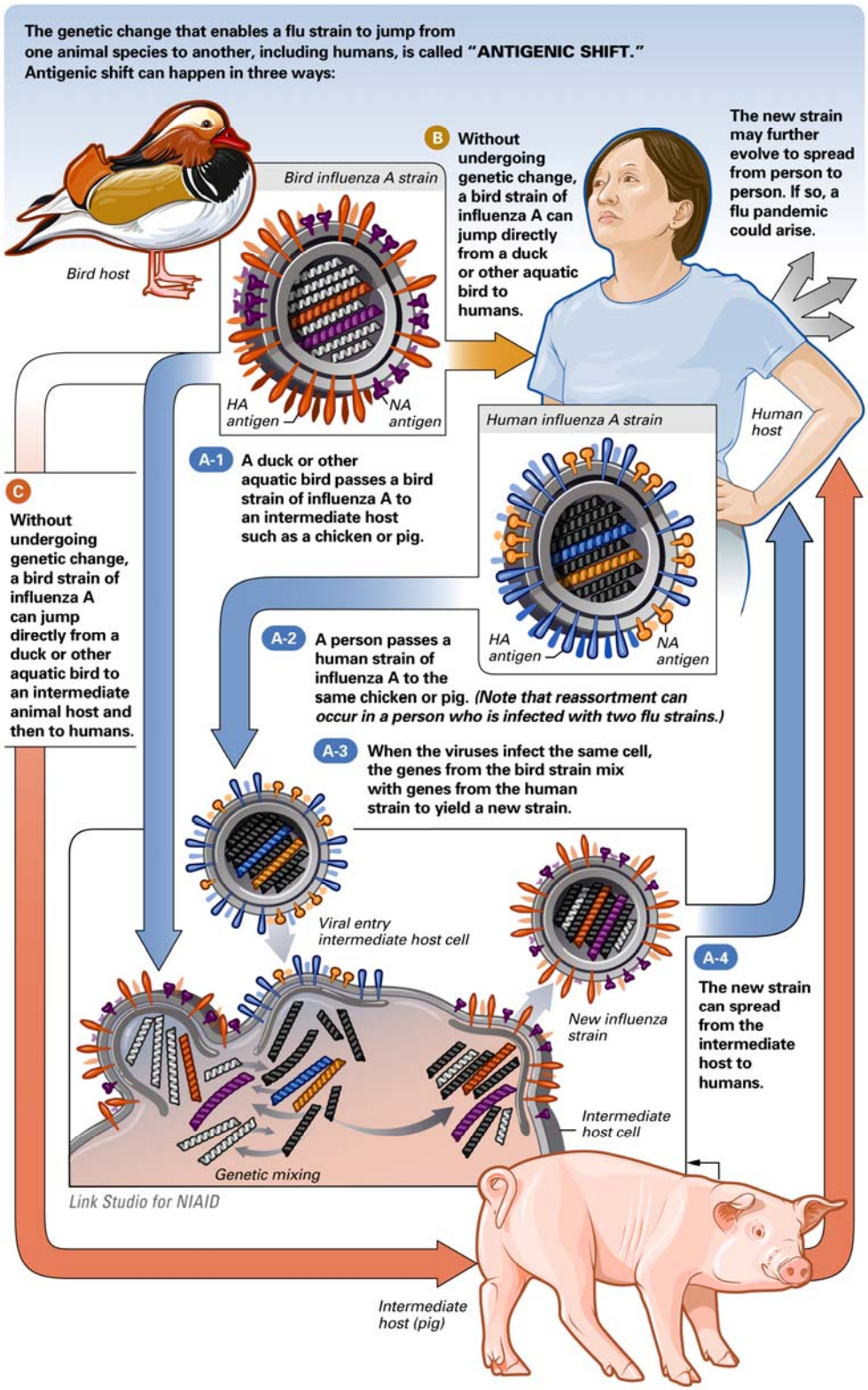

Figure 5: Antigenic Shift[19] This image is in the public domain. Please credit the National Institute of Allergy and Infectious Diseases.

Pandemic Influenza

The most significant threat posed by influenza is that of a global pandemic. This happens when antigenic shift produces a novel strain of the virus with high virulence, that is easily transmissible human to human, and against which there is little to no existing immunity in human populations.

There are three well documented pandemics of influenza in the last century, the most notable being that of the Spanish Flu of 1918. This pandemic is estimated to have infected 50% of the world's population, with half of those becoming ill. The total mortality was estimated to be 40-50 million, producing a mortality rate of 2-2.5%. The attack and mortality rates were highest among healthy adults (20-40 years old).[7] Other estimates of mortality range from approximately 50 to 100 million people worldwide.[20]

In addition to the Spanish Flu, there were two other pandemics noted in the 20th Century; the Asian Flu in 1957 and the Hong Kong Flu in 1968. These both caused significant disease and mortality. The Asian flu pandemic of 1957 was an outbreak of influenza A H2N2 that started in China in February 1957 and extended until 1958. A second wave of infection was observed early in 1958. The two waves together affected some 40-50% of people, of which 25-30% experienced clinical disease.[21] In the Asian Flu pandemic the death toll in the U.S. was approximately 69,800 and estimates of the worldwide death rate ranged from 1 million to 4 million.[22]

The Hong Kong pandemic of 1968 originated in Asia as well and was thought to be spread to the U.S. by returning servicemen from the Vietnam War. It was identified as Influenza A H3N2

and labeled the Hong Kong Flu. Estimates of victims of the 1969 pandemic show a range of one to three million fatalities of which over 33,000 were from the United States. [23]

In contrast to seasonal epidemics where mostly those with underlying medical conditions, children, or the elderly experience severe illness, all of these pandemics had a substantial component of severe illness in otherwise healthy young adults.[24] In plotting age vs. mortality, the 1918 Spanish Flu pandemic shows an increased risk of mortality in adults between the ages of 16 and 40 (see Figure 6).

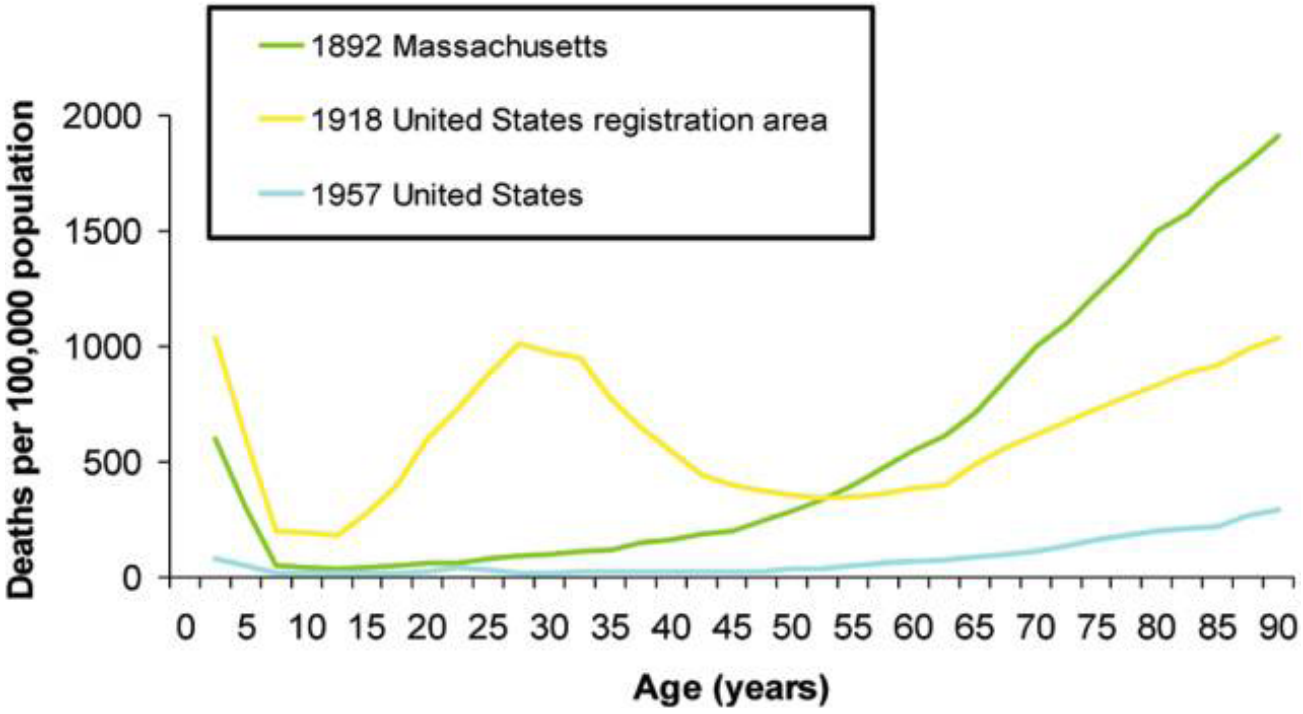

Figure 6: The classic "W" curve of the 1918 Spanish Flu Pandemic, illustrating increased mortality in the 16-40 age range [25]

This classic "W" shaped mortality by age curve reveals another characteristic feature of the 1918 pandemic. This increased demonstration of increased mortality in an otherwise healthy population continues to be a point of concern in the emergence of any novel strain of influenza.

It is the risk of pandemic influenza or other novel influenza strain not covered by vaccine that currently poses the greatest risk to sailors aboard U.S. Navy ships.

A/FRI in U.S. Military Personnel not aboard ships

Much of the research on A/FRI in the U.S. Military has focused on U.S. military personnel in training. Studies have shown this group to be at greater risk of hospitalization for A/FRI than the U.S. population as a whole. In a study of U.S. Army trainees and hospitalizations from 1991 to 1994, the hospitalization rate for A/FRI was approximately 16 per 10,000 per year vs. 5 per 10,000 per year in the civilian population. (see figure 7) [26, 27, 28, 29]

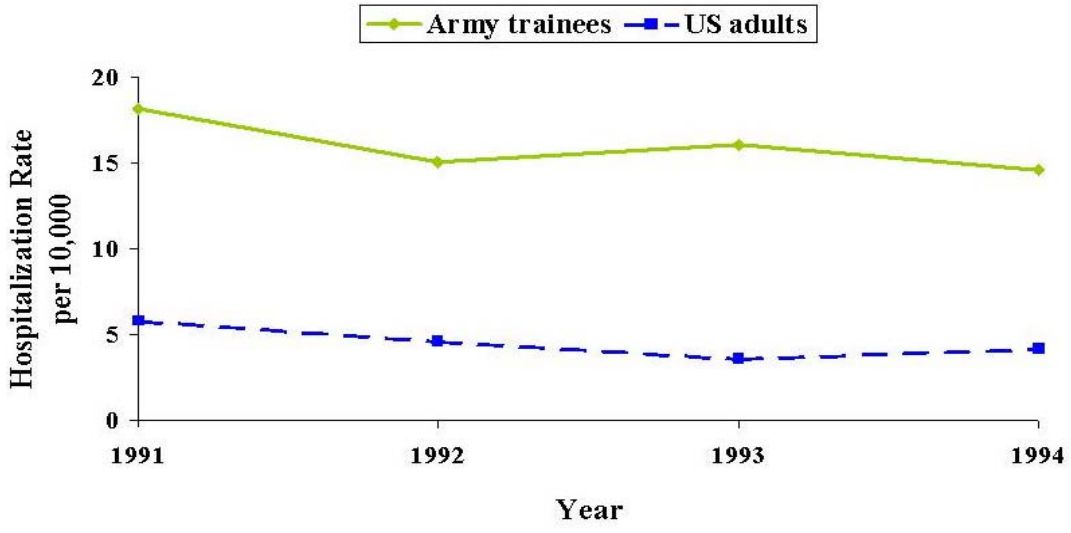

Figure 7: Hospitalization rates for A/FRI per 10,000 persons, 1991 to 1994: U.S. army recruits vs. young adults in U.S. nonfederal hospitals. U.S. army recruit estimates are converted from percentage febrile acute respiratory disease rates per 100 trainee-week figures. On average, recruits were 19 years old. U.S. national nonfederal estimates were taken from first-listed diagnoses with the International Classification of Diseases codes 460 to 466 (9) among persons of ages 15 to 44 years (10-13). [30]

Acute/Febrile Respiratory Illness (A/FRI) is a leading cause of outpatient illness and a major cause (25% to 30%) of hospitalization for infectious disease in U.S. military personnel.[30] Another study on A/FRI in military recruits at the Naval Training Center in San Diego, looked at etiology and rates of hospitalization in 100 cases of A/FRI. It found that hospitalization rates

were 30 times higher than that of non-recruits. The most common etiologies were *M. pneumoniae, H. influenzae,* influenza A and adenovirus.[31] Two studies looked at outbreaks of adenovirus in military recruits. In the first study, 678 U.S. military recruits were involved in a prospective study to determine rates of infection during training. Roughly 80% of recruits seroconverted (titer greater than 1:4) during the eight weeks of basic training.[32] In the second study, an adenovirus outbreak was looked at in Spanish military recruits. In the study, 4,930 recruits were followed, and 3,450 (69.9%) experienced an episode of A/FRI during the nine weeks of training with 3,200 (64.9%) of those infected in a period of just four weeks. The principle etiologic agents found were influenza A and adenovirus type 11. The above studies serve to illustrate the increased risk of A/FRI in military recruits in training.

Outbreaks on U.S. Navy ships

There have been relatively few documented outbreaks of influenza aboard U.S. Navy ships, however those that are reported in the literature serve to demonstrate the potential seriousness of a highly contagious respiratory illness aboard ships.

One such incident was documented on the USS Arkansas, a nuclear powered guided missile cruiser.[33] The ship was conducting operations off the coast of California February 1996 when an outbreak of what was later determined to be Influenza A (H3N2) occurred. Of 558 crew members, 523 crew members (95%) had received the 1995-96 influenza vaccine in December 1995. Administration of the vaccine had been uniform, and the cold chain was maintained. The vaccine lot number and administration time were the same as those used for the crew of the companion ship, the USS California, in which no outbreak occurred. In a post outbreak study, a total of 232 of 552 or (42%) of USS Arkansas crew members were identified with an influenza-like illness during the outbreak. The medical department identified 158 cases,

while 74 additional patients did not seek medical attention but met case criteria. An additional 63 crew members (11%) reported having some influenza-like symptoms (probable cases) but did not meet the definite case criteria. New cases peaked at 40 per day on day six, and the epidemic spanned two weeks.[33] The ship was unable to continue operations and was forced to return to port to deal with the epidemic pierside. (see figures 8 & 9)

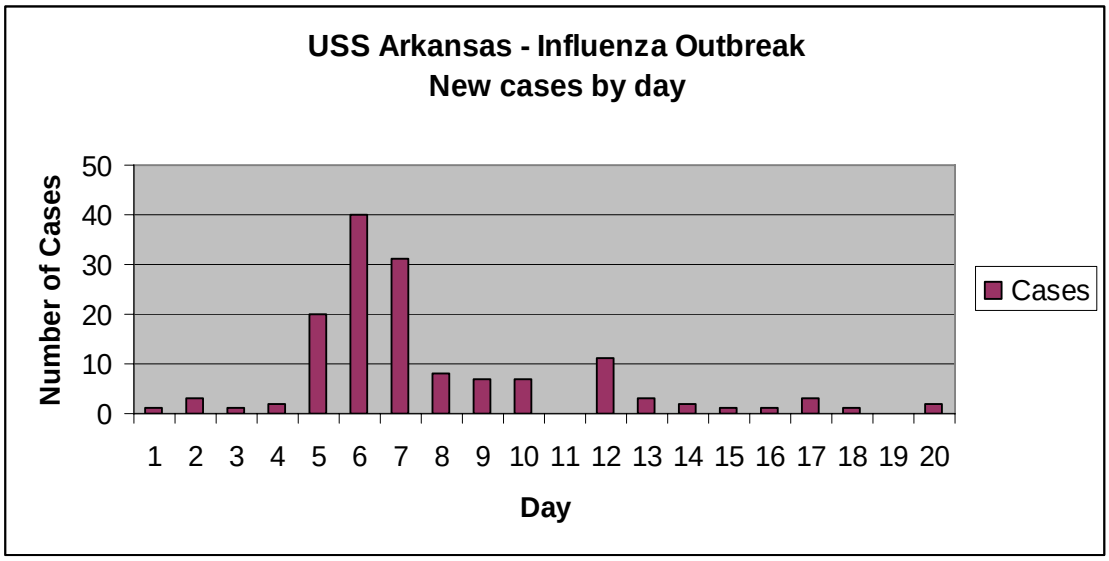

Figure 8: Influenza outbreak aboard USS Arkansas, February 1996, showing cases by day of the outbreak. [33]

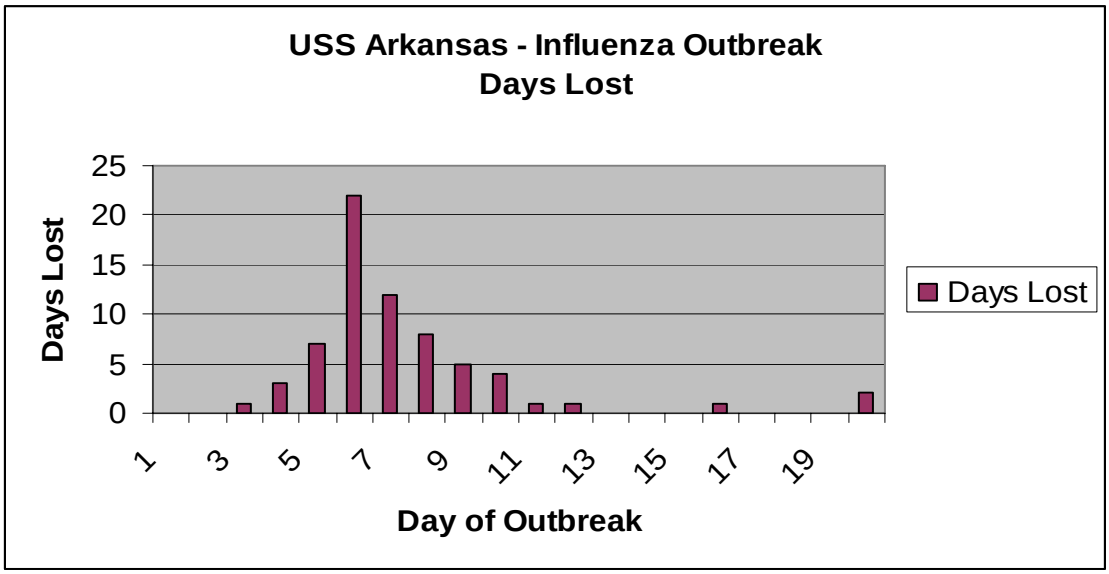

Figure 9: Number of lost workdays during outbreak aboard USS Arkansas. One lost workday = one day a patient is placed at bed rest with influenza. [33]

The explosive nature of this outbreak shows how easily influenza A spread through a confined population despite appropriate vaccination. The efficiency of human-to-human transmission was further emphasized by the fact that no discernible differences in attack rates were noted between various areas of the ship by the end of the outbreak. [33]

In another case involving a seagoing US Navy tugboat operating out of the Philippines in 1978, 42 out of 68 crew members (62%) came down with high fever and respiratory symptoms of fairly short duration (1-2 days).[34] The epidemic lasted for about 10 days; however, 78% of the 42 cases presented on just two days. The virus turned out to be H1N1 Influenza A/Victoria/75. There was no difference in attack rates between those immunized and those not, indicating prior vaccination was not effective. There was a much higher attack rate in those under 22, who were unlikely to have exposure to H1N1 in the past.[34]

Both of the cases noted above serve to demonstrate the highly explosive nature of A/FRI disease propagation aboard a ship when there is very little existing immunity. Fortunately, both of these strains were of low virulence and fairly short duration. Both episodes, however, required that the ship abandon its mission and return to port to deal with the epidemic.

Outbreaks on Cruise Ships

There have been many episodes of A/FRI aboard cruise ships. Several have been described in the literature. For example, in September 2000 there was an outbreak on a cruise ship sailing between Sidney, Australia and Noumea. A questionnaire was sent to passengers three weeks after the cruise and a total of 310 out of 836 passengers (37%) reported symptoms described as an influenza like illness either during or following the cruise. A case control study done at the time showed no significant protective effect from the current influenza vaccination.[35]

In another case in 1997, passengers from three different cruises on the same ship suffered increased incidence of A/FRI during and in the week following their cruise.[36] The outbreak presented when six passengers from the ship required hospitalization for A/FRI following the first leg of their cruise. Influenza A was isolated from the nasal swabs of two of these passengers. As the cruise continued, more passengers became ill. A total of 215 of 1284 passengers (17%) became ill with a strain of influenza not previously identified in North America. It was concluded that an off season outbreak of influenza had occurred.[36]

In a third case from 1987, Influenza A (H3N2) was isolated from a passenger hospitalized for A/FRI following a 19 day tour and cruise in Asia. Follow-up questionnaires to other passengers revealed that 104 of 277 (38%) reported symptoms consistent with A/FRI either during or immediately following the trip.[37]

Also reported in April 1984, a large outbreak of both influenza-like illness and diarrheal illness occurred on a cruise ship in the Mediterranean, visiting ports in both Southern Europe and Northern Africa.[38] Of the 391 passengers that responded to the questionnaire, 335 (86%) had gotten ill, 295 of these with an influenza-like illness. There were multiple etiologies, and no single source of the illness was found. The only common feature of the epidemic was its occurrence after the air conditioning was turned on and it was attributed to a general lack of cleanliness in this part of the ventilation system.[38]

There are obvious differences in the demographics of typical cruise ship passengers and US Navy crewmen. Additionally, cruise ships typically allow for more social distancing with far fewer persons per berthing space and fewer spaces with shared ventilation. In spite of these differences however, the common features of close quarters and shared ventilation still appear to be potent accelerators for the spread of infectious A/FRI among susceptible individuals.

Factors that Increase Risk In the Shipboard environment

There are a number of factors that increase the risk of A/FRI in military recruits and newly mobilized troops including crowded living conditions, stressful working environment, and exposure to respiratory pathogens in disease-endemic areas.[39] These are factors that are also present on board U.S. Navy ships, and are likely to increase the risk of A/FRI epidemics among U.S. Navy and Marine forces. These include 1) environmental factors such as close quarters, loss of social distancing and shared ventilation, 2) increased frequency of exposure to new infectious agents, through port visits and arrival of new personnel, and 3) increased susceptibility of personnel due to stress or fatigue.

Environmental factors

The shipboard environment necessitates living in very close quarters with large numbers of personnel. The average crew size aboard one aircraft carrier on deployment, including ships company and air wing personnel, consists of approximately 5,500 personnel. Passageways are generally narrow and require personnel to come in very close proximity to pass by one another. In some areas it is typical for personnel to have to squeeze by each other while transiting the ships passageways. Galley lines are formed in major passageways, increasing the proximity and duration of contact. Social distancing is impractical, if not impossible, in most areas of the ship.

There is increased risk for contact transmission of disease, as well. Aboard any ship there are a large number of surfaces that are touched by hundreds of sailors everyday. For example, there are no “hands free” stairways on the ship; rather all personnel transiting between decks must do so by steep ladders where handrail use is obligatory for safety reasons. Some ladder rails such as those leading to the mess deck are touched by nearly 100% of the crew 2-3 times per day. In addition to ladder rails, there are often multiple hatches that must be transited

on any given passageway. These hatches have a single handle that must be activated to open the hatch and seal it behind you. In heavily transited area, these surfaces can be touched by a large percentage of personnel daily.

Another example is that of sleeping quarters, shared by up to 120 sailors at a time. Ventilation below decks is shared throughout the ship. While efforts are made to properly ventilate all spaces, respiratory pathogens can easily be transmitted. In a recently published report of TB transmission aboard the USS Ronald Reagan (CVN-76) an outbreak investigation was undertaken following the diagnosis of a single crew member found to have active TB.[40] It is interesting to note that an initial determination found that he had 320 people qualifying as close contacts aboard the ship. Screening of these contacts revealed new positive TB skin tests (TST) in 12 or 4%. Wider screening was then undertaken of all shipboard personnel revealing an additional 139 new positive TSTs. The airborne spread of this respiratory disease appears to have been enhanced by the close proximity and shared ventilation in the shipboard environment.[40]

Increased Susceptibility

In addition to environmental factors, crew members may also be more susceptible to infectious illness. Factors such as high stress environments, fatigue, and sleep deprivation can lower one's immune defenses to infectious diseases. The concept of allostatic load is useful to describe the potential for increased susceptibility to infection.[41] Allostatic load is a theory that refers to the body's response and the physiological costs of chronic exposure to stress. It is used to explain how frequent activation of the body's stress response, an essential tool for managing acute threats, can in fact damage the body in the long run. Allostatic load is generally measured through a composite index of indicators of cumulative strain on several organs and tissues,

including the immune system. The hormones and other physiological agents that mediate the effects of stress on the body have protective and adaptive effects in the short run and yet can accelerate pathophysiology when they are over-produced or mismanaged.[42]

A ship at sea is certainly a high stress environment. Inherently dangerous activities such as flight deck or small boat operations coupled with the demands of around-the-clock operations and maintaining equipment in a noisy and dangerous environment all combine to produce stress on crew members. Living in close quarters and prolonged absence from home add to this stress.

Fatigue is common aboard a ship during deployment. With around-the-clock or high tempo operations, crew members can become fatigued. Noise aboard a ship at sea can be extreme. Noise levels on the flight deck or in engineering spaces during operations can exceed 120 dB and is easily transmitted throughout the ship. This can add to stress, degrade one's ability to get restful sleep, and contribute to fatigue.

Increased Exposure

Frequent exposures to different populations world wide through deployments, port calls, embarkation of refugees, detainees, U.S. citizens abroad in distress, or returning expeditionary troops can increase the likelihood of exposure to diseases for which personnel have no developed immunity. These exposures may or may not occur during the typical influenza season (winter) months.

U.S. Navy crews are on average granted liberty in five or six port calls during a six to eight month operational deployment. In these instances port calls will often occur after long periods of arduous sea time. As a result, crew members may be exposed to a foreign population at a time when they may be more susceptible.

The Navy Health Research Center compiles statistics on influenza outbreaks following port calls and found clusters occurring after port calls in the following instances: Pearl Harbor, HI (USS Nimitz, March 03); Sydney, Australia (USS Boxer, July 03); Singapore (USS Peleliu, October 03); Port Kalang, Malaysia (USS Stennis, August 04); San Diego, CA (USS Nimitz, January 05); Astoria, OR (USCGC Fir, February 05); Victoria, Canada (USS Belleau Wood, April 05); Townsville, Australia (USS Boxer, June 05); Honolulu, HI (USS Peleliu, Mar/Aug 06); and Phuket, Thailand (USS Peleliu, Jul 06).[43]

There is also considerable evidence presented in cruise ship data that supports this idea of increased exposure. In one report, previously healthy cruise ship travelers embarked on a cruise during the summer in Asia after touring Hong Kong for two days. During the subsequent 30 day cruise 104 (38%) out of 277 passengers interviewed reported symptoms of an A/FRI during the cruise. The peak of the outbreak occurred on about day 20, six days after the ship's visit to Shanghai and three days after the visit to Pusan, Korea.[37]

In another instance, a mid-summer influenza outbreak was investigated in Alaska and the Yukon Territories.[44] In the month of August, prospective surveillance and retrospective case-finding identified 2,199 cases of A/FRI occurring during the months of May through August. Among these illnesses, a high percentage, 35% (766 cases) were in tourists and tourism workers.[44]

Existing Countermeasures

Currently the risk of shipboard epidemics of A/FRI is being fairly effectively controlled through the use of three existing countermeasures: 1) vaccination of personnel where possible, 2) surveillance for geographical regions where risk is high, and avoidance when possible of these regions of high risk, and 3) current medical capability of the ship. This last element involves

reliance on standard detection methods, accurate medical diagnosis, effective treatment and isolation practices in treating relatively healthy young adults in ships' medical departments. With the increased potential for highly contagious, high severity non-vaccine-preventable disease, these strategies may no longer be sufficient.

Vaccination

Vaccination has been extensively employed in the U.S. military as a first line of defense against a host of illnesses. Prior to routine use of vaccination in the military for respiratory pathogens, more than 80% of military trainees experienced respiratory infections during training, and as many as 20% were hospitalized for A/FRI during their two months of recruit training.[45] With the routine use of influenza vaccine, meningococcal vaccine and previously adenovirus vaccine (no longer available), as well as TB testing and strict adherence to vaccination policy and coverage, there has been reasonable control over respiratory disease outbreaks.

There is now, however, greater potential for servicemembers to come in contact with virus strains for which they have not been vaccinated. With the recent emergence of highly virulent viral respiratory infections such as SARS and avian influenza, plus the threatened emergence of possibly other novel or potentially pandemic influenza strains, the risk for serious morbidity or mortality from A/FRI not covered by existing vaccines has become more significant.

Surveillance

Surveillance is achieved on several scales. At the individual ship level, data concerning the health of ship's personnel is collected weekly and forwarded to fleet commands weekly, via Disease Non Battle Injury (DNBI) reports. These reports are reviewed by the Naval Environmental & Preventive Medicine Unit responsible for that region, and serve to alert fleet

commands if any units are experiencing higher than usual numbers of any medical condition, including A/FRI. The etiology of A/FRI is not, however, specifically defined in these reports, as in most cases a definitive diagnosis is beyond the capability of the ships that are reporting it. This data is designed primarily to inform commanders of the medical readiness of their forces, but can provide an alert regarding potential outbreaks that may require more investigation as to cause.

On a global level, the Armed Forces Medical Intelligence Center (AFMIC) compiles data on much of the world by region, regarding any medical threats likely to be encountered. The Senior Medical Officer or Force Surgeon typically investigates all areas likely to be visited and reviews existing disease and medical threat reports on that area. This information is used to make operational recommendations to the command, mitigate the threat and educate the medical staff and crew. This information may not be as current as is needed for certain threats, such as viral causes of A/FRI, which can rapidly change for a given region. The CDC and WHO also compile information on influenza and other A/FRI cases, especially avian influenza cases. This information is made available through their websites, however the information is only accurate if the region providing it is accurately and consistently reporting the incidence of these conditions. There is no one source for complete real time information regarding upcoming ports of call or deployments.

Current Medical Capability

Current medical capability available aboard ship for those ill with A/FRI ranges from basic care aboard large platforms, such as an aircraft carrier, to very small, limited facilities aboard a smaller ship such as a cruiser or destroyer. Diagnostic capabilities are very limited on most ships, with minimal or no on site capability to detect influenza or differentiate it from other

causes of A/FRI. There is currently no onboard availability of avian influenza testing and off ship laboratory studies typically require a one to three week turn around time. Facilities in ship's medical departments are not conducive to medical or respiratory isolation. An aircraft carrier, for instance, has on average 55 beds in its hospital, but the majority of those beds are in a single open bay, with isolation limited to two quiet rooms of four beds each and an ICU with three beds. Airflow in these rooms is variable, and there is no direct venting over the side. Smaller ships, such as destroyers, cruisers and frigates, have only one or two beds that can be used for isolation. In the event of an epidemic there are contingency plans aboard some aircraft carriers, calling for isolation of ill personnel in quarters that can be vented over the side with de-smoking equipment, but these procedures are not standardized ship to ship and are of unproven effectiveness. There are currently no commercial off the shelf respiratory (COTS) isolations units available in the fleet.

Treatment of A/FRI is limited to supportive care only and treatment of bacterial complications. Ships do not currently carry any supplies of antiviral medications aboard, and when remotely deployed, supply times for critical supplies can take up to a week to receive. Earlier detection of treatable A/FRI, coupled with effective employment of limited antiviral medications, could potentially be useful in preventing a larger outbreak.

Summary

The above serves to illustrate the very real risk of Acute/Febrile Respiratory Illness aboard U.S. Navy ships and draws some attention to features more prominent in a shipboard environment. The potential for outbreaks of influenza strains not covered by current vaccine, the emergence of more virulent A/FRI such as SARS, the potential for emergence of human to human transmissible avian influenza or other pandemic influenza strain as well as the recent

emergence of H1N1 Swine Flu cases makes this problem all the more significant. Epidemics of any of these illnesses could jeopardize the health of personnel aboard ships, seriously impact the operations of U.S. Navy Ships abroad, and prevent them from carrying out their missions.

From the evidence presented about incidence of ship board A/FRI, it is clear that the risks of serious epidemics are very real. The limited direct data shows a rapid, almost explosive spread of infectious disease throughout the crews of U.S. Navy ships in the few instances reported. In studies of other outbreaks under comparable circumstances, such as cruise ships, recruits in training, or travelers, similar rapid spread is noted. Factors affecting this enhanced effect include environmental factors, susceptibility factors and increased exposure. Defense against this kind of spread requires 1) excellent medical intelligence to avoid areas where illness is prevalent when ever possible, 2) maximizing prophylactic measures such as vaccines, crew education on avoidance and crew awareness of signs and symptoms and their responsibility to seek help, 3) early detection of any shipboard cases, 4) early effective respiratory isolation of known or suspected cases and 5) early employment of effective medications to halt the spread of disease to the rest of the crew.

Aim Two - Current Pandemic Flu Policies and Instructions

What follows is a summary of Pandemic Influenza strategy and planning at the National level, Department of Defense level, Department of the Navy level, Unified Combatant Command level (USPACOM), Major Fleet Level (PACFLT) and Numbered Fleet level (Third Fleet). These summaries are directed at reviewing the parts of strategy or policy that have a direct bearing on U.S. Navy ships, and plans to mitigate the risk or effect of epidemic influenza on them. As the policy, practice or instruction gets closer to the “deckplates” it will be reviewed in more detail and with an eye to more specific application to ships.

National Strategy for Pandemic Influenza

The National Strategy for Pandemic Influenza was signed by President Bush in 2005.[46] It is quite broad in scope and meant to provide an overall strategy for dealing with pandemic influenza in the United States. It contains and elaborates on the basic concepts of a national strategy for response to this threat. Some of these concepts represent requirements and responsibilities for the Department of Defense, Department of the Navy and/or Fleet Commands, so are useful to briefly review here. There are three basic elements to the National Strategy:

1) Stop, slow or otherwise limit the spread of pandemic influenza to the United States.

2) Limit domestic spread and mitigate disease suffering and death.

3) Sustain infrastructure and mitigate the impact to the economy and the functioning of society.

It goes on to further establish and define the three pillars of the National Strategy:

1) Preparedness and Communication

2) Surveillance and Detection

3) Response and Containment

Several of the elements of each pillar have direct application to military organizations and therefore represent areas where the Department of Defense (DOD), the Department of the Navy (DON), Unified Combatant Commands (UCC), and/or Fleet Commands should take responsibility. The following three paragraphs will list those elements of the pillars that represent areas of responsibility for the Department of Defense and its organizations.

The first pillar - Preparedness and Communication – contains requirements to develop a plan, communicate, stockpile vaccines and antiviral medications, and provide a distribution plan. All of these elements represent responsibilities of DOD, DON, Unified Combatant Commands and Fleet Commands.

The second pillar - Surveillance and Detection - contains requirements to ensure rapid reporting of outbreaks and employ surveillance to limit spread. Both of these elements represent responsibilities of DOD, DON, Unified Combatant Commands, and Fleet Commands.

The third pillar - Response and Containment - contains the requirements to contain outbreaks, create a surge capacity and sustain essential services. This is essentially the requirement to maintain the capacity to conduct operations and defend the interests of the United States at home and abroad.

National Strategy - Implementation Plan

The Federal Government followed up the National Strategy with the release of The National Strategy for Pandemic Influenza – Implementation Plan in May of 2006.[47] It contains fairly specific assignments for the Department of Defense that fall under the general assignment of responsibility for national defense and assistance in civil defense as follows:

> "The Secretary of Defense will be responsible for protecting American interests at home and abroad. The Secretary of Defense may assist in the support of domestic infrastructure and essential government services or, at the direction of the President and in coordination with the Attorney General, the maintenance of civil order or law enforcement, in accordance with applicable law. The Secretary of Defense will retain command of military forces providing support".
>
> "While we rely upon local and State entities to maintain civil order, it is essential that we be prepared to respond in the event of a breakdown of order that cannot be handled at the local or state level. We will ensure that Federal law enforcement agencies and the military have the necessary plans to assist States with law enforcement and related activities in the event that the need arises." [47]

In summary, the National Strategy Implementation Plan assigns responsibility to the Department of Defense to 1) continue its core mission of protecting American interests at home and abroad, and 2) assist, where possible or required, states or other agencies in their responsibilities to carryout the national implementation plan. The primary and overriding responsibility given to the Department of Defense is to ensure its ability to carry out operations protecting American interests at home and abroad.

Department of Defense - Current Policies and Instructions

In August of 2006 the Department of Defense released its Implementation Plan for Pandemic Influenza.[48] In it were outlined critical planning categories.

There are nineteen Critical Planning Categories required to be considered in Department of Defense Pandemic Influenza plans. These categories were developed from the five Homeland Security Council (HSC) planning priorities and the thirteen HSC priority areas, and are based on Department of Defense (DOD) capabilities. Each HSC priority area is aligned with one or more DOD Critical Planning Categories. A review of all Department of Defense planning categories for pandemic influenza, is beyond the scope of this capstone project. Listed below are only those categories that have a bearing on shipboard A/FRI or pandemic influenza, followed by a brief explanation of that category's relevance to the topic of this capstone project. These tasks are as follows:

Dept of Defense - Critical Planning Categories That Relate To Ships		
Category #1:	Intelligence -	Medical intelligence data needs to be readily available to all those charged with the medical care of forward deployed sailors, including the extent and location of potential outbreaks of any illness that can be spread person to person aboard ship.
Category #2:	Force Protection -	This is the ultimate goal and the purpose of DOD planning. Force Health Protection is essential if the Military is to retain its ability to carry out national policy and protect US interests
Category #3:	Biosurveillance, Disease Detection and Information Sharing	Similar to #1 except that this applies to the individual ship as well and should include programs for rapid testing and surveillance, and assurances that this is readily available and employed in appropriate circumstances permitting early detection of infectious disease if it gets aboard ship
Category #5:	Surge Medical Capability to Assist Civil Authorities	A possible need under the requirement to assist states and other agencies in maintaining civil order
Category #6:	Medical Care to U.S. Forces	This is provided aboard all US ships, but capability is widely variable and dependant on the size of the platform.
Category #7:	Patient Transport and Strategic Airlift	Rapid evacuation may be the best quarantine. Strategic airlift may be required to replenish necessary medical supplies
Category #9:	Bulk Transport of Pharmaceuticals/Vaccines	Logistics will need to be worked out well in advance to rapidly supply anti-viral medications and vaccine if it is available. The current "just in time" procurement system may be seriously taxed in period of peak demand for certain commodities, and potential needs should be well planned in advance.
Category #16:	Mortuary Affairs	Provisions need to be in place for handling large numbers of fatalities safely
Category #17:	Continuity of Operations & Continuity of Government	Again, the ultimate goal of all pandemic planning at this level is to maintain the capability to carry out required missions
Category #18:	Support to International Allies and Non-Governmental Organizations (NGO's)	Extending medical support to other allies during joint operations is a possibility, as well as providing assistance to NGO's, especially if that is considered to a critical part of any operation. Foreign Disaster relief and Humanitarian Assistance is becoming a more prominent mission to US Navy forces deployed abroad.

Table 2: Department of Defense Critical Planning Categories that Relate to ships. [48]

From the categories above, it is clear that several of the Department of Defense critical planning categories for pandemic influenza have relevance to A/FRI aboard U.S. Navy ships and indicate requirements for planning to mitigate the risk of shipboard spread of A/FRI.

Department of the Navy - Current Policies and Instructions

Current Navy instruction written to comply with the Department of Defense implementation plan is provided by OPNAVINST 3500.41[49] released by the Chief of Naval Operations. In this instruction, specific responsibilities are assigned to different commands, organizations and agencies in the US Navy. Of interest in this capstone project are the assignments of responsibility to US Fleet Forces Command (USFFC) and Pacific Fleet (PACFLT), as those are the commands that oversee administrative activities for all US Navy ships afloat. In the instruction, several responsibilities assigned to USFFC and PACFLT are relevant to ships.
(see table 3)

1) Train and equip the forces on protective measures against the strain.

2) Maintain operational capability in a Pandemic Flu environment.

3) Identify critical supplies, etc required to maintain operational capability.

4) Exercise plans biennially in coordination with the appropriate combatant commander.

5) Identify resource shortfalls.

6) Properly position forces with the required numbers, skills, and materiel support to meet the projection of forces in the changing PI environment.

7) Develop and evaluate existing PI plans, guidance, and programs to include existing Personal Protective Measures (PPM), identification of Personal Protective Equipment (PPE) requirements, targeted layered containment, and community mitigation strategies.

8) Ensure that public health and disease outbreak emergency response policies, plans, procedures, and guidelines are supported by sufficient command and control capabilities and other equipment to respond properly to disasters, public health emergencies, and disease outbreaks.

Table 3: Dept of the Navy - Responsibilities Assigned to USFFC and PACFLT. [49]

These are specific areas of responsibility and planning dictated to major fleet commands by higher strategy and planning, for which there should be specific and detailed planning at the fleet instruction level or below. Currently, only Pacific Fleet (PACFLT) has produced and disseminated an instruction for preventing and/or responding to the threat of pandemic influenza. There is currently no available instruction for PI planning from US Fleet Forces Command (USFFC) at the time of this capstone project.

US Pacific Command - Current Policies and Instructions

US Pacific Command (PACOM) is the Unified Combatant Command responsible for the Pacific Ocean and Eastern Asia. They produced guidance on 24 Aug 05. This instruction can be found under USPACOMINST 0507.1.[50] USPACOM assigned tasks and responsibility to be carried out on a time line by operational stage of pandemic. These operational stages of pandemic are defined in table 4:

Operational Stage 0 (OS-0) No sustained human-to human transmission identified.
Operational Stage 1 (OS-1). Sustained human-to human transmission is identified in areas without U.S. Forces
Operational Stage 2 (OS-2). Sustained human-to human transmission is identified in areas where U.S. Forces are based
Operational Stage 3 (OS-3). Broad or rapid sustained human-to-human transmission is identified
Operational Stage 4 (OS-4). Spread to the Continental United States (CONUS).

Table 4: Operational Stages of PI as defined by USPACOM [50]

Since we are reviewing preparation to mitigate the risk of epidemic A/FRI aboard ship, and are not at present experiencing pandemic spread of illness, we will only be looking at Operational Stage 0 and 1. To limit the scope of this discussion, only those tasks that directly apply to ships have been included below. The tasking currently required by USPACOM is as follows:

Operational Stage 0 (OS-0) – No sustained human to human transmission identified

2. Ensure education plans are developed and implemented.
4. Ensure communication procedures are in place.
5. Monitor disease occurrence in the Area of Responsibility (AOR).
8. Develop and/or promulgate initial force health protection (FHP) guidelines to include but not limited to: updating vaccinations, use of personal protective equipment and practices, and avoidance of high-risk areas such as poultry/livestock farms and live animal markets.
9. Establish priorities for vaccination against Pandemic Influenza.
10. Document pertinent preparation and response activities for lessons learned and after action reports.
11. Provide a plan for collection, chain of custody, transport, and securing samples that require management using appropriate Biological Safety Level (BSL) procedures.
12. Ensure systems and processes are in place to effectively track the status of USPACOM Forces and individual personnel with regard to their exposure, infection with PI, travel to affected countries/regions, etc.

Table 5: Tasking assigned by USPACOM for OS-0 [50]

Operational Stage 1 (OS-1) - Sustained human-to human transmission is identified in areas without U.S. Forces. In addition to applicable actions taken in Stage 0

1. Review, and exercise Pandemic Influenza (PI) response procedures.
2. Review, update, and implement force health protection (FHP) guidance including FHP messages, travel advisories, and/or restrictions to target countries
3. Authorize the administration of antiviral prophylaxis for personnel traveling to affected areas.
4. Increase coordination with local, state, territory, possession, host nation, coalition, international organizations and supported government public health officials so rapid notification can be made if PI enters the area.
6. Conduct an initial availability assessment of personnel, medications, supplies, and equipment (e.g. laboratory testing gear, ventilators, and disposable surgical masks for patients) needed for responding to PI. Make adjustments as appropriate.
8. In response to spreading PI, consider suspending non-critical military operations in order to preserve personnel availability for critical response for PI operations.
9. Establish policies for restriction of personnel movement and use of prophylaxis and personal protective equipment for U.S. forces required to deploy to areas experiencing PI outbreak.

Table 6: Tasking Assigned by USPACOM for OS-1 [50]

Pacific Fleet - Current Policies and Instructions

Pacific Fleet (PACFLT) is in charge of the numbered fleets Third, Fifth and Seventh in the Pacific Ocean from U.S. West Coast to Central Asia. In Aug 2007 they published specific guidance in message format, outlining current response and implementation to pandemic influenza plans.[51] Again, only those elements with specific application aboard ship are listed. (see Table 7)

4.A. Pacific Fleet will conduct operations and implement measures in order to slow the spread of PI, mitigate impact and restore full operational capability upon outbreak cessation. The Fleet must sequester, quarantine and isolate units and personnel to prevent PI exposure and slow the spread of infection.
6.E.3. Develop and publish PI specific force Health Protection guidance for PACFLT forces and OTSUF populations.
6.E.5. Develop and prepare to implements a robust and focused local medical surveillance program aboard all ships and installations.
6.E.6. Oversee and coordinate the development of shipboard quarantine and isolation tactics, techniques and procedures for each ship class. Include the use of commercial off the shelf (COTS) filtration equipment to improve the efficacy of isolation barrier systems.
6.G.1. Coordinate with US PACOM to ensure that DOD intelligence efforts in the AOR provide the fleet with timely notification of PI emergence and geographical spread.
6.I.1. Identify logistical requirements to distribute antiviral medications, PPE, and other associated pharmaceuticals or equipment base on existing stocks and their locations. Focus initially on operational forces that may be assigned to support operations.

Table 7: PACFLT Guidance and Policies [51]

Third Fleet- Current Policies and Instructions

Third Fleet instruction for medical response to pandemic influenza was published 15 Nov 2007 and found under Annex Q to COMTHIRDFLT SUPPLAN 5003-06.[52] It assigns tasks for all commands and ships under administrative control of the Third Fleet. In developing its guidelines, it made some useful assumptions that will be reviewed here as well.

Assumptions – There will be a 50% attack rate aboard ships, with 50% of those seeking medical help. Hospitalization rate will be 10% of those seeking medical help. Recovery will come with immunity. Medical infrastructure will be stressed beyond capacity, necessitating patient movement. The pandemic will occur in waves, weeks to months after the initial outbreak. DOD reliance on "just in time" procurement will compete with U.S. and foreign entities for critical supplies. The instruction goes on to delineate tasks based on five phases as follows:

Phases of Pandemic Defined

Phase 0 & 1– Prepare/Prevent – No documented sustained human to human transmission. Education of personnel about indications, effects and response required during PI outbreak. Pre-position medical supplies.

Phase 2 – Contain – Documented sustained human to human transmission within the AOR. Establish definitions for probable, suspect and confirmed cases.

Phase 3 – Respond – Containment has failed, PI has spread to multiple regions. Forces sequestered aboard ship. Establish San Clemente and San Nicholas Islands as designated enclaves with 25 bed Expeditionary Medical Force (EMF).

Phase 4 – Recover – Epidemic is subsiding. Reconstitute forces and continue mass vaccinations in preparation for subsequent waves of PI.

Again, for the purpose of this capstone project, we will be dealing only with planning that should be in place now, in preparation for an outbreak of A/FRI or PI. We will look only at phase 0 & 1 – Prepare/Prevent.

Guidance to Third Fleet Commands - Phase 0 and Phase 1 (Prepare/Prevent):

1) Evacuation policy – patients will be moved only if isolation can be maintained throughout the transfer. Service members suspected of incubating PI will be quarantined until it can be determined that they are not infectious. Shipboard personnel presenting with symptoms of active disease will be moved to a shore based facility if possible 2) Host nation support – will be sought only when HNS facilities meet US standards of care. 3) Force Health Protection – Maintain influenza vaccination programs. Forces entering a PI infected area will be provided appropriate education, medications, and vaccination prior to departure from their home station. 4) Antiviral Medicines/Vaccine - Supplies of appropriate antiviral medications and antibiotics will be stored at locations under U.S. control. Antiviral medications will be administered in the following priority: (1) operational units present in a PI affected area, (2) operational units who must enter a PI affected area, (3) other active duty personnel in or entering a PI affected area, and (4) non-active duty personnel and OTUSF in a PI affected area.

Table 8: Guidance for Third Fleet Commands [52]

Tasks assigned to Third Fleet Medical Departments - Phase 0 and Phase 1 (Prepare/Prevent):

(a) Review, update, and implement force health protection guidance

(b) SMDRs will develop plans to minimize the spread of pandemic influenza via respiratory droplets.

(c) Conduct an initial availability assessment of personnel, medications, supplies, and equipment (e.g. laboratory testing gear, ventilators, personal protective equipment, and disposable surgical masks for patients) needed for responding to PI. Inform COMTHIRDFLT J00S (Surgeon) of results, shortfall, and shortfall fulfillment requirements.

(d) THIRDFLT Units will stockpile the following items for use during a PI emergency: surgical masks (2 per crewmember), N-95 masks (10 per crewmember), face shields/protective goggles, hand sanitizer (install near all food service areas), disposable gloves (10 per crewmember, various sizes), and antibiotics for the treatment of secondary respiratory infections.

(e) Senior Medical Department Representatives (SMDRs) will contact Commander Third Fleet (COMTHIRDFLT) to identify the nearest oseltamivir (Tamiflu) stockpile locations and distribution methods.

(f) Submit DNBI data as required by existing instruction. Promptly report any outbreak of febrile respiratory disease, regardless of whether PI is suspected or not.

(g) Shipboard SMDRs will educate all personnel about the threat of PI by providing annual PI briefings and distributing applicable influenza self-care health information. Individuals will be provided education to make them aware of PI, help them understand PI management procedures such as isolation, quarantine, social distancing and to enforce simple actions to reduce the risk of infection including:

(h) Compliance with the routine influenza vaccination program to ensure all receive an annual flu vaccination.

(i) Avoid poultry farms and bird markets and contact with animals in live markets or contact with any surfaces appearing contaminated with waste from poultry or live animals. Avoid sick or dead poultry.

(j) Emphasize hand washing to avoid infection. As with other infectious illnesses, one of the most important precautions is careful and frequent hand washing. Cleaning hands often, using either soap and water or waterless alcohol based hand rubs, removes potentially infectious materials from the skin and helps prevent disease transmission.

(k) Proper food preparation. Influenza viruses are destroyed by heat; therefore, as a precaution, all foods from poultry, including eggs and poultry blood, should be thoroughly cooked.

Table 9: Tasks Assigned to Third Fleet Medical Departments [52]

On the following 2 pages, table 10 summarized the primary features of current published pandemic influenza policy and guidance. These features are categorized under the three pillars of National Strategy. Significant in the upper level instruction is the mandate to maintain operational capability. Other significant and recurring elements involve surveillance and the development of force health protection plans. The policies are broad and non specific at all levels down to the Third Fleet, which has considerable detail, but is not complete enough as shown in the next section, to suffice as a shipboard instruction.

The Three Pillars of National Strategy for Pandemic Influenza

Organization	Preparedness & Communication	Surveillance & Detection	Response & Containment
National Strategy & Implementation Plan	-Plan -Communicate -Stockpile Vaccine and Anti Viral medications -Distribution Plan	-Report Outbreaks -Surveillance to limit spread	-Contain outbreaks -Create surge capacity -Sustain essential services -Protect US interests at home and abroad -Assist in maintaining civil order
Department of Defense Plan	-FHP planning -Strategic airlift planning -Bulk transport of pharmaceutical and vaccines	-Medical Intelligence -Biosurveillance	-Medical care to U.S. forces -Patient transport -Continuity of operations -Support to allies and NGO's
Department of the Navy OPNAVINST	-Train and equip all personnel on protective measures -Identify critical supplies -Exercise response biennially -Identify resource shortfalls	(no surveillance or detection responsibilities specifically assigned to USFFC of to PACFLT)	-Maintain Operational capability
US Pacific Command	-Educational planning -Communications procedures - Develop force Health Protection Plan Guidelines -Develop vaccine priority guidelines -Review and exercise PI response	-Monitor disease occurrence in the AOR -Develop lab sample collection and safety procedures -Ensure tracking of exposed personnel -Coordinate with other organizations for notification if PI enters the AOR	-Implement FHP guidelines -Administer antiviral medications and vaccines -Conduct an initial availability assessment of needs for responding to PI -Suspend non-critical military operations if necessary
Pacific Fleet	-Develop specific FHP guidelines -Develop ship board isolation and quarantine tactics -Identify logistics needed to distribute meds and vaccines	-Develop a local medical surveillance program aboard all ships -Coordinate with PACOM to receive intelligence about PI in the AOR	-Sequester, quarantine or isolate as needed to prevent spread

Table 10: Summary of Shipboard Related Command Responsibilities for PI Planning

Organization	Preparedness & Communication	Surveillance & Detection	Response & Containment
Third Fleet	-Review, update, and implement force health protection guidance -Conduct an initial availability assessment of personnel, medications, supplies, and equipment -Stockpile Surgical masks N-95 masks Face shields/protective goggles Hand sanitizer Disposable Gloves Antibiotics for the treatment of secondary respiratory infections -Identify oseltamivir (Tamiflu) stockpile and distribution methods -Annual briefings on the threat of PI,I management, isolation, quarantine, social distancing and to simple actions to reduce the risk of infection -Ensure compliance with the influenza vaccination -Avoid poultry farms, bird markets, live markets, contact with surfaces contaminated with waste from poultry, sick or dead poultry.	-Submit DNBI data as required by existing instruction. -Promptly report any outbreak of febrile respiratory disease, regardless of whether PI is suspected or not.	-Develop plans to minimize the spread via respiratory droplets

Table 10(cont): Summary of Shipboard related Command Responsibilities for PI Planning

Aim Three - Comparison of existing need and current policy

Considerable strategies, implementation of strategy and policy have been written at the National level. There are adequate levels of instruction at the Department of Defense level and the Department of the Navy/Chief of Naval Operations level. There is good instruction at the Combatant Command level (PACOM) and good implementation guidelines from Pacific Fleet. Instruction from Third Fleet is sufficiently detailed and valuable. In Aim 1, existing need was established in the following five areas: 1) medical intelligence, 2) maximizing preventive measures, 3) early detection, 4) early isolation, and 5) early effective treatment. These five areas will be compared with the existing policy established in Aim 2

Medical intelligence

The ship's senior medical department representative (SMDR) will require excellent and timely medical intelligence in order to offer accurate advisement to operations planning regarding areas where illness is prevalent. This necessarily calls for effective two way communication between ships and the chain of command, including robust surveillance at the shipboard level, with timely reporting up the chain, and rapid dissemination of collected medical intelligence down the chain of command to individual ship's medical departments.

Medical intelligence flow up the chain of command is well spelled out in instruction. National strategy calls for plans to increase communication and surveillance to limit spread. Department of Defense (DOD) calls for bio-surveillance and medical intelligence. The Department of the Navy (DON) does not specifically assign surveillance or detection responsibilities to the major fleet commands. USPACOM calls for methods to monitor occurrence in their area of responsibility (AOR) as well as notification if disease enters their AOR. PACFLT is the first command to call for a local program of surveillance on all ships.

Third Fleet goes on to spell out DNBI reporting as well as real time reporting of any A/FRI outbreak, but no mention of rapid influenza testing or reflex testing for Avian Flu or novel strains.

Currently none of the instruction sets up an easily accessible single source for real time medical intelligence dissemination down the chain. Rather, the information is available only through multiple sources with reliance on shipboard internet which can be sporadic at best and unavailable at worst.

Maximizing preventive measures

Effective and necessary preventive measures such as vaccines, crew education on avoidance, and crew awareness of signs and symptoms and their responsibility to seek medical care, can improve a ship's ability to avoid epidemic illness.

Vaccination programs are a well established and well utilized aspect of prevention that is already in place. National policy calls for stockpiling vaccines for use and calls for the development of distribution plans. DOD dictates establishment of bulk transport and distribution plans. DON does not assign responsibility to major fleets regarding vaccines. USPACOM specifically calls out for development of vaccine priority guidelines for PI vaccine and development of Force Health Protection (FHP) guidelines which would include routine vaccination as well. PACFLT also requires the development of FHP guidelines as well as the identification of logistics needed to distribute vaccines and medications. Third Fleet requires that ships ensure compliance with influenza vaccination programs. There appears to be no significant gap in vaccination policy.

Crew education and training is essential to improve crew hygiene, hand washing, etc, and avoidance of circumstances or environments that could put individuals at risk, such as contact

with live, sick or dead poultry or contamination from birds. There is no reference to educational programs in either the national strategy or DOD plans. DON addresses the issue as train and equip all personnel on protective measures. USPACOM calls for educational planning and development of Force Health Protection (FHP) plans which covers the topic in a general sense. PACFLT also calls for FHP guidelines. Third Fleet however, gives detailed instruction on annual briefings including topics related to threat, isolation requirements, quarantine requirements, social distancing during outbreaks, hygiene, and avoidance of contamination. That guidance is detailed and useful. There is however, no mention of crew education about recognition of signs and symptoms, or their responsibility to immediately report illness.

Early detection

Early detection of any shipboard cases is essential to facilitate isolation and early treatment, which are necessary to help minimize contagion and spread. Early detection requires a good disease definition for A/FRI and clear guidelines on when to employ rapid testing. All plans from the national level to fleet commands call for surveillance and reporting of all A/FRI, but do not specifically call for rapid testing at the point of contact. The crews aboard U.S. Navy ships generally have a high percentage of vaccinated members, typically in excess of 95%. As a result, an outbreak of A/FRI identified quickly as influenza A or B, could well be a novel strain or one that is significant that was not included in the current vaccine. There is a certain amount of "canary in the coal mine" aspect to U.S. Navy ships on deployment, which could provide a valuable early warning about significant outbreaks. This is only possible with good early detection and not just the syndromic surveillance provided by the disease non battle injury (DNBI) reporting that is currently required.

Early effective respiratory isolation

Early quarantine or isolation of known or suspected cases is essential to prevent further spread of infectious illness. In the case of A/FRI with highly efficient respiratory transmission, this will require early effective respiratory isolation if there is any chance to contain it aboard a ship. In lieu of sustainable effective respiratory isolation, early medical evacuation would be a suitable alternative, although this is not always achievable. National strategy, DOD, DON and USPACOM do not specifically mention early quarantine, isolation, or evacuation. PACFLT calls for commands to sequester, quarantine, or isolate as needed to prevent spread and to develop shipboard isolation and quarantine tactics. Third Fleet calls for developing plans to minimize spread via respiratory droplets as well as stockpiling personal protective equipment (surgical masks, N-95 masks, gloves and hand sanitizer). What is lacking is specific instruction on <u>how</u> to develop adequate shipboard respiratory isolation on different ship classes or specific direction for commands to purchase and train on the use of any of the available Commercial Off The Shelf (COTS) negative pressure respiratory isolation units. Shipboard isolation procedures have been for the most part left in the hands of senior medical department representatives, who have neither the time nor expertise to develop a unique program for their ship. Additionally, all instructions were found lacking in any specific policies regarding evacuation in lieu of isolation for potential highly infectious cases or those requiring isolation or treatment beyond the capabilities of the ship.

Early employment of effective medications

Early employment of effective medication is necessary to decrease the length of illness. This can effectively decrease the amount of time patients are ill, helping to maintain mission capability. Additionally, it can decrease the length of time patients are contagious, in turn

helping decrease the spread of illness to the rest of the crew. To do this however, requires early diagnosis (addressed above) plus ready access to the appropriate medication. National policy advocates stockpiling of antiviral medications. DOD planning requires planning for bulk transport of pharmaceuticals. DON asks for major fleets to only identify critical supplies, but does not specifically spell out antiviral medications. USPACOM specifically calls for administration of medications and vaccines, while PACFLT only requires commands to identify logistics to distribute medications. Third Fleet mandates commands identify oseltamivir (Tamiflu) stockpiles and distribution methods. Ships have an Authorized Medical Allowance List (AMAL) which determines what medications and supplies they should carry aboard at all times. There have been no changes to ships AMAL to include oseltamivir however, so the medication is not likely to be carried aboard.

Chapter 5 – Discussion

Many of the risks posed by shipboard A/FRI outbreaks have been adequately addressed through existing policy and instruction directed toward PI strategy, planning and response. The documents in question tend to be quite broad and non-specific at the higher levels, but become more applicable and relevant as instruction gets further down the chain of command and closer to individual commands or ships. However, there is inconsistent application to the shipboard environment in several areas and a number of vulnerabilities still exist. Policy change or more specific instruction is needed.

The following five topics are the elements that are essential to adequate shipboard preparation, as well as timely and effective response to the threat of epidemic A/FRI. Each is discussed and specific recommendations are offered to improve their implementation.

Medical Intelligence

Medical intelligence is critical and needs to flow both up and down the chain of command. Ships need ready access to real time medical intelligence about the location, severity and type of A/FRI outbreaks anywhere in the fleet or ports of call. This information must be made continuously available to Senior Medical Department Representatives (SMDR) for consideration in any operational planning, including consideration of ports of call.

Surveillance is the essential element of that intelligence, and while it is done in many locations available, it also needs to be very robust at the individual ship level as well. With a high degree of vaccination against seasonal influenza, outbreaks among Navy personnel have a higher than usual probability of involving novel or uncovered seasonal influenza strains, which would be a finding of considerable significance. Deployed ships have an even more unique

potential to encounter novel influenza strains or potential pandemic strains of A/FRI. On site testing for influenza A and B needs to be readily available, strongly encouraged for use in all cases that meet the definition of A/FRI, and fully utilized. Reflex testing for avian influenza (H5N1) or novel strains needs to be made available and used whenever influenza A is identified. Information on influenza cases needs to be transferred up the chain of command as it is generated.

Maximizing Preventive Measures

Preventive measures of importance are vaccination and education. Vaccination is well addressed in existing policy. Education addresses the issues of personal hygiene, social distancing and avoidance of environments that can increase risk. The aspect of education that is not addressed is the need to inform and educate sailors about the importance of recognizing flu-like symptoms and seeking medical help early on to avoid potential spread to others. Currently many sailors tend to ignore illness, continue to do their job, press on despite illness, so as not to make their shipmates do their work for them. This culture needs to be changed or replaced by the idea of responsibility to seek medical care, protecting not only themselves, but their shipmates as well, by not needlessly exposing them to illness. That idea needs to be changed to reinforce the responsibility seeking medical help early on, improving rapid detection, isolation, treatment and decreasing the risk infecting others.

Early detection

Early detection and identification of A/FRI is essential to preventing an epidemic aboard ship. In addition to the syndromic surveillance that is already mandated aboard ship, rapid testing for influenza A and B needs to be aggressively employed, as well as reflexive testing with

the new avian influenza rapid test, and any other new rapid testing available. Rapid tests need to be available and mandated aboard all ships that are not within easy range of a higher level medical facility. There need to be very specific and liberal guidelines for their use. If a patient presents with a febrile respiratory illness that fits definition, it needs to be identified as clearly as it can be in order to potentially warn others, adequately isolate the patient if necessary, or begin effective treatment to decrease the contagious period.

Isolation

Currently the single greatest vulnerability to shipboard epidemic is the ease with which respiratory pathogens can spread throughout the ship. There need to be well thought out policies and procedures in place for establishing effective negative pressure respiratory isolation aboard ship. This can potentially be achieved through the use of existing de-smoking gear, already positioned on the ship. If this is vented over the side aft of all air intakes, a negative pressure respiratory isolation zone could conceivably be established. This will take some planning drill however, and specific instruction should be created for each class of ship, then briefed to the medical department and those needed to successfully carry it out. Alternatively, respiratory isolation could be accomplished through the use of purchased "Commercial off the shelf" (COTS) systems for establishing negative pressure isolation. There would need to be specific training and additional funding for purchase of these. Lastly, when isolation requirements or medical needs exceed the capabilities of the ship, there need to be well planned policies, criteria and safeguards for evacuation of contagious personnel.

Early intervention

The final critical element is early intervention. This includes all forms of treatment, but the one aspect of this that is lacking is the ready availability of effective anti-viral medications. Relying on "just in time" purchasing will unacceptably delay the acquisition of these medications and can contribute to the risk of a single infection turning into an epidemic. Anti-viral as well as other appropriate medications need to be written into the ships AMAL and supplies kept on board for ready use. Logistic support needs to be already worked out to replenish those supplies in the event of a major outbreak or need for prophylaxis of large numbers of crewmembers.

Conclusion

A serious epidemic aboard ship has the potential to be very costly in terms of human morbidity, possible mortality, financial cost of removing a ship from operations, and potential national security costs of losing an essential asset protecting U.S. interests. The primary defense against such an epidemic of A/FRI lies in the effective use of medical intelligence, preventive measures (including education), early detection, isolation and treatment. By effectively employing these measures, we can greatly decrease the risk or attenuate the effects of an epidemic of A/FRI aboard ship and the significant costs associated with it.

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Vita

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