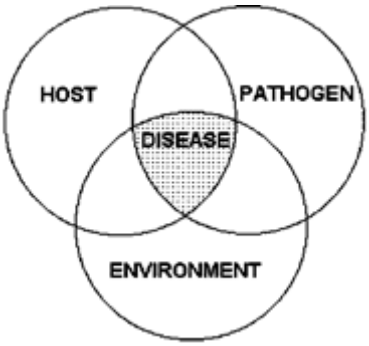
U.S. Army Heritage and Education Center October 2014

U.S. Army War College Carlisle Barracks, Pa.



Battling the Bug

The Army's Response to Epidemics and Pandemics

Battling the Bug:
The Army's Response to Epidemics and Pandemics

I. Executive Summary

The epidemic is seldom mentioned and most Americans have apparently forgotten it. This is not surprising. The human mind always tries to expunge the intolerable from memory.[1]

- H.L. Mencken

Numerous Ebola outbreaks have devastated West African communities. Beginning in March 2014, 7,470 people contracted the virus and 3,431 died in Liberia, Sierra Leone, Guinea, Senegal, and Nigeria. The disease has since spread to the United States and Europe. In the U.S., the disease has claimed one life and two more have become infected.[2] Previous Ebola epidemics occurred in West and Central Africa in 1976, 1995, 2000, and 2007. The 2014 outbreak is by far the deadliest, already approaching ten times the number of cases of the 1976 outbreak, the previous worst in history and the year of the virus' discovery.[3]

The magnitude of the epidemic has caused a global crisis and evoked a powerful response from the United States Government. On September 16, speaking at the Centers for Disease Control and Prevention headquarters in Atlanta, Georgia, Pres. Barack Obama resolved to "make [Ebola] a national security priority." The President's strategy comprises four elements: containing the spread, countering negative economic and communal ramifications, coordinating a global response, and developing public health systems in affected countries for the future. Further, President Obama announced the establishment of a military command center and field hospitals in Liberia, a healthcare training center in Senegal, and an "airbridge" to the region for supply and personnel transfer.[4]

President Obama's actions initiate a trend: military operations specifically targeting disease containment. This approach is comprehensive, but not new. Moreover, viruses such as Ebola emphasize the unpredictable nature of disease, emerging sporadically, without warning, and potentially virulently. Early planning for the aftermath of an outbreak is an essential component of containment and mitigation.

The U.S. military has encountered disease on a large scale throughout its history. This latest deployment benefits from centuries of combined wisdom in disease control. From 1776 until 1918, the so-called "Disease Era" of American conflict, the microbe, rather than the enemy combatant, was the Soldier's most lethal adversary. Indeed, all casualty counts must include a "disease and non-battle injury" (DNBI) category to

---

[1]Lynette Iezzoni, *Influenza, 1918: The Worst Epidemic in American History* (New York: TV Books, 1999), 17.

[2]"WHO: Ebola Response Roadmap Situation Report," *World Health Organization*, October 3, 2014, accessed Oct. 16, 2014, http://apps.who.int/iris/bitstream/10665/135765/1/roadmapupdate3oct14_eng.pdf?ua=1.

[3]Joe Burgess, et al., "What You Need to Know about the Ebola Outbreak," *New York Times*, Sept. 17, 2014, accessed Sept. 19, 2014, http://www.nytimes.com/interactive/2014/07/31/world/africa/ebola-virus-outbreak-qa.html?_r=0).

[4]Barack Obama, "Remarks by the President on the Ebola Outbreak," The White House, Office of the Press Secretary, September 16, 2014.

include those who succumb to such maladies. Scientific and medical advancements have since learned the causes of various diseases, provided treatments, improved sanitation, and promoted hygiene. Disease rates in the military subsequently plummeted.[5]

Despite those successes, and the now-universal use of vaccines to protect the military and civilian workforce, their families, and retirees, disease remains a constant and growing threat. "Old" diseases thought to be eliminated, such as typhoid fever, or at least controlled, such as influenza, have returned, sometimes in new and more virulent form. Diseases such as Ebola, previously thought to be limited to developing nations, have appeared in more modern societies. "New" diseases, such as Severe Acute Respiratory Syndrome (SARS), have emerged.

This survey provides three case studies from American history in which epidemic disease affected U.S. Army operations. The Yellow Fever in Havana, Cuba in the 1890s and in Panama in the early 1900s demonstrates a case in which disease eradication required multiple Army control measures. Success was critical to complete the Panama Canal. The 1918-19 Spanish influenza demonstrates a case in which pandemic swept through the Army, taking advantage of mass mobilization as it devastated civilian populations as well. Diseases as debilitants during World War II and later conflicts demonstrate scenarios in which medicine taken according to a precise regimen drastically reduced mass infection.

These examples demonstrate how military forces have fought or contained disease of epidemic proportions. Although the diseases in these case studies use different vectors and vary greatly from Ebola in numerous respects, the Army's response to them provides some similarities. The nature of Ebola, its speed of transmission, and the regions in which it is currently rampant provide the commander with significant challenges. The challenges to protect the force are much more complex under the threat of widespread infectious disease. This study offers some considerations for the commander and staff planning operations in support of mitigating the Ebola outbreak.

Training: The need for infectious protocol training exists not only for medical professionals, for whom it may be only a refresher, but also of all other deploying personnel. Anyone deploying to the affected region may run the risk of infection, and thus training is required. This training may include training on new, mission-specific equipment.

Equipment: Humanitarian operations often require different and specialized equipment from that which is currently assigned under U.S. Army Modified Table of Organization and Equipment (MTOEs), or at least readily available. That equipment, to include clothing and other mission-specific gear, must be identified, located, and issued to the deploying unit.

Resourcing: Army units are not typically funded for such missions, and the requirements for any such mission will be significant.

---

[5]V. J. Cirillo, "Two Faces of Death: Fatalities from Disease and Combat in America's Principal Wars, 1775 to Present." *Perspectives in Biology and Medicine* 51, no. 1 (Winter 2008): 121-33.

Interagency Cooperation: The case studies indicate the Army took the lead in these operations because only the Army at the time had the capability and/or capacity for such large-scale actions, with the medical expertise to direct appropriate actions. In the modern era, however, the Army will operate within a framework of the interagency and NGOs with medical professionals from around the world. Liaison officers to such agencies as the Centers for Disease Control (CDC), World Health Organization (WHO), Doctors without Borders, and the medical agencies of the countries affected could prove invaluable. Multiple, diverse participants increasingly characterize current operations in a diplomatic atmosphere calling for international responses. This reality underlines the criticality of clear articulation of command and control and lines of authority.

The US Army Medical Department History Office provides a wealth of information of value to the commander and staff. The bibliography at the end of this study provides numerous resources, but the AMEDD materials may be found at http://www.cs.amedd.army.mil/borden/.

I. The Origins of Infectious Disease and the Development of Immunization

Epidemiology is the study of the incidence, distribution, and control of a disease in a population. The study includes tracing the geographical and biological origins of a particular disease; determining the disease's scope, i.e. who is or can be infected; assessing the established and potential geographical range of diffusion; and virulence, including symptoms and secondary infections, such as pneumonia. Epidemiological study is the first step in prevention and containment of an outbreak before, during, and after it reaches epidemic or pandemic levels.

The World Health Organization (WHO) categorizes the widespread outbreak or incidence of infectious diseases as endemic, epidemic, or pandemic:

Table 1 – World Health Organization (WHO) Classifications

Endemic	Disease regularly found in or restricted to a certain area or population. Endemic diseases are often the source of an epidemic's "patient zero."
Epidemic	Regional or communal outbreak among particular population.
Pandemic	An epidemic that affects multiple populations. For influenza, this involves the appearance of a new virus subtype and easily spread (e.g. through respiratory droplets) human-human transmission.

(Adapted from Col. Pietro Tornabene, "The Military Response to Pandemic: The New Global Threat" Strategy Research Project (SRP), USAWC Class of 2009 (Carlisle, Pa.: U.S. Army War College, 2009), 4-5.; Peter Doshi, "The Elusive Definition of Pandemic Influenza," World Health Organization Bulletin available at http://www.who.int/bulletin/volumes/89/7/11-086173/en/ accessed September 2, 2014.)

These conditions for qualification as endemic, epidemic, or pandemic are applicable to any disease in one or multiple populations.

Many diseases that pose an epidemic threat to humans, such as influenza and SARS, originate in animals such as birds, pigs, and bats. These animal vectors then act as reservoirs for transfer to a human host. Some animal populations also exhibit endemic infection. The 2003 H5N1 Avian Flu was endemic to poultry in parts of Asia and later became pandemic due to the infection of migratory birds.[6]

Other diseases, such as typhoid, are transmitted through the ingestion of bacteria found in fecal matter. As with dysentery, prevention lies in proper hygiene and sanitation. Mosquitos transmit diseases such as yellow fever and malaria, but such diseases do not infect the animals themselves.

[6]"Responding to the Avian Influenza Pandemic Threat: Recommended Strategic Actions." Communicable Disease Surveillance and ResponseGlobal Influenza Programme, (World Health Organization, 2005), 3. Available at http://www.who.int/csr/resources/publications/influenza/WHO_CDS_CSR_GIP_05_8-EN.pdf

Table 2 documents some of the most serious epidemic and pandemic outbreaks in the last century:

Table 2: Major 20th- and 21st-Century Epidemics and Pandemics

Pandemic	Deaths	Background
1918-1919, H1N1; '**Spanish Flu**'	~50-100 million	2/3 of deaths occurred in 24-week period; 675,000 US deaths; 20-40% globally infected
1957-1958, H2N2; '**Asian Flu**'	~2 million	Originated in China, spread to UK within 4 months; immunity rare in those under 65
1968-1969, H3N2; '**Hong Kong Flu**'	~1 million	Similar to but more mild than 1957 flu; originated in China, detected in Hong Kong
2003, H5N1; '**Avian Flu**'	243	Highly virulent – 63% mortality; 230+ million domestic birds culled to stop spread of disease
2003, **SARS** (Severe Acute Respiratory Syndrome)	774	Low human-human transmission rate; major global social and economic disruptions
2009-2010, H1N1; '**Swine Flu**'	~8,870-18,300	CDC estimates 43-89 million contracted flu; rapid response and vaccination caused decline
2014, **Ebola Virus Disease**	7,470 as of Oct. 3, 2014	Originated in Guinea, likely from fruit bat vectors, spread to Liberia, Sierra Leone, Nigeria

(Adapted from "What You Need to Know About the Ebola Outbreak," updated September 18, 2014, The New York Times, http://www.nytimes.com/interactive/2014/07/31/world/africa/ebola-virus-outbreak-qa.html (accessed September 4, 2014).; G. A. Opie, *Pandemic Flu: Will the World Catch a Cold?* London: Ministry of Defence, 2009, Seaford House Papers, 162-5.; "Pandemic Flu History" FLU.GOV, http://www.flu.gov/pandemic/history/ (accessed September 2, 14).)

Immunization had been a preemptive defense against disease for American soldiers since Gen. George Washington mandated compulsory smallpox inoculation of the Continental Army in 1777.[7] Vaccine immunology progressed significantly in the next century due to the research and discoveries of French microbiologist Louis Pasteur, German physician Robert Koch, and other pioneers of medical science.[8] Nonetheless, cholera, diarrhea, dysentery, and "camp fevers" such as Typhoid plagued soldiers throughout nineteenth-century conflicts. Preventive medicine remained rudimentary. Limited medical knowledge had not yet developed regimens for various diseases associated with wartime mobilization.

Disease barely killed more American soldiers than combat in World War I, at 51 percent. Moreover, the disease rate just for the AEF was down to 21 percent.[9] Prior to

[7]Erna Risch, *Supplying Washington's Army*, Special Studies Series (Washington, D.C.: U.S. Army Center of Military History, 1981), 380. Available at http://www.history.army.mil/html/books/040/40-2/index.html.

[8]"The History of Vaccines," 2014, The College of Physicians of Philadelphia, http://www.historyofvaccines.org/content/timelines/all (accessed 9 October 2014).

[9]Col. Leonard P. Ayers, *The War with Germany: A Statistical Summary* (Washington, D.C.: U.S. Govt. Printing Office, 1919), 123. Available at

overseas deployment, the Army immunized soldiers against smallpox and typhoid but could not foresee the outbreak of the catastrophic Spanish influenza nor the rate of its spread, exacerbated by close-quartered living conditions.[10] By the beginning of World War II, the Army immunized soldiers against smallpox, typhoid fever, cholera, plague, tetanus, yellow fever, and typhus.[11] Penicillin was the groundbreaking development of inestimable value. Wartime experience reportedly advanced medical knowledge by an estimated fifteen years.[12]

Wartime disease accounted for less than 2 percent of total lives lost in World War II, Korea, and Vietnam. Gulf War losses amounted to one hundred and forty-seven in combat and thirty from disease. Of those thirty, cardiovascular disease accounted for seventeen; infectious disease accounted for only one. At 0.004 percent, the disease death rate in the Persian Gulf was the lowest disease rate ever. In OIF and OEF, disease was a nonfactor. Cardiovascular, neoplastic, and other noninfectious diseases, as well as suicide, have eclipsed the old wartime scourges in death toll.[13]

Charts 1 and 2 compare disease and combat deaths in major American military conflicts from 1775 to 1991. Even as the average number of troops mobilized for war has increased, disease to combat death ratios as well as overall disease deaths have significantly decreased. Moreover, disease death (mortality) rates have decreased dramatically to as low as 0.004 percent during the Gulf War.

---

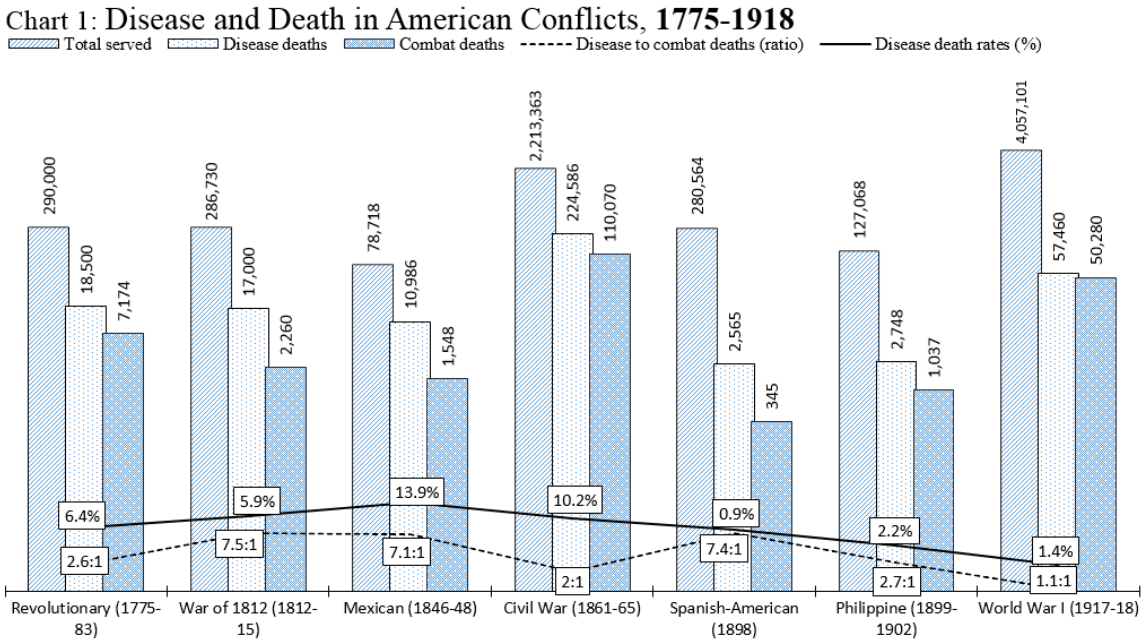
http://babel.hathitrust.org/cgi/pt?id=mdp.39015030674876#view=1up;seq=7. An extract is available at http://www.vlib.us/medical/stats/statsus.htm.

[10]John D. Grabenstein et al., "Immunization to Protect the U.S. Armed Forces: Heritage, Current Practice, Prospects," Vaccines.mil, http://www.vaccines.mil/documents/library/MilitaryImztn2005fulc.pdf.

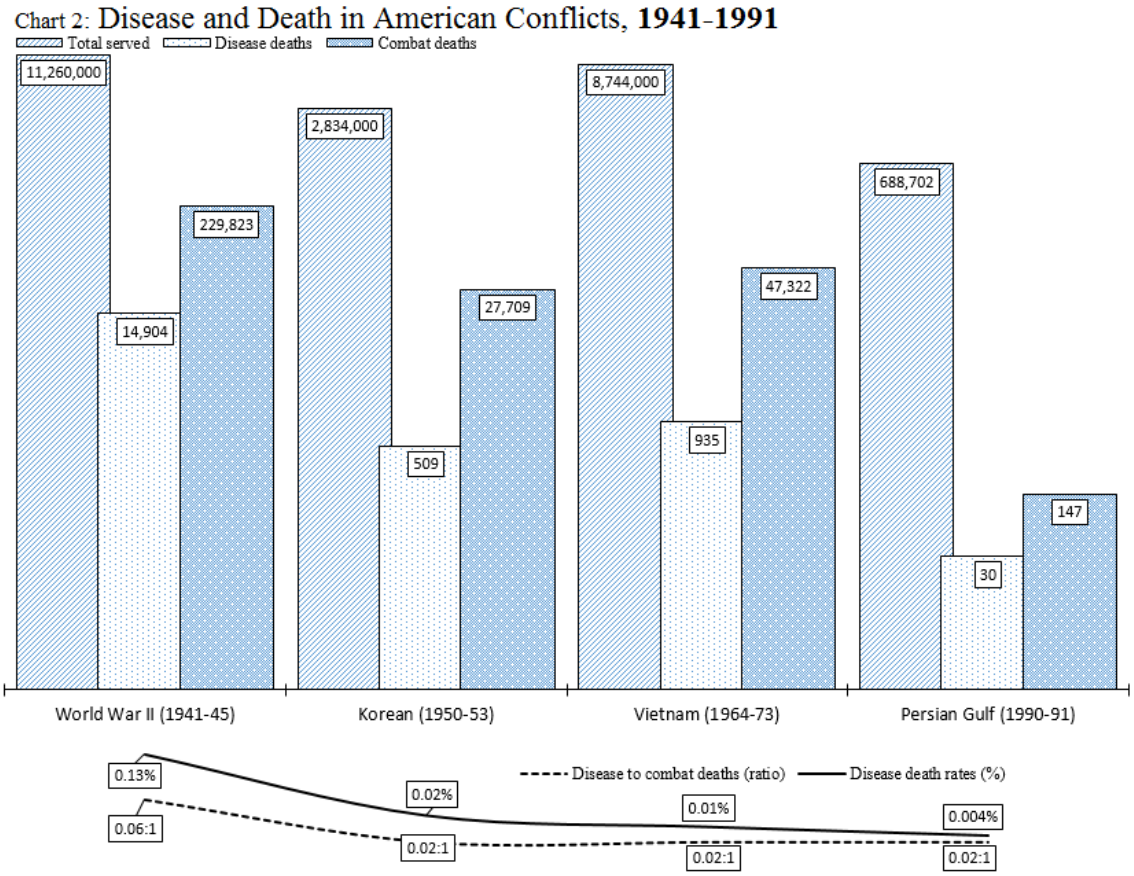
[11]Cirillo, "Two Faces of Death," 128.

[12]Historical Division, Army Medical Library, "Developments in Military Medicine during the Administration of Surgeon General Norman T. Kirk," The Second World War, Special Subjects Series (Washington, D.C.: U.S. Army Medical Department (AMEDD), Office of Medical History, n.d.), 620-21 republished from *The Bulletin of the U.S. Army Medical Department* 7, nos. 6-7 (June-July 1947), 520-62 & 594-646. Available at http://history.amedd.army.mil/booksdocs/wwii/DvlpmntsinMilMed.htm

[13]Cirillo, "Two Faces of Death," 130.



(*Source:* Vincent J. Cirillo, "Two Faces of Death: Fatalities from Disease and Combat in America's Principal Wars, 1775 to Present," *Perspectives in Biology and Medicine* 51, no. 1 (Winter 2008): 123.)



(*Source:* Vincent J. Cirillo, "Two Faces of Death: Fatalities from Disease and Combat in America's Principal Wars, 1775 to Present," *Perspectives in Biology and Medicine* 51, no. 1 (Winter 2008): 123.)

III. Yellow Fever: from Havana to the Panama Canal

A. *Background*

On December 10, 1898, the Treaty of Paris ended the Spanish-American War. The treaty ceded Guam, the Philippines, and Puerto Rico to the United States and relinquished Spain's claims to Cuba, allowing the U.S. government to establish a provisional protectorate over the island.

Apart from the initial tasks of maintaining order and overseeing Spanish troop withdrawal, U.S. military leaders targeted an ambitious objective: eradicating the rampant yellow fever virus from the island. The virus, endemic to large parts of Latin America, had spread rapidly across the island since the beginning of the Cuban War of Independence in 1895. Further, yellow fever epidemics originating in Havana, a Caribbean commercial hub, had swept through the United States throughout the previous century.[14] Understanding and eradicating the virus was necessary for continued local operations, future missions in the region, and, potentially, the public health of citizens in the U.S.

The late nineteenth century was a momentous time for the study of infectious disease. From the 1860s through 1880s, the work of German physician Robert Koch and French chemist Louis Pasteur had led to pivotal advancements in health sciences. Their experiments displaced miasma theory, the assumption that noxious air caused disease. Instead, they promulgated the idea that microorganisms caused disease. "Germ theory" became a fundamental concept in medical microbiology.[15] Medical professionals attributed filth and infected individuals to the spread of contagion. In Havana, sanitation, and street cleaning began immediately.[16]

U.S. leadership understood yellow fever as an urban disease, forming due to the filth of city streets. The military government stationed soldiers outside city limits, placed immigrants and those who lacked immunity in camps outside of Havana, and fined residents for littering. The Department of Street Cleaning maintained a force of more than 500, sweeping 273 miles of street daily and rinsing the roads regularly with disinfectant.[17] Despite the Army's efforts to sanitize the city of 250,000, the virus persisted. LTC Tasker H. Bliss, operating in Cuba as the Sixth Army Corps Chief Commissary in 1898, voiced his concerns:

---

[14]Mariola Espinosa, *Epidemic Invasions: Yellow Fever and the Limits of Cuban Independence, 1878-1930* (Chicago: University of Chicago Press, 2009), 7-9.

[15]Agnes Ullman, "Pasteur-Koch: Distinctive Ways of Thinking about Infectious Diseases," American Society for Microbiology, August 2007, accessed September 14, 2014, http://forms.asm.org/microbe/index.asp?bid=52099.

[16]Espinosa, *Epidemic Invasions*, 55-7.

[17]Ibid., 34-7.

> We came back by the village not far from which are the hospitals where there are over three thousand yellow fever patients. It is this disease that makes our problem so difficult. The fever always exists here. The records show that for 160 years there has been only one month without yellow fever. These cases occur among a comparatively small part of the population which is not immune. If we bring over thousands of men from the north there is no reason why they should be exempt from epidemic . . . As for me I shall protest against bringing troops here until the healthiest sites are selected and every possible precaution against infection has been taken.[18]

Nicknamed "yellow jack" in the tropics for the lemon-colored tint of its victims' skin, yellow fever is an acute infectious disease transmitted by the female *Aëdes aegypti* mosquito. Symptoms include fever, chills, head and body aches, nausea, jaundice, and fatigue, though the majority of infected persons are asymptomatic or develop mild illness. Rare cases included hemorrhaging into the stomach and intestinal tract, causing "black vomit," and death.[19] Treatment is symptomatic and patients are hospitalized for supportive care and observation when possible.[20]

The earliest authentic records of yellow fever virus come from seventeenth century Spaniards in the West Indies. The disease, endemic to large parts of Central and South America, emerged across cities in the region throughout the eighteenth century. Emigrating northward via human hosts, yellow fever epidemics cropped up sporadically in North America, invading New York, Philadelphia, Boston, Baltimore, and various southern cities more than 160 times between 1705-1905.

In 1793, the disease took hold of Philadelphia, prompting its citizens to flee to the countryside. Nearly a century later, in 1878, yellow fever swept through the Mississippi River basin from New Orleans, infecting more than 100,000 and killing between 13,000 and 20,000.[21] The ship carrying the disease had arrived from Havana, Cuba.[22] Once in the United States, the virus moved upriver and spread along railroad lines, halting local economies and prompting rapid quarantines supported by Congress' 1878 Federal Quarantine Legislation. "When the disease was announced in a town, everybody left who could," recounted Maj. Gen. William C. Gorgas, (ret.), "The sick were frequently left without care, and often a great deal of cruelty and cowardice was shown."[23]

---

[18]Frederick Palmer, *Bliss, Peacemaker: The Life and Letters of General Tasker Howard Bliss* (New York: Dodd, Mead & Company, 1934), 58.

[19]Jon T. Hoffman et al., *The Panama Canal: An Army's Enterprise*, CMH Pub 70-115-1 (Washington, D.C.: U.S. Army Center of Military History, 2009), 27. Available at http://www.history.army.mil/html/books/panama/panamacanal/CMH-70-115-1-PanamaCanal.pdf

[20]"Yellow Fever," December 13, 2011, Centers for Disease Control and Prevention, http://www.cdc.gov/yellowfever/symptoms/index.html (accessed September 5, 2014)

[21]Hoffman et al., *The Panama Canal: An Army's Enterprise*, 27.

[22]Espinosa, *Epidemic Invasions*, 32-3.

[23]Hoffman et al., *The Panama Canal: An Army's Enterprise*, 27.

By the beginning of the 20th century, improved sanitation and advancements in medical microbiology had all but eradicated former menaces such as cholera and dysentery within the United States. Still, overseas excursions brought new medical challenges. In Cuba, sanitation had proven ineffective in eradicating yellow fever. Maj. Gen. George M. Sternberg, Surgeon General of the Army, appointed the U.S. Yellow Fever Commission to investigate the etiology of the virus. He appointed to head the commission Army bacteriologist Maj. Walter Reed. Maj. Reed's staff included James Carroll, Aristides Agramonte, and Jesse W. Lazear.[24]

B. *Eradication of Yellow Fever in Havana*

Cuban physician Carlos J. Finlay, at the U.S. National Board of Health since 1879, posited that mosquitos were transmitting the yellow fever virus to humans. Finlay also cast doubt on germ theory, showing that exposure to human waste did not spread the virus.[25]

In August 1900, Dr. Reed's team successfully conducted human trials. Early testing supported the mosquito-vector hypothesis. Dr. Lazear, who oversaw the experiments, contracted yellow fever on September 18 after allowing himself to be bitten while visiting Las Ánimas, Havana's yellow fever hospital, and succumbed one week later. Reed's submitted a report based on the human tests to the American Public Health Association in October 1990.[26] The human trials continued in the newly constructed Camp Lazear and solidified the theory that yellow fever was a mosquito-borne illness.[27]

In December 1900, Maj. Gen. Leonard Wood, the military governor of Cuba, authorized Dr. William C. Gorgas, the newly assigned Chief Sanitary Officer, to implement the findings of Reed's commission. Gorgas abandoned his first strategy, intentional infection as inoculation, following the death of three of the first sixteen volunteers. Following the guidance of Maj. Reed, Gorgas enacted a more ambitious strategy: the extermination of the mosquito population of Havana. "If it is the mosquito," said Gorgas, "I am going to get rid of the mosquito."[28]

By February 1901, Gorgas' new strategy included quarantining patients behind screens to avoid spread via mosquito vectors; fumigating every building in Havana; and

---

[24]Hoffman et al., *The Panama Canal: An Army's Enterprise*, 28.

[25]Espinosa, *Epidemic Invasions*, 33; *The Panama Canal: an Army's Enterprise*, 28. Henry R. Carter, a Public Health Service scientist, corroborated Finlay's theory. Working in Mississippi during an 1898 outbreak, Carter took note of the 10-14 day period between yellow fever cases in new patients. He attributed the unusually long incubation period to an external vector: the mosquito.

[26]William Crawford Gorgas, et al., *Yellow Fever, a Compilation of Various Publications. Results of the Work of Maj. Walter Reed, Medical Corps, United States Army, and the Yellow Fever Commission* (Washington, D.C.: G.P.O., 1911), 17-26.

[27]Espinosa, *Epidemic Invasions*, 60-1.

[28]Grace T. Hallock, *Walter Reed and the Conquest of Yellow Fever* (New York: School Health Bureau, Health and Welfare Division, Metropolitan Life Insurance Co., 1958), 21.

placing oil in, screening, or draining every receptacle containing standing water.[29] Cesspools were common in Havana homes and provided an ideal breeding place for mosquitos. Adding oiling to the receptacles killed the mosquito larvae within.[30] Special "disinfectant brigades" identified and fumigated infested areas to remove mosquitos and larvae. By March 1901, the government reassigned two-thirds of Sanitary Department crews to the house-to-house oiling campaign. In the first month, the crews treated nearly 20,000 houses.[31]

Though the Sanitary Department's intrusive methods fomented public indignation, yellow fever cases in Havana decreased dramatically, from 1,400 in 1900, to thirty-seven in 1901, to zero in 1902.[32] In 1901, almost 100 percent of homes in Havana contained larvae infestations. By March 1902, Gorgas' efforts reduced the rate to 0.6 percent.[33] The efficacy of the methods was apparent: only four cases of yellow fever occurred in May 1901 and all survived. The following month was Havana's first June without an incidence of yellow fever since 1761.[34] "This is so much better than anything that has occurred before," Gorgas wrote in September 1901, "that we feel convinced it can only be due to the methods of disinfection adopted by order of the Military Governor; that is, the thorough destruction of infected mosquitoes in the neighborhood of the focus of infection."[35]

B. *The Yellow Fever in Panama*

The United States had first contemplated a canal to link the Atlantic and Pacific in Nicaragua. Instead, in 1902 Congress authorized the purchase of French assets for an aborted project to build a canal across the Isthmus of Panama. The French had abandoned the effort, hounded by terrain, weather, disease, financial mismanagement and wrongdoing. They had invested over $260 million and 20,000 lives since commencing in 1881. The U.S. would require about $375 million and another 5,600 lives to complete the task. Designers conquered the formidable terrain with an engineering marvel. Their

[29]Hoffman et al., *The Panama Canal: An Army's Enterprise*, 29.

[30]William C. Gorgas, "Report of Vital Statistics of Havana, Guanabacoa, and Regla." *Public Health Reports* vol. 16 (April 1901).

[31]Espinosa, *Epidemic Invasions*, 34-37, 65; Hoffman et al., *The Panama Canal: An Army's Enterprise*, 32, 38-9.

[32]Hoffman et al., *The Panama Canal: An Army's Enterprise*, 29.

[33]Joseph A. Le Prince, Assistant to Chief Sanitary Officer, to William C. Gorgas, Chief Sanitary Officer of Havana, May 19, 1902, File 4, Reports of Officials of the Military Government, 1901-1902, MGC/RG 140.

[34]William C. Gorgas, "Report of Vital Statistics of Havana, Guanabacoa, and Regla" *Public Health Reports* vol. 16 (June 1901).

[35]William C. Gorgas, "Report of Vital Statistics of Havana, Guanabacoa, and Regla," File 1901/275, Letter Received, 1899-1902, MGC/RG 140, August 1901.

success, however, relied upon a concerted, coordinated effort across several medical fronts. The defeat of mosquito-borne yellow fever and malaria was paramount.[36]

The Hay-Bunau-Varilla Treaty of 1903 provided a legal basis for operations and entrusted the United States with management of public health in Panama City, Colón, and the Canal Zone. This responsibility included caring for sick and injured patients, and basic sanitation measures such as street cleaning and garbage disposal. To assist, the cities of Colón and Ancon maintained large, well-equipped hospital facilities. Other medium- and small-sized patient care facilities were scattered throughout public health districts and villages.[37]

In 1904, Gorgas arrived in Panama in an advisory capacity as the Chief Public Health Officer, operating under Admiral John Grimes Walker, appointed Chairman of the Isthmian Canal Commission.[38] During the previous decade, the inhabitants of the isthmus had suffered a history of diverse ailments: influenza and measles outbreaks, a severe smallpox epidemic, and yellow fever epidemics in 1897, 1899, and 1900. "Among infectious diseases on the Isthmus[,] yellow fever is undoubtedly the most to be feared by unacclimated [sic] persons," wrote retired Brig. Gen. Henry L. Abbot, a veteran of the Civil War and former U.S. Army engineer working as a consultant at the Panama Canal.[39]

Upon surveying the region, Gorgas' proposed a strategy estimated to cost the Canal Commission $1 million. The plan included requirements of medical staffs as well as costs of labor and supplies to continue with the task of mosquito eradication. Despite the support of Maj. Gen. Leonard Wood, the military governor of Cuba from 1899-1902, who had witnessed Gorgas and Reed's success, Admiral John Walker denied Gorgas' request. Instead, Admiral Walker authorized $50,000 for supplies.[40] Walker's shortsightedness delayed the containment of mosquito-borne illnesses and contributed to Pres. Roosevelt's eventual decision to replace him.

In June 1904, despite skepticism and underfunding from Admiral Walker, Gorgas and his staff of seven began their work. Gorgas' staff included Henry Carter, serving as his Director of Hospitals and Chief Quarantine Officer, and Joseph A. Le Prince, serving as Chief Inspector; both had previous work experience with Gorgas in Cuba.[41]

---

[36]Elizabeth Nix, "7 Fascinating Facts about the Panama Canal," History in the Headlines, History Channel, August 15, 2014, available at http://www.history.com/news/7-fascinating-facts-about-the-panama-canal.

[37]Hoffman et al., *The Panama Canal: an Army's Enterprise*, 31.

[38]Ibid., 30-1.

[39]Henry L. Abbot, *Problems of the Panama Canal: Including Climatology of the Isthmus, Physics and Hydraulics of the River Chagres, Cut at the Continental Divide and Discussion of Plans for the Waterway, with History from 1890 to Date* (New York: Macmillan, [1907]), 102-7.

[40]Hoffman et al., *The Panama Canal: an Army's Enterprise*, 32.

[41]Ibid.

C. *Army Leaders' Response*

Many remained obstinate that sanitation was the key in the battle against yellow fever. When the disease continued to spread, Secretary of War William Howard Taft appointed Charles A.L. Reed, former American Medical Association (AMA) president, to investigate. Reed toured the area, scrutinizing health standards and the work of the Commission. On February 17, 1905, Gorgas hand-delivered Reed a memorandum detailing the commission's myopic shortcomings and recommending policy and funding reform. A yellow fever breakout in April-May 1905 that caused sixty-three workers to fall ill and claimed the lives of nineteen, including several high-ranking commission officials, caused further panic. In response to the outbreak, 500 American employees, three-fourths of the total, including John Wallace, the chief engineer, fled for home. The commission's intransigent misjudgments were costing lives, labor, and expertise.[42]

Reed published an article in the *Journal of the American Medical Association* supporting Gorgas and requesting that President Roosevelt ask for the resignation of the commission. Already concerned with the project's progress, Roosevelt and Congress replaced the Commission's leaders. Disagreement between Gorgas and the commission persisted as Theodore P. Shonts, the new Chairman of the Canal Commission, requested the replacement of the Chief Public Health Officer. The request was forwarded to Secretary Taft and then to President Roosevelt. The President sought outside advice from Dr. William H. Welch, a founder of Johns Hopkins Hospital and first Dean of its School of Medicine, and Alexander Lambert, a close friend. Lambert captured the President's imagination with his observation, "If you fall back upon the old methods of sanitation, you will fail, just as the French failed. If you back up Gorgas and let him pursue his campaign against the mosquitoes, you will get your canal." The American Medical Association (AMA) and Robert Maitland O'Reilly, the U.S. Army Surgeon General, also supported Gorgas' efforts. President Roosevelt decided to support Gorgas and provided him the resources that were required.[43]

Eradication or strict control of the spread of yellow fever was essential to the completion of the canal. The French had abandoned their eighteen-year effort in large part due to the tens of thousands who succumbed to the virus.[44] Gorgas' policies, although enacted later than intended due to doubts among Panama Canal Commission leaders, showed success within two years. A letter from Gorgas on Sept. 12, 1906 conveys the Colonel's satisfaction:

> Our most important accomplishment, so far, from the point of view of the construction of the Canal is the eradication of yellow fever. . . If we were doing this work under the conditions and with the knowledge we had twenty-five years ago, we would be losing from yellow fever at the rate of 40 men per month, and this loss would fall entirely among the Americans, for we twenty-five years ago could probably have done no better in sanitary directions than the French did.[45]

---

[42]Hoffman et al., *The Panama Canal: An Army's Enterprise*, 33-4.

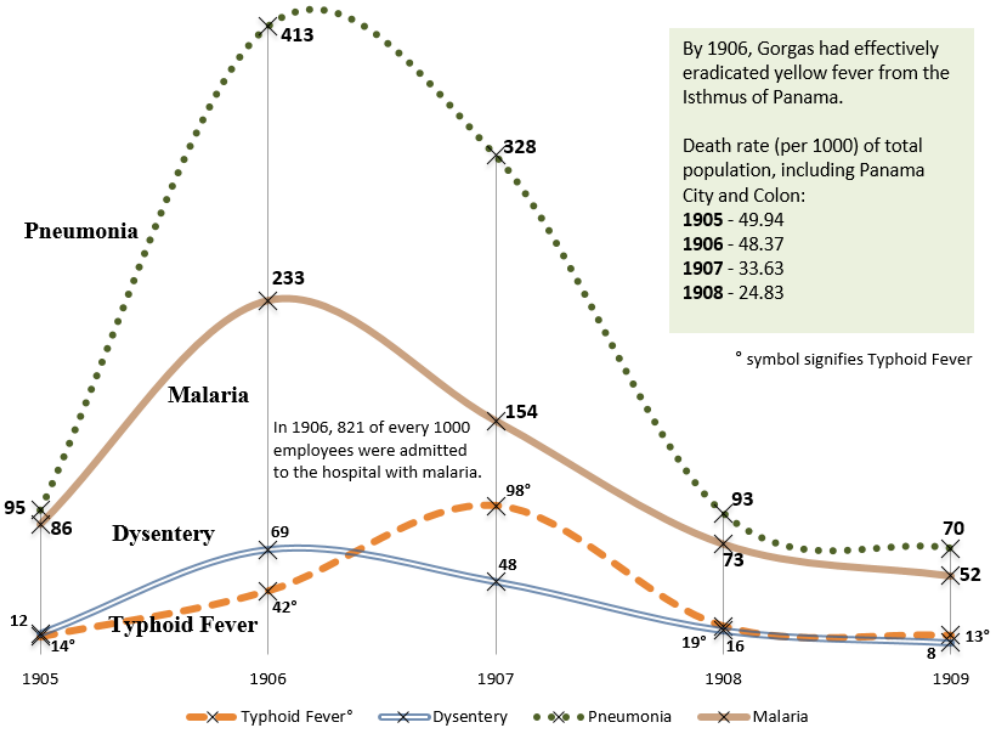
[43]Ibid., 35-6.

[44]Espinosa, *Epidemic Invasions*, 120.

[45]Abbot, *Problems of the Panama Canal*, 106-7.

Gorgas' fight against yellow fever ensured continued construction of the Panama Canal and, as a result, continued American commercial expansion.[46] By 1906, Gorgas and the efforts of his laborers eradicated yellow fever from the Panama Isthmus. Still, pneumonia, malaria, and other maladies would continue to plague workers. Malaria, though less virulent than yellow fever, was more widespread and physically incapacitating.[47] By 1913, Gorgas' measures of mosquito-control dropped malaria incidence to 10 percent of its 1906 rate in the Canal Zone.[48] As in Havana, various public sanitation policies continued despite prioritization of mosquito eradication. [49] Chart 3 depicts the success of the commission's comprehensive public health policies as recorded in Gorgas' 1909 sanitation report from the Canal Zone. In the absence of yellow fever, pneumonia, malaria, dysentery, and typhoid fever continued, albeit with decreasing incidence.

Chart 3: **Deaths by disease** among Panama Canal employees, 1904-1909



(*Source:* W.C. Gorgas, Annual Report of the Department of Sanitation of the Isthmian Canal Commission for the Year 1909, Washington Government Printing Office, 1910, 5-7.)

---

[46]Paul S. Stutter, "Nature's Agents or Agents of Empire?" *Isis* 98, no. 4 (2007): 724-54.

[47]W.C. Gorgas, Annual Report of the Department of Sanitation of the Isthmian Canal Commission for the Year 1909, Washington Government Printing Office, 1910, 5-7. Parts of the 1909 Annual Report of the Department of Sanitation of the Isthmian Canal Commission providing Gorgas' commentary regarding disease incidence are included at the end of this section.

[48]Espinosa, *Epidemic Invasions*, 6-9.

[49]Ibid., 63-4.

IV. The 1918 Spanish Flu

A. *Background*

On April 2, 1917, three years after the onset of World War I in Europe, the United States entered the conflict on the side of the allies, Great Britain and France.[50] Looking to the horror of industrialized warfare from the safety of the United States, the American Expeditionary Force rapidly assembled military posts, camps, arsenals, airfields, and supply depots all over the country.[51] With the federalization of the National Guard and a newly established draft, the Army grew from less than 100,000 in 1917 to 3.7 million by war's end.[52] This rapid, explosive growth produced an Army for war on a scale previously unknown in American history, but also created and environment ripe for the incubation of disease. Further, the constant movement of troops to different camps, to ports, and finally overseas allowed the diseases to travel quickly and easily.[53]

The previous couple of decades had seen momentous advancements in medicine. In March 1917, less than a month before Congress' declaration of war, a U.S. Public Health Service official wrote, "Those pestilences once considered as the inevitable accompaniment of military movement have been shorn of terror by the hand of science."[54] In 1885, Louis Pasteur performed the first successful rabies vaccination. The same year, Spanish physician Jaime Ferrán developed a vaccine against cholera, the first vaccine against a bacterial disease. From 1898 to 1914, the work of Dr. Carlos Finlay, Maj. Walter Reed, and Maj. Gen. William C. Gorgas confirmed yellow fever to be a mosquito-borne illness and facilitated the virus' eradication in Havana, Cuba and the Isthmus of Panama. By the time the U.S. entered World War I, American military personnel received vaccinations against smallpox and typhoid.[55] Maj. Gen. Gorgas had been appointed Surgeon General of the Army in 1914, and he continued to promote sanitation, hygiene, and nutrition among troops.[56]

---

[50]"Milestones: 1914-1920," U.S. Department of State, Office of the Historian, https://history.state.gov/milestones/1914-1920/wwi (accessed September 12, 2014).

[51]Carol R. Byerly, "The U.S. Military and the Influenza Pandemic of 1918-1919," *Public Health Reports*, supplement 3 (April 2010): 84.

[52]Maurice Matloff, *American Military History*, Army Historical Series (Washington, D.C.: CMH, 1956; reprinted., 1989), 351-52, 376.

[53]Carol R. Byerly, *Fever of War: The Influenza Epidemic in the U.S. Army during World War I* (New York: New York University Press, 2005), 84.

[54]William Colby Rucker, "The Influence of the European War on the Transmission of the Infections of Disease, with Special Reference to its Effect upon Disease Conditions in the United States," MS 40 (March 1917): 258 cited in Byerly, *Fever of War*, 191 FN2.

[55]John D. Grabenstein et al., "Immunization to Protect the U.S. Armed Forces: Heritage, Current Practice, Prospects," Vaccines.mil, http://www.vaccines.mil/documents/library/MilitaryImztn2005fulc.pdf.

[56]Carol R. Byerly, "The U.S. Military and the Influenza Pandemic of 1918-1919," 85.

Still, the contemporary advancements in health sciences and subsequent preventative measures did and could not prepare the Army – or humanity, for the severity of the "Spanish" influenza. In March 1918, Fort Riley, Kansas teemed with thousands of newly inducted soldiers living in cramped quarters. A wave of influenza swept through the ranks but doctors overlooked the seriousness of this first, mild wave, unaware that the virus was spreading across the country.[57] On August 27, influenza appeared in Boston, Massachusetts, incapacitating three on the first day, eight on the second, and fifty-eight on the third. On September 8, illness broke out at Camp Devens, outside the city. The second wave had begun. Within ten days, thousands were hospitalized.[58] By October, the deadliest month of the pandemic for American soldiers, the Spanish flu would claim 195,000 American lives.[59]

From Camp Devens, the contagion spread to Camp Upton, New York on September 13; onto Camp Grant, Illinois on September 21; and within a month had affected soldiers at every camp in the United States. Due to the close quarters in which soldiers lived, the rapidity with which the virus overtook camps was, upon outbreak or arrival of the initial patient, inevitable. Spread through microscopic droplets passed by sneeze, cough, touch, and lingering on surfaces, few could hope to escape infection.[60] Even so, Army provisions aimed at prevention and containment continued. "We knew perfectly well that we can control pneumonia absolutely if we could avoid crowding the men," Maj. Gen. Gorgas, Army Surgeon General, reportedly told a training camp commander, "but it is not practicable in military life to avoid this crowding."[61]

In the United States, the Medical Department increased the number of beds in Army hospitals more than tenfold, from 9,500 to 120,000. By 1918, almost 30 percent of American physicians were in military service.[62] These physicians documented symptoms, cases, and findings; ran tests; performed autopsies; and shared their information through reports and articles.[63] Some commanders, such as Camp Upton's Col. John Mallory, quarantined the 30,000 under his command, allowing travel for only "the most urgent business."[64]

---

[57]"Spanish Influenza in North America, 1918-1919," Contagion Historical Views of Diseases and Epidemics, Harvard University Library Open Collections Program, 2014, http://ocp.hul.harvard.edu/contagion/influenza.html.

[58]Carol R. Byerly, "The U.S. Military and the Influenza Pandemic of 1918-1919," 86.

[59]"Spanish Influenza in North America, 1918-1919," Harvard University Library Open Collections Program, Contagion Historical Views of Disease and Epidemics, 2014, accessed September 4, 2014, http://ocp.hul.harvard.edu/contagion/influenza.html.

[60]G. A. Opie, *Pandemic Flu: Will the World Catch a Cold?* London: Ministry of Defence, 2009, Seaford House Papers, 161.

[61]W. C. Gorgas to H. L. Scott. 1918 April 10. Box 41, Entry 31, RG 112, Box 41, National Archives and Records Administration, College Park, MD.

[62]Carol R. Byerly, "The U.S. Military and the Influenza Pandemic of 1918-1919," 85.

[63]Ibid., 85-6.

[64]"Close Camp Upton to Check Influenza," *The New York Times*, September 1918, 17:10.

Within the camps, medical personnel provided facemasks for all camp residents and inspected bedridden patients daily. Hospitals offered relative isolation or screening between beds, well-ventilated chambers, and experimental vaccines.[65] Nonetheless, the virus persisted, ending the war for many troops long before they reached the battlefront. Military medical historian Carol Byerly studied the influenza epidemic of 1918 in *Fever of War: The Influenza Epidemic in the U.S. Army during World War I*, and concluded:

> The Americans' brief military participation . . . meant that the influenza epidemic colored much of the American combat experience. Both were concentrated in September, October, and November 1918. Once it arrived in its deadly form in early September, the flu dramatically affected American war activities.[66]

As thronged as trainees were in the overcrowded camps, the mildewed, rat-infested trenches of the European battlefield placed soldiers in even worse conditions. Some researchers, such as evolutionary biologist Paul Ewald, believe that the conditions of trench warfare empowered the aggressive virus against already compromised immune systems.[67] Once influenza had arrived in Europe, it spread again through the seaports to Asia, Africa, and Latin America.[68]

During the American Expeditionary Force's largest campaign, the Meuse-Argonne Offensive from September to November 1918, influenza affected all facets of military efficiency, overwhelming hospitals as well as transportation lines. It left thousands of soldiers either dead or unable to train or conduct combat missions.[69] By year's end, the War Department calculated an overall loss of 8,743,102 days of labor among incapacitated and bedridden enlisted men.[70]

Over the course of the war, disease accounted for 60 to 90 percent of AEF troop "noneffectiveness," or incapacity of duty. The primary offenders were influenza and epidemic diarrhea, but other maladies, such as typhoid fever, measles, mumps, and venereal diseases also impacted troop effectiveness. Due to the nature and relatively short timeframe of military operations as well as available health care, American troops rarely incurred trench nephritis, trench foot, or tetanus. Lice and scabies, endemic to the trenches, infested as many as 75 percent of the AEF's units.[71] Military historian James T.

---

[65] Carol R. Byerly, "The U.S. Military and the Influenza Pandemic of 1918-1919," 90.

[66]Byerly, *Fever of War*, 8.

[67]P. W. Ewald, *Evolution of Infectious Disease* (Oxford: Oxford University Press, 1994), 110-13.

[68]Department of the Navy, *Annual Report, 1919*. (Washington, D.C.: U.S. Government Printing Office; 1920).

[69]Byerly, *Fever of War*, 9.

[70]Ibid. Byerly notes that exact rates of death and sickness are almost impossible to determine due to incoherent or incomplete records, medical misdiagnoses, and other factors.

[71]*Reports of the Commander-in-Chief, Staff Sections and Services*, United States Army in the World War 1917-1919, vol. 15 (Washington, D.C.: U.S. Army Center of Military History, 1991), 372-375.

Seidule has studied the effects of environmental factors on soldiers' welfare in the AEF. He determined that malnutrition, inadequate clothing, and lack of sleep lowered morale and caused thousands of soldiers to suffer from combat exhaustion, and reduced the army nearly to ineffectiveness.[72]

B. *Army Leaders' Response*

In units plagued by influenza, field officers dealt with the day-to-day challenges of soldiering while trying to keep up morale and the practice of preventative measures.[73] As revealed by the Army Medical Department, results were rarely positive: "the best result to be expected from any or all of these measures is a slowing of the progress of an epidemic rather than any considerable diminution in the number of cases."[74] Soldiers stationed abroad, daily enduring the trials of the trenches, shelling and bloodshed, feared for the lives of their non-military kin. "Every day nearly someone of my outfit will hear that his mother, sister, or sweetheart is dead," 24-year-old Captain Harry S. Truman wrote. "It is heartbreaking almost to think that we are so safe and so well over here and that the ones we'd like to protect more than all the world have been more exposed to death than we."[75]

Emotional stress also took its toll on leaders. Col. Charles B. Hagadorn, a West Point graduate who had served in Russia and at the Panama Canal, was acting camp commander at Camp Grant, Illinois in October 1918 when the virus' brutal second wave took hold. Striking in earnest in late November, pneumonia-induced fatalities grew in number daily. In early October, mortality rates spiked: seventy-six deaths on October 4, more than one hundred on October 5, and one hundred and seventeen on October 6. On October 7, Col. Hagadorn, having lost more than 500 soldiers under his command, committed suicide.[76]

At the highest ranks of Army leadership, applied research and efforts to stop the spread were offset by the disease's virulence and epidemic proliferation. Army Surgeon General Gorgas stressed hygiene, sanitation, clean water, fresh air, and proper nutrition, but admitted that little could be done to prevent overcrowding.[77] "There is to be expected

---

[72]James T. Seidule, "Morale in the Expeditionary Forces," (Ph.D.. diss., Ohio State University, 1997), 259.

[73]Byerly, "The U.S. Military and the Influenza Pandemic of 1918-1919," 90.

[74]War Department, Office of the Surgeon General, *Medical Department of the United States Army in the World War, vol. 9: Communicable and Other Diseases.* Washington: U.S. Government Printing Office, 1928, 123-4.

[75]David G. McCullough, *Truman* (New York: Simon & Schuster, 1992), 136.

[76]"Col. Hagadorn a Suicide," *The New York Times*, October 9, 1918, 24.

[77]Byerly, "The U.S. Military and the Influenza Pandemic of 1918-1919," 85.

a definite relation between the degree of crowding and the amount of respiratory infection," the Army Medical Department added.[78]

In an attempt to understand the virus, Gorgas sent a small group of distinguished epidemiologists to Camp Devens to investigate. Calling the situation "grave," the team recommended 16 measures for containment, including ceasing all personnel transfers to and from the base until the virus had subsided. When the scientists witnessed the autopsies of the deceased, they feared that "some new kind of infection or plague" had taken form.[79] With symptoms including high fever, head and body aches, fatigue, sore throat, nausea, congestion, and in some cases leading to pneumonia and pulmonary hemorrhaging, the H1N1 influenza subtype was so abnormally virulent that physicians misdiagnosed it as cholera and bubonic plague during the early stages of its spread.[80]

In fact, the new infection was a highly virulent and communicable influenza subtype that thrived in a dense population of potential hosts. The environment in which influenza develops is a key determinant of its carnage or containment.[81] The settings and circumstance of the H1N1 subtype, burgeoning army camps and insalubrious European battlefields, allowed the virus to flourish. By November 11, 1918, the AEF had evacuated 84,215 officers and enlisted men due to illness.[82] In the U.S. Army, including Marines, disease deaths amounted to 57,460.[83] Overall, the virus circulated the global and proliferated until it had affected an estimated 500 million people and killed 50-100 million worldwide.[84]

---

[78]War Department, Office of the Surgeon General, *Medical Department of the United States Army in the World War, vol. 9: Communicable and Other Diseases.* Washington: U.S. Government Printing Office, 1928, 111.

[79]Simon Flexner and J.T. Flexner, *William Henry Welch and the Heroic Age of American Medicine* (New York: Viking Press, 1941), 376-7.

[80]"The Great Pandemic: The United States in 1918-1919," United States Department of Health and Human Service, Flu.gov, accessed September 4, 2014, http://www.flu.gov/pandemic/history/1918/the_pandemic/fightinginfluenza/.

[81]Stacey L. Knobler et al., *The Threat of Pandemic Influenza* (Washington, D.C.: National Academies Press, 2005) 30.

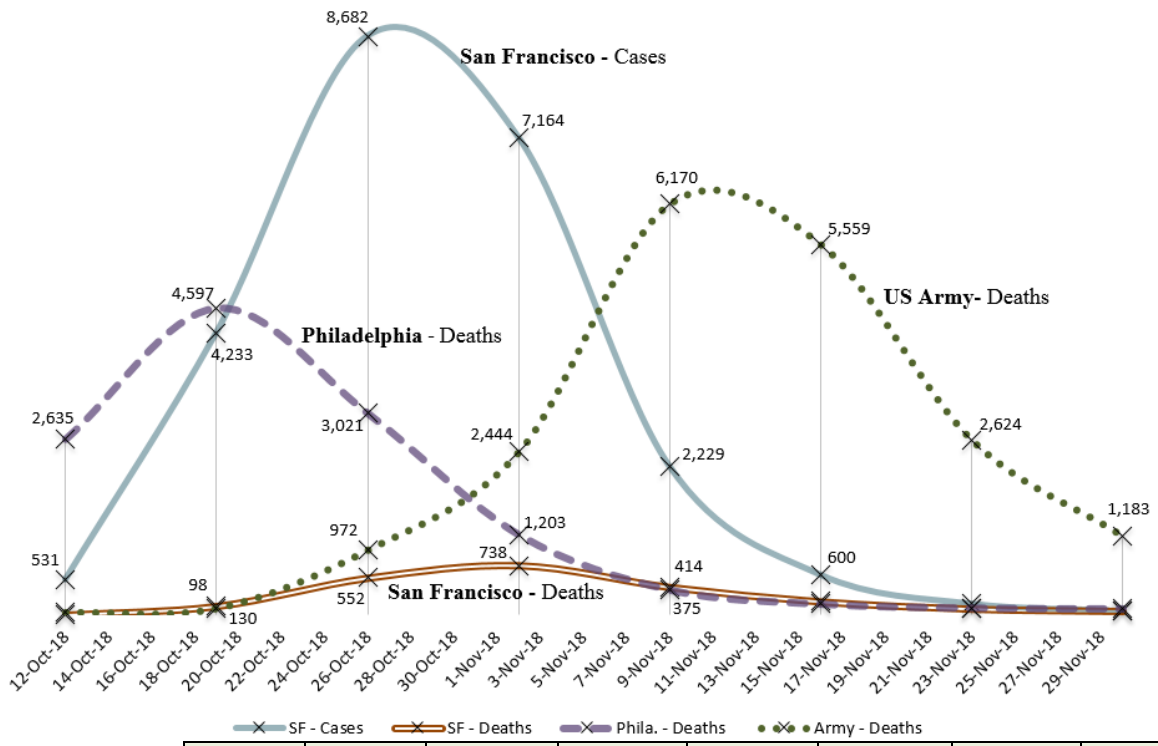
[82] *Reports of the Commander-in-Chief, Staff Sections and Services*, 377.

[83]Cirillo, "Two Faces of Death, 123.

[84]Niall P. A. S. Johnson and Juergen Mueller, "Updating the Accounts: Global Mortality of the 1918-1920 Spanish" Influenza Pandemic," *Bulletin of the History of Medicine* 76 (2002): 105-115.

Chart 4: **1918 Spanish Influenza** - Second Wave, October-November 1918

Influenza and Pneumonia Cases and Deaths



1918	12-Oct	19-Oct	26-Oct	2-Nov	9-Nov	16-Nov	23-Nov	30-Nov
SF - Cases	531	4,233	8,682	7,164	2,229	600	164	57
SF - Deaths	-	130	552	738	414	198	90	56
Phila. - Deaths	2,635	4,597	3,021	1,203	375	164	103	93
Army Deaths	36	98	972	2,444	6,170	5,559	2,624	1,183

(*source:* Alfred W. Crosby, *America's Forgotten Pandemic, The Influenza of 1918* (New York: Cambridge University Press, 1989): 59, 86, 114.)

V. World War II to the Present: Disease as Debilitant

World War II inaugurated a new era, when disease was no longer the serious killer of armies, but rather the great debilitant with endemic maladies. The combination of geography, climate, and combat operations rendered certain theaters in WW II veritable havens of disease. Today a detailed coding system categorizes the myriad disease subtypes. In general, these were dysentery, cholera, Hepatitis A and B, malaria, beriberi, dengue fever, scrub typhus, leishmaniasis, and the infamous "jungle rot."[85]

The Army's battle against malaria in particular during World War II is a case study in the development and adoption of multiple methods to combat a disease short of a cure. Malaria was by far the greatest casualty producer and struck troops in all theaters, though obviously far more serious in certain areas. Malaria averaged 19.43 cases per 1,000 in the Army worldwide between 1942 and 1945. The South West Pacific Area (SWPA) had the highest number of cases, but China, Burma, India (CBI) experienced the worst overall rate at 98.46.[86]

The key to conquer malaria in the Army during WW II was atabrine. Quinine, a known antidote, had been a rare commodity before the war. Germany developed atabrine as a synthetic substitute, and the U.S. began production under license in 1931. Atabrine became even more significant after the Japanese captured Java, the sole source of quinine for decades, in February 1942. A microcosm of America's industrial base, U.S. monthly production rose to 100 million tablets in 1943 and to 400 million tablets per month in 1944.[87]

Specified regimen to combat malaria added controversy. First, extant medical literature provided little material on atabrine. The Office of Scientific Research and Development, a federal agency created by Executive Order in June 1941, commenced large-scale research in 1942.[88] Unfortunately, the field Army was already prejudiced based on negative experiences to date throughout the North African and Mediterranean Theaters of Operation (NATO and MTO), and on Guadalcanal in the Pacific, principally due to side effects. Other issues were troop discipline to take atabrine as directed, initial prescription of insufficient dosages, and serious relapses by soldiers taken off atabrine when moved to rear/rest areas. Field experience and research results revealed these shortcomings, and the need for the continued presence of certain atabrine levels in the

---

[85]Freda Brinson, "WW II Military Health in the Pacific," December 1, 2013, American Academy of Professional Coders (AAPC), http://news.aapc.com/index.php/2013/12/wwii-military-health-in-the-pacific/ (accessed September 2, 2014).

[86]W. Paul Havens Jr., M.D., ed., *Internal Medicine in World War II, Vol. 2: Infectious Diseases*, Medical Department of the United States Army in World War II Series (Washington, D.C.: Office of the Surgeon General, 1963), 451-53; Tables 55 through 59 inclusive, which tabulate "attack rates" of the various strains of malaria in Army troops by area and year from 1942 to 1945, 456-58; and Tables 61 through 65 which document the deaths, 460-62.

[87]Eric Bergerud, *Touched with Fire: The Land War in the South Pacific* (New York: Viking Press, 1996), 92.

[88]See Leo B. Slater, *War and Disease: Biomedical Research on Malaria in the Twentieth Century* (New Brunswick, NJ: Rutgers University Press, 2009), 3-4, 8-13 for details on the interagency effort.

blood for effective suppression. Early experience also revealed an array of side effects. Many of these were unique to a very small number of soldiers. The most prevalent side effect remained skin yellowing; gastrointestinal upset usually left in time.[89]

Malaria was a scourge for most of the war. Unlike the earlier fight against yellow fever, large-scale efforts to eradicate mosquitos and/or breeding grounds were not realistic options. The use of DDT in CBI around camp perimeters and buildings did contribute to reduced outbreaks in CBI by February 1944 and especially 1945.[90] The Army developed strict programs of troop discipline with continual supply of proper dosages of atabrine. Nonetheless, malaria remained a major cause of non-battle casualties throughout the war. Moreover, a certain strain had "remarkable relapsing tendencies" and medical professionals could not determine a relapse rate with any precision.[91]

During the Korean War from July 1950 to July 1953, disease accounted for 65.49 percent of all hospital admissions in theater. That number is 373 percent of the wounded and 386 percent of the non-battle injuries.[92] The Vietnam War confirmed the trend with a wide range of infectious diseases. In 1967 alone, 70.6 percent of hospital admissions were due to disease, compared to 15.6 percent battle injuries and 13.8 percent non-battle injuries. An analysis of malaria rates in 1965-69 shows a dramatic, statistically significant spike starting in September 1965, peaking at ca. 90 cases per 1,000 in November 1965. There were highs of ca. 50 per 1,000 in April and June 1966, with averages between 20 and 30 in 1968-69. The Army suffered 40,414 malaria cases with seventy-eight deaths between 1965 and 1970.[93] Service-wide statistics were 65,053 total and 124 deaths.[94]

Operations in Southwest and South-Central Asia from the Persian Gulf War of 1990-91 to current operations in Afghanistan and Iraq again demonstrated the existence of numerous infectious diseases. However, advanced medical knowledge with prescribed regimens mitigated, but did not eliminate, many of the familiar scourges. The predominant ailments to date have been diarrheal and acute upper respiratory infections. Medical professionals have studied a wide array of infectious diseases in four categories,

---

[89]Havens, ed., *Infectious Diseases*, 465-77, 484-87.

[90]Charles F. Romanus and Riley Sunderland, *The China-Burma-India Theater: Time Runs Out in CBI*, The U.S. Army in World War II Series (Washington, D.C.: CMH, 1959), 93.

[91]Havens, ed., *Infectious Diseases*, 488-89.

[92]Frank A. Reister, *Battle Casualties and Medical Statistics: U.S. Army Experience in the Korean War* (Washington, D.C.: U.S. Army Medical Department (AMEDD), n.d.), 5. Statistics cited are adaptations for this study. Available at http://history.amedd.army.mil/booksdocs/korea/reister/reister.html

[93]Brig. Gen. Andre J. Ognibene and Col. O'Neill Barrett, Jr., *Internal Medicine in Vietnam, vol. 2: General Medicine and Infectious Diseases* (Washington, D.C.: U.S. Army Office of the Surgeon General & Center of Military History (CMH), 1977; reprint ed., 1989), adapted from Chart 1, Chart 13, and Table 40. Available at http://history.amedd.army.mil/booksdocs/vietnam/GenMedVN/default.html

[94]Cirillo, "Two Faces of Death," 129.

all with greater prevalence in theater than in the USA.[95] The VA currently recognizes nine infectious diseases related to military service in theater from 1990 to the present.[96]

Deployments to the African continent potentially open a new array of challenges. Established methodologies and troop discipline remain key, but each environment remains unique. American troops in the Rwanda AO in 1994-97 for Operation Support Hope had to protect against typical infectious diseases, from familiar vectors, in an environment with hot and cold humidity, but also other local animals. Pre-deployment necessitated certain immunizations and malaria medication. A major factor was potable water, of which deploying troops were frequent and major producers.[97]

---

[95]Committee on Gulf War and Health, *Gulf War and Health, vol. 5: Infectious Diseases* (Washington, D.C.: National Academies Press, 2006), 61 and Box 2.2, "Infectious Diseases That Are Endemic in Southwest and South-Central Asia and Have Long-Term Adverse Health Outcomes." Aside from the date of publication eight years ago, some details for OEF and OIF are not available in a public forum.

[96]U.S. Department of Veterans Affairs, Public Health, Infectious Diseases and Gulf War Veterans, available at http://www.publichealth.va.gov/exposures/gulfwar/infectious_diseases.asp

[97]U.S. Army Research Institute of Environmental Medicine and Walter Reed Institute of Research, *Sustaining Soldier Health and Performance in Operation Support Hope: Guidance for Small Unit Leaders*, USARIEM Technical Note 94-3 (Fort Detrick, MD: U.S. Army Medical Research, Development, Acquisition and Logistics Command, 1994), 1-2. Available at https://www.researchgate.net/publication/235020354_Sustaining_Soldier_Health_and_Performance_During_Operation_Support_Hope_Guidance_for_Small_Unit_Leaders?ev=prf_pub_bmark

VI. Conclusion

This report does not prescribe the actions to take in the case of an epidemic or pandemic such as the growing outbreak of Ebola, but rather provides insights and lessons learned from the U.S. Army's experience battling previous outbreaks, and the outcomes achieved. The answer was never simply to "find a cure." Rather, the Army orchestrated concerted efforts in vaccinations, preventive drugs, medicines to facilitate recovery, comprehensive sanitation measures, and other preventive medicine (PM) measures. The response included specialized medical research and development, collective unit measures, and individual Soldier discipline.

The last century alone of American military experience has showcased the importance of both pre-deployment planning and preparation and thoughtful, careful reassessment during ongoing operations. Contemporary publicity has focused heavily on terrorist threats wielding chemical, biological, radiological, nuclear, and high-yield explosives (CBRNE) weapons. The 2014 Ebola outbreak has raised acute, sometimes vociferous concerns on pandemics. Scientists and medical professionals have known and recognized for some time that disease in nature and human accident constitute far greater risks statistically, compounded by the combination of natural evolution and unique, specific aspects of the world in the twenty-first century.[98]

[98]For example, see Brenda A. Wilson, "Global Biosecurity in a Complex, Dynamic World," *Complexity* 14, no. 1 (2008), Table 1 on 72, 78-81. Available at http://onlinelibrary.wiley.com/doi/10.1002/cplx.20246/pdf

Appendix – AMEDD references

Appendix to Pandemic Study: Highlights from *Military Preventive Medicine: Mobilization and Deployment*, 2 vols., Textbooks of Military Medicine Series (Washington, D.C.: Walter Reed Army Medical Center Borden Institute, 2003-5). Available at
http://www.cs.amedd.army.mil/borden/Portlet.aspx?ID=14419d2d-ae71-4409-ac21-c32592c5f515
http://www.cs.amedd.army.mil/borden/Portlet.aspx?ID=232d8377-6616-4557-81f2-219f8f9b8a42

The series in general is highly specialized, focusing on military medical education.

Volume 1 consists of four sections with thirty chapters. These provide an historical overview of Military Preventive Medicine, a discussion of national mobilization and training, deployment preparations, and sustainment issues.

- Chapter 3, "The Historic Role of Military Preventive Medicine and Public Health in U.S. Armies of Occupation and Military Government," pp. 59-77 briefly reviews Army experience during the Mexican War of 1846-48; the Spanish-American War of 1898-99 and subsequent missions in Cuba, Puerto Rico, and the Philippines; the American Expeditionary Force (AEF) in Europe during WWI; and experience during and after WW II in Italy, Germany, Okinawa, Japan, and Korea.

- Chapter 4, "Preventive Medicine in Military Operations Other Than War," pp. 79-103 covers humanitarian efforts at home, i.e. current defense support of civil authorities (DSCA), from smallpox vaccination of western Indian tribes in 1832 to Hurricane Andrew relief in 1992. The chapter also reviews a wide range of overseas efforts from the construction of the Panama Canal to the most recent efforts with Iraqi Kurds and Haitian refugees. This chapter has an impressive, comprehensive coverage. There are well-known examples such as the Vietnam War and various interventions in Latin America. As well, one can read of the Army's assistance to devastated areas in Eastern Europe after WW I, including an emerging Soviet Russia.

- Chapter 5, "Conserving the Fighting Strength: Milestones of Operational Military Preventive Medicine Research," pp. 105-25 examines the subject with a focus on outbreak investigation teams and overseas research labs. Case studies include the little-known 1942 outbreak of leptospirosis, known as Fort Bragg fever, the well-known battle against malaria, and the development of water purification techniques.

Volume 2 has continuous pagination from Volume 1, adding another four sections with nineteen chapters, numbered 31 to 49. The text focuses heavily on infectious diseases, including chapters on arthropod, i.e. mosquito and other insect vectors; animal to human diseases; and diseases controlled by vaccination. The discussion is detailed and specialized.

- Chapter 40, "Principles of Infection Control and Prevention during Military Deployment," pp. 1249-66 provides concrete recommendations such as occupational health on deployment, three levels of infection control, and handling methodologies whether linen or human remains. There is an example table for Ebola symptoms.

- Section 7, “Preventive Medicine Efforts Following Disasters,” consisting of Chapters 41 to 47, deals specifically with disaster relief efforts, the role of the U.S. military, public health aspects, etc. For example, Chapter 41, "The Challenge of Humanitarian Assistance in the Aftermath of Disasters," pp. 1269-87 analyzes different approaches to disaster relief based on past experience. The analysis considers type, consequence, and magnitude of the disaster; and challenges to deliver humanitarian assistance, e.g. population vulnerabilities, international legal ramifications, and security threats.

There are two additional volumes in the Series entitled *Medical Aspects of Harsh Environments*.

Bibliography

Books

Abbot, Henry L. *Problems of the Panama Canal: Including Climatology of the Isthmus, Physics and Hydraulics of the River Chagres, Cut at the Continental Divide and Discussion of Plans for the Waterway, with History from 1890 to Date*. New York: Macmillan, c. 1907.

Ayers, Leonard P. The War with Germany: A Statistical Summary. Washington, D.C.: U.S. Govt. Printing Office, 1919. Available at http://babel.hathitrust.org/cgi/pt?id=mdp.39015030674876#view=1up;seq=7. An extract is available at http://www.vlib.us/medical/stats/statsus.htm.

Bergerud, Eric. *Touched with Fire: The Land War in the South Pacific*. New York: Viking Press, 1996.

Byerly, Carol R. *Fever of War*. New York: New York University Press, 2005.

Center for Military History. *New Guinea, The US. Army Campaigns of World War II Series*. Washington, D.C.: CMH, 2003.

Committee on Gulf War and Health. *Gulf War and Health, vol. 5: Infectious Diseases*. Washington, D.C.: National Academies Press, 2006.

Crosby, Alfred W. *America's Forgotten Pandemic: The Influenza of 1918*. New York: Cambridge University Press, 1989.

Espinosa, Mariola. *Epidemic Invasions: Yellow Fever and the Limits of Cuban Independence, 1878-1930*. Chicago: The University of Chicago Press, 2009.

Ewald, PW. *Evolution of Infectious Disease*. Oxford: Oxford University Press, 1994.

Flexner, Simon and J.T. Flexner. *William Henry Welch and the Heroic Age of American Medicine*. New York: Viking Press, 1941.

Hallock, Grace T. *Walter Reed and the Conquest of Yellow Fever*. New York: School Health Bureau, Health and Welfare Division, Metropolitan Life Insurance Co., 1958.

Knobler, Stacey L., Alison Mack, Adel A. F. Mahmoud, and Stanley M. Lemon. *The Threat of Pandemic Influenza: Are We Ready?* Washington, D.C.: National Academies Press, 2005.

Lezzoni, Lynette. *Influenza 1918: The Worst Epidemic in American History*. New York: TV Books, 1999.

Matloff, Maurice. *American Military History*. Army Historical Series. Washington, D.C.: CMH, 1956; reprinted 1989.

McCullough, David G. *Truman*. New York: Simon and Schuster, 1992.

Ognibene, Brig. Gen. Andre J. and Col. O'Neill Barrett, Jr. *Internal Medicine in Vietnam, vol. 2: General Medicine and Infectious Diseases*. Washington, D.C.: U.S. Army Office of the Surgeon General & Center of Military History (CMH), 1977. Reprint ed., 1989.

Palmer, Frederick. *Bliss, Peacemaker: The Life and Letters of General Tasker Howard Bliss*. New York: Dodd, Mead & Company, 1934.

Risch, Erna. *Supplying Washington's Army*. Special Studies Series. Washington, D.C.: U.S. Army Center of Military History, 1981. Available at http://www.history.army.mil/html/books/040/40-2/index.html.

Romanus, Charles F., and Riley Sunderland. *The China-Burma-India Theater: Time Runs Out in CBI*. The U.S. Army in World War II Series. Washington, D.C.: CMH, 1959.

Slater, Leo B. *War and Disease: Biomedical Research on Malaria in the Twentieth Century*. New Brunswick, NJ: Rutgers University Press, 2009.

Articles

"Infectious Diseases and Gulf War Veterans." *Public Health*, U.S. Department of Veterans Affairs. http://www.publichealth.va.gov/exposures/gulfwar/infectious_diseases.asp.

Brinson, Freda. "WW II Military Health in the Pacific." American Academy of Professional Coders (AAPC). December 1, 2013. Accessed September 2, 2014. http://news.aapc.com/index.php/2013/12/wwii-military-health-in-the-pacific/.

Burgess, Joe, et al. "What You Need to Know About the Ebola Outbreak." *New York Times*. September 17, 2014. Accessed September 19, 2014. http://www.nytimes.com/interactive/2014/07/31/world/africa/ebola-virus-outbreak-qa.html?_r=0).

Burgess, Joe, et al. "What You Need to Know About the Ebola Outbreak." *New York Times*. September 17, 2014. Accessed September 19, 2014. http://www.nytimes.com/interactive/2014/07/31/world/africa/ebola-virus-outbreak-qa.html?_r=0).

Byerly, Carol R. "The U.S. Military and the Influenza Pandemic of 1918-1919." *Public Health Reports* 125, supplement 3 (April 2010).

Centers for Disease Control and Prevention. "Yellow Fever." Last modified December 13, 2011. Accessed September 5, 2014. http://www.cdc.gov/yellowfever/symptoms/index.html.

Cirillo, VJ. "Two Faces of Death: Fatalities from Disease and Combat in America's Principal Wars, 1775 to Present." *Perspectives in Biology and Medicine* 51 (Winter 2008): 121-33.

FLU.GOV. "Pandemic Flu History." Accessed September 2, 2014. http://www.flu.gov/pandemic/history/.

Grabenstein, John D., et al. "Immunization to Protest the U.S. Armed Forces: Heritage, Current Practice, Prospects." *Vaccines.mil*. http://www.vaccines.mil/documents/library/MilitaryImztn2005fulc.pdf.

Harvard University Library Open Collections Program. "Spanish Influenza in North America, 1918-1919." Contagion Historical Views of Disease and Epidemics. 2014. Accessed September 4, 2014. http://ocp.hul.harvard.edu/contagion/influenza.html.

Historical Division, Army Medical Library. "Developments in Military Medicine during the Administration of Surgeon General Norman T. Kirk," The Second World War, Special Subjects Series. Washington, D.C.: U.S. Army Medical Department (AMEDD), Office of Medical History, n.d. 620-21. Republished from *The Bulletin of the U.S. Army Medical Department* 7. Nos. 6-7 (June-July 1947). 520-62 & 594-646. Available at http://history.amedd.army.mil/booksdocs/wwii/DvlpmntsinMilMed.htm

Hoffman, Jon T., et al. "The Panama Canal: An Army's Enterprise." Paper, CMH Pub 70-115-1, Center for Military History, 2009.

Johnson, Niall P. A. S. and Juergen Mueller. "Updating the Accounts: Global Mortality of the 1918-1920 "Spanish" Influenza Pandemic." *Bulletin of the History of Medicine* 76 (2002): 105-115.

New York Times. "Col. Hagadorn a Suicide." October 9, 1918.

New York Times. "Close Camp Upton to Check Influneza." September 1918. 17:10.

Nix, Elizabeth. "7 Fascinating Facts about the Panama Canal." History in the Headlines, History Channel. August 15, 2014. Accessed October 16, 2014. http://www.history.com/news/7-fascinating-facts-about-the-panama-canal.

Opie, G.A. *Pandemic Flu: Will the World Catch a Cold?* London: Ministry of Defence, 2009. Seaford House Papers. 161

Seidule, James T. "Morale in the Expeditionary Forces." Ph.D. dissertation, Ohio State University, 1997.

Stutter, Paul S. "Nature's Agents or Agents of Empire?" *Isis* 98, no. 4 (2007): 724-54.

"The History of Vaccines." The College of Physicians of Philadelphia. 2014. Accessed October 9, 2014. http://www.historyofvaccines.org/content/timelines/all.

Ullman, Agnes. "Pasteur-Koch: Distinctive Ways of Thinking about Infectious Diseases." *American Society for Microbiology*. August 2007. Accessed September 5, 2014. http://forms.asm.org/microbe/index.asp?bid=52099.

United States Department of Health and Human Service. "The Great Pandemic: The United States in 1918-1919." *Flu.gov*. Accessed September 4, 2014. http://www.flu.gov/pandemic/history/1918/the_pandemic/fightinginfluenza/.

Wilson, Brenda A. "Global Biosecurity in a Complex, Dynamic World." *Complexity* 14, no. 1 (2008): 78-81. Available at http://onlinelibrary.wiley.com/doi/10.1002/cplx.20246/pdf

World Health Organization. "Responding to the Avian Influenza Pandemic Threat." Communicable Disease Surveillance and Response Global Influenza Programme. 2005.

World Health Organization. "Who: Ebola Response Roadmap Situation Report." Last modified September 18, 2014. Accessed September 19, 2014. http://apps.who.int/iris/bitstream/10665/133833/1/roadmapsitrep4_eng.pdf?ua=1.

Government Documents

Department of the Navy (US), Annual report, 1919. Washington, U.S. Government Printing Office; 1920.

Gorgas, W.C. Annual Report of the Department of Sanitation of the Isthmian Canal Commission for the Year 1909. Washington Government Printing Office. 1910.

Gorgas, William C. "Report of Vital Statistics of Havana, Guanabacoa, and Regla." *Public Health Reports* vol. 16 (June 1901).

Gorgas, William C. "Report of Vital Statistics of Havana, Guanabacoa, and Regla." File 1901/275, Letter Received, 1899-1902, MGC/RG 140. August 1901.

Havens, W. Paul, Jr. *Internal Medicine in World War II, Vol. 2: Infectious Diseases*. Medical Department of the United States Army in World War II Series. Washington, D.C.: Office of the Surgeon General, 1963.

Le Prince, Joseph A., Assistant to Chief Sanitary Officer, to William C. Gorgas, Chief Sanitary Officer of Havana, May 19, 1902, File 4, Reports of Officials of the Military Government, 1901-1902, MGC/RG 140.

Obama, Barack. Remarks by the President on the Ebola Outbreak. The White House, Office of the Press Secretary. September 16, 2014.

Reister, Frank A. *Battle Casualties and Medical Statistics: U.S. Army Experience in the Korean War*. Washington, D.C.: U.S. Army Medical Department (AMEDD), n.d.

Reports of the Commander-in-Chief, Staff Sections and Services. United States Army in the World War 1917-1919, vol. 15 (Washington, D.C.: U.S. Army Center of Military History, 1991).

Rucker, William Colby. *The Influence of the European War on the Transmission of the Infections of Disease, with Special Reference to its Effect upon Disease Conditions in the United States*. MS 40. March 1917. Cited in Carol R. Byerly. *Fever of War*. New York: New York University Press, 2005. 191.

Stone, James H., comp. and ed. *Crisis Fleeting: Original Reports on Military Medicine in India and Burma in the Second World War*. Washington, D.C.: Office of the Surgeon General, 1969.

U.S. Army Research Institute of Environmental Medicine and Walter Reed Institute of Research. *Sustaining Soldier Health and Performance in Operation Support Hope: Guidance for Small Unit Leaders*. USARIEM Technical Note 94-3. Fort Detrick, MD: U.S. Army Medical Research, Development, Acquisition and Logistics Command, 1994.

U.S. Department of State, Office of the Historian. *Milestones: 1914-1920*. Accessed September 12, 2014. https://history.state.gov/milestones/1914-1920/wwi.

War Department, Office of the Surgeon General. *Medical Department of the United States Army in the World War, vol. 9: Communicable and Other Diseases.* Washington: U.S. Government Printing Office, 1928, 123-4.

William C. Gorgas, "Report of Vital Statistics of Havana, Guanabacoa, and Regla" *Public Health Reports* vol. 16 (April 1901).

Two Faces of Death

fatalities from disease and combat in America's principal wars, 1775 to present

Vincent J. Cirillo

ABSTRACT Throughout America's first 145 years of war, far more of the country's military personnel perished from infectious diseases than from enemy action. This enduring feature of war was finally reversed in World War II, chiefly as a result of major medical advances in prevention (vaccines) and treatment (antibiotics). Safeguarding the health of a command is indispensable for the success of any campaign. Wars are lost by disease, which causes an enormous drain on the military's resources and affects both strategy and tactics. Disease and combat mortality data from America's principal wars (1775–present) fall into two clearly defined time periods: the Disease Era (1775–1918), during which infectious diseases were the major killer of America's armed forces, and the Trauma Era (1941–present), in which combat-related fatalities predominated. The trend established in World War II continues to the present day. Although there are currently more than 3,400 U.S. military fatalities in Iraq, the disease-death toll is so low that it is exceeded by the number of suicides.

Death is always and under all circumstances a tragedy.

—Theodore Roosevelt (1951)

1387 Joseph Street, North Brunswick, NJ 08902-1509.
E-mail: vjcirillo@optonline.com.

The author is greatly indebted to James A. Bolognese, Senior Director Scientific Staff, Department of Experimental Medicine Statistics, Merck Research Laboratories, Rahway, NJ, for the statistical analysis of the data in Table 1.

Perspectives in Biology and Medicine, volume 51, number 1 (winter 2008):121–33

IN THE ENORMOUS LITERATURE ON American war casualties, the number of disease fatalities is routinely concealed within such devitalizing categories as "nonbattle deaths," "nonhostile deaths," "unintentional deaths," and "other deaths in service." This is unfortunate, because it obscures the fact that all of America's wars fall into two clearly defined historical periods based on whether disease or combat trauma was the major killer of American servicemen.

This article analyzes death rates from disease within the U.S. military during its principal wars from 1775 to the present. Disease-death rates for wartime civilian populations and foreign armies during the relevant periods are beyond the scope of this study. Smallman-Raynor and Cliff (2004) have demonstrated that wars create the physical conditions (poverty, famine, destruction of public health infrastructure, population displacements, and ecological changes) that are conducive to spreading old and new diseases among civilians. They also have shown that America's medical disasters were not unique. Numerous military organizations made the same mistakes for the same reasons and suffered the same consequences. For example, armies repeatedly confined thousands of raw recruits from disparate epidemiological backgrounds in high-disease environments that supercharged epidemics.

Disease deaths/combat deaths ratios and disease mortality rates (expressed as the percentage of deaths among the people who served in the military during a given conflict) are appropriate measures to quantify the roles of disease and combat trauma in wartime. Based on these ratios and rates, America's principal wars from 1775 to the present can be separated into a Disease Era (1775–1918), during which infectious diseases were the major killer of military personnel, and a Trauma Era (1941–present), in which combat-related fatalities predominated (Table 1). Although the compilation of wartime disease morbidity and mortality data are subject to a number of limitations (misdiagnoses, imperfect records), the magnitudes of difference which support the key findings reported here are so large that even if the true numbers were off 50% or more, the conclusions would still hold. Leonard Bruce-Chwatt (1985) has put this issue into proper perspective: "Naturally, no statistics can be complete under war conditions, but the lessons that those data teach are of enormous value" (p. 85).

During the Disease Era (1775–1918), nearly all of the nonbattle deaths were attributable to infectious diseases. In the Mexican War, for example, 10,986 (96.8%) of the 11,347 nonbattle deaths were due to "camp diseases"—overwhelmingly dysentery (Scott 1864, p. 649). Volunteer troops had twice the disease mortality rate of U.S. Regulars, because the latter had a better grasp of the importance of personal hygiene and camp sanitation and had all the acquired immunities of men living in close contact. In the Civil War, disease mortality rates for the Union army declined over time, suggestive of a learning curve as raw recruits adjusted to military life (Grob 2002).

In the Trauma Era (1941–present), on the other hand, accidental injuries accounted for most of the nonbattle deaths. The Vietnam War was typical, in that

TABLE 1 RATIOS OF DISEASE DEATHS TO COMBAT DEATHS (KILLED IN ACTION AND DIED OF WOUNDS) AND DISEASE MORTALITY RATES AMONG U.S. ARMED FORCES IN AMERICA'S PRINCIPAL WARS, 1775–PRESENT (99.98% CIS IN PARENTHESES)

War	*Total served*	*Disease deaths*	*Combat deaths*	*Disease to combat deaths (ratio)*	*Disease death rates (%)*
		DISEASE ERA			
Revolutionary (1775–83)	ca.290,000	ca.18,500[a]	7,174	2.6:1 (2.44, 2.73)	6.4 (6.20, 6.56)
War of 1812 (1812–15)	286,730	ca.17,000[a]	2,260	7.5:1 (6.90, 8.25)	5.9 (5.75, 6.10)
Mexican (1846–48)	78,718	10,986	1,548	7.1:1 (6.40, 7.94)	13.9 (13.47, 14.44)
Civil War[b] (1861–65)	2,213,363	224,586	110,070	2.0:1 (2.01, 2.07)	10.2 (10.07, 10.23)
Spanish-American[c] (1898)	280,564	2,565	345	7.4:1 (6.03, 9.54)	0.91[d] (0.84, 0.99)
Philippine (1899–1902)	127,068	2,748	1,037	2.7:1 (2.30, 3.08)	2.2 (2.00, 2.32)
World War I[c] (1917–18)	4,057,101	57,460	50,280	1.1:1 (1.12, 1.17)	1.4 (1.39, 1.44)
		TRAUMA ERA			
World War II[c] (1941–45)	11,260,000	14,904	229,823	0.06:1 (0.063, 0.067)	0.13 (0.128, 0.137)
Korean[c,e] (1950–53)	2,834,000	509	27,709	0.02:1 (0.015, 0.022)	0.02 (0.015, 0.021)
Vietnam (1964–73)	8,744,000	935[f]	47,322	0.02:1 (0.017, 0.022)	0.01 (0.009, 0.012)
Persian Gulf[g] (1990–91)	688,702	30[h]	147	0.2:1 (0.061, 0.391)	0.004 (0.001, 0.008)
Iraq[i] (2003–present)	NA	63	2,854	0.02:1 (0.011, 0.033)	NA

Notes: Statistical methods: Disease-to-combat mortality ratios were computed. Simultaneous confidence intervals (CIs) around the ratios were computed by normal approximation of the binomial distribution, application of Fieller's theorem to the ratio of those approximations, and Bonferroni-adjusted confidence levels. If the CIs for ratios from two wars do not overlap, then those two wars are considered to have statistically significantly different ratios. Simultaneous CIs for the mortality rates were computed similarly. CIs were computed for each ratio and rate. Since none of the CIs for the Disease Era overlaps any of the CIs from the Trauma Era, the two eras are statistically significantly different to the alpha level of <0.01. [a]Estimate includes an undetermined number of deaths by accident, drowning, homicide, suicide, and execution. [b]Union forces only; most of the Confederacy's official records were destroyed during the conflagration of Richmond on April 3, 1865. [c]U.S. Army only. [d]Of the 107,973 volunteers in the national assembly camps who never saw combat, 1,832 died from disease, a mortality rate of 1.6%. Typhoid fever accounted for 86.8% of the total disease deaths (Cirillo 2004b, p. 71). [e]The Army accounted for 2,452 (75.5%) of the 3,249 non-battle deaths that occurred among U.S. forces in the Korean theater. [f]Includes 312 deaths from heart disease and stroke. [g]Includes the mobilization phase (Operation Desert Shield, Aug. 1990–Jan. 1991) and the combat phase (Operation Desert Storm, Jan.–Mar. 1991). [h]Includes 17 deaths from cardiovascular diseases, and only one from infectious disease. [i]As of June 2, 2007.

Sources: Brooks (1966); Byerly (2005); Chambers (1999); Cirillo (2004b); Hickey (1995); Moïse (2001); Peckham (1974); Reister (1973, 1975); Scott (1864); Tucker (2000); U.S. Dept. of Defense (1994, 2007); U.S. War Dept. (1903); Writer, DeFraites, and Brundage (1996).

only 935 (8.7%) of the 10,700 nonbattle deaths were due to disease, whereas aircraft and vehicular crashes accounted for 4,351 (40.7%) deaths (Moïse 2001, pp. 75–76).

THE DISEASE ERA (1775–1918)

The success or failure of a war depends, not upon the outcome of its battles, but upon the appearance or non-appearance of pestilence.

—F. Prinzing (1916)

Throughout the nation's first 145 years of war, infectious diseases claimed the lives of more U.S. soldiers, sailors, and marines than did battle injuries. Even in minor conflicts microbes proved more deadly than bullets. In the Second Seminole War (1835–42), for example, 75% of deaths were due to disease—chiefly malaria (Smith 1994).

The disease deaths/combat deaths ratios increased from the Revolutionary War through the Spanish-American War and then declined toward unity at the beginning of the 20th century (Table 1). Although the low ratio for the Civil War (2:1) appears to be an exception, it has less to do with the prevalence of disease and more to do with the frightful casualty rates of Civil War battles. Indeed, the 2,108 Union soldiers killed in action in a single day at Antietam (Livermore 1900, p. 92) exceeded the total number of combat deaths in the Mexican War, the Spanish-American War, and the Persian Gulf War *combined*. In the case of the Civil War, the disease mortality rate (10.2%) is a better indicator of the impact of disease on the Union forces. Furthermore, a large proportion of Civil War combatants listed as dying of wounds actually perished from wound infections after reaching medical care. Penetrating gunshot wounds were often infected by germs from dirt, wadding, and bits of clothing driven into the body by low-velocity projectiles fired from smoothbore and rifled muskets. An added complication, prior to the use of X-rays in the Spanish-American War, was that army surgeons explored gunshot wounds with unwashed fingers and unsterilized probes—both of which had pernicious consequences.

With the exception of the low disease mortality rate in the Spanish-American War (0.91%, the lowest rate in the Disease Era), disease mortality rates declined successively from the Mexican War to World War I. Notwithstanding, the disease mortality rate in the Spanish-American War is significantly higher than the highest rate in the Trauma Era (World War II, 0.13%).

Medical officers were powerless against invisible microbial foes that proved far more lethal than enemy bullets and bayonets. Two events of this era were powerful stimuli for military reform: the typhoid fever outbreak during the Spanish-American War and the influenza epidemic in World War I (Byerly 2005; Cirillo 2004b). The typhoid epidemic exposed the culpability of line officers and revealed the importance of preventive medicine to preserving the fighting strength of the army, while the influenza epidemic exploded the unrealistic confidence

20th-century army doctors had in their ability to keep soldiers healthy. Far from being aberrations, both medical disasters were fueled by rapid mobilization, overcrowding, and abysmal camp and field sanitation. Improper disposal of human and animal wastes and of kitchen refuse led to the rapid proliferation of houseflies, which were potent agents in the spread of bacterial and viral pathogens (Cirillo 2006). As noted above for the Mexican War, unseasoned volunteers were especially vulnerable to new pathogens lurking in the unhealthy camps. Nearly three-quarters of the deaths from disease in the Spanish-American War occurred among raw volunteer units in the assembly camps within the continental United States (Cirillo 2004b, p. 33).

Death tolls understate the full impact of disease on warfare. The health of a command is crucial for combat readiness. Wars are won by able-bodied combatants and, in the words of military hygienist Alfred A. Woodhull (1909): "the sick are for the time as ineffective as the dead" (see also Cirillo 2004a). Disease is the enemy's ally, because it causes an enormous drain on the military's resources and affects both strategy and tactics. This point was appreciated by both sides in the Revolutionary War and exploited to sinister effect. The British were suspected of intentionally introducing smallpox among the colonists to impede the Continental Army's campaigns (Becker 2004), and a British surgeon who attended the casualties from the Battle of Breed's Hill (1775) reported that Americans loaded their muskets with shrapnel, and deliberately fired at the legs of redcoats so as not to kill but to cripple them, "to leave them as burdens on us, to exhaust our provisions and to engage our attention" (Frey 1981, p. 47).

In the 18th and 19th centuries, America's foes also suffered from the ravages of the so-called war pestilences, "those infectious diseases which . . . usually followed at the heels of belligerent armies," such as chronic diarrhea, dysentery, cholera, typhus, typhoid, smallpox, and measles (Prinzing 1916, p. 4). Poor personal hygiene, overcrowded and unsanitary living conditions, recycling the clothing of soldiers dead from disease, lack of bathing facilities, and inadequate rations—all contributed to the spread of communicable diseases. Although there are no comprehensive disease mortality statistics for the Royal Army for the entire period of the Revolutionary War, Cantlie (1974, p. 156) estimates the total number sick from 1775 to 1780 at 23,500, with 6,100 deaths (mortality rate = 25.9%). The disease mortality rate for Great Britain's six German auxiliary corps—known collectively as the Hessians—was 20.1%. Although the Hessians' disease deaths/combat deaths ratio (3.3:1) was similar to that of their American adversaries (2.6:1), the Americans' disease mortality rate was significantly lower, at 6.4%.

Smallpox was a serious health problem for the Continental Army, especially during the first two years of the war (Glynn and Glynn 2004). The American invasion of Canada in 1775 failed because of a smallpox epidemic. His Majesty's troops did not suffer from this epidemic, because they either had survived smallpox in childhood or had been inoculated when they joined the military. The

degree of exposure to disease prior to enlistment has been shown to be the main determinant of wartime mortality; that is, exposure to certain contagious diseases, such as smallpox and typhoid fever, would confer immunity and thereby reduce the risk of a recruit contracting and dying from those diseases while in the army (Lee 2003). Since most colonists came from sparsely populated rural areas, they had little exposure to the variola virus before the war, and were not immunized until 1777 when General Washington made smallpox inoculation compulsory in the Continental Army. Having survived a bout of the dreaded disease as a young man, Washington fully appreciated its dangers. On April 13, 1777, he wrote to Gov. Patrick Henry urging inoculation of all of Virginia's enlistees, adding that smallpox "is more destructive to an Army in the Natural way, than the Enemy's sword" (Gillett 1981, p. 75). Mandatory inoculation was the most significant medical success of the Revolutionary War, and it contributed substantially to America's victory.

Intestinal disorders were the bane of Civil War combatants. Diarrhea and dysentery caused more disability and death among Union and Confederate soldiers than any other diseases. Union army medical statistics show 1,451,613 cases of acute and chronic diarrhea with an estimated 57,000 deaths (mortality rate = 3.9%), and 287,522 cases of dysentery with 9,431 deaths (mortality rate = 3.3%; Adams 1952, pp. 241–42). Although Confederate medical records are fragmentary, the following data give some indication of their plight: of the 848,555 cases of disease found in Confederate field reports, 226,828 (26.7%) were listed as diarrhea or dysentery. Also, of the 50,350 admissions to Chimborazo Hospital in Richmond, Virginia—the Confederacy's largest military hospital—10,503 (20.9%) were diagnosed with one of these ailments (Cunningham 1970, p. 185). Bowel complaints were so universal that their debilitating, and sometimes humorous, aspects found their way into popular music ("The Tennessee Quickstep") and novels about the Lost Cause. In *Gone with the Wind*, Mammy lamented: "Dey ain' a soun' set of bowels in de whole Confedrut ahmy. It's mah notion dat 'twarn't de Yankees whut beat our gempmum. 'Twuz dey own innards. Kain no gempmum fight wid his bowels tuhnin' ter water" (Mitchell 1936, p. 501).

Camp fevers—typhoid fever, typhomalarial fever, and malarial remittent fever—also played a significant role in the morbidity and mortality of Civil War soldiers. The Union army experienced a total of 453,997 cases and 39,551 deaths (mortality rate = 8.7%) from the principal camp fevers (Cirillo 2004b, p. 61). Yellow fever and typhus were relatively rare. Union forces were fortunate that a "considerable dissimilarity exists between the chief diseases observed among troops on this continent and those which have decimated the combatants in European wars" (Woodward 1863, p. vii). Indeed, louse-borne typhus had recently killed more than 17,500 French soldiers during the Crimean War of 1854–1856 (Major 1943, p. 89).

Union army surgeon Joseph Janvier Woodward (1863) introduced the concept of typhomalarial fever into military medicine. He envisioned this form of

camp fever, a mixed bag of malarial and typhoid elements, as a disease sui generis (Smith 1982, pp. 216–18), but Walter Reed and his colleagues on the U.S. Army Typhoid Board later established that typhomalarial fever "was none other than typhoid fever" (Reed, Vaughan, and Shakespeare 1900, p. 167). Notwithstanding, the category "typhomalarial fever" had served a useful nosological purpose in the Civil War, because a large number of typhoid cases included under this heading would otherwise have been lost by being designated "malarial remittent fever" (Sternberg 1912, pp. 25–26).

The World War I U.S. Army disease deaths/combat deaths ratio (1.1:1) was worse than that of the other belligerents. In addition to influenza and pneumonia, 12 to 15% of American wounded died from infection. The German army's ratio was only 0.10:1. As with Union army losses in the Civil War, this low ratio had more to do with staggering battlefield losses—in this case from machine gun and artillery fire—than a lower prevalence of disease (Byerly 2005, p. 132).

The Plains Indian Wars (1866–1890), fought by Native Americans to contest the westward expansion of whites, were not wars in the conventional sense. Rather, they were a conglomerate of more than 1,000 clashes (skirmishes, sieges, sorties, and ambushes) between the U.S. Army and the nomadic tribes of the northern (Lakota Sioux, Cheyenne, and Arapaho) and southern (Cheyenne, Arapaho, Comanche, and Kiowa) Great Plains. Because Indian warriors employed hit-and-run tactics and avoided open combat, casualties were low on both sides (Utley 1973). The frontier army reported a total of 919 combat deaths out of 106,000 men who served during the 25 years of intermittent warfare. The Adjutant General's Office listed 4,371 battle fatalities (many were noncombatants) among the warring tribes during the same time period (Chambers 1999, p. 849; U.S. War Department 1891, pp. 1–65).

That diseases of whites—especially smallpox and tuberculosis—decimated many indigenous tribes is indisputable. However, accurate statistics on disease deaths among Native Americans during the Plains Indian Wars do not exist. The U.S. Army's winter campaigns were especially successful against the Indians. Contrary to popular belief, these victories were not due to an increased incidence of disease in the Indian villages during the bitter weather, but to starvation, exposure, short rations, scarcity of grass for their horses, and heavy snowfalls—all of which nullified the superb horsemanship and guerrilla tactics that made Indian fighters superior to the bluecoats. Winter clothing and plentiful supplies were additional factors in turning the harsh environment to the Army's advantage (Utley 1973; Weigley 1967).

THE TRAUMA ERA (1941–PRESENT)

Science is the best friend war has ever had; it has made slaughter possible on a scale never dreamt of before.

—William Osler (1915)

The horrific killing power of 20th- and 21st-century weaponry gives deadly meaning to Russian military surgeon Nikolai Pirogov's (1810–1881) definition of war as an epidemic of trauma (Garrison 1929; Halperin 1956). Indeed, Pirogov's interpretation is well supported by the Trauma Era data (Table 1): for every American soldier who died of an infectious, parasitic, or other disease in World War II, 15 of his comrades succumbed to enemy action (Reister 1975, p. 11).

From a medical standpoint, science has also benefited humanity in wartime. Improvements in the proper disposal of human, animal, and kitchen wastes, and fly control in camps and bivouacs in the pre–World War II years were a step in the right direction (Dunham 1940). These new technologies reduced camp pollution, which had previously been accepted by line officers and enlisted men as inseparable from army life (Cirillo 2000). The hegemony of disease was finally ended, chiefly as a result of significant medical advances in prevention (vaccines) and treatment (antibiotics).

Entering World War II, U.S. troops were immunized against smallpox, typhoid fever, cholera, plague, tetanus, yellow fever, and typhus. Brig. Gen. Elliott Carr Cutler (1888–1947), chief surgical consultant in the European theater, was impressed by the striking protection afforded the troops by mass inoculations, especially the near eradication of tetanus from military surgery. Tetanus, which had exacted a dreadful toll (mortality rate = 20–58%) in World War I, accounted for only 11 cases and four deaths among 11 million GIs serving in World War II (Fulton 1953; Shepard and Rich 1972).

Although his interests centered on surgery, Cutler would have been equally impressed by the medical success of the yellow fever vaccine that had been developed just prior to World War II. After the isolation of the yellow fever virus in 1927, researchers at Harvard University and the Rockefeller Foundation Yellow Fever Laboratory in New York City collaborated on developing a live, attenuated vaccine. By 1940, the clinical results with the experimental vaccine were so promising that the National Research Council recommended that all U.S. servicemen traveling to the tropics be immunized against yellow fever. By April 1942, the Rockefeller laboratory had produced 7 million doses of the vaccine. Although 84 deaths were linked to the vaccine itself (due to hepatitis-contaminated human serum used in the vaccine's manufacture), not a single U.S. serviceman contracted yellow fever during World War II (Pierce and Writer 2005, pp. 232–37).

The introduction of penicillin, which was undoubtedly the most significant medical development of World War II, revolutionized wound care and the management of bacterial infections. Penicillin, a laboratory curiosity at the start of

the war, was transformed by the U.S. pharmaceutical industry—in concert with the military and government—into a therapeutic reality. By D-Day (June 6, 1944), 100 billion units of penicillin per month—enough to treat 40,000 men—were being manufactured in the United States. From that point onward to the unconditional surrender of Nazi Germany on V-E Day (May 8, 1945), U.S. military deaths from infection approximated zero (Helfand et al. 1980; Neushul 1998). For the first time in American military history, battle fatalities exceeded disease fatalities during wartime. The trend established in World War II has continued through the current conflict in Iraq.

Disease in the Trauma Era

This will be a long war if for every division I have facing the enemy I must count a second division in the hospital with malaria and a third division convalescing from this debilitating disease.

—Douglas MacArthur (Beadle and Hoffman 1993)

Even though the number of disease fatalities paled in relation to the number of combat deaths throughout the latter half of the 20th century, disease still inflicted enormous losses on U.S. troops. In addition to the loss of manpower, debilitating illnesses and relapses increased the drain on the military's health support system and lowered unit morale.

Malaria plagued the U.S. Army in World War II: between 1942 and 1945, there were 492,299 cases of the disease and 302 deaths among U.S. troops. The majority of cases (65%) were due to *Plasmodium vivax*. The highest incidence of malarial attacks occurred in the India-Burma-China theater. All told, U.S. forces lost an astounding 9 million man-days during that period (Bruce-Chwatt 1985).

Malaria reemerged as the outstanding medico-military problem in Vietnam; in Vietnam, however, *P. falciparum* was the etiologic agent in the majority of cases (85%; Bruce-Chwatt 1985). The chief factors contributing to the high incidence of the disease in the Asia-Pacific region were the failure of line officers to enforce chemoprophylaxis regimens (CP tablets containing chloroquine and primaquine) and other preventive measures in malarious areas, and the emergence of chloroquine-resistant strains of *P. falciparum*. Drug-resistant parasites were acquired by U.S. Army combat units in contact with the Vietcong (the principal reservoir of the disease) in the Central Highlands of Vietnam (Neel 1973). U.S. Navy and Marine Corps operations were also disrupted by malaria. Naval morbidity and mortality data, when combined with the Army's, yielded a total of 65,053 cases of malaria, and 124 deaths due to malaria. Importantly, effective fighting strength was seriously compromised by 1,186,465 man-days lost from duty (Beadle and Hoffman 1993).

The U.S. military's experience in Vietnam awakened authorities to a greater appreciation of the medical threat posed by arthropod-borne diseases, especially malaria. Resulting reforms included use of Permethrin-impregnated battle uniforms, application of insect repellent to exposed skin, reduced unit exposure

during peak anopheline mosquito biting times (dusk to dawn), head nets and bed nets in the field, tent screens, and destruction of vector breeding sites. Most importantly, malaria prevention and control became a command responsibility. Commanders and unit leaders were required to work closely with their medical officers to eliminate the medical threat (Robert 2001).

Infectious diarrheal diseases affected more than half of the U. S. troops initially deployed in northeastern Saudi Arabia during the mobilization phase (Operation Desert Shield, August 1990–January 1991) of the Persian Gulf War. Disabling diarrhea, abdominal cramps, vomiting, and hematochezia hampered deployment during the early months of August and September. The causative agents in nearly 50% of the gastroenteritis cases were identified as enterotoxigenic *Escherichia coli* and *Shigella sonnei*; there were no confirmed cases of cholera, typhoid fever, amoebic dysentery, or giardiasis. The enteropathogens were spread by personal contact, contaminated communal latrines, and desert filth flies (Hyams et al. 1995). After the purchase of locally supplied fresh produce was stopped in October, the rate of gastrointestinal complaints declined dramatically. *Plus ça change, plus c'est la même chose*.

ENVOI

Between Lexington and the 1918 Armistice, disease reigned uncontested as the number one killer of American troops. This enduring feature of war was finally ended in World War II as a result of significant medical advances in prevention and treatment. Since then, fatalities from trauma sustained in battle have been predominant, while disease has become responsible for an ever-decreasing percentage of nonbattle deaths. Moreover, the types of fatal diseases have changed too, as infectious diseases, the leading cause of mortality during the Disease Era, have been replaced in the Trauma Era by cardiovascular, neoplastic, and other noninfectious diseases.

Although there are presently 3,480 U.S. military fatalities in the Iraq War (2,854 combat, 626 nonbattle, as of June 2, 2007), the disease-death toll of 63 is so low as to be eclipsed by the 113 suicides (U.S. Department of Defense 2007). This is a new phenomenon. In the Vietnam War, there were 382 suicides, substantially fewer than the 935 disease deaths. Likewise, in the Persian Gulf War, there were 10 deaths by self-inflicted gunshot wounds and 30 fatalities due to disease (Moïse 2001, p. 76; Writer, DeFraites, and Brundage 1996, p. 119). U.S. Army personnel in Iraq spend more time in continuous combat than their comrades in arms did in Vietnam (Zoroya 2007). The high suicide rate among U.S. servicemen in Iraq—the Army leads the other branches with 96—may be related to the mental stresses the ground forces face in fighting an unconventional enemy that strikes and then dissolves into the civilian population, the psychological terror of improvised explosive devices (responsible for 80% of U.S. Army casualties), the insufficient rest and rehabilitation time, and the sheer physical

exhaustion of having to serve longer tours of duty and multiple tours without sufficient down time.

References

Adams, G. W. 1952. *Doctors in blue: The medical history of the Union army in the Civil War*. New York: Henry Schuman.

Beadle, C., and S. L. Hoffman. 1993. History of malaria in the United States Naval Forces at war: World War I through the Vietnam conflict. *Clin Infect Dis* 16:320–29.

Becker, A. M. 2004. Smallpox in Washington's army: Strategic implications of the disease during the American Revolutionary War. *Soc Mil Hist* 68:381–430.

Brooks, S. 1966. *Civil War medicine*. Springfield, IL: Charles C. Thomas.

Bruce-Chwatt, L. J. 1985. Mosquitoes, malaria and war: Then and now. *J R Army Med Corps* 131:85–99.

Byerly, C. R. 2005. *Fever of war: The influenza epidemic in the U.S. Army during World War I*. New York: New York Univ. Press.

Cantlie, N. 1974. *A history of the Army Medical Department*, vol. 1. Edinburgh: Churchill Livingstone.

Chambers II, J. W., ed. 1999. *The Oxford companion to American military history*. Oxford: Oxford Univ. Press.

Cirillo, V. J. 2000. "The patriotic odor": Sanitation and typhoid fever in the national encampments during the Spanish-American War. *Army Hist* (49):17–23.

Cirillo, V. J. 2004a. Alfred Alexander Woodhull. In *Encyclopedia of New Jersey*, ed. M. N. Lurie and M. Mappen, 884. New Brunswick: Rutgers Univ. Press.

Cirillo, V. J. 2004b. *Bullets and bacilli: The Spanish-American War and military medicine*. New Brunswick: Rutgers Univ. Press.

Cirillo, V. J. 2006. Winged sponges: Houseflies as carriers of typhoid fever in 19th- and early 20th-century military camps. *Perspect Biol Med* 49(1):52–63.

Cunningham, H. H. 1970. *Doctors in gray: The Confederate Medical Service*. Gloucester, MA: Peter Smith.

Dunham, G. C. 1940. *Military preventive medicine*, 3rd ed. Harrisburg, PA: Military Service Publishing.

Frey, S. R. 1981. *The British soldier in America: A social history of military life in the Revolutionary period*. Austin: Univ. of Texas Press.

Fulton, J. F. 1953. Medicine, warfare, and history. *JAMA* 153:482–88.

Garrison, F. H. 1929. *An introduction to the history of medicine*, 4th ed. Philadelphia: Saunders.

Gillett, M. C. 1981. *The Army Medical Department 1775–1818*. Washington, DC: GPO.

Glynn, I., and J. Glynn. 2004. *The life and death of smallpox*. Cambridge: Cambridge Univ. Press.

Grob, G. N. 2002. *The deadly truth: A history of disease in America*. Cambridge: Harvard Univ. Press.

Halperin, G. 1956. Nikolai Ivanovich Pirogov: Surgeon, anatomist, educator. *Bull Hist Med* 30:347–55.

Helfand, W. H., et al. 1980. Wartime industrial development of penicillin in the United States. In *The history of antibiotics: A symposium*, ed. J. Parascandola, 31–56. Madison: American Institute of the History of Pharmacy.

Hickey, D. R. 1995. *The War of 1812: A short history*. Urbana: Univ. of Illinois Press.
Hyams, K.C., et al. 1995. The impact of infectious diseases on the health of U.S. troops deployed to the Persian Gulf during Operations Desert Shield and Desert Storm. *Clin Infect Dis* 20:1497–1504.
Lee, C. 2003. Prior exposure to disease and later health and mortality: Evidence from Civil War medical records. In *Health and labor force participation over the life cycle: Evidence from the past*, ed. D. L. Costa, 51–87. Chicago: Univ. of Chicago Press.
Livermore, T. L. 1900. *Numbers and losses in the Civil War in America 1861–65*. Boston: Houghton Mifflin.
Major, R. H. 1943. *War and disease*. London: Hutchinson's Scientific & Technical Publications.
Mitchell, M. 1936. *Gone with the wind*. New York: Macmillan.
Moïse, E. E. 2001. *Historical dictionary of the Vietnam War*. Lanham, MD: Scarecrow Press.
Neel, S. 1973. *Medical support of the U. S. Army in Vietnam, 1965–1970*. Washington, DC: GPO.
Neushul, P. 1998. Fighting research: Army participation in the clinical testing and mass production of penicillin during the Second World War. In *War, medicine and modernity*, ed. R. Cooter, M. Harrison, and S. Sturdy, 203–24. Somerset, UK: Sutton.
Osler, W. 1915. An address on science and war. *Lancet* 2:795–801.
Peckham, H. H. 1974. *The toll of independence: Engagements and battle casualties of the American Revolution*. Chicago: Univ. of Chicago Press.
Pierce, J. R., and J. Writer. 2005. *Yellow jack: How yellow fever ravaged America and Walter Reed discovered its deadly secrets*. Hoboken, NJ: Wiley.
Prinzing, F. 1916. *Epidemics resulting from wars*. Oxford: Clarendon Press.
Reed, W., V. C. Vaughan, and E. O. Shakespeare. 1900. *Abstract of report on the origin and spread of typhoid fever in U. S. military camps during the Spanish war of 1898*. Washington, DC: GPO.
Reister, F. A. 1973. *Battle casualties and medical statistics: U.S. Army experience in the Korean War*. Washington, DC: GPO.
Reister, F. A., ed. 1975. *Medical statistics in World War II*. Washington, DC: GPO.
Robert, L. L. 2001. Malaria prevention and control in the United States military. *Med Trop* 61:67–76.
Roosevelt, T. 1951. *Letters*, vol. 2, ed. E. E. Morison. Cambridge: Harvard Univ. Press.
Scott, H. L. 1864. *Military dictionary: Comprising technical definitions; information on raising and keeping troops; actual service, including makeshifts and improved matériel; and law, government, regulation, and administration relating to land forces*. New York: Van Nostrand.
Shepard, G. H., and N. M. Rich. 1972. Treatment of the soft tissue war wound by the American military surgeon: A historical resume. *Mil Med* 137:264–66.
Smallman-Raynor, M. R., and A. D. Cliff. 2004. *War epidemics: An historical geography of infectious diseases in military conflicts and civil strife, 1850–2000*. Oxford: Oxford Univ. Press.
Smith, D. C. 1982. The rise and fall of typhomalarial fever. I. Origins; II. Decline and fall. *J Hist Med Allied Sci* 37:182–220, 287–321.
Smith, D. C. 1994. Military medicine. In *Encyclopedia of the American military*, ed. J. E. Jessup and L. B. Ketz, 1575–1626. New York: Simon & Schuster Macmillan.

Sternberg, G. M. 1912. *Sanitary lessons of the war and other papers*. Washington, DC: Byron Adams.

Tucker, S. C., ed. 1993. *Encyclopedia of the Korean War: A political, social, and military history*, vol. 1. Santa Barbara, CA: ABC-CLIO.

U.S. Department of Defense. 1994. *Defense 94: Almanac* (no. 5). Washington DC: GPO.

U.S. Department of Defense. 2007. Military casualty information. Operation Iraqi Freedom (Military deaths from 19 March 2003–2 June 2007). http://siadapp.dmdc.osd.mil/personnel/CASUALTY/castop.htm.

U.S. War Department. Adjutant General's Office. 1891. *Chronological list of actions, &c., with Indians, from January 1, 1866, to January, 1891*. Washington, DC: GPO.

U.S. War Department. 1903. *Annual report of the Adjutant General*. In *Annual reports of the War Department for the fiscal year ended June 30, 1902*, vol. 1. Washington, DC: GPO.

Utley, R. M. 1973. *Frontier regulars: The United States Army and the Indian, 1866–1891*. New York: Macmillan.

Weigley, R. F. 1967. *History of the United States Army*. New York: Macmillan.

Woodhull, A. A. 1909. *Military hygiene for officers of the line*, 4th ed. New York: Wiley.

Woodward, J. J. 1863. *Outlines of the chief camp diseases of the United States armies as observed during the present war*. Philadelphia: Lippincott.

Writer, J. V., R. F. DeFraites, and J. F. Brundage. 1996. Comparative mortality among US military personnel in the Persian Gulf Region and worldwide during Operations Desert Shield and Desert Storm. *JAMA* 275:118–21.

Zoroya, G. 2007. Army: Can't give troops more time off. *Home News Tribune* (NJ), June 19.

Institutional Response

St. Louis Chapter of the American Red Cross loading a patient into an ambulance. Source: Still Picture Unit, National Archives and Records Administration, College Park, MD.

The U.S. Military and the Influenza Pandemic of 1918–1919

Carol R. Byerly, PhD[a]

SYNOPSIS

The American military experience in World War I and the influenza pandemic were closely intertwined. The war fostered influenza in the crowded conditions of military camps in the United States and in the trenches of the Western Front in Europe. The virus traveled with military personnel from camp to camp and across the Atlantic, and at the height of the American military involvement in the war, September through November 1918, influenza and pneumonia sickened 20% to 40% of U.S. Army and Navy personnel. These high morbidity rates interfered with induction and training schedules in the United States and rendered hundreds of thousands of military personnel non-effective. During the American Expeditionary Forces' campaign at Meuse-Argonne, the epidemic diverted urgently needed resources from combat support to transporting and caring for the sick and the dead. Influenza and pneumonia killed more American soldiers and sailors during the war than did enemy weapons.

[a]Independent scholar, Boulder, CO

Address correspondence to: Carol R. Byerly, PhD, 1811 Columbine Ave., Boulder, CO 80302; tel. 303-546-6654; fax 303-449-6243; e-mail <Carol.Byerly@Colorado.edu>.

In the fall of 1918, U.S. Army and Navy medical officers in camps across the country presided over the worst epidemic in American history, but the story was not new. War and disease have been linked throughout history as armies, weapons, and human pathogens have met on the battlefield. The conquistadores brought with them diseases that devastated the New World; typhus plagued Napoleon's armies; and typhoid fever humiliated the American Army during the Spanish-American War. But now U.S. Army and Navy personnel knew how to test and sanitize water supplies, vaccinate troops against typhoid and smallpox, and treat or prevent other infections. Modern bacteriology, it seemed, had tamed many diseases. Navy Surgeon General William C. Braisted proudly stated that "infectious diseases that formerly carried off their thousands, such as yellow fever, typhus, cholera, and typhoid, have all yielded to our modern knowledge of their causes and our consequent logical measures taken for their prevention."[1]

Twentieth-century warfare, however, had evolved to an even more deadly scale as industrialized armies of millions battled on the plains of Eastern Europe, the cliffs of Gallipoli, and in the deadly trenches of the 550-mile-long Western Front. When the European arms race exploded into war in 1914, the empires shocked themselves and the world with the killing power of their artillery and machine guns, their U-boats and mines, and their poison gas. These new weapons generated new, horrible injuries that took life and limb in a flash or festered into gangrenous wounds that could further maim and kill. The carnage traumatized some men into shellshock, and poison gases burned and suffocated others so horribly that nurses dreaded caring for them because they could provide little comfort. War diseases—notably the soldiers' nemeses diarrhea, dysentery, and typhus—flourished, and the trenches offered new maladies such as "trench foot," an infection caused by wearing sodden boots and standing in water and mud for days on end, and "trench fever," a debilitating fever transmitted by body lice.

Then, in the fourth dreadful year of the war, as the American Expeditionary Forces (AEF) assumed fighting strength and prepared their first great offensive against the Germans, the flu struck. By the War Department's most conservative count, influenza sickened 26% of the Army—more than one million men—and killed almost 30,000 before they even got to France.[2,3] On both sides of the Atlantic, the Army lost a staggering 8,743,102 days to influenza among enlisted men in 1918.[4] (p. 1448) The Navy recorded 5,027 deaths and more than 106,000 hospital admissions for influenza and pneumonia out of 600,000 men, but given the large number of mild cases that were never recorded, Braisted put the sickness rate closer to 40%.[5,6] (p. 2458)

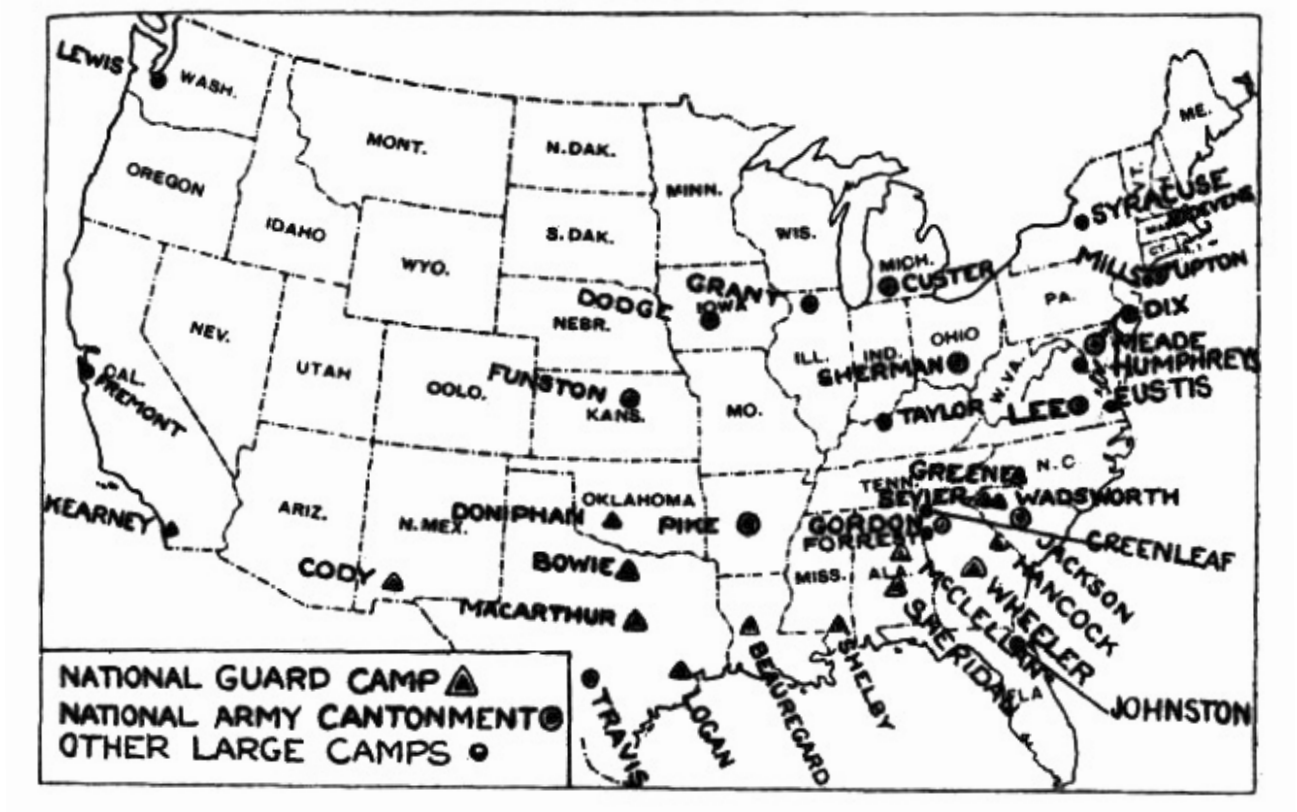
The Army and Navy medical services may have tamed typhoid and typhus, but more American soldiers, sailors, and Marines would succumb to influenza and pneumonia than would die on the industrialized battlefields of the Great War. The story of the influenza epidemic in the military is often lost in the historical narrative of the Great War, included merely as a coda to that four-year horror, coinciding with the final battles and the Armistice. But an examination of medical reports and War Department and Department of the Navy documents from the war reveals that the war and the epidemic were intertwined.[7] World War I and influenza collaborated: the war fostered disease by creating conditions in the trenches of France that some epidemiologists believe enabled the influenza virus to evolve into a killer of global proportions. In turn, disease shaped the war effort by rendering much of the Army and Navy non-effective and diverting resources, personnel, and scarce human attention and energy from the military campaign. The exigencies of war also thwarted many of the efforts such as crowd mitigation and quarantines to control the epidemic. The influenza epidemic in the U.S. military therefore provides a cautionary tale about the power of war to change the health environment and the power of disease to influence the conduct of war.

GOING TO WAR

The United States at first hung back from the killing in Europe, as many Americans believed it was not their fight. But under increasing pressure from Britain and France, and angered by German U-boat attacks that threatened American commerce and security, and the revelations in the Zimmermann Telegram that Germany was urging Mexico to attack the United States, President Wilson abandoned neutrality and in April 1917 asked Congress for a declaration of war.

The U.S. economy was already booming as farmers and manufacturers shipped foodstuffs and military supplies to the belligerent nations. Now the United States would also generate its own military force that would help overwhelm the enemy and bring about the armistice of November 11, 1918. Congress quickly established a draft, and more than 4,600 Selective Service draft boards screened 10 million men to find the strongest and most fit soldiers and sailors. The military grew from just 378,000 strong in April 1917 to more than 4.7 million by war's end, with an Army of 4.1 million and a Navy of 600,000. Seventy-two percent of enlisted forces were inducted, and the military

Figure 1. Locations of Army training camps in the U.S. in 1918



Source: War Department (US). Annual report, 1919. Washington: Government Printing Office; 1920. p. 1519.

population reflected the country's ethnically diverse and racially segregated society. An estimated 20% of Army draftees were foreign-born and the troops spoke at least 46 languages, some 5,700 were Mexican aliens, and 12,500 were American Indians.[8] (p. 367-409) More than 400,000 African Americans served in the Army, some in two black combat divisions but most in labor battalions. The Navy employed only 5,300 black sailors, confining them to positions as cooks and stewards.[9]

War mobilization drew millions of civilians into military institutions and extended the military into all corners of the country. To train and supply these men, the Army and Navy expanded existing facilities and directed training activities at various civilian organizations. Military camps, arsenals, air fields, and supply depots sprouted up in every state. The Army began training recruits in the fall of 1917 at 32 large camps, each home to 25,000 to 55,000 troops. Soldiers also went to specialized camps for training in specific fields such as artillery training at Camp Knox, Kentucky, railway operations at Camp Benjamin Harrison in Indianapolis, military engineering at Camp Forrest, Georgia, and medical unit training at Camp Crane, Pennsylvania. The War Department also operated some 40 air fields for aviator training and 10 embarkation and debarkation camps.[8] (p. 677—78) The Navy expanded its training capacity from 6,000 recruits to more than 100,000 at stations on both coasts, the Gulf of Mexico, and Lake Michigan, and also had specialized training centers such as the Navy gas engine school and the aviation ignition school at Columbia University in New York. In addition to the training camps, in the summer of 1918 the War Department established the Student Army Training Corps (SATC), intended to augment the work of the Reserve Officers Training Corp (ROTC) and prevent war mobilization from emptying institutions of higher education. Under the program, more than 500 colleges and universities trained officer candidates and provided technical instruction in fields such as auto mechanics and radio operation. By the Armistice, about 158,000 young men had enrolled in SATC programs.[8] (p. 556) This expansion of military institutions created a virtual network of young adults across which influenza could and would travel (Figure 1).

As the Army grew, the Army Medical Department raced to meet its needs. Military medicine was more like public health medicine (which managed large

populations) than private medicine (which focused on care for individuals). By necessity, line officers cared less about who was sick or on leave than who they could send into battle. This was called the "effective" rate—how many men were available in a given unit to work and fight. Medical officers therefore tried to keep non-effective rates as low as possible, and measured their success statistically more than by individual patient care. The Army Medical Department tracked sickness in camps, combat units, labor battalions, ports, and ships by the day, week, month, and year, and compared its record with civilians, earlier wars, and other armies. Army Medicine also combined the old sanitation model of clean water and fresh air with the new public health approaches of educating soldiers on how to stay healthy and prevent disease. Army Surgeon General William C. Gorgas came out of the sanitary tradition and stressed good food, clean water, fresh air, and no crowding, but like other Progressives, also saw the Army as an opportunity to instill young men with middle-class values such as good personal hygiene.[10]

To care for the growing Army, the Medical Department increased its hospital capacity from 9,500 beds to 120,000 in the United States alone. The Red Cross assisted by recruiting trained nurses for the Army Nurse Corps and organizing ambulance companies and 50 hospitals of 1,000 beds each out of American universities and medical institutions. The Army Medical Department ultimately numbered 30,500 medical officers, 21,500 nurses—including 350 African American physicians but no black nurses until December 1918—and 264,000 enlisted men.[8] (p. 257) The Navy Bureau of Medicine and Surgery had some 3,000 medical officers, 1,700 nurses, and 11,000 enlisted men.[5] (p. 2066, 2073) As one civilian public health official pointed out, with almost 30% of American physicians in military service, ". . . there were sections of the country that were absolutely stripped of physicians." During the pandemic in civil society, therefore, ". . . the great majority of available, medical and nursing personnel, were already in the Army or Navy, so that the available personnel from which to draw was limited."[11]

World War I was largely a ground war, so the Army bore the brunt of the fighting. While some 55,000 Marines served with the AEF, most of the Navy's responsibilities involved patrolling for U-boats, sweeping for enemy mines, escorting troop and cargo ships across the Atlantic, and mining the North Sea against the German Navy. Mobilization got off to a slow start in the United States, and a year after the declaration of war, the AEF in Europe numbered fewer than 400,000. By May 1918, however, hundreds of thousands of soldiers were crossing the Atlantic each month to build a combat force of two million by November. This transport of an army to another continent and back was one of the great achievements of World War I and demonstrated the power of the American government and economy. But such triumph also carried danger because as the doughboys traveled "Over There," they did not travel alone.

A LETHAL VIRUS

Influenza sailed with American troops across the Atlantic and when it exploded in late August and September in Europe and the United States, medical officers found themselves on the front lines of an epidemic worse than any of them had ever seen or imagined. Many were among the most knowledgeable and skilled physicians in the country and had just recently entered military service. They did their best to save those stricken by influenza, but could do little more than provide palliative care of warmth, rest, and a gentle diet, and hope that their patients did not develop pneumonia.

One of the tragedies of the influenza epidemic is that by the 1910s, the medical profession held many of the scientific and epidemiological tools to understand the nature and extent of the damage influenza and pneumonia were wreaking on their patients, but lacked the tools to effectively fight them. While virology would not emerge until the 1930s, physicians could identify many of the bacteria causing the deadly pneumonias that were killing their patients, but without antibiotics they could do little to fight the infections. Thus, as the epidemic struck their camps, hospitals, ships, ports, or divisions, many medical officers documented what they saw, as if trying to define that which they could not control. They ran tests and did autopsies, recorded their laboratory and clinical findings, compared morbidity and mortality rates across time and with other units, and tried to stay healthy themselves. They wrote detailed reports to their superiors and published myriad articles on the influenza of 1918–1919. These studies and reports would provide some of the most extensive documentation on the pandemic, informing civilian and military researchers alike as they struggled for years after the war to understand what had caused the epidemic and its widespread suffering.[2,4,5,7]

As they conducted their analyses, military medical officers soon understood that the wave of influenza that had run through many U.S. training camps during the spring of 1918 constituted a first wave of the pandemic. Fourteen of the largest training camps had reported influenza outbreaks in March, April, or May, and some of the infected troops carried the virus with them aboard ships to France.[12] In the late

spring and summer, influenza visited all of the armies of Europe, including the AEF, but because influenza was common in the military, and few patients became critically ill, medical officers were not alarmed. But by the late summer some saw the emergence of a new, lethal influenza.

Captain Alan M. Chesney, medical officer with an AEF hospital at Valdahon, an artillery training camp behind the front lines in France, documented the evolution of a more virulent influenza from his vantage point. A physician who was later dean of the Johns Hopkins Medical School, Chesney noted that three different infantry brigades of 4,000 men occupied the post in succession, "thus every three or four weeks there occurred a marked change in the population of the post." He theorized that "the history of the epidemic, therefore, resolved itself into distinct periods corresponding to the various brigades which entered the post," and "the frequent changes in the population of the post, brought about by the short stay of each brigade, exercised considerable influence upon the course of the epidemic of influenza."

During Chesney's first documented period, the month of June to July 27, the 5th Artillery Brigade had 77 "relatively mild" cases of influenza. During the second phase, July 27 to August 23, 200 men of the 58th Artillery Brigade became ill, about 6.5%. None of them died, but the outbreak was serious enough that the next brigade cleaned out the barracks, even washing the walls, before they moved in. Despite this precaution, during Chesney's third phase, August 23 to November 8, more than one-third of the 6th Artillery Brigade, 1,636 soldiers, contracted influenza and 151 died. Chesney concluded that ". . . these successive outbreaks tended to be progressively more severe both in character and extent, which would speak for an increasing virulence of the causative agent."[13]

Medical officers such as Chesney wanted clean barracks and also worried about crowding. Surgeon General Gorgas had recommended that Army housing provide 60 square feet per man, but did not often prevail. As Gorgas told one training camp commander, "We know perfectly well that we can control pneumonia absolutely if we could avoid crowding the men, but it is not practicable in military life to avoid this crowding."[14] The Medical Department even asserted that "there is to be expected a definite relation between the degree of crowding and the amount of respiratory infection."[2] (p. 111) But if it was difficult to control crowding in the training camps, it was impossible in the battlefields. Evolutionary biologist Paul Ewald has argued that trench warfare and its crowded conditions enabled an especially aggressive and deadly influenza virus to gain footing in humans.[15] As soldiers in the trenches became sick, the military evacuated them from the front lines and replaced them with healthy men. This process continuously brought the virus into contact with new hosts—young, healthy soldiers in which it could adapt, reproduce, and become extremely virulent without danger of burning out. From there, according to a Navy report, "It is reasonable to suppose that late in August influenza of severe type was spread from French, Spanish, and Portuguese seaports to the Orient, South Africa, the United States, and South America."[5] (p. 2427) As Chesney and Ewald suggest, the influenza of 1918 was a product of trench warfare, and the influenza that attacked the 6th Artillery at Valdahon would travel the highways of war, circling the globe.

INFLUENZA IN THE CAMPS

Braisted pinpointed the arrival of the epidemic in the United States to Tuesday, August 27, 1918, at Commonwealth Pier in Boston ". . . when three cases of influenza were committed to the sick list." The next day produced eight cases, and on August 29, 58 cases were reported, 15 so ill they were transferred to the U.S. Naval Hospital in Chelsea.[5] (p. 2427) Within 48 hours, three medical officers who had seen the patients also fell ill.[5] (p. 2473–4) Influenza reached civilians in Boston and on September 8, arrived "completely unheralded" at the Army's Camp Devens, outside of the city. Within 10 days, the base hospital and regimental infirmaries were overwhelmed with thousands of sick trainees.[16,17]

Gorgas sent his best epidemiologists to Camp Devens to investigate. His team included Victor C. Vaughan, dean of the University of Michigan School of Medicine and director of the Surgeon General's Office of Communicable Disease; William Henry Welch, famed pathologist from Johns Hopkins; and Rufus Cole, respiratory diseases expert from the Rockefeller Institute.[18] They found the medical situation "grave," and recommended 16 measures to control the outbreak, the most dramatic being a halt to transfers in or out of Devens until the epidemic passed. Camp Devens physicians performing autopsies described influenza pathology as unique, characterized by "the intense congestion and hemorrhage" of the lungs.[19] Cole and Welch observed one such autopsy, and Cole noted that Welch, "turned away from the blue, swollen lungs with wet, foamy, shapeless surfaces [and] became excited and nervous, saying, 'This must be some new kind of infection or plague.'" Added Cole, "It was not surprising that the rest of us were disturbed, but it shocked me to find that the situation, momentarily at least, was too much even for Dr. Welch."[20]

But as Vaughan and Welch investigated Camp Devens, the virus kept moving. Before any travel ban could be imposed, a contingent of replacement troops departed Devens for Camp Upton, Long Island, the Army's debarkation point for France, and took influenza with them. Medical officers at Upton said it arrived "abruptly" on September 13, 1918, with 38 hospital admissions, followed by 86 the next day, and 193 the next. Hospital admissions peaked on October 4 with 483, and within 40 days, Camp Upton sent 6,131 men to the hospital for influenza. Some developed pneumonia so quickly that physicians diagnosed it simply by observing the patient rather than listening to the lungs. "The patient looked sick and suggested a serious condition," they wrote, "his face was often cyanotic, sometimes ashy, sometimes just pinched looking. He expressed no pain or suffering. If his mind was clear he expressed a sense of euphoria, or of unnatural realization of his condition, which in particular marked the advanced stages of the disease."[21] Private James Downs entered the hospital on September 23 with a temperature of 104 degrees and died three days later. An Army pathologist clipped a piece of Downs' lungs and sent it to the Army Medical Museum as a specimen of the damage influenza was doing to young soldiers.[22] As they walked through Camp Upton's pneumonia wards of 900 patients, medical officers experienced "horror at the frightfulness of the sight of the hopelessly sick and dying and at the magnitude of the catastrophe that had stricken wholesale the young soldiers prepared to face another enemy but helpless before this insidious one." That sight, they said, "will haunt for life the minds of those who saw it."[21]

In efforts to contain the outbreak, Camp Upton's commander John Mallory put its 30,000 inhabitants under quarantine, barring travel in and out except on "the most urgent business."[23] But in wars and epidemics there is much urgent business and people got through. Naomi Barnett of Brockton, Massachusetts, had sped to Upton to care for her fiancé Jacob Julian when she learned he was ill. They planned to be married before he departed for duty in France but the young woman died of pneumonia two days after arriving at the camp. Her beloved died 30 minutes later. "Relatives," reported the local newspaper, "are planning a double funeral in Brockton."[24] To control influenza and pneumonia, the hospital provided patients with 100 square feet of floor space, separated beds by sheets, and furnished face masks to everyone in the camp. As pneumonia spread, medical officers also sprayed the mouths and throats of 800 healthy men daily with the solution of dichloramine-T as a preventive measure, but when they compared their influenza rates with 800 untreated men, they were disappointed to find that "…over a period of twenty days the incidence in the two groups was the same."[2] (p. 121)

As Upton medical officers climbed the peak of their epidemic, the virus traveled west and south, arriving at Camp Grant, Illinois, on Saturday, September 21, 1918, with 70 hospital admissions. "So sudden and appalling was the visitation that it required the greatest energy and cooperation of every officer, every man, and every nurse to meet the emergency," wrote one observer.[4] (p. 749) Hospital admissions rose to 194, then 370, then 492, to a high of 788 admissions on September 29. Hospital officials summoned all officers on leave, converted barracks to hospital wards, and by "extreme effort" expanded the hospital capacity from "10 occupied beds to a capacity of 4,102 beds in six days."[4] (p. 751) Influenza still overwhelmed every department. The hospital laboratory resorted to local civilian facilities to perform specimen tests. Camp ophthalmologists saw patients with conjunctivitis, an influenza complication, and ear, nose, and throat specialists saw those with other dangerous secondary infections. As individuals became seriously ill, camp officials sent out "danger" or "death" telegrams to families and loved ones, but soon they received so many return calls, telegrams, and visitors, they had to set up a separate hospital tent as an information bureau. Medical personnel were not immune. Eleven of the 81 medical officers fell ill, and three civilian and three Army nurses died. The epidemic even caused the Medical Department to drop its prohibition on black nurses so that Camp Grant called African American nurses to care for patients. The women had to wait, however, until separate, segregated accommodations could be constructed.[25]

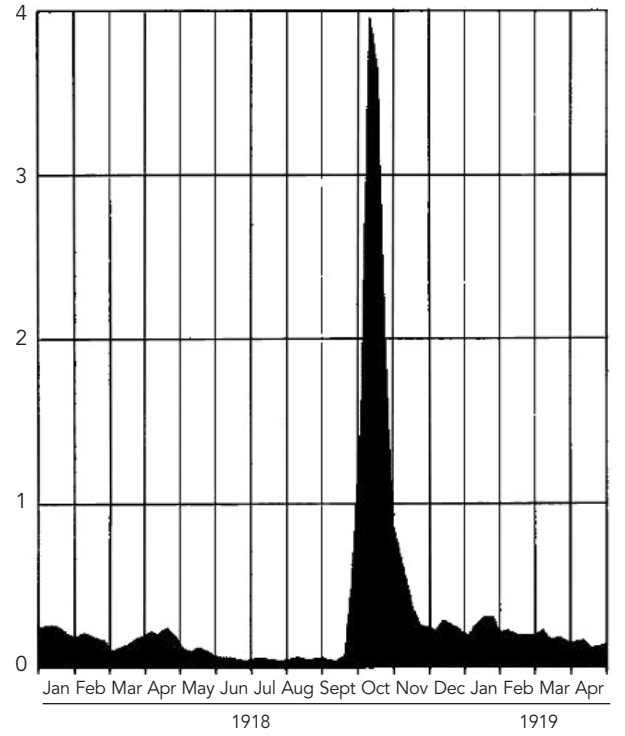
Ten days after the epidemic struck, hospital admissions began to fall but pneumonia took hold, and Camp Grant's daily death toll began to climb. It reached double digits on October 1 with 14 deaths, then 30 the next day, 46 the next, and 76 on October 4. The mortuary was designed to handle only four deaths a day. On Friday, October 4, with more than 100 bodies in the mortuary camp, officials negotiated with local undertakers to take the bodies at $50 each, but when someone produced a flatbed truck to remove the dead, the Army quickly provided more dignified closed trucks. The number of dead broke 100 on October 5 and reached a horrifying high of 117 deaths on October 6.[4] (p. 750–4) The last day the Camp Grant death toll exceeded 100 was October 9, but the decline was too late for its commander. Col. Charles B. Hagadorn, a West Point graduate and career officer who had served in Russia and the Panama Canal Zone, was acting camp commander when influenza struck. Although

Camp Grant's sickness and death rates were no worse than other camps and better than some, fellow officers later told reporters that Hagadorn had been showing the strain of the epidemic.[26,27] Troubled as more than 500 soldiers died of pneumonia under his command, on October 7, he committed suicide with a pistol shot to his head. In the end, Camp Grant suffered 10,713 influenza victims, including 1,060 deaths in a population of 40,000.[4] (p. 749)

Across the country, medical officers noted the rapidity with which the epidemic hit each camp, in some cases reaching its highest number of cases within 10 days (Figure 2).[5] (p. 2429) The steep gradient of the flu attacks can be seen in the headlines of *The Camp Dodger,* the weekly newspaper of Camp Dodge, Iowa, which strobe the trajectory of the epidemic. The flu struck on September 29, so its first mention is an October 4 headline: "Dodge Battles Spanish 'Flu'; Impose Quarantine, Cases Number 1500, One Death Reported." The next week's front page announced, "Flu Epidemic Subsiding; Fewer New Cases; Death Rate Is Low," and the following week's headline read, "Peak Flu Scourge Has Passed." Influenza disappeared from the front page of the October 25 edition, and the November 1 front page noted, "Services in Memory of Dodge Dead; Soldiers and Civilians Will Pay Tribute Sunday to Victims of Epidemic."[28–31] And that was it. Although Camp Dodge would have one of the worst records among Army camps with more than 13,700 hospital admissions and 700 deaths, the epidemic had passed and the Armistice dominated the news.[4] (p. 2017)

Influenza reached all Army training camps in a month, arriving September 8 at Camp Devens, September 13 at Camp Upton, September 21 at Camp Grant, September 26 at Camp Cody, and then on to the West Coast, arriving October 8 at Camp Fremont, California, and October 9 at Camp Lewis, Washington.[2] (p. 138) War Department training reports show that as influenza arrived at each camp, it "interfered with," "curtailed," "brought to a standstill," or even caused the discontinuation of training activities as recruits and instructors fell ill.[32] The deadly second wave of the epidemic lasted about four weeks in individual camps and ran its course in the Army in about eight weeks, roughly from September 15 to November 15, 1918. The high-water mark for deaths in the United States came the week of October 4 and in the AEF, the week of October 11.[4] (p. 2755) Navy and Army officers observed that the U.S. camps had higher morbidity and mortality rates than shipboard sailors or AEF soldiers and Marines; one report set hospital admissions for influenza at 167 per 1,000 in the AEF compared to 361 per 1,000 in the U.S.

Figure 2. Deaths per 1,000 soldiers each week during 1918–1919 in the U.S. Army

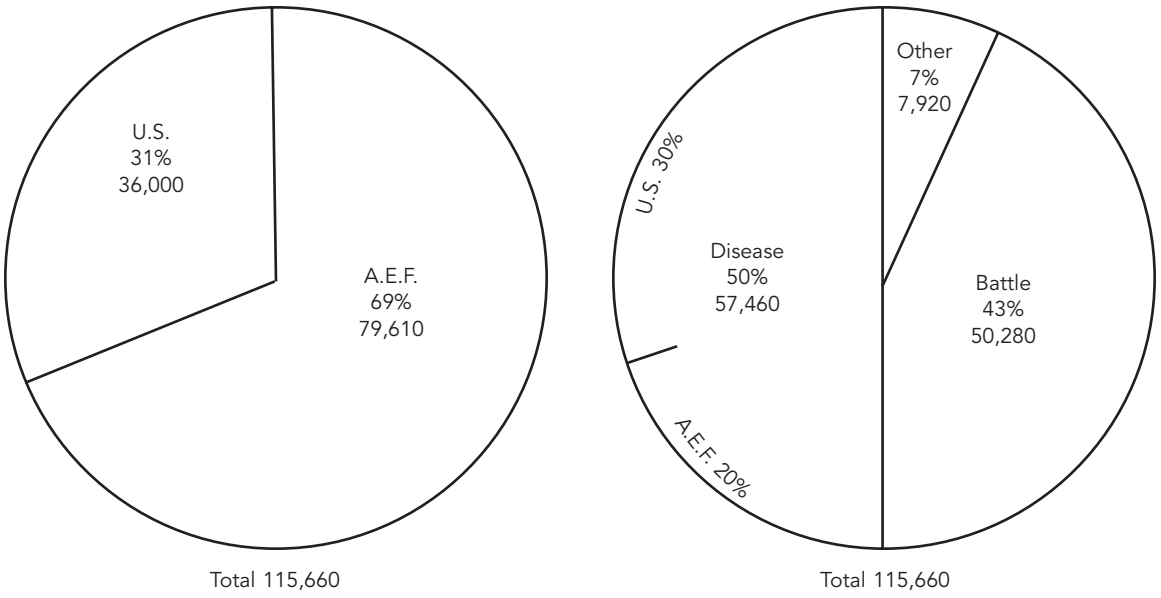


Source: Ayres LP. The war with Germany: a statistical summary. Washington: Government Printing Office; 1919. p. 127.

camps.[4] (p. 1469) Officers believed this was because deployed personnel had been exposed to influenza in an earlier wave and therefore had some immunity to the second deadly wave.[5] (p. 2414)

In some camps, African American soldiers had lower morbidity but higher mortality rates than white soldiers, and some medical officers erroneously attributed this to racial weakness and susceptibility. But segregation, ironically, may have shielded some black units from influenza infection, and the higher mortality could have been due to African Americans' often inferior living conditions and medical care in the military. Segregation in the Army was rarely "separate but equal." One study of the army rations allocated to men at camps Grant, Dodge, and Funston over four months revealed that the 366th Infantry of the Ninety-second Division, one of the black combat divisions, received less protein and fewer calories than the white units, even though they were on the average taller and heavier than their white counterparts.[33] Private Robert Stevens of Louisiana, with the 803rd Pioneers, a black unit that fought in the Meuse-Argonne, also remembered that when several hundred men in his regiment were sick with pneumonia, they had only one medical officer.[34]

Figure 3. Total deaths in the U.S. Army including Marines attached to it: April 6, 1917, to July 1, 1919



Source: Ayres LP. The war with Germany: a statistical summary. Washington: Government Printing Office; 1919. p. 123.
A.E.F. = American Expeditionary Forces

In Europe, influenza attacked Allied and German armies alike, filling field hospitals and transport trains with weak, feverish men all along the Western Front. On October 18, the AEF chief surgeon reported that ". . . influenza and pneumonia continue to prevail in all parts of the A.E.F."[35] Influenza cases outnumbered combat casualties. According to one tally, 227,000 soldiers were hospitalized for battle wounds in 1918, but half again as many AEF soldiers—340,000—were hospitalized for influenza.[4] (p. 1429–41) The epidemic struck during the climax of the American military effort, compromising the AEF's performance in its largest campaign of the war, the Meuse-Argonne Offensive. Influenza clogged transportation lines along the battlefront, choked hospitals, killed thousands of soldiers, and rendered many more non-effective. The flu depleted and demoralized troops, and may have diverted military and political leaders from fighting the war to combating disease. It ultimately killed more American military personnel than did enemy machine guns and artillery (Figure 3).

THE ARMY AND NAVY RESPOND

As he watched the epidemic unfold, Acting Army Surgeon General Charles Richard warned the Medical Corps that ". . . no disease which the army surgeon is likely to see in this war will tax more severely his judgment and initiative."[36] His office distributed numerous bulletins on influenza and pneumonia to Army personnel and fired off daily memos to Army Chief of Staff Peyton March and others making recommendations on the epidemic.[37,18] Concerned about influenza spreading on crowded troopships, Richard advised March against sending troops from infected camps to France until the epidemic was over in their region.[18] March approved this recommendation, which at first affected only a few training camps. But as the epidemic widened, Richard called for canceling all draft calls for registrants destined for infected camps and minimizing transfers between camps. "Epidemic influenza has become a very serious menace," he told March, "and threatens not only to retard the military program, but to exact a heavy toll in human life, before the disease has run its course throughout the country."[18,38] March's office instructed camp commanders to reduce crowding and increase medical personnel, but halted only some of the draft calls, so that in late September new recruits were still entering training camps. Only the Provost Marshall's cancellation of the October draft finally eased pressure on the camps.[39]

Richard also recommended a one-week quarantine of all troops prior to embarkation and reducing the capacity of troopships by one-half. Desperate to build up the forces in France, March rejected these suggestions in favor of rigorous pre-boarding physical screening to control the epidemic. Richard countered: "It is impossible for medical officers to state with any degree of safety that any particular command is free from infection, or that it may safely embark on troopships

for overseas service." He then recommended "that all troop movements overseas be suspended for the present, except such as are demanded by urgent military necessity."[18] Richard was willing to suspend war mobilization to protect the health of the soldiers. March agreed to a 10% reduction in crowding on troopships, but that was all. The controversy reached the White House when President Wilson asked March why he refused to stop troop transport during the epidemic. March described the Army's screening precautions and invoked the exigencies of a war of attrition, pointing out ". . . the psychological effect it would have on a weakening enemy to learn that the American divisions and replacements were no longer arriving."[40] Troop shipments should not be halted for any reason, he told Wilson, and the president deferred to his judgment. March and Wilson had no intention of retarding U.S. participation in the war. By mid-October, however, the practice of taking men from camps that had already weathered the epidemic did finally reduce the influenza rates on troopships and in the AEF.

Sickness rates in U.S. camps ultimately ranged from 10% at Camp Lewis, Washington, to 63% at Camp Beauregard, Louisiana, averaging between 25% and 40%; death rates ranged from less than 1% at many camps to 3.3% at Camp Sherman, Ohio.[2] (p. 138) But the sickness rates probably understated the problem because they captured only those soldiers who reported sick and received medical attention. Army investigators found that some regimental physicians did not send soldiers to hospitals unless they had temperatures higher than 101 degrees.[4] (p. 3794) Many stricken soldiers may have just stayed in bed with or without knowledge or permission of their superior officers. Others may have gone home when they got sick, either with leave or AWOL. "One of the boys played wise and got sick while he was home," Charles Johnston, a soldier at Camp Funston, Kansas, wrote home in early October. "He is down with pneumonia, so will have a prolonged visit while home. Think I will try that when I come home, eh!" Several days later Johnston reported, "There have been hundreds of boys taken A.W.O.L. since [the camp was] quarantined."[41] The situation became so bad that the War Department ordered the investigation of absentees from government service.[42]

While the implementation of treatment and prevention measures varied from camp to camp, medical officers generally tried "all preventive measures which seemed logical," according to Braisted. Quarantines were almost impossible to maintain and had little effect. The Navy, rushing to transport troops across the Atlantic, imposed modified quarantines at many stations but ". . . invariably this measure failed to prevent the introduction of influenza."[5] (p. 2486) As the Army Medical Department explained, ". . . to be of avail in excluding influenza, quarantine must more nearly approach perfection than proved practicable in the large camps of the war."[2] (p. 116) Other prevention measures included daily inspections and temperature-taking, patient isolation, face masks and gowns for attendants, good ventilation, screening between beds, prohibition of indoor gatherings, nose and throat sprays for the healthy, and experimental vaccines. In assessing these measures, however, Braisted concluded that "each particular preventive measure failed in some instances to accomplish recognizable results."[5] (p. 2483) The Army Medical Department similarly admitted that "the best result to be expected from any or all of these measures is a slowing of the progress of an epidemic rather than any considerable diminution in the number of cases."[2] (p. 123-4)

The Great Lakes Naval Training Station in Rockford, Illinois, provided an example of a failed measure. When it offered masks to personnel, only 96 out of 674 hospital corpsmen wore them and they experienced a higher influenza rate than those who did not wear masks—8.3% compared with 7.9%.[5] (p. 2490) Great Lakes was by far the largest Navy camp, with a population of 44,000, and influenza arrived with "explosive violence" on September 16 and within 30 days generated 9,623 cases.[5,11] (p. 2430) Harney Stover, a sailor from Indiana training at Great Lakes, explained to his mother that influenza "affects most men pretty hard for the first few hours. They turned ashen gray and usually faint." He commented that "at the rate it is spreading, everyone will have had it and be well in a week," but he was overly optimistic.[43] Within weeks hundreds of his fellow trainees would die, as would many of those who were caring for them.[5] (p. 2452) Although only one Navy nurse had died during the war to date, 25 succumbed to the pandemic, seven of them at Great Lakes camp: Theresa Burmeister, Myrtle Grant, Edith Hokanson, Emma Kotte, Alice Lea, Garnet Olive Peck, and Amber Story.[5] (p. 2071)

Stover escaped the flu but chafed at the quarantine. He was furious when a local mayor objected to lifting it. "When we get liberty once more the mayor of Waukegan is going to have his darn little town run off the map and get tar and fethered [sic] himself." But if it was difficult to contain the influenza virus, it was harder to contain sailors and soldiers. When false rumors of an armistice hit the camp, "the whole station went wild," wrote Stover. "In the next Regiment, they tore the doors off 2 barracks trying to get out. . . . It was almost an hour before the Provost Guards could make everybody get back in their barracks."[43]

When the Armistice finally came on November 11, it was impossible to maintain quarantines, but by then influenza had passed through most camps, leaving much to celebrate and to mourn. Influenza would again sweep American military camps in the United States and Europe in early 1919, but would be less virulent than the previous wave and find less fuel, as demobilization rapidly depopulated the camps. While the U.S. military had helped to subdue the Germans, the medical profession had failed to conquer an even more deadly, unseen enemy. Now in peacetime, thousands of physicians left military service to return to civilian life, taking with them their searing experiences of war and disease, victory and defeat.

REFERENCES

1. Braisted WC. The Navy and its health problems. Am J Public Health 1917;7:931.
2. War Department (US). Office of the Surgeon General, Medical Department of the United States Army in the World War, vol. 9: Communicable and other diseases. Washington: U.S. Government Printing Office; 1928.
3. Ayres LP. The war with Germany: a statistical summary. Washington: U.S. Government Printing Office; 1919. p. 125-6.
4. War Department (US). Annual report, 1919. Washington: U.S. Government Printing Office; 1920.
5. Department of the Navy (US). Annual report, 1919. Washington: U.S. Government Printing Office; 1920.
6. Still WN Jr. Crisis at sea: the United States Navy in European waters in World War I. Gainesville (FL): University Press of Florida; 2006. p. 225.
7. Byerly CR. Fever of war: the influenza epidemic in the U.S. Army during World War I. New York: New York University Press; 2005.
8. War Department (US). Order of battle of the United States land forces in the World War. Vol. 3. Washington: U.S. Government Printing Office; 1931–1949.
9. Astor G. The right to fight: a history of African Americans in the military. Novato (CA): Presidio Press; 1998. p. 110.
10. Bristow N. Making men moral: social engineering during the Great War. New York: New York University Press; 1996.
11. McLaughlin AJ. Society proceedings, American Public Health Association. JAMA 1918;71:2170-5.
12. Soper G. The influenza pandemic in the American camps, September 1918. 9 October 1918. Box 393, Entry 29, RG 112, National Archives and Records Administration, College Park, MD.
13. A report on epidemic of influenza occurring at the post of A.P.O. 704, AEF [undated memo]. Box 7, Entry 1011, RG 112, National Archives and Records Administration, College Park, MD. Later published as: Chesney AM, Snow FW. A report of an epidemic of influenza in an army post of the American Expeditionary Forces in France. J Lab Clin Med 1920:78-95.
14. Gorgas WC to Scott HL. 1918 April 10. Box 41, Entry 31, RG 112, Box 41, National Archives and Records Administration, College Park, MD.
15. Ewald PW. Evolution of infectious disease. Oxford (UK): Oxford University Press; 1994. p. 110-3.
16. War Department (US). Office of the Surgeon General, Medical Department of the United States Army in the World War, vol. 4, activities concerning mobilization camps and ports of embarkation. Washington: U.S. Government Printing Office; 1926. p. 49-50.
17. Wooley PC to Surgeon General, 1918 Sep 16. Box 84, Entry 31, RG 112, National Archives and Records Administration, College Park, MD.
18. War Department (US). Office of the Surgeon General, Medical Department of the United States Army in the World War. Vol. 6, Sanitation in the United States and in the American Expeditionary Forces. Washington: U.S. Government Printing Office; 1926. p. 349-71.
19. Wolbach B, Frothingham C. A study of pathology of cases dying at Camp Devens during the influenza epidemic in 1918. Trans of the Amer Acad of Physicians 1928;38:177.
20. Flexner S, Flexner JT. William Welch and the heroic age of American medicine. New York: Viking Press; 1941. p. 376-7.
21. Lyon IP, Tenney CF, Szerlip L. Some clinical observations on the influenza epidemic at Camp Upton. JAMA 1919;72:1726-9.
22. Kolata G. Flu. New York: Farrar, Straus and Giroux; 1999. p. 30-1.
23. Close Camp Upton to check influenza. New York Times 1918 Sep 17:10.
24. Brockton girl and fiancé died at camp. Boston Daily Globe 1918 Oct 4:10.
25. War Department (US). Office of the Surgeon General, Medical Department of the United States Army in the World War. vol. 5: military hospitals in the United States. Washington: U.S. Government Printing Office; 1923. p. 200-1.
26. Col. Hagadorn a suicide. New York Times 1918 Oct 9:24.
27. Barry JM. The great influenza: the epic story of the deadliest plague in history. New York: Viking; 2004. p. 212-9.
28. Dodge battles Spanish 'flu.' The Camp Dodger (Camp Dodge, Iowa) 1918 Oct 4:1(col. 6,7,8) [The State Historical Society of Iowa, Des Moines].
29. Flu epidemic subsiding. The Camp Dodger (Camp Dodge, Iowa) 1918 Oct 11:1(col. 8) [The State Historical Society of Iowa, Des Moines].
30. Peak of flu scourge has passed. The Camp Dodger (Camp Dodge, Iowa) 1918 Oct 18:1(col.8) [The State Historical Society of Iowa, Des Moines].
31. Services in memory of Dodge dead. Camp Dodger (Camp Dodge, Iowa) 1918 Nov 1:1(col.1) [The State Historical Society of Iowa, Des Moines].
32. War Department (US). Office of the Surgeon General, Medical Department of the United States Army in the World War. Vol. 7, Training. Washington: U.S. Government Printing Office; 1927. p. 26, 100, 427, 461, 474.
33. Congdon LA. A study of the Army ration and its relation to the height and weight of soldiers in Army cantonments. Mil Surg 1921;48:569-80.
34. Stevens R. WWI questionnaire collection: pioneer infantry. Military History Institute, Carlisle Barracks, Pennsylvania.
35. McCaw JD to Harbord J. Influenza and pneumonia situation. 18 October 1918. Box 5493, Entry 2109, RG 120, Entry 2109, National Archives and Records Administration, College Park, MD.
36. Memorandum, C-362, 24 September 1918. Box 5493, Entry 2109, RG 120, National Archives and Records Administration, College Park, MD.
37. War Department (US). Office of the Surgeon General, Medical Department of the United States Army in the World War, vol. 1: The Surgeon General's office. Washington: U.S. Government Printing Office; 1923. p. 998-1003.
38. Richard C to Adjutant General, 25 September 1918. Box 394, Entry 29, RG 112, National Archives and Records Administration, College Park, MD.
39. War Department (US). Second report of the Provost Marshall General to the Secretary of War on the operations of the Selective Service System to December 20, 1918. Washington: U.S. Government Printing Office; 1919. p. 237.
40. March PC. The nation at war. Garden City (NJ): Doubleday, Doran & Co.; 1932. p. 360.
41. Johnston CL. Life at Camp Funston: reflections of army sergeant Charles L. Johnston. 1918 Oct 6 and undated [cited 2010 Mar 5]. Available from: URL: http://pages.suddenlink.net/tjohnston7/ww1hist
42. Investigation of absentees in government service, 14 October 1918, index of correspondence, September to November 1918. Box 5, Entry 9, RG 163, National Archives and Records Administration, College Park, MD.
43. Burch M. `I don't know only what we hear': the soldiers' view of the 1918 influenza epidemic. Indiana Med Hist 1983;4:23-7.

Strategy Research Project

THE MILITARY RESPONSE TO PANDEMIC: THE NEW GLOBAL THREAT

BY

COLONEL PIETRO TORNABENE
Italian Army

USAWC CLASS OF 2009

This SRP is submitted in partial fulfillment of the requirements of the Master of Strategic Studies Degree. The views expressed in this student academic research paper are those of the author and do not reflect the official policy or position of the Department of the Army, Department of Defense, or the U.S. Government.

U.S. Army War College, Carlisle Barracks, PA 17013-5050

The U.S. Army War College is accredited by the Commission on Higher Education of the Middle State Association of Colleges and Schools, 3624 Market Street, Philadelphia, PA 19104, (215) 662-5606. The Commission on Higher Education is an institutional accrediting agency recognized by the U.S. Secretary of Education and the Council for Higher Education Accreditation.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
28-01-2009	Strategy Research Paper	

4. TITLE AND SUBTITLE

The Military Response to Pandemic: The New Global Threat

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Colonel Pietro Tornabene, International Fellow - Italy

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Colonel Roberto Nang
Department of Command, Leadership, and Management

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army War College
122 Forbes Avenue
Carlisle, PA 17013

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

DISTRIBUTION A: UNLIMITED

13. SUPPLEMENTARY NOTES

Only a work of the United States Government is not subject to copyright. Based upon the nature of a particular student-author's employment, a paper may not be a work of the United States Government and may, in fact, be protected by copyright.

14. ABSTRACT

The more we develop, the more people gather in enormous urban conglomerates, the more we become intertwined in a complex society characterized by large availability of means of transportation, and the more the disruptive effects of a global plague stemming from an unknown infection will be. It is necessary to address this new type of menace in order to know the enemy we face, and once known, find feasible, acceptable, and suitable course of actions to defeat it or, at least, minimize the undesirable effects to our complex society. To fight this kind of "war" is not only the duty of a few researchers or doctors. The Army, as the ultimate bulwark between order and chaos when a threat becomes disruptive for the entire society, has a big role to play in order to assure order, deliver goods and medicines, control the stream of infected people, and maintain open vital communication`s routes. The threat of pandemic does not find place in the "The Spectrum of Conflict," and requires new tasks to be accomplished by the Armed Forces. This paper has been developed to address this kind of problem.

15. SUBJECT TERMS

Influenza, Microbes, Menace, Army, Training, Preparedness

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(include area code)*
UNCLASSIFED	UNCLASSIFED	UNCLASSIFED	UNLIMITED	27	

USAWC STRATEGY RESEARCH PROJECT

THE MILITARY RESPONSE TO PANDEMIC: THE NEW GLOBAL THREAT

by

Colonel Pietro Tornabene
Italian Army

Colonel Roberto Nang
Project Adviser

This SRP is submitted in partial fulfillment of the requirements of the Master of Strategic Studies Degree. The U.S. Army War College is accredited by the Commission on Higher Education of the Middle States Association of Colleges and Schools, 3624 Market Street, Philadelphia, PA 19104, (215) 662-5606. The Commission on Higher Education is an institutional accrediting agency recognized by the U.S. Secretary of Education and the Council for Higher Education Accreditation.

The views expressed in this student academic research paper are those of the author and do not reflect the official policy or position of the Department of the Army, Department of Defense, or the U.S. Government, the Italian Department of Defense or the Italian Army.

U.S. Army War College
CARLISLE BARRACKS, PENNSYLVANIA 17013

ABSTRACT

AUTHOR: Colonel Pietro Tornabene

TITLE: The Military Response To Pandemic: The New Global Threat

FORMAT: Strategy Research Project

DATE: 28 January 2009 WORD COUNT: 5,510 PAGES: 27

KEY TERMS: Influenza, Microbes, Menace, Army, Training, Preparedness.

CLASSIFICATION: Unclassified

The more we develop, the more people gather in enormous urban conglomerates, the more we become intertwined in a complex society characterized by large availability of means of transportation, and the more the disruptive effects of a global plague stemming from an unknown infection will be. It is necessary to address this new type of menace in order to know the enemy we face, and once known, find feasible, acceptable, and suitable course of actions to defeat it or, at least, minimize the undesirable effects to our complex society. To fight this kind of "war" is not only the duty of a few researchers or doctors. The Army, as the ultimate bulwark between order and chaos when a threat becomes disruptive for the entire society, has a big role to play in order to assure order, deliver goods and medicines, control the stream of infected people, and maintain open vital communication`s routes. The threat of pandemic does not find place in the "The Spectrum of Conflict," and requires new tasks to be accomplished by the Armed Forces. This paper has been developed to address this kind of problem.

THE MILITARY RESPONSE TO PANDEMIC: THE NEW GLOBAL THREAT

> So the Lord said: 'I will wipe out from the earth the men whom I have created, and not only the men, but also the beasts and the creeping things and birds of the air, for I am sorry that I have made them.'
>
> —Genesis 6, 7[1]

In the last years, the appearance of incurable diseases, previously unknown, with disgusting symptoms has called for a reflection on the dangers that seemed buried in history.

Ebola, HIV, SARS, and Avian Flu are scary words that recall the spectrum of incurable diseases. The mind goes to the past diseases that have plagued human societies and it is horrified for the unforeseeable consequences on our complex society. How would we react to a pandemic disease able to kill 10—20 percent of the population? Would society remain intact or would it be disrupted? Who would maintain order? What would be the role of the Armed Forces and the Army in particular?

We are part of the bio-ecological system and even if our science and technological development assure us a clear victory on the invisible enemies of the human body, we cannot escape the limits of the ecosystem,[2] and the more

> …we win, the more we drive infections to the margin of human experience, the more we clear a path for possible catastrophic infection.[3]

Pandemic diseases have been common in the past and claimed a recurrent heavy toll on the humans. The last pandemic occurred just *yesterday*, in 1918-1919, called *Spagnola* (Spanish flu), and claimed a staggering number, between 20 to 100 million human lives,[4] more than the grand total of military and civilian deaths of the entire World War I (about 18.5 million) in four years of fighting.[5]

The future has a name and this name is “globalization”. You can be an enthusiast or a stalwart opponent of it, but it is undisputable that

> ... the present and future state of globalization will be a major determinant of the shape and nature of world politics, and governmental attitudes to it will in turn be major determinants of strategy and defense policy[6].

Internet, technology, economy, and social relationships have already integrated the world into a single interwoven organism. As an *organism* the globalized world pays particular attention to its “physiology.” This is clear when an epidemic occurs. The population that faces an epidemic behaves as a single ecological unit and the epidemic, in an ecological sense, acts as a force of natural selection, killing some people with certain genes but sparing people with others. An epidemic, also, links separate populations into a single evolutionary unit. A pandemic is an epidemic that occurs simultaneously in many different parts of the world. From an ecological perspective, a pandemic temporarily connects many, perhaps even all, humans into a single ecological and evolutionary unit.[7]

If it is true, that globalization has forced the international community to rethink the concept of National Interest to include the notion of “Collective Security,” the same is true for the health of the system. Today a health problem in any part of the world can become a problem for the system as a whole. The dramatic increase in worldwide movement of people and goods due to wars, trade, and travel exposes *everyone* to the emerging global threat of infectious diseases. We give to the microbes new homes in tires, tanks, containers, trucks and airplanes that go back and forth to every corner of the world. Furthermore, urbanization and global climate change pose additional problems. In 1900 only five cities in the world had populations larger than one million; by the year 2020, there will be twenty-five megacities with more than twenty million people

and scores of cities with more than a million.[8] The crowded conditions in urban regions favor the transmission, both directly and indirectly, of pathogenic microbes from person to person. The rise of temperature due to the combustion of fossil fuel and the increasing deforestation, have significantly increased the range in which insect vectors can live and breed. Such climate changes could alter precipitation patterns which could alter vegetation patterns and, in turn, alter the distribution of animal species that are vectors of a wide range of infectious diseases.

In the modern “global village” people, vectors, and microbes, as well as medicines, medical information, and evildoers can travel around the globe with great frequency and ease. The potential for an epidemic of infectious disease that can become a pandemic is real and perhaps unavoidable. Especially influenza has the potential for pandemic spread and leads to intriguing ethical, legal, and organizational questions about public intervention to avoid a situation that could severely disrupt trade, economics, travel, and personal liberty. The nature of the menace is so threatening that it needs to be addressed not only with Public Health interventions but also with all the state`s means including the Military Force.

In this study, we explore the nature of pandemic disease as a menace for the international system. We begin by describing what is a pandemic and the threats it poses to the international system when associated to particular diseases. We briefly expound on the impact of infectious diseases in history, then we Infer what type of “side” consequences can spur the outbreak of a pandemic disease (above all the stigmatization of persons, communities, and ethnic groups). Finally, we identify the possible role of the Armed Forces, and the Army in particular, in facing a pandemic

disease in order to assure order, deliver goods and medicines, control the stream of infected people, and maintain open vital communication`s routes.

Pandemic, Endemic and the Influence of Disease in History

A pandemic disease, called also just “pandemic,” is a disease prevalent over a whole area or country.[9] This is the definition you can find in a dictionary, but is it satisfying? No, because it does not account for an important characteristic that a pandemic disease must possess: to be infectious. It is better to turn to the World Health Organization that identifies three essential prerequisite for the start of a pandemic:

- A novel type of disease must be transmitted to humans;
- The infectious agent must be able to replicate in humans and cause disease;
- The infectious agent must be efficiently transmitted from one human to another; efficient human-to-human transmission is expressed as sustained chains of transmission causing community-wide outbreaks.[10]

Following these characteristics, a disease or condition is not a pandemic merely because it is widespread or kills many people; it must also be infectious. Cancer is not a pandemic because, even if it is widespread, it is not infectious.

Moreover, it is necessary to make a distinction between pandemic, epidemic and endemic. The term epidemic refers to any disease that occurs suddenly among people in a particular region,

> it affects or tends to affect a disproportionately large number of individuals within a population, community, or region at the same time.[11]

Conversely, endemic:

> Are diseases which exist in particular localities or among certain races. Some diseases, which are at times epidemic over wide districts, have a

> restricted area where they are always endemic, and from which they spread.[12]

The adaptation of an infectious agent, that we can call *germ* or *parasite*, and host (a human, animal or, generally speaking, a complex biological entity) goes through stages called epidemic, endemic, and symbiotic. A germ entering a virgin population (i.e. one that is unfamiliar and has few defenses against it) often causes acute disease in people of all ages. The survivors are usually left with improved defenses against reinfection. The disease eventually becomes endemic, a widespread, lower grade infection or routine childhood disease. With further adaption by germ and host comes symbiosis, in which parasite and host sustain mutual tolerance (mutualism) or even mutual benefit (commensalism).[13] A pandemic is an epidemic that occurs simultaneously in many different parts of the world.

Many diseases have caused pandemics, and in the past humankind has experienced pandemic of smallpox, plague, cholera and others. Most of these diseases came from other species, smallpox probably from dogs and cattle, tuberculosis from cattle and birds, AIDS probably from African monkeys.[14] Today, the most worrying disease able to begin the next pandemic is influenza. The flu virus has many varieties, many reservoirs (such as swine and fowl) that can exchange it, and a spectacular ability to mutate and baffle human immune defenses. The last deadly pandemic faced by humankind was the Spanish Flu, which occurred in 1918-1919, comparable to the Black Death in the fourteenth century.

In this study, we will concentrate on pandemic influenza to analyze the threat it poses to contemporary society and to devise the most appropriate responses to address this potentially destructive menace effectively. However, before analyzing the

nature of the threat the flu poses to our society, it is important to understand how disease and parasitism play a pervasive role in life and in history. Viruses have depleted the native populations of entire countries and have posed the basis for dramatic changes in their economic and religious life, affecting the course of history.

Disease has been a concealed companion of every war and until recent time the real demanding killer of war was not war itself but the host of diseases that were the unerring mates of it. Two examples are telling on this subject: during the First World War some 113,000 American soldiers died, 51,000 in battle, 62,000 from disease,[15] and during the Civil War about 600,000 American soldiers died, 207,000 in battle, 392,000 from disease.[16]

In the Bible, there are indications of the influence of disease in war.[17] How vulnerable a population could be to a sudden eruption of unfamiliar infection is illustrated by what happened in Athens during the Peloponnesian War in 430-429 B.C. Thucydides has left a detailed clinical description of the epidemic that did so much to demoralize the Athenians and killed off about a quarter of the Athenian land Army.[18] An outbreak of dysentery weakened the Prussian force invading France in 1792 and helped to convince their leaders to turn back after losing the battle of Valmy, thus saving the French Revolution.[19] The conquest of the Aztec Empire was due to the most powerful ally of Hernan Cortez: smallpox![20]

When black slaves revolted in Haiti, in the early years of the nineteenth century, to put down the revolt, Napoleon sent over 27,000 French troops (1802). When the French came in contact with the yellow fever virus transmitted by mosquitoes, they fell ill and died from the infection. The huge loss influenced the decision not to risk the even

larger numbers of troops necessary to protect other French territories in the New World and was one of the major considerations leading Napoleon to negotiate the sale of the Louisiana Territory to the United States.[21] These are a few examples that compel us to see a more complex view of history that takes account of diseases as a component of the life of societies along with their political, social, and economic activities.

The comprehension of the remedies to put in place to cope with the menace carried out by the diseases to a society needs an understanding of the differences between an outbreak of a familiar disease amid an experienced population and the ravages of the same infection on a community lacking acquired immunities. At this point, we need to analyze what role disease and parasitism play in life.

All animals are dependent for their nourishment on other biological elements (vegetables or other animals), and human beings are no exception. At biological levels there is astounding parallel between the visible world of the “macrobes”, where some animals feed themselves with others, and the invisible world where microbes feed on other microbes. Microbes are viruses, bacteria, or multi-celled creatures that find a source of food on a host creature and act as microparasites. The successful search for food on the part of one organism can become for its host, a nasty infection or disease.[22] Some microparasites provoke acute disease and either kill their host after only a brief period of time, while there are other microparasites that achieve more stable relations with their host, establishing a relationship called symbiosis.

In the world of the “macrobes” something similar happens and some animals act as plunderers killing the prey, as wolves or lions do, or act as parasites exploiting the ability to find nourishment within a host. Man is not an exception, and in his history he

has acted as plunderer or parasite. Usually, he acted as a parasite with his similar beings, exploiting the abilities of others to work and producing wealth. The first civilizations were built by rulers, who decided to take part of the harvest for the need of the upper class of the nobles, priests, and soldiers, leaving the people with enough food to sustain the lower classes indefinitely, establishing a social symbiosis.

Like the societies of the “macrobes,” inside the human body, white corpuscles fight and phagocyte enemy microbes responsible for infectious diseases. The microbes that they cannot phagocyte, are able to absorb the nourishment of the human body, behaving, sometimes as a plunderer, killing the host body, or as a parasite living in the host body and leaving him enough nourishment to live together indefinitely in symbiosis.

When the parasite is able to live indefinitely with the host body a sort of equilibrium is found, and in our body there are traces of this kind of equilibrium.

In the intestine exists an abundant intestinal flora, fruit of this equilibrium that is of mutual benefit for the body and for the microbes that act as parasites.

The problems arise when an infesting agent not recognized by the body alters the balanced or calm equilibrium and gives way to unrestrained reactions that can cause the death of the body. This situation is common when the infesting agent achieves a “leap” of species or of “environment.” Every species and every environment have and work in dynamic equilibrium with intertwined and complex relations that allow the system (species and environment) to perform normally.

It is necessary to be aware of this precarious equilibrium to avoid what already happened in the world of the “macrobes” when different civilizations at different stages of development (in disequilibrium) met each other with the annihilation of the weakest.

Our unrelenting quest for resources, along with the tremendous increase in contacts due to the cheap availability of the means of transportation, and the globalized nature of the contemporary world makes the human community particularly prone to the menace of a new devastating plague carried out by an unknown infectious element that sleeps somewhere in the darkness of some far away deposit of natural resources or in the depth of an unexplored forest.[23]

The Nature of the Menace

Among the known diseases that can cause a pandemic, of relevance for this study are those that have high contagiousness and an ability to spread among the human population in short time. The most threatening disease with these characteristics is influenza. It is a disease that already has a high genetic unpredictability in the causing virus,[24] a high speed of transmissibility, every year appears as a pandemic, and is quite dangerous, claiming every year 36,000 deaths per year in the United States.[25]

Pandemic flu, or pandemic influenza, is a global outbreak of flu that occurs when a new flu virus appears in people, causes serious illness, and spreads easily from person to person. On average, pandemics occur about every 30 or 40 years[26] (the last pandemic occurred in 1968) and the next is conservatively expected to cause between 2 and 8 million deaths.[27]

The Institute of Medicine (IOM) has noted three essential prerequisites for an influenza pandemic:

> (1) The identification of a novel viral subtype in animal populations such as swine or poultry, (2) viral replication causing disease in humans, and (3) efficient human-to-human transmission. The species "jump" from animals to humans could occur through a process known as "reassortment." If a person is exposed to both animal and human viral infections, "the genetic mixing" could lead to a strain that is

transmissible from human to human, sometimes in ways that are highly resistant to vaccination or antiviral treatment.[28]

The flu virus has many varieties and many biological reservoirs (such as swine and birds) that allow it to mutate and evolve in order to baffle the human defenses and to generate trouble.[29] Because influenza is not considered eradicable,[30] the faster we change the environment around us, the faster we force the evolution of the viruses that find niches in the animals that surround us, and the faster new types of infections will reach us.

The outburst of a pandemic with high lethality is a menace not only to public health, but for the system itself, demanding strategies to:

- Prevent and control transmission in birds and other animals;
- Put in place state and local preparation measures;
- Devise biomedical measures to prevent and control the pandemic;
- Manage legal issues in pandemic prevention and control;
- Address the need for integration and communication across various fields of medicine;
- Coordinate public and private sectors;
- Carry out military policies to properly address mass mobilization and area control.[31]

The SARS, severe acute respiratory syndrome, epidemic of 2003 has been the first harbinger of future events that might be catastrophic for the global system as we know it today. SARS has been successful addressed, for now, but continues to be a future pandemic menace. It was a menace of global magnitude that demonstrated that effective surveillance and a prompt, appropriate response are critical to containing an

outbreak.[32] Effective surveillance and appropriate responses could raise questions about the role of national sovereignty in an increasingly interconnected world and could call on all the energy of the World Health Organization, the international scientific community, and the civilian and military authorities as well.

The Role of the Armed Forces

Illness, death, lost of sources of revenues, disrupted commerce, social unrest, and widespread complaints are the consequences of a pandemic.

Politics needs to keep time with the biological development of the disease. Selfishness, reticence, and economic miscalculations, until now, have created obstacles in fighting emerging diseases, and have dampened the efforts put in place by dedicated organizations to fight them. The nature of the threat is so awesome that it is necessary to be ready to fight the incoming pandemic with rigorous scientific approach, and *the leveraging of all instruments of national power* [33] including the Armed Forces.

An epidemic exerts immense political and social pressure for swift, decisive, visible response. When this response is perceived as insufficient, the public can react with rage, without regard to the negative effects of the government's wrong or mis-guided actions. A sense of rage can easily take the form of stigma toward individuals, ethnic minorities, places, etc. This problem needs to be addressed at the very beginning, first with police resources but if it reaches overwhelming proportions, then, to the Armed Forces. Officials have an obligation to take steps to mitigate the suffering consequent to stigmatization, being aware of the irrationality that underlies the behavior of human beings, and of the inequity of ethnic stereotyping. The army is the best national resource to discourage hate crimes, prevent the stigmatization of specific

people or places as “contaminated” or unhealthy, bolster the ability of individuals and the large community to rebound from unpredictable and traumatic events; and provide food and materials to those who need it.

The Armed Forces, and the Army in particular, are exercised to act in very difficult situations, and their self-sufficient, trustworthy nature as an organization are precious characteristics that are vital in such a situation, where maintaining essential functions and services is critical.

Along with the legal measurers to put in place to face nearly every facet of pandemic preparedness, it is necessary to be prepared to use the army in duties that can be expected to reduce the risk of animal-to-human transmission of disease; to prevent or control the spread of infection; to impose voluntary or mandatory quarantine and/or isolation measures, travel limitations, trade restrictions, border closures, and surveillance/detection activities (when necessary).

Each of these interventions, while potentially beneficial to the society, also imposes a burden on at least some of its members in the form of economic disadvantage, loss of political power, or sacrifice of human rights. To render these burdens more bearable to the people, it is necessary that these activities should be performed by a trusted and fair organization such as the Army.

Moreover, if these measures are to be effective, they should be imposed early in the course of a pandemic, before it can be scientifically ascertained whether they are actually warranted.[34] Local police and public health laws are not sufficiently robust to meet this daunting challenge.

Pandemic preparations can be viewed as an insurance policy, an investment accumulated over time, in anticipation of an eventual crisis. Conducting planning and preparedness exercises to strengthen the response to a broad range of possible public health emergencies, should involve the military along with the local and state institutions.

The occurrence of an epidemic of epizootic foot-and-mouth disease (FMD) (*Aphtae epizooticae*) in United Kingdom in 2001 was a first glimpse of things to come. Only with the use of the Royal Army, was the United Kingdom able to cope with the spread of this disease, and with a well devised plan of containment, control and destruction of the affected animals carried out by the Army, the United Kingdom was able to succeed in defeating a disease that was bound to destroy the entire cow stocks of the country.

As in the United Kingdom case, control of animal population is critical. When pandemic influenza begins, a critical early strategy is to try and control animal populations and to try and limit the disease's ability to "jump" species. A lot of the biological mixing that occurs with the flu occurs with the cohabitation of pigs and/or birds and humans (this is common not only in China and in many Southeastern Asian countries but in other countries as Indonesia, West Africa and North West Pakistan).[35] There is a lot of avian spread of respiratory disease: first transmitted by migrating wild birds between each other and then to large domesticated poultry farm populations by wild birds and then between the many, many birds (chickens and turkeys) in large poultry farms. To diminish the risk it will be necessary to separate animals from humans through infection control and disinfection, and to manage deceased and exposed

animals. This is a critical factor not only for the directly affected countries but is also important for every country as well, in order to prevent world-wide spread of the disease. Even in the United States with its robust Public Health agencies and its trusted Department of Agriculture, this issue is very difficult to be sorted out.[36] The numbers of animals to control can be staggering and impossible to deal for every civilian organization and it is likely that the Army will be employed to:

- eliminate large numbers of exposed animals;
- provide burial or elimination of the bodies of the suppressed animals;
- put in place aggressive policies of culling those animals who may have been infected;
- and assure control of geographical areas affected by the disease.[37]

This is just an example of the employment of the Armed Forces. The needs of homeland security require extraordinary efforts for rapid-reaction forces to be ready for emergency response. Even if a strategy for pandemic influenza already exists, it is critical to analyze what could be key contributions of the military.

The U.S. National Strategy for pandemic influenza is based on three pillars: preparedness and communication, surveillance and detection, response and containment.[38] In each of these camps the military can offer their invaluable contribution.

Preparedness and Communication. In the field of preparedness, the military can offer their contribution developing efficient mechanisms for mobilization and fast transfers of resources (human and equipment) into municipalities where they are needed and assuring the fast delivering of reserve resources to jeopardized areas. In a

scenario built on the possible impact of a pandemic, the public would react with a widespread sense of vulnerability, social hysteria, and social disruption causing panic mass migrations using cars to move away from the affected area with the likely result of complete traffic gridlock in busy city streets or major arterial highways. In this situation the only way to reach the people in the affected area would be by air and the railway. Helicopters could intervene efficiently, but their limited load capacity will have difficulty with the large amount of materials and medicines needed. The railway is a better way to deliver large amounts of materials at low cost. Preparing some military units to manage and to deal with the railways are critical tasks to accomplish in order to be prepared in the occurrence of a pandemic. The railway net is widespread enough to reach every corner of the country and has a big potential to funnel whatever is needed in an affected area. In addition, some train convoys can be easily transformed as “mobile hospitals” in order to give specialized care to the needy.

Management of Risk Communication and Health Information dissemination must be seen as critical factors to accomplish in order to avoid social hysteria and public irrationality or overreaction. The official communication, normally, comes out as a trickle and is outpaced by the media information with little interest in sorting “noise” from critical information.[39] An effective system of public communication, reliable in the flow of information and with regularly scheduled updates could be put easily in place by military specialized units utilizing dedicated TV and radio channels, as well as high-tech outreach such as the internet, to broadcast reliable and up-to-date information. The ultimate aim is to create an informed and involved public able to help solve the problem

and at ease with its political and community leaders. To reach mutual confidence is the basis for any effective action to cope effectively with the disease.

Surveillance and Detection. Constant monitoring of the "hot spots" where a new virus can develop, detailed testing and screening, fever monitoring, reporting and monitoring trends for a large population are responsibilities carried out by the World Health Organization (WHO) and the US military, with its invaluable contribution through the US Military Influenza Surveillance Network that includes sites outside the United States.[40] The US Army Center for Health Promotion and Preventive Medicine (USACHPPM), the US Center for Disease Control, and State Public Health Departments all have good surveillance systems with good synchronizations with each other.[41] Nevertheless, it is necessary to expand virologic and disease surveillance in order to close gaps in the current geographical coverage for early warning of the emergence of variants and animal strains with pandemic potential. Better integration of human and animal influenza surveillance is essential for understanding and preparing for threats to human health posed by animal influenza viruses.[42]

Response and Containment. The best response to a pandemic influenza is vaccination. In order to avoid the collapse of the existing medical infrastructures, a mass campaign of vaccination using mobile centers of vaccinations could be managed by military. The military will be involved to deal with unrest among the population striving to get vaccination, and to maintain good order and discipline for the people waiting for their turn. Customized railway trains can be used as hubs from which these mobile centers can radiate.

To prevent the spread of infection across borders, restrictions and controls will be enforced on the people and merchandise entering back and forth between borders. The sheer large numbers of people and merchandise to control will require the employment of the Army in activities of police control to be performed along with the existing agencies at present in charge of these kinds of activities.

The potential for a mass outbreak of disease raises the specter of civil confinement to separate those who are infected from those who are healthy and could require mandatory measures to be accomplished only through the use of military force. Furthermore, it may be necessary to quarantine a geographic area, a task needing to be accomplished with exclusive recourse to military force. In case of civil confinement, the problem to provide the necessities of life such as safe food, water, and medicine arises. This problem can be addressed by establishing “logistic pipelines” big enough to satisfy the population`s needs. Once again, the railway is a critical infrastructure that can efficiently address all the necessary needs.

The challenges of a pandemic are so daunting that the employment of the Armed Forces will be required since the first stage of its occurrence could cause the civilian authorities to be overwhelmed. It happened in the past in the occurrence of painful disasters such as 9/11 and Hurricane Katrina. These situations call for a temporary exception to the caveats of the Posse Comitatus Act, the 130-year-old federal law restricting the military`s role in domestic law enforcement. Furthermore, the fact that terrorist organizations can resort to the use of dangerous pathogens able to generate a pandemic underlies the necessity to be ready to deploy the troops on behalf of

homeland security and to prepare the military force for multiple, simultaneous mass casualty incidents.[43]

All plans are, more or less, worthless when the time comes to apply them because all plans cannot properly foretell specific and unexpected exigencies that always seem to occur. What it is important is not any one specific plan, but that all the responsible agencies are able to communicate and get to know each other and become familiar with each other's capabilities so that the team can train and exercise synergistically together. The exercises will make the organizations, and the people inside them, aware of the potential difficulties in applying the plan and will force them to find solutions to overcome all the shortcomings.[44]

Drawing smart plans is important, but it is not sufficient. Training is what *is* really important. The military needs to be aware of the indispensable role they will be called on to perform in the occurrence of a pandemic, and the Armed Forces need to train units for this specific task along with the other actors of the different departments involved. What it is requested is a truly civilian-military interagency effort to be carried out on behalf of the entire society. Pandemic simulation exercises should be developed for civilian and military planners, and in the course of running the simulations, the civilian and military players should trade places.[45]

Conclusion

In today's information-saturated environment, outburst of a disease in a remote area that has little Public Health or Epidemiological support can easily become a problem for more distant and advanced 1st-world countries and can cause panic due to sensationalized media headlines. Public panic and loss of confidence in public safety

can lead to population demands that are not helpful, with no real practical basis for the demands, but which could then overwhelm Healthcare and Public Works Systems. Furthermore, a deadly pathogen nurtured in geographically distant places can be quickly transported to our industrialized countries and can spring a new disease, with pandemic characteristics, with sudden urgency and devastating Public Health consequences.

In both cases, every effort should be put in place in order to assure the public that *every* element of power (included the military) is committed to protect the society. The military, as the ultimate bulwark between order and chaos is able to face this new kind of menace, and with its unparalleled logistic capabilities and case management capacity, can properly assure order and discipline, efficient delivery of goods and medicines, control the stream of infected people, and maintain open vital communication's routes. The Armed Forces are already involved with their laboratory and epidemiological expertise in an effective surveillance effort for new influenza viruses and their associated morbidity and mortality.[46] This is not enough, to be prepared for the next pandemic, it will be necessary to commit all national resources available with the same intent with which the human society has been involved to fight the macroparasitism of the man-on--man (armies, international organizations, and all the structures built to lessen the international violence). We must be aware that an invisible enemy is somewhere in the world and it is developing to start a disruptive attack, perhaps the most disruptive that humankind has ever faced.

The military is ready to give its invaluable contribution in order to mitigate suffering, give help, and reassure people. Its units can deliver adequate human and

material capabilities to cope with the threat, serving the country in silence and with professionalism. Even if a natural-occurring threat of pandemic does not occur in the "The Spectrum of Conflict," the Armed Forces must become involved and should be made ready to succeed with planning and training now. It is necessary to move from a framework to an action plan, taking advantage of bio-terrorism planning and to address all the issues related to this new fruit of the volatile, uncertain, complex, and ambiguous modern environment.

Endnotes

[1] *The Catholic Study Bible* (New York: Oxford University Press, 1990), 10.

[2] Laurie Garrett, *Coming Plague* (New York: Penguin Books, 1994), 6.

[3] Ibid.

[4] The first significant attempt to quantify the death toll came in 1927. An American Medical Association sponsored study estimated that 21 million died. When today`s media refers to a death toll of "more than 20 million" the source is this study. But every revision of the deaths since 1927 has been upward. The U.S. death toll was originally put at 550,000. Now epidemiologists have settled on 675,000 out of a population of 105 million. Worldwide, both the estimated toll and the population have gone up by a far greater percentage. In the 1940s Macfarlane Burnet, the Nobel laureate who spent most of his scientific life studying influenza, estimated the death toll at 50 to 100 million. John M. Barry, *The Great Influenza* (New York: Penguin Books, 2004), 396-397.

[5] Peter Simkins, Geoffrey Jukes, & Michael Hickey, *The First World War. The War to End all Wars* (Osceola, WI: Osprey, 2003), 337.

[6] Geoffrey Till, "New directions in Maritime strategy?*,"* in *Readings in the Theory of War and Strategy* (Carlisle Barracks, PA: U.S. Army War College, Department of National Security and Strategy, 2008 vol.II), 107.

[7] Rob DeSalle, "Epidemics and Pandemics" in *Epidemic! The World of Infectious Disease*, ed. Rob DeSalle (New York: The New Press, 1999), 153.

[8] Rob DeSalle, "Epidemics and Pandemics" in *Epidemic! The World of Infectious Disease*, 154.

[9] Voice "Pandemic" in *Webster NewWorld Dictionary*, Third College Edition (New York: MacMillian, 1994), 975.

[10]" WHO Consultation on Priority Public Health Interventions Before and During Influenza Pandemic. Executive Summary" in *Epidemic! The World of Infectious Disease*, ed. Rob DeSalle (New York: The New Press, 1999), 145.

[11] Voice "Epidemic" in *Webster`s New Explorer Encyclopedic Dictionary* (Springfield, MA: Federal Press Street, 2006), 611.

[12] Voice "Endemic" in *Black`s Medical Dictionary*, 41st Edition (London, UK: A & C Black Publishers Limited, 2005), 233.

[13] Arno Karlen, *Man and Microbes* (New York: Touchstone, 1996), 17.

[14] Arno Karlen, *Man and Microbes*, 11.

[15] Voice "World War I" in *The Oxford Companion to United States History* (New York: Oxford University Press, 2001), 845.

[16] Allan R. Millett & Peter Maslowski, *For the Common Defense* (New York: The Free Press, 1994), 238.

[17] 2 Kings 19, 32-35: [32] 'Therefore, thus says the Lord concerning the king of Assyria: He shall not reach this city, nor shoot an arrow at it, nor come before it with a shield, nor cast up a siege-works against it. [33] He shall return by the same way he came, without entering the city, says the Lord. [34] I will shield and save this city for my own sake and for the sake of my servant David.' [35] That night the angel of the Lord went forth and struck down one hundred and eighty-five thousand in the Assyrian camp. Early the next morning there they were, all the corpses of the dead. *The Catholic Study Bible*, 400.

[18] William H. McNeill, *Plagues and Peoples* (New York: Anchor Press, 1976), 105.

[19] William H. McNeill, "Infectious Alternatives" in, *What if?: The World`s Foremost Military Historians imagine What Might Have Been,* ed. Robert Cowley (New York: Berkeley Books, 2000), 2.

[20] William H. McNeill, *Plagues and People* (New York: Anchor Press, 1976), 2.

[21] Michael B.A. Oldstone, *Viruses, Plagues, & History* (New York: Oxford University Press, 1998), 5.

[22] William H. McNeill, *Plagues and Peoples*, 6.

[23] Rising food prices are pushing people, unable to afford basic supplies, especially communities in Central Africa, to turn to the forests for food. In doing so, hunters expose themselves to hidden dangers-microscopic pathogens living in the blood of forest animals. Most of the viruses are harmless, but some are potentially deadly when passed to humans. Scientists point out there is nothing new about these viruses. What is new is the frequency of people's contact with them and how easily they can now be spread around the world. "Tracking deadly viruses' spread from animals to humans," in CNN.com/world http://www.cnn.com/2008/WORLD/africa/12/08/pip.zoonotics/index.html?iref (accessed Dec. 10, 2008).

[24] A virus (from the Latin virus meaning toxin or poison) is a sub-microscopic infectious agent that is unable to grow or reproduce outside a host cell. Viruses infect all cellular life. It is about 100 times smaller than bacteria (unicellular microorganisms). The term is applied to a group of infective agents which are so small that they are able to pass through the pores of collodion filters. Voice "Virus" in *Black`s Medical Dictionary*, 763.

[25] Influenza (Flu) Prevention, USACHPPM (US Army Center for Health Promotion and Preventive Medicine), http://chppm-www.apgea.army.mil/news/influenzaWebsite/index.htm (accessed October 5, 2008).

[26] Ibid.

[27] *The Threat of Pandemic Influenza,* Workshop Summary prepared for Forum on Microbial Threats Board on Global Health, ed. Stacey L. Knobler, Alison Mack, Adel Mahmoud, and Stanley M. Lemon (Washington, D.C.: National Academies Press, 2005), xii.

[28] Lawrence O. Gostin, "Public Health Preparedness and Ethical Values in Pandemic Influenza" in *The Threat of Pandemic Influenza,* 358.

[29] Arno Karlen, *Man and Microbes* (New York: Touchstone Book, 1996), 8.

[30] *The Threat of Pandemic Influenza,* 30.

[31] Ibid., xii.

[32] Joel C. Gaydos, "Rapporteur`s Challenge" in Strengthening Influenza Pandemic Preparedness through Civil-Military Cooperation, ed. J. Neville and O.I. Kisilev (Fairfax, VA: IOS Press, 2005), vii.

[33] *National Strategy for Pandemic Influenza* (Washington, D.C.: Homeland Security Council, 2005), 2.

[34] *The Threat of Pandemic Influenza,* 46.

[35] Interview on the 16th December 2008 with Jose L. Sanchez, Influenza Team Leader, of the Armed Forces Health Surveillance Center.

[36] Interview on the 16th December 2008 with Joel C. Gaydos, Military Health System Coordinator for Emerging Disease Programs, and Jose L. Sanchez, Influenza Team Leader, of the Armed Forces Health Surveillance Center.

[37] Lawrence O. Gostin, "*Public Health Preparedness and Ethical Values in Pandemic Influenza"* in *The Threat of Pandemic Influenza,* Workshop Summary prepared for Forum on Microbial Threats Board on Global Health, 357-368.

[38] *National Strategy for Pandemic Influenza*, 3.

[39] Monica Schoch-Spana, "*Strategies to Remedy Panic in a Pandemic: Lessons from Biodefense"* in *The Threat of Pandemic Influenza,* Workshop Summary prepared for Forum on Microbial Threats Board on Global Health, 351.

[40] L.C. Canas and N.J. Cox, “Influenza Surveillance: Civilian-Military Cooperation in the United States and Considerations for Worldwide Improvement” in Strengthening Influenza Pandemic Preparedness through Civil-Military Cooperation, 68.

[41] Interview on the 16th December 2008 with Jose L. Sanchez, Influenza Team Leader, of the Armed Forces Health Surveillance Center.

[42] L.C. Canas and N.J. Cox, “*Influenza Surveillance: Civilian-Military Cooperation in the United States and Considerations for Worldwide Improvement*” in *Strengthening Influenza Pandemic Preparedness through Civil-Military Cooperation,* 70.

[43] “Pentagon to Detail Troops to Bolster Domestic Security,” Washington Post, December 1, 2008. http://ebird.osd.mil/ebfiles/e20081201642701.html (accessed Dec. 10, 2008).

[44] Interview on the 16th December 2008 with Joel C. Gaydos, Military Health System Coordinator for Emerging Disease Programs, of the Armed Forces Health Surveillance Center.

[45] Joel C. Gaydos, “Rapporteur`s Report” in Strengthening Influenza Pandemic Preparedness through Civil-Military Cooperation, 106.

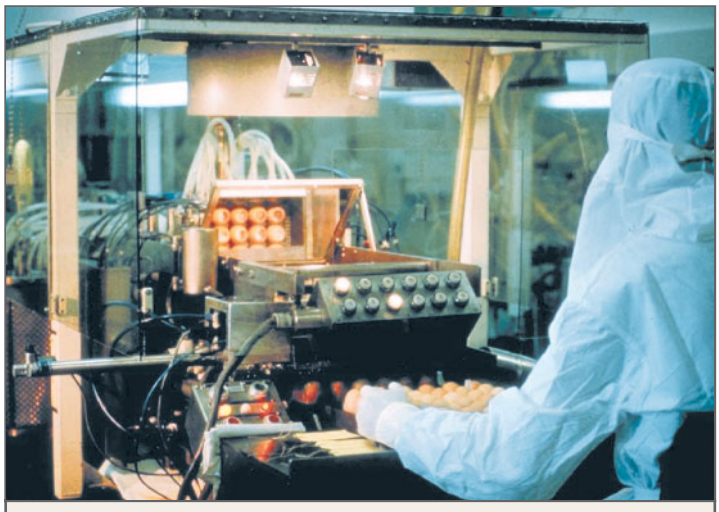
[46] Joel C. Gaydos, “Rapporteur`s Challenge” in Strengthening Influenza Pandemic Preparedness through Civil-Military Cooperation, vii.

Preparing for the Next Pandemic

Michael T. Osterholm, Ph.D., M.P.H.

An interview with Dr. Osterholm can be heard at www.nejm.org.

Annual influenza epidemics are like Minnesota winters — all are challenges, but some are worse than others. No matter how well we prepare, some blizzards take quite a toll. Each year, despite our efforts to increase the rates of influenza vaccination in our most vulnerable populations, unpredictable factors largely determine the burden of influenza disease and related deaths. During a typical year in the United States, 30,000 to 50,000 persons die as a result of influenzavirus infection, and the global death toll is about 20 to 30 times as high as the toll in this country. We usually accept this outcome as part of the cycle of life. Only when a vaccine shortage occurs or young children die suddenly does the public demand that someone step forward to change the course of the epidemic. Unfortunately, the fragile and limited production capacity of our 1950s egg-based technology for producing influenza vaccine and the lack of a national commitment to universal annual influenza vaccination mean that influenza epidemics will continue to present a substantial public health challenge for the foreseeable future.



Aventis Pasteur MSD/Getty Images.

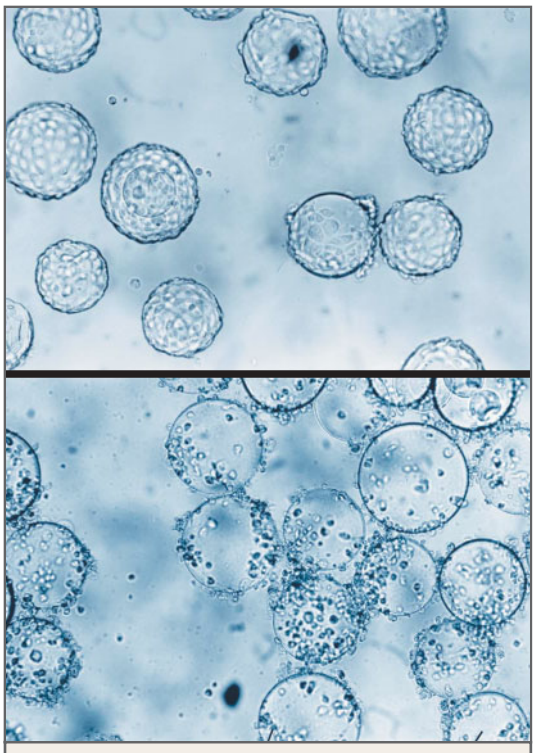
Technician Working on Egg-Based Production of Influenza Vaccine.

An influenza pandemic has always been a great global infectious-disease threat. There have been 10 pandemics of influenza A in the past 300 years. A recent analysis showed that the pandemic of 1918 and 1919 killed 50 million to 100 million people,[1] and although its severity is often considered anomalous, the pandemic of 1830 through 1832 was similarly severe — it simply occurred when the world's population was smaller. Today, with a world population of 6.5 billion — more than three times that in 1918 — even a relatively "mild" pandemic could kill many millions of people.

Influenza experts recognize the inevitability of another pandemic. When will it begin? Will it be caused by H5N1, the avian influenzavirus strain currently circulating in Asia? Will its effect rival that of 1918 or be more muted, as was the case in the pandemics of 1957 and 1968? Nobody knows.

So how can we prepare? One key step is to rapidly ramp up research related to the production of an effective vaccine, as the Department of Health and Human Services is doing. In addition to clinical research on the immunogenicity of influenza vaccines, urgent needs include basic research on the ecology and biology of influenzaviruses, studies of the epidemiologic role of various animal and bird species, and work on early interventions and risk assess-

Dr. Osterholm is the director of the Center for Infectious Disease Research and Policy, the associate director of the National Center for Food Protection and Defense, and a professor of public health at the University of Minnesota, Minneapolis.



Baxter Vaccine

Cell-Culture–Based Production of Influenza Vaccine.
Microcarriers with Vero cells are shown before (top) and after (bottom) infection with influenzavirus.

ment.[2] Equally urgent is the development of cell-culture technology for production of vaccine that can replace our egg-based manufacturing process. Today, making the 300 million doses of influenza vaccine needed annually worldwide requires more than 350 million chicken eggs and six or more months; a cell-culture approach may produce much higher antigen yields and be faster. After such a process was developed, we would also need assured industrial capacity to produce sufficient vaccine for the world's population during the earliest days of an emerging pandemic.

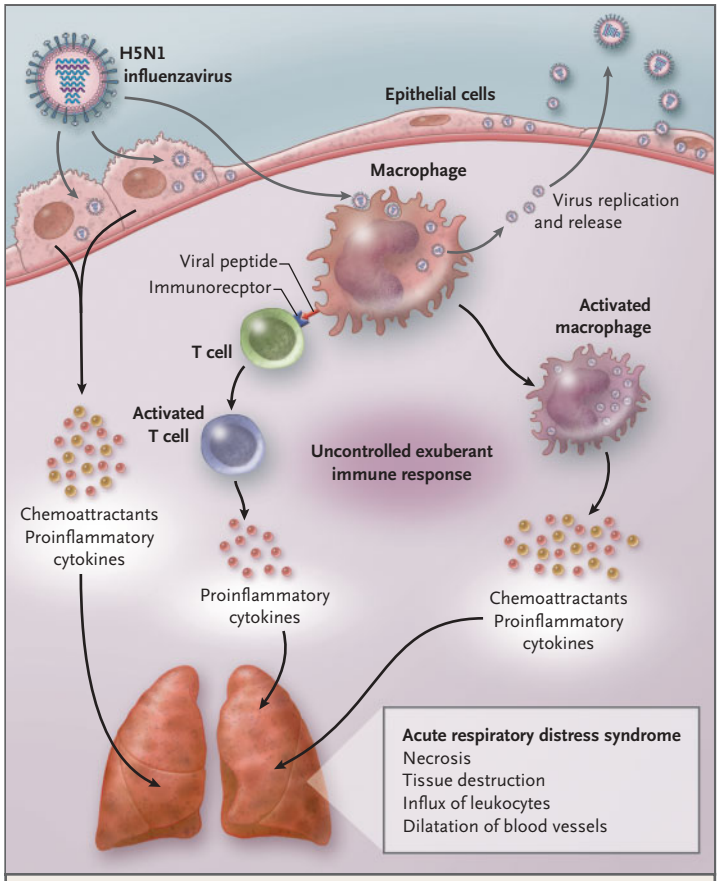
Beyond research and development, we need a public health approach that includes far more than drafting of general plans, as several countries and states have done. We need a detailed operational blueprint of the best way to get through 12 to 24 months of a pandemic.

What if the next pandemic were to start tonight? If it were determined that several cities in Vietnam had major outbreaks of H5N1 infection associated with high mortality, there would be a scramble to stop the virus from entering other countries by greatly reducing or even prohibiting foreign travel and trade. The global economy would come to a halt, and since we could not expect appropriate vaccines to be available for many months and we have very limited stockpiles of antiviral drugs, we would be facing a 1918-like scenario.

Production of a vaccine would take a minimum of six months after isolation of the circulating strain, and given the capacity of all the current international vaccine manufacturers, supplies during those next six months would be limited to fewer than a billion monovalent doses. Since two doses may be required for protection, we could vaccinate fewer than 500 million people — approximately 14 percent of the world's population. And owing to our global "just-in-time delivery" economy, we would have no surge capacity for health care, food supplies, and many other products and services. For example, in the United States today, we have only 105,000 mechanical ventilators, 75,000 to 80,000 of which are in use at any given time for everyday medical care; during a garden-variety influenza season, more than 100,000 are required. In a pandemic, most patients with influenza who needed ventilation would not have access to it.

We have no detailed plans for staffing the temporary hospitals that would have to be set up in high-school gymnasiums and community centers — and that might need to remain in operation for one or two years. Health care workers would become ill and die at rates similar to, or even higher than, those in the general public. Judging by our experience with the severe acute respiratory syndrome (SARS), some health care workers would not show up for duty. How would communities train and use volunteers? If the pandemic wave were spreading slowly enough, could immune survivors of an early wave, particularly health care workers, become the primary response corps?

Health care delivery systems and managed-care organizations have done little planning for such a scenario. Who, for instance, would receive the extremely limited antiviral agents that will be available? We need to develop a national, and even an international, consensus on the priorities for the use of antiviral drugs well before the pandemic begins. In addition, we have no way of urgently increasing



Proposed Mechanism of the Cytokine Storm Evoked by Influenzavirus.
The key element in generating the storm is an uncontrolled exuberant immune response to the virus, in which there is an outpouring of proinflammatory cytokines and chemoattractants. An animated version of this figure is available at www.nejm.org.

production of critical items such as antiviral drugs, masks for respiratory protection, or antibiotics for the treatment of secondary bacterial infections. Even under today's relatively stable operating conditions, eight different antiinfective agents are in short supply because of manufacturing problems. Nor do we have detailed plans for handling the massive number of dead bodies that would soon exceed our ability to cope with them.

What if an H5N1 influenza pandemic began not now but a year from now? We would still need to plan with fervor for local nonmedical as well as medical preparedness. Planning for a pandemic must be on the agenda of every public health agency, school board, manufacturing plant, investment firm, mortuary, state legislature, and food distributor. Health professionals must become much more proficient in "risk communication," so that they can effectively provide the facts — and acknowledge the unknowns — to a frightened population.[3]

With another year of lead time, vaccine might have a more central role in our response. Although the manufacturing capacity would still be limited, strategies such as developing antigen-sparing formulations — that is, intradermal formulations that take advantage of copious numbers of dendritic cells for antigen processing or formulations including adjuvants to boost the immune response — might extend the vaccine supply. Urgent planning efforts are required to ensure that we have the syringes and other essential equipment, as well as the workforce, for effective delivery. Finally, a detailed plan for vaccine allocation will be needed — before the crisis, not during it.

What if the pandemic were 10 years away and we embarked today on a worldwide influenza Manhattan Project aimed at producing and delivering a pandemic vaccine for everyone in the world soon after the onset of sustained human-to-human transmission? In this scenario, we just might make a real difference.

The current system of producing and distributing influenza vaccine is broken, both technically and financially. The belief that we can greatly advance manufacturing technology and expand capacity in the normal course of increasing our annual vaccination coverage is flawed. At our current pace, it will take generations for meaningful advances to be made. Our goal should be to develop a new cell-culture–based vaccine that includes antigens that are present in all subtypes of influenzavirus, that do not change from year to year, and that can be made available to the entire world population. We need an international approach to public funding that will pay for the excess production capacity required during a pandemic.

Today, public health experts and infectious-disease scientists do not know whether H5N1 avian influenzavirus threatens an imminent pandemic. Most indications, however, suggest that it is just a matter of time: witness the increasing number of H5N1 infections in humans and animals, the documentation of additional small clusters of cases suggestive of near misses with respect to sustained

human-to-human transmission, the ongoing genetic changes in the H5N1 Z genotype that have increased its pathogenicity, and the existence in Asia of a genetic-reassortment laboratory — the mix of an unprecedented number of people, pigs, and poultry.

It is sobering to realize that in 1968, when the most recent influenza pandemic occurred, the virus emerged in a China that had a human population of 790 million, a pig population of 5.2 million, and a poultry population of 12.3 million; today, these populations number 1.3 billion, 508 million, and 13 billion, respectively. Similar changes have occurred in the human and animal populations of other Asian countries, creating an incredible mixing vessel for viruses. Given this reality, as well as the exponential growth in foreign travel during the past 50 years, we must accept that a pandemic is coming — although whether it will be caused by H5N1 or by another novel strain remains to be seen.

Should H5N1 become the next pandemic strain, the resultant morbidity and mortality could rival those of 1918, when more than half the deaths occurred among largely healthy people between 18 and 40 years of age and were caused by a virus-induced cytokine storm (see diagram) that led to the acute respiratory distress syndrome (ARDS).[4] The ARDS-related morbidity and mortality in the pandemic of 1918 was on a different scale from those of 1957 and 1968 — a fact that highlights the importance of the virulence of the virus subtype or genotype. Clinical, epidemiologic, and laboratory evidence suggests that a pandemic caused by the current H5N1 strain would be more likely to mimic the 1918 pandemic than those that occurred more recently.[5] If we translate the rate of death associated with the 1918 influenzavirus to that in the current population, there could be 1.7 million deaths in the United States and 180 million to 360 million deaths globally. We have an extremely limited armamentarium with which to handle millions of cases of ARDS — one not much different from that available to the front-line medical corps in 1918.

Is there anything we can do to avoid this course? The answer is a qualified yes that depends on how everyone, from world leaders to local elected officials, decides to respond. We need bold and timely leadership at the highest levels of the governments in the developed world; these governments must recognize the economic, security, and health threats posed by the next influenza pandemic and invest accordingly. The resources needed must be considered in the light of the eventual costs of failing to invest in such an effort. The loss of human life even in a mild pandemic will be devastating, and the cost of a world economy in shambles for several years can only be imagined.

1. Johnson NP, Mueller J. Updating the account lobal mortality of the 1918-1920 "Spanish" influenza pandemic. Bull Hist Med 2002;76:105-15.
2. Stöhr K. Avian influenza and pandemics — research needs and opportunities. N Engl J Med 2005;352:405-7.
3. Sandman PM, Lanard J. Pandemic influenza risk communication: the teachable moment. 2005. (Accessed April 14, 2005, at http://www.psandman.com/col/pandemic.htm.)
4. Kobasa D, Takada A, Shinya K, et al. Enhanced virulence of influenza A viruses with haemagglutinin of the 1918 pandemic virus. Nature 2004;431:703-7.
5. Peiris JS, Yu WC, Leung CW, et al. Re-emergence of fatal human influenza A subtype H5N1 disease. Lancet 2004;363:617-9.

Deadly comrades: war and infectious diseases

Máire A Connolly, David L Heymann

Throughout history, the deadly comrades of war and disease have accounted for a major proportion of human suffering and death. Infectious diseases ruthlessly exploit the conditions created by war, affecting both armies and civilians. During the Napoleonic wars, eight times more people in the British army died from disease than from battle wounds. In the American civil war, two-thirds of the estimated 660 000 deaths of soldiers were caused by pneumonia, typhoid, dysentery, and malaria, and this death toll led to a 2-year extension of the war. These diseases became known as the "third army".

Among civilians, conflict promotes factors that lead to increased incidence of infectious diseases, including mass movement of populations, overcrowding, lack of access to clean water, poor sanitation, lack of shelter, and poor nutritional status. In addition, the collapse of public health infrastructure and the lack of health services hampers control programmes such as vaccination or vector control.

More than 25 countries are affected by conflict needing humanitarian assistance, mostly in sub-Saharan Africa, in which respiratory tract infections, diarrhoeal diseases, measles and, in endemic areas, malaria are major causes of death and disease. It is estimated that infectious diseases cause up to 70% of all deaths in these countries. Epidemics of cholera, dysentery, meningitis, relapsing fever, and typhus have caused high mortality, and tuberculosis and HIV/AIDS are becoming increasingly important. This burden of preventable death and disease affects not only the estimated 40 million refugees and internally displaced people worldwide but also non-displaced populations living in war-torn countries.

During conflict, populations are often suddenly displaced and relocated to temporary settlements or camps. Crude mortality rates over 60 times higher than baseline rates have been recorded after such displacement. To reduce human death and suffering, several targeted prevention and control measures (eg, measles vaccination, provision of safe water) need to be implemented. Where these interventions have not been agreed and implemented, there have been many preventable deaths. For instance, the outbreak of cholera and dysentery in Goma, former Zaire, in June, 1994, killed more than 12 000 Rwandan refugees in just 3 weeks.

However, the context of conflict situations has changed over the past decade—camp scenarios are no longer the norm since populations are often dispersed among local communities. In many conflict situations, ongoing war has led to "chronic emergencies" affecting entire countries and with long rehabilitation phases—eg, Afghanistan, Angola, Somalia, and the Democratic Republic of the Congo. Very often, populations are dependent in the long term on non-governmental organisations for the most basic health services—in Afghanistan, over 70% of health-care services are provided by such organisations. Rebuilding the public health infrastructure in these countries might be seen as a priority but it rarely receives the long-term investment required from the international community.

Prevention and control programmes deteriorate in war-torn areas, with a consequent increase in vector-borne diseases such as malaria, trypanosomiasis (sleeping sickness), yellow fever, and Lassa fever; tuberculosis and AIDS; and vaccine-preventable diseases such as measles. In Afghanistan, malaria was well controlled before civil strife began in 1979. However, in the past 20 years the disease has resurged, with 2–3 million cases per year, an increasing proportion of which is due to the more severe *Plasmodium falciparum*. In the Democratic Republic of the Congo, trypanosomiasis has dramatically resurged as a direct consequence of the conflict. In 1930, more than 33 000 cases were recorded, falling to fewer than 1000 cases in 1959 after active case finding and treatment. Then, conflict in the 1960s led to collapse of the control programme and in 2001, the number of cases was estimated at 40 000, with a prevalence of more than 70% in some villages.

The increasing prevalence of HIV/AIDS in conflict situations from poor injection safety, lack of treatment for sexually transmitted infections, increased incidence of sex work, and lack of condoms are also major threats to the long-term health of these populations.

Máire A Connolly joined WHO in 1995 and has worked in emergency situations in 12 countries. She now leads the Programme on Communicable Diseases in Complex Emergencies. **David L Heymann** is the Executive Director for Communicable Diseases. He has worked with WHO since 1988 and before that, worked in Africa for 13 years.

Communicable Diseases, World Health Organization, CH-1211 Geneva 27, Switzerland (M A Connolly MBChB; D L Heymann MD)
(e-mail: connollyma@who.int)

The high excess mortality and morbidity from infectious diseases in war-affected populations results from the lack of availability of even the most basic health protection and care. If the humanitarian imperative is not sufficient to convince the international community that these health needs need to be addressed, then there are several others that illustrate the importance of controlling infectious diseases in these countries.

First, globalisation and increased travel have made previously remote threats relevant to health security worldwide. In 2001, more than half of outbreaks of international importance occurred in conflict zones. International humanitarian workers, if they are not adequately protected, may be infected while working in these situations. Delays in detection, response, and containment of epidemics in countries affected by conflict are a constant threat to surrounding countries and to countries worldwide.

Second, conflict-affected countries are potential zones of new disease emergence such as Ebola in Uganda or resurgence of old or rare diseases. Detection and characterisation of new pathogens may be delayed, and diseases may then spread before control measures are implemented. In addition, improper and incomplete use of antibiotics and lack of regulatory controls can drive emergence of drug resistance in conflict-affected areas.

Third, the continued presence of diseases targeted for eradication or elimination in conflict-affected countries greatly threatens global goals such as polio eradication in Angola, Afghanistan, and the Democratic Republic of the Congo; and Guinea worm eradication in southern Sudan (see article by Hopkins and Withers, p 21).

Finally, after the anthrax incidents in the USA in October, 2001 (see article by Barbera and Macintyre, p 33), there are growing concerns that infectious diseases could be used as biological weapons. If this were to happen, the toll on already highly vulnerable civilian populations in conflict situations would be great.

Prevention and control of infectious diseases are key pillars of public health action and major opportunities to reduce the suffering of populations affected by war. However, the task is not easy, in view of the destruction of infrastructure; continued instability; fragility of peace agreements; potential for anarchy, corruption, and weak governance; and, some would argue, the unpredictability of international humanitarian responses.

Prevention and control interventions exist for the major high mortality infectious diseases. Provision of oral rehydration solutions, measles immunisation, antibiotics, effective antimalarials, and bednets in malaria endemic regions can substantially reduce disease morbidity and mortality. These interventions need to be widely implemented but also need to have long-term plans that address issues of availability, access, training, and community involvement. New tools are needed, such as rapid diagnostics, insecticide-treated materials like blankets and plastic sheeting, new heat-stable vaccines, and improved surveillance, mapping, and learning tools. Use of standard diagnostic and treatment protocols in health facilities with agreed first-line drugs is necessary to ensure effective diagnosis and treatment. Implementation of effective early warning systems to detect and rapidly control epidemics (whether deliberate or natural in origin) is also crucial. Above all, better coordination is needed between all partners—local and national authorities, UN agencies, non-governmental organisations, the military, and the private sector.


WHO/Global Outbreak Alert Response Network

Health workers combating Ebola in northern Uganda in 2000

To strengthen implementation of infectious disease control interventions in conflict-affected countries, WHO has established a programme of Communicable Diseases in Complex Emergencies. This programme focuses on providing technical and operational support to partners, setting standards, developing new tools, providing technical co-ordination at the field level and holding training courses for non-governmental organisations, UN agencies, and national health workers.

There is a need for a renewed international commitment to basic health protection and care of war-affected populations and recognition of the importance of infectious diseases as major killers. There is also a need to better address all people affected by conflict with a long-term perspective, and not only refugees and internally displaced people. The progress being made in peace building and reconstruction in Afghanistan, Angola, Democratic Republic of the Congo, and East Timor offers hope for the future. It is crucial that the international community seize the opportunity to assist governments and partners in these countries to rebuild their health-care systems. By focusing assistance on delivery of key interventions for infectious diseases, preventable death and disease could be greatly reduced while putting in place the health systems necessary for these and other disease interventions in the long term.

USAWC STRATEGY RESEARCH PROJECT

AVIAN INFLUENZA PANDEMIC MAY EXPAND THE MILITARY ROLE IN DISASTER RELIEF

by

Colonel Frank William Sherod II
United States Army

Colonel Dallas C. Hack
Project Adviser

U.S. Army War College
CARLISLE BARRACKS, PENNSYLVANIA 17013

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
15 MAR 2006		**00-00-2005 to 00-00-2006**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Avian Influenza Pandemic May Expand the Military Role in Disaster Relief	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
Frank Sherod	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
U.S. Army War College,Carlisle Barracks,Carlisle,PA,17013-5050	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
See attached.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**		**28**	

ABSTRACT

AUTHOR: Colonel Frank William Sherod II

TITLE: Avian Influenza Pandemic May Expand The Military Role in Disaster Relief

FORMAT: Strategy Research Project

DATE: 15 March 2006 WORD COUNT: 8,002 PAGES: 28

KEY TERMS: Pandemic, Avian Influenza, Military Support to Civil Authority, Posse Comitatus

CLASSIFICATION: Unclassified

Recent involvement by the U.S. military with hurricane relief and comments by the President on expanding the DOD's role in disaster relief indicates increased missions for an already stretched military. The next national disaster facing the U.S. could be an influenza pandemic. The bird flu virus H5N1 currently threatening Asia and Europe can potentially mutate into a deadly human influenza pandemic with global consequences. The last major flu pandemic in 1918 killed 50 million people worldwide and 600,000 in the U.S. alone. The United States is not prepared for a human pandemic and the military will have a significant role in any national response. While some departmental level planning has been accomplished recently, interdepartmental coordination and clear identification of the lead federal agency is still lacking. This project explains possible effects of a pandemic on the U.S. and current responsibilities of federal departments involved in disaster relief. Analysis is presented on the evolving role the DOD plays should this event become reality and finally recommends preparations that should be accomplished to prepare the nation for this very real threat. An ad-hoc approach to a pandemic will have severe negative and far reaching affects on our nation and must be avoided.

AVIAN INFLUENZA PANDEMIC MAY EXPAND THE MILITARY ROLE IN DISASTER RELIEF

The role of the United States military in disaster relief operations both internationally and domestically is increasing. In the wake of Hurricane Katrina in the United States gulf coast region, the President of the United States indicated the U.S. military will have an increased role in domestic disaster relief operations. This responsibility primarily belongs to the Department of Homeland Security at the federal level but recent comments by some national leaders suggest that this could change. Based on unique command and control capabilities and other resources that can be mobilized quickly to respond to a disaster, putting the Department of Defense in charge of domestic disaster relief, at first glance, makes sense to many people.

There is no doubt that military assets will be used in the future for domestic disaster relief. The Asian Bird Flu has the potential to lead to a human influenza pandemic that could have staggering affects on the United States and the world. The military's role in an event of this magnitude will be significant and raises many questions. Issues such as local, state, federal and interagency responsibilities as well as lead agency control will be critical. What legal authority and limitations the military has with regard to the Posse Comitatus Act must be reviewed and clarified. And what other effects a disaster relief of this magnitude would have on the military must be explored.

This paper will examine what the potential effects of a human influenza pandemic might be on the United States and what the scope of the disaster response would entail. We will review current roles and planning that is underway, review national documents that have been recently published on a pandemic response, and potential military roles that must be addressed to make a coordinated federal response effective. Changes to current U.S. policy and law may be required. Recommendations for changes in disaster relief operations as well as planning and preparations that must be initiated now will be presented.

The Influenza Pandemic of 1918

A pandemic is an event that occurs over a wide geographic area and affects an exceptionally high proportion of the population.[1] Outbreaks of "the flu" are common and happen every year. "Seasonal outbreaks are caused by subtypes of influenza viruses that already circulate among people whereas pandemic outbreaks are caused by new subtypes that have not circulated among people…"[2] In the United States alone, 36,000 deaths are attributed to influenza annually. [3] When influenza turns into a global pandemic the impacts normally become much more serious with high levels of illness, death, and disruption to economic and societal

systems. There have been a number of influenza pandemics during the 20th century. The most notable and deadly influenza pandemic on record occurred in 1918. Coming at the end of World War One, this pandemic killed an estimated 40 million people worldwide and 675,000 people in the United States alone. Additionally 43,000 United States service members mobilized to fight in World War One died due to the influenza pandemic.[4] This strain of influenza was very contagious and infected over 28 percent of the U.S. population. This fact, combined with no anti-viral medications available during the time period, produced a mortality rate in the United States of 2.5 percent, several times greater than the average mortality rate.[5] Unlike most influenza pandemics that effect very young and very old populations the most, this pandemic's highest death rate was in the 15-34 year old age group. The death rate for this group was 20 times higher in 1918 than in previous years due to the pandemic. Why this unusual age group was most affected is still unknown today. During the peak of the infections, more than 10,000 deaths occurred per week in many major American cities. The impact was so great it caused the life expectancy in the United States to drop by 12 years.[6]

The U.S. population in 1918 was much less concentrated (more rural), less mobile, and on a war footing, and therefore much more inclined to listen to guidance from the state and federal government than could be expected in today's modern society. These and other factors will present significant challenges for the United States when the next influenza pandemic occurs.

The Avian Influenza "Bird Flu" H5N1

There is a wide variety of influenza viruses. Type A influenza viruses are categorized into sub-types based on changes to proteins on the surface of the virus itself. Hemagglutinin (HA) subtypes have 16 variations and Neuraminidase (NA) variations have six different strains. These H and N subtypes combine in various forms to make many types of avian influenza.[7] Additionally, influenza A viruses can change over time by either a gradual mutation or what is called a reassortment of one or more of its gene segments between viruses.[8] The key point is that this ability of the virus to change could produce a virus that is very susceptible to human transmission.

The H5N1 influenza strain is extremely contagious and lethal in birds. Since the emergence of the strain in 1997 hundreds of millions of birds have died or been destroyed, to limit its spread in Asia and Eastern Europe. Although originally thought to be not transferable to humans, there have been a number of cases of humans contracting H5N1. These cases have been almost exclusively the result of handling or direct exposure to infected birds. So currently

the ability of humans to catch the virus from birds is not high and the ability of humans to pass the virus to other humans is very low. The sobering fact is that in the 169 documented cases of human H5N1 to date, 91 deaths have occurred.[9] Asia has been hit hardest by the H5N1 virus with human deaths being reported in Cambodia, China, Indonesia, Thailand, and Vietnam. H5N1 deaths have also been confirmed in Turkey and Iraq.[10] Many other Asian countries have now reported H5N1 in bird populations. As well, countries throughout Europe such as Great Britain, Germany, Romania, Greece, Turkey and now Russia are reporting cases of H5N1 as the virus appears to be spreading by birds on migratory routes.[11] As the avian H5N1 becomes more widespread, contact with humans increases thereby increasing the potential for H5N1 to mutate into a form that is more easily passed between humans.

The World Health Organization (WHO) breaks down global pandemics into six phases:

- Inter-pandemic Period
  - Phase 1 – No new influenza virus subtypes detected in humans
  - Phase 2 – No new subtypes in humans, however, circulating animal virus poses a substantial risk of human disease
- Pandemic Alert Period
  - Phase 3 – Human Infections with a new subtype but no new human-to-human spread
  - Phase 4 – Small clusters with limited human-to-human transmission suggesting virus is not well adapted to humans
  - Phase 5 – Larger clusters but human-to-human transmission is still localized suggesting virus is becoming more adapted to humans – substantial pandemic risk
- Pandemic Period
  - Phase 6 – Pandemic – increased and substantial transmission in the general population[12]

We are currently in the phase three alert period for the H5N1 virus. Because H5N1 has not been identified in humans before the current outbreak, there is very little human immunity for this strain. Although the severity of the next influenza pandemic cannot be determined until it emerges, a mutated virus that is easily spread between humans coupled with a high mortality rate is cause for serious concern.

Primary Means to Combat Pandemic Influenza

Although there is no cure to prevent a pandemic, since the devastation of 1918, a number of methods to combat its effects have been developed. The HHS Pandemic Influenza Plan, published in November 2005, describes a number of response actions which include: surveillance measures, the use of antiviral drugs and vaccine, public heath measures, healthcare and emergency response, and public communications.

Surveillance of populations will aid in the early identification of human to human spread of the influenza. This will aid clinical evaluation of the pandemic strain of influenza and help local, state, and federal officials take necessary action to contain the spread of the pandemic.

A vaccine is defined as a living or dead virulent organism that is administered to produce or artificially increase immunity to a particular disease.[13] Vaccines will be a key component of pandemic response as a measure to prevent the spread of the virus. However, a vaccine for a novel pandemic flu strain cannot be mass produced until the virus presents itself and can be studied and broken down. Despite work by scientists at the National Institutes of Health, predictions say the process to develop a vaccine will likely take six to nine months.[14] Only then can an effective vaccine be mass produced – leaving populations unprotected during the early stages of the pandemic.

Antiviral drugs do not prevent infections but lessen the severity of influenza in the body and will be a key treatment during a pandemic particularly in the early stages until a vaccine is available. The two classes of antiviral drugs target hemagglutinin (HA) and neuraminidase (NA) inhibitors respectively. The H5N1 strain has already shown resistance to HA antivirals, leaving the NA inhibitors of oseltamivir (Tamiflu TM) and zanamivir (Relenza TM) as showing benefit in fighting H5N1 viral effects. Production of these antiviral drugs is limited and there is currently no production within the United States. There are a number of antiviral initiatives under way. Generic production is increasing in several countries which will increase overall availability but all U.S. government planning assumptions indicate the demand for antiviral drugs will far exceed on hand quantities. U.S production of oseltamivir is being pursued by HHS to help improve our national posture.[15] The federal government also maintains the Strategic National Stockpile (SNS) of emergency medical supplies which includes antiviral drugs. Even after increasing stockage levels at the end of 2005, quantities in the SNS will treat less than two percent of the U.S. population.[16] The President and Congress are both serious about increasing our preparedness in this area and have approved funding of increases of antiviral drugs to the range of seven percent [17]coverage with more increases likely. In addition to the SNS, the Department of Defense (DOD) has begun to stockpile antiviral medications to cover

military needs and ensure timely distribution to priority populations based on DOD national security priorities.[18]

Public heath measures will be an important component of pandemic flu containment. Measures including the use of personal protective equipment such as gloves, masks and hand hygiene, cleaning and disinfecting of common surfaces, and handling of pandemic flu patients must all be addressed. Actions such as canceling public events and activities that put people in close quarters such as school, church, or mass transit will all have to be evaluated for impacts on public health. Control measures such as isolation and quarantine may also be useful tools in slowing the spread of a pandemic and fall within the realm of public health measures.[19]

Healthcare response is another area critical to pandemic response. The ability to surge healthcare services, particularly ICU beds and ventilation services for treatment of pneumonia, will be key. HHS is developing a mass causality capability that is deployable and targeted to augment organic hospital capacity. A pandemic could quickly become a catastrophic incident with mass fatalities. The ability to transport, process, store and make final disposition of deceased victims will likely overwhelm local capabilities. State and federal augmentation for mortuary services will likely be required.[20]

Finally a public communications campaign that raises awareness and keeps the population accurately informed of pandemic issues is critical. HHS has the federal lead for pandemic information and has developed a Communications and Public Outreach Strategy for Pandemic Influenza. This plan focuses on public information and enabling state and local authorities to communicate effectively with their populations using a variety of means. Intergovernmental coordination at the federal level is also addressed as a key component for a successful communications campaign.[21]

Potential Impact of an Influenza Pandemic Outbreak in the United States

The Department of Health and Human Services (HHS) is reluctant to fix casualty figures for a future pandemic based on the number of variables involved. Just during an annual influenza season, the impact on the United States correlates to approximately 36,000 deaths, 226,000 hospitalizations, and direct health care costs between $1B and $3B.[22] These are normally low figures based on some type of immunity built up in the human population for various strains already in circulation. Deaths attributed to seasonal influenza are primarily related to aged populations that have reduced immunity or some other progressed/terminal illness and in many cases leads to pneumonia which becomes terminal. Pandemic influenza would be a new strain with little or no human immunity in the human population possibly leading

to more serious morbidity and mortality rates than seasonal influenza. HHS estimates an influenza pandemic similar in scope to 1918, without intervention measures applied against it could result in 1.9 million American deaths, 10 million hospitalizations, and hundreds of billions of dollars in health related costs throughout the course of the pandemic that could last over a year.[23] These numbers are driven by modern trends such as more population in urban areas, increased aging population, and global travel which could lead to significantly more people affected than in past pandemics. Global travel alone will dramatically change the way a pandemic will spread. Pandemic influenza is easily transmitted between people and can be transmitted by people that do not yet show symptoms making it possible for nearly simultaneous outbreaks to occur globally.[24] The pandemic could be spread globally in months or even weeks. With these estimates, health care systems could easily become overloaded. Couple this with many health care providers, first responders, and emergency service providers as victims of the pandemic themselves and you have public systems that will begin to break down.

Possible Affects of Pandemic on the U.S. Military

The pandemic of 1918 caused 43,000 deaths in the U.S. military. In the U.S population approximately one in twenty persons between the ages of 18 to 50 (prime service age) died in a span of 10 weeks because of the pandemic.[25] While advances have been made in medical treatment and prevention of influenza, the military will suffer serious effects during the next pandemic along with the general population. Many military activities take place in close quarter areas. Person to person contact is increased in barracks housing, troop formations, on board ships and aircraft and other military activities which help spread the virus. A high percentage of service members in specific units could be affected simultaneously, degrading combat readiness. A pandemic could have significant impact on combat readiness of Soldiers to the point of restricting military operations. Other effects include: overwhelming of the military health care system, restriction of individual and unit movements, and the diversion of manpower from military missions to disaster relief missions.

The military has had good success with its sustained flu vaccine program over many years for the prevention of annual influenza epidemics in military populations, but the introduction of a new or novel flu strain would mean no immunity in all humans and a higher incident rate of influenza. With a vaccine not available for at least six months after a pandemic is identified, the military's use of antiviral drugs to treat flu victims will be crucial to maintaining combat readiness. Prioritization for these treatments within the DOD has been identified in guidance from the Assistant Secretary of Defense.

Current Federal Roles in National Emergency Response

The federal government has a large role in national emergency response. This role continues to evolve and expand since the watershed events of September 11, 2001. By executive order, President Bush established the Homeland Security Council (HSC) and the Assistant to the President for Homeland Security. The Office of Homeland Security which evolved into the Department of Homeland Security was also established. These federal organizations now have significant responsibility for federal response to manmade and natural disasters.

Interagency coordination will be critical due to the number of federal departments and agencies involved with pandemic planning and response. Other critical organizations in a pandemic response that will be discussed here are the Department of Health and Human Services and the Department of Defense.

Department of Homeland Security (DHS) Role

The Department of Homeland Security (DHS),created by Congress with the Homeland Security Act of 2002, "is responsible for coordinating federal operations within the United States to prepare for, respond to, and recover from terrorist attacks, major disasters, and other emergencies."[26] DHS began reorganizing the 22 agencies directed to be combined into one organization focused on homeland security. The effectiveness of this process has been the subject of numerous debates. Improvements in effectiveness have been made but diversity of missions and cultures have proved to be significant issues with synergizing these functions. In addition to the internal challenges of major reorganization, DHS has the challenge of coordinating federal emergency responses involving assets of many departments and agencies. Interdepartmental coordination is difficult for established organizations, let alone a new department in the throws of getting established. The Homeland Security Presidential Directive - 5 (HSPD-5) signed in February 2003 clearly identifies the Secretary of Homeland Security as the principle federal official for coordinating federal resources

> utilized in response to or recovery from terrorist attacks, major disasters, or other emergencies if and when any one of the following four conditions applies: (1) a Federal department or agency acting under its own authority has requested the assistance of the Secretary [of Homeland Security]; (2) the resources of State and local authorities are overwhelmed and Federal assistance has been requested by the appropriate State and local authorities; (3) more than one Federal department or agency has become substantially involved in responding to the incident; or (4) the Secretary [of Homeland Security] has been directed to assume responsibility for managing the domestic incident by the President.[27]

There are a number of organizations within DHS that will play a role in a pandemic response. Although the Federal Emergency Management Agency (FEMA) focuses on natural disasters, FEMA's core competencies of preventing loss of life and coordinating federal resources during disasters give them a role in DHS response to pandemic. The Coast Guard will have an interdiction role in preventing banned products associated with limiting the spread of pandemics, specifically enforcing the USDA ban on birds and bird products from countries that have documented cases of H5N1 Avian Influenza. Immigration and Customs Enforcement (ICE) will limit the spread of the pandemic through tightened immigration and customs measures. The Bureau of Customs & Border Patrol has the tough task of securing the nation's borders to limit the spread of the virus via illegal entry into the country. Illegal immigrant routes on the southern border with Mexico lead to population centers in southern California and could exacerbate spread of the pandemic in the United States.

HSPD-5 directed the Secretary of Homeland Security to develop and administer a National Response Plan (NRP) as a guiding framework for federal preparation, prevention, response and recovery for domestic incidents of any type. The NRP was coordinated with and signed by all cabinet members and published by DHS in December 2004.[28] HSPD-5 also directed the Secretary of Homeland Security to develop and administer a National Incident Management System (NIMS). The NIMS can be viewed as the implementing instructions for the NRP. It provides the structure, mechanisms, and operating policy for federal government departments and agencies to use for management of domestic incidents, regardless of the cause, complexity, or size.[29] The NIMS was published on 1 March 2004 by DHS. Hurricane Katrina was the first large domestic incident that should have tested the NIMS.

Other actions DHS has taken to prepare for national incident response include standing up the Homeland Security Operations Center (HSOC) to coordinate with other operation/command centers to be the focal point for federal incident management information. The HSOC operates on a 24 hour basis and is staffed full time by members of approximately 40 departments and agencies. The HSOC also fuses many intelligence products into its functions to provide complete situational awareness,[30] but does not exercise any decision authority over ongoing actions. These actions should improve DHS response as the federal lead in the event of a pandemic.

Department of Health and Human Services (HHS) Role

With the Secretary of Homeland Security in charge of coordinating federal agency response, the Secretary for Health and Human Services has the lead for all health and medical

issues relating to a major disaster or emergency.[31] This is obviously a large portion of the total federal response to a pandemic. The HHS Secretary has the authority to declare a public health emergency under the provisions of Public Health Service Act.[32] HHS coordinates externally with the World Health Organization and other international organizations on pandemic planning, information sharing and response. HHS also coordinates internally with state and local governments to incorporate plans and response actions.

In conjunction with DHS, HHS manages a large stock of medicines and medical supplies called the Strategic National Stockpile (SNS). HHS was charged by Congress in 1999 to develop and maintain the SNS to protect the public in the event of a national health emergency of such significance that local supplies are depleted.[33] The SNS is configured into push-packages that can be deployed to affected areas in 12 hours and follow up packages for deployment in 24 to 36 hours. Influenza anti-viral stocks in the SNS have recently been increased but still can only service one to two percent of the U.S. population.[34]

HHS has a host of subordinate organizations playing a role in pandemic preparedness and response. Several with prominent roles are addressed below. HHS uses the Center for Disease Control and Prevention (CDC) to implement the HHS Pandemic Influenza Plan, raise public awareness, conduct laboratory development and testing, and conduct surveillance activities to limit the spread of pandemic. CDC will also make recommendations on use of the SNS and administer controls on quarantines for HHS in the event they become necessary during a pandemic. HHS is directing efforts at the National Institutes of Health for the development and testing of a vaccine for the H5N1 virus strain.[35] The Food and Drug Administration, another HHS agency, approves testing procedures and drugs such as vaccines and anti viral medication for human use and has worked closely with other agencies to fast track pandemic related issues.[36]

Department of Defense Roles

The DOD can leverage tremendous assets in support of domestic disaster relief but is normally in a supporting role. Commitments vary widely depending on the nature of the disaster and the preparedness of the states involved. As an example the U.S. military had a large role in Hurricane Katrina relief operations. At its peak, approximately 72,000 service members assisted in this effort. Other assets included 346 helicopters, 76 fixed-wing aircraft, 21 ships, amphibious landing crafts, satellite imagery, construction support and mortuary teams. Thousands of Gulf coast residents were rescued and evacuated by military forces. Additionally, over 30 million meals ready-to-eat and 10,000 truckloads of ice and water were delivered to the region[37].

Because the magnitude of the hurricane was so large and first responders at the local and state levels were overwhelmed, the federal response was even more critical. With the problems encountered between all levels of government and the various federal agencies involved, the President suggested the Department of Defense (DOD) may be required to take a leadership role in disaster relief operations.[38]

DOD has an improved structure for supporting disaster relief with an Assistant Secretary for Homeland Defense who is the department's POC for support to civil authorities, emergency preparedness, and domestic crisis management.[39] Northern Command (NORTHCOM), the newest unified command in the DOD, was created in 2002 to focus on defense of the homeland and civil support.[40] NORTHCOM does not have forces permanently assigned, but as a combatant command receives forces to accomplish missions that are assigned by the Secretary of Defense. The Assistant Secretary of Defense for Health Affairs (ASD/HA) also has a leading role within DOD during pandemic planning and response.

Missions DOD will be required to execute in the event of pandemic are far reaching. Previous DoD guidance on pandemic planning focused on Force Health Protection (FHP). Updated guidance from ASD/HA expands planning direction to include Defense Support to Civil Authorities (DSCA) and support to Humanitarian Assistance and Disaster Relief (HA/DR) operations.[41] A recent Chairman of the Joint Chiefs of Staff (CJCS) Planning Order directed combatant commands to conduct execution level planning for DOD's response to a pandemic. Potential missions the combatant commanders were directed to include in planning are:

- Augment public health and medical services
- Provide logistic support and distribution of commodities to quarantined and / or isolated persons
- Provide manpower and security support to points of distribution and ports of entry
- Provide subject matter experts, manpower, and technical assistance to augment mortuary affairs operations
- Provide transportation support
- Provide continuity of government
- Augment communications for local, state, tribal and federal communications resources for interoperability
- Provide base and installation support to other local, state and federal agencies
- Ensure protection of defense industrial base, critical infrastructure and mission assurance

- Provide military assistance to civil disturbance for restoration of civil order as it relates to quarantine and isolation enforcement[42]

DOD recently began maintaining its own stockpile of antiviral drugs and vaccine to support military requirements in the event of a pandemic. Once complete, the stockpile will contain sufficient quantities of anti-viral treatments to treat priority requirements until a pandemic vaccine is available to military forces.

Expanding the role of federal military forces will have second and third order effects that must be weighed carefully. The impact of stretching the force by committing more manpower to disaster support during a time of war, legal implications for the force, increased budget costs, and the impact on public perception of the military must all be considered.

Impact of the Posse Comitatus Act on Military Response to Pandemic Support

The ramifications of any new mission for the U.S. military in support of disaster relief within the borders of the United States requires close study based on the 1878 congressional act commonly referred to as "Posse Comitatus".[43]

The Latin term posse comitatus translated means "the power of the county" [44] and in this context, relates to the power of a local county sheriff to form a posse of armed men to expand the size and capability of local law enforcement officials to assist with the enforcement of laws. During civil war reconstruction, the U.S. Army stationed in the southern states was commonly used to enforce reconstruction policy and local laws. The act was initially passed as reconstruction ended, to prevent the common practice of the Army being used to conduct domestic law enforcement.[45]

Because Posse Comitatus is a legislative act and not a constitutional amendment its principle of preventing the federal military from being used for law enforcement actions can be undermined by subsequent laws passed by Congress. In the first half of the 20th century federal troops were used to end the Chicago riots of 1919 and the Truman administration ended a railroad workers strike when he temporarily nationalized the railroads and placed them under the control of the Corps of Engineers. The 1947 National Security Act that created the Department of Defense contains an updated and reinforced reference to Posse Comitatus limiting the role of the armed forces in law enforcement.[46]

The examples of exceptions to the principle of the act are numerous and varied in scope.[47] The Air Force and Navy have been used in the war on drugs, immigration control, and tariff enforcement to interdict smugglers beyond U.S. borders. Federal forces have been used to quell civil disturbances when requested by a state governor or when a state is unable to protect

civil rights and/or property. When the President declares a major natural disaster he may use military forces and support on an emergency basis to preserve life and property such as Hurricane Andrew relief operations in Florida. Several exceptions have been granted to support the war on terror. After approval of the President, The Secretary of Defense can use federal forces, in the event of a terrorist attack involving weapons of mass destruction, nuclear material, or chemical and biological weapons. The President may also use federal forces in the execution of his duties to maintain transportation, education, commerce and civil rights. These exceptions are not part of U.S. Code but are broadly addressed as executive powers in Article II of the U.S. Constitution. Examples of these exemptions include using federal troops for desegregation of southern schools in the 1960's and use of over 10,000 troops to provide security for the 1996 Olympics in Atlanta. These examples are not all inclusive but clearly show there have been significant exceptions made to the original intent of the Posse Comitatus Act.

Posse Comitatus does not apply to National Guard forces while they are under the control of the governors of their respective states. Therefore, these forces may participate in law enforcement activities (and other duties) while in a "state control" status. Title 32 of the U.S. Code details state control of National Guard forces.[48] The President also has the power to federalize National Guard forces placing them under the control of the federal government. Once National Guard forces have been federalized they are subject to the same Posse Comitatus restrictions as active duty federal forces.

The trend in use of federal military for domestic purposes has risen significantly over the last thirty years. This use has led to more conflicts with the Posse Comitatus statues as written and more exemptions being made by the legislative and executive branches. The debate over this use of federal forces has almost entirely been in the academic arena. There has been no public or political outcry of misuse of the military. In most cases where there has been public attention it has been focused on the impediments to allowing more force to be used in relief operations. It must be stated however, that a large majority of federal military support to civil authorities has been relief operations where the military is viewed as a savior and not to law enforcement operations where the federal military could be viewed as an enforcer with negative implications for DOD.

With the use of executive authority over the military and the exemptions to Posse Comitatus enacted by Congress, there is an apparent shift of power from the legislative to executive branch during times of crisis. This could create potential political hurdles for the President in pushing for the Department of Defense to take a leading role in disaster relief operations. It may be viewed as an attempt to consolidate more power in the executive branch

of government and Congress may be unwilling to further modify Posse Comitatus. During a pandemic, the military will likely perform many roles including some law enforcement missions. Clear definition of what actions are authorized by the military to support the federal response is crucial.

Current Actions Underway to Prepare For a Pandemic

The Federal government is now engaged in preparing the U.S. for the next pandemic. In 2004 and 2005 there were several national policy documents developed and published that set the course for federal response to national domestic emergencies starting with the National Incident Management System (NIMS) published by DHS in March 2004. Then the National Response Plan (NRP) was published in December 2004. Both of these documents lay out national priorities and provide specific guidance on roles and responsibilities for federal agencies. Although these documents are published, the effectiveness of the national response to hurricane Katrina indicates a coordinated implementation of the guidance is still to be realized.

In November 2005, in conjunction with a presidential visit to the Department of Health and Human Services, the Homeland Security Council published the National Strategy for Pandemic Influenza. The strategy focuses solely on national preparation, monitoring and response to pandemic influenza.[49] At the same time HHS rolled out their Pandemic Influenza Plan. This document contains extensive information on pandemic influenza and great detail on roles and responsibilities during a pandemic. It contains many detailed supplements providing guidance to state and local authorities as well as information on vaccine and antiviral drug distribution plans. The HHS Pandemic Influenza Plan is also synchronized with the World Health Organization (WHO) Preparedness Plan that was published in May 2005.[50] In addition to published documents on pandemics, HHS and CDC have posted a number of internet websites that provide great information for both public education as well as more detailed and technical information for health care and science professionals.[51]

Another action being taken by HHS is state wide summits conducted in each state, hosted by the HHS Secretary and Governors to raise awareness among state and local leaders, emergency service chiefs, business executives and other public agencies on planning and response to a pandemic. Outreach to the international community is also underway with a team of pandemic experts from USDA, US-AID, HHS, and DOS deployed to Turkey in January 2006 to capture lessons learned and determine how the U.S. can assist Turkey in their fight against Avian Influenza.[52]

On 1 November 2005, the President requested $8.1B in emergency funding from Congress to prepare the U.S. for a pandemic. The request includes funding for development and purchase of vaccine and antiviral drugs, detection and containment of outbreaks, international activities, and preparation of all levels of government to respond.[53] As an example, contracts have been awarded to several vaccine companies to speed the development of cell-culture technology production of vaccines to be used as an alternative to egg based vaccine production that is a 60 year old technology. The fiscal year 2006 portion of the request for $3.8B was authorized by House Resolution 2863 on 30 December 2005. Also in December of 2005, the Homeland Security Advisor and members of the cabinet conducted an executive level tabletop exercise to address interagency coordination in planning and response to a pandemic. An outcome was the need to exercise plans at local, state and federal level to ensure compatibility. So there is plenty of action at the federal level.

The Homeland Security Council is also pushing ahead with publishing the National Implementation Plan for Pandemic Influenza. The implementation plan follows up on the national strategy with detailed guidance on interagency coordination and actions to be accomplished in the event of a pandemic. Coordinating officers detailed from stakeholder departments and agencies to the HSC have been drafting the plan since the end of 2005. It is expected to be signed by cabinet members and published in March 2006.

DOD activity on pandemic preparedness has significantly increased over the last six months. Starting with the publishing of the DOD Strategy for Homeland Defense and Civil Support in June 2005, the department is reshaping the way it supports domestic crisis. All combatant commanders are completing execution level planning for DOD response to pandemic influenza based on a Chairman, JCS planning order published in November 2005. Plans will be coordinated between combatant commands and submitted for CJCS review by February 2005. The Assistant Secretary of Defense for Health Affairs (ASD/HA) published updated guidance on 25 January 2006 to all services on pandemic preparedness and response.[54] This document provides excellent detail on planning assumptions and responsibilities broken down by the phases of a pandemic. DOD is taking aggressive action to stockpile its own anti-viral drugs and vaccine in the event of a pandemic. Stockage levels are being increased to meet potential needs and detailed coordination meetings between the Joint Staff, Services, TRANSCOM and the Defense Supply Center Philadelphia (DSCP) have been completed with regard to distribution of DOD stocks and N-hour sequences.[55] DOD's Implementation Plan for Pandemic Response is currently in staff review with the Services, Joint Staff, and OSD with a target date of 31 March 2006 for signature by the Secretary of Defense.

Interdepartmental partnerships have been established with DOD, DHS, HHS, DOS and the Veterans Administration. In fact DOD and HHS have a signed interagency support agreement dealing with shortfalls in critical medical materials.[56]

Other departments are also taking action in their respective areas to ensure a coordinated response. As an example the USDA is updating its ban on poultry and poultry products from countries affected with H5N1 Avian flu. This action began back in February 2004 and is modified as H5N1 continues to spread across Europe, Asia and Africa.[57] Each federal agency will be required to have its own supporting plan to the National Implementation Plan for Pandemic Influenza once it is published in 2006.

Summary - Conclusions

A flu pandemic will happen again and will affect the United States. The H5N1 Avian influenza virus currently circulating in bird populations in Asia, Europe, and now Africa is spreading at an increasing rate. While human cases of the virus remain limited in number and only to people in direct contact with sick birds, the mortality rate for humans who contract the virus is over 50 percent. If the virus is able to mutate and becomes easily spread between humans a pandemic with staggering affects across the globe is possible. Depending on the morbidity and mortality rates of the virus strain, the impacts on the U.S. health care system and population in general could be debilitating. Affects on the military will be significant and preparation must be completed in order to maintain combat readiness as well as maintain forces that can assist with the disaster response.

Much work has been done in the last six months. A national strategy has been developed and published. Planning is underway in agencies across the federal government and many leaders are taking the threat of a pandemic seriously. Significant funding for preparation has been requested by the President and approved by Congress. Many physical preparations, coordinated by HHS, to increase the Strategic National Stockpile of medicines are underway and some coordination between federal agencies is ongoing. The Department of Homeland Security is making improvements in its organizational structure as well as its ability to coordinate federal actions. However, recent reports on Hurricane Katrina response underscore that much work is still required for DHS to be effective at interagency coordination and direction. The report by the HSC also brings back the recommendation that DOD should be placed in charge of disaster relief under certain circumstances.[58]

HHS, the lead for all health related issues during a pandemic, is taking an active role in preparing the nation. I believe the HHS understands that pandemic influenza is its “Hurricane

Katrina" on a larger scale and is taking extensive action to be ready. The state by state meetings with the HHS Secretary, governors and state responders is an outstanding method to get state and local governments energized on this threat. Its work with CDC, FDA, DOD and other agencies on the development of vaccine and the stockpile of required treatments and equipment is impressive.

Homeland Security Presidential Directive 5 (HSPD-5) published 28 Feb 2003 gives clear guidance and direction. It makes the Homeland Security Advisor responsible for interagency policy coordination on domestic incident management. It defines roles and responsibilities and directs interagency cooperation. However, cooperation does not equal directive authority and assigning responsibility for action without granting the requisite authority to carry it out is problematic. The NIMS and NRP have been published by DHS and provide a framework for operations during an incident of national significance but need to be further refined to make them more effective. A willingness by other departments and agencies to "buy-in" to this interagency process is also required.

DOD resources that can be used in a federal response to a pandemic are significant. The extent to which those assets are employed will be scrutinized at many levels. Changes in structure and the creation of NORTHCOM have postured the department to respond better to support a domestic incident of national significance. DOD is taking action to prepare specifically for a pandemic. These actions have grown from the internal view of force health protection to the myriad of support missions DOD units may be called on to execute. Detailed planning at OSD, Joint Staff and combatant commands will enable a quicker and more effective response to assigned missions. Creation of the DOD stockpile of antiviral and vaccine drugs with detailed prioritization for issue based on the developing situation is a significant step to ensuring the continued readiness of our military force. DOD is involved in some interagency coordination, particularly with HHS and DHS. Continued improvements are required in this arena to ensure a seamless federal response. Posse Comitatus restrictions should be considered with planning military missions during a pandemic. The statute is designed to prevent federal forces from directly conducting law enforcement tasks within the United States. However, with the number of exemptions currently found in the U.S. Code and the desire of the legislative and executive branches to have the military significantly involved in support to civil authorities during disaster relief, it is unlikely that military roles will be limited during a pandemic. The HSC after action report for Hurricane Katrina contains eleven recommendations concerning DOD. One recommendation states that DOD should assume a federal leadership role when dealing with catastrophic relief efforts which is a departure from published guidance giving DHS this leading

role. This unsettled issue must be analyzed and decided long before the next incident of national significance is upon us.

Although some preparation to respond to a pandemic had been in the works, the events of Hurricane Katrina, and its aftermath, clarified the need for federal government agencies to get serious about this different, but potentially devastating threat. The level of preparatory action since Katrina indicates departments and agencies are now serious about their own pandemic preparedness.

Recommendations

HHS must continue to partner with world and regional health organizations such as the WHO, the United Nations, and the European Union. Support to WHO Global Surveillance Laboratories will help halt the spread of bird flu and give us our best early information on a pandemic that begins in another part of the world. HHS should continue to increase the amount of antiviral drugs in the SNS. The Pandemic Response Plan puts the U.S. target at 25% of the population. But organizations such as the Infectious Diseases Society of America (IDSA) and the Society for Healthcare Epidemiology of America (SHEA) advocate a 40% level ideally. [59] Increasing the SNS level to 40% now will offer the U.S. population more protection in the early stages of a pandemic, reduce scrambling to obtain more doses once the pandemic begins, and will help stimulate domestic production of these medications.[60] HHS is involved with some coordination at the federal level but should increase its interagency leadership on health issues of pandemic response. The HHS Pandemic Response Plan does not list “coordinate information sharing with other federal agencies” as a task until Phase 6 of a pandemic. [61] This needs to be a core task conducted during all phases of pandemic planning.

Most of the technical issues of pandemic planning, preparation and response are now being adequately addressed at the departmental level. Departments and agencies are actively involved with their own internal planning and state and local governments are being brought into medical preparations of the national response plan. However interagency coordination needs to be improved. Not enough information sharing is taking place across the federal government. As the HSC continues to develop the National Implementation Plan for Pandemic Influenza some improvement at the action officer level can be observed but more needs to be accomplished. If this process is not improved during the planning and preparation phase, the response phase of the pandemic will be fragmented and the American people will suffer in the end.

We as a government cannot figure out who is going to be in charge of a national pandemic response after it starts or worse yet, when it become a catastrophic event. Based on

the federal response to Hurricane Katrina, President Bush indicated he wants Congress to consider placing the Department of Defense in charge of disaster relief operations.[62] The Federal Response to Hurricane Katrina Lessons Learned report published in February 2006 also recommends that in some cases DOD should be the lead in federal response to a catastrophic incident. These statements run counter to all recently published strategy and implementing policy on disaster relief and the role of DHS. DHS has clearly been identified as the lead federal agency for incidents of national significance and should be allowed to develop that capability. It does not make sense to develop a national response system and then change the leadership organization when a worst case situation is at hand. DHS is just three years old and has not matured as an agency to the point it can maximize the effectiveness of the many disparate functions it now controls. The larger organizational question is whether DHS should be responsible for such a wide variety of missions or should it shed functions such as disaster relief that are not specifically related to security of the homeland. Regardless of that debate, DOD should not be given the lead role for disaster relief, but use its significant resources, as directed by the President, to support relief efforts as appropriate. DOD must maintain focus on its prime mission of national defense. Clear command and control relationships must be decided at the executive level then enforced across all departments to coordinate the federal response. Much of this structure has already been laid out in the NRP and the NIMS and needs to be enforced at the executive level.

The Posse Comitatus Act will not prevent the military from participating or even playing an expanded role in disaster relief. However, for clarity and unity of command the code should be rewritten so there is no doubt about the role of the Department of Defense, its federal forces and reserve forces before the next disaster hits. There should be a clear legislative and executive definition of what limits will be imposed on the use of military forces for domestic law enforcement. The military role should be limited and more precisely defined. Clarity of the law in fast moving disaster relief operations is critical.

The Department of Defense should take action to improve its response in future disaster relief operations. The recently published Strategy for Homeland Defense and Civil Support[63] lays out a good strategy and core concepts for civil support. The document should be improved by including more detailed annexes for the types of disasters that DOD is likely to support such as pandemic influenza. These annexes should detail the types of preparations and interagency coordination required to meet each of these varied challenges. Hard trigger events should be developed for some predictable civil support scenarios. This approach is proactive instead of reactive, takes the politics out of the equation, and allows for better interagency planning.

DOD needs to address force composition and consider the increased demand on military forces for disaster relief missions. Factors that must be considered include what percentage of the force should be active or reserve component and to what extent military forces will be used to support security and disaster relief operations. The President's fiscal year 2007 budget calls for reductions in National Guard and Army Reserve forces which equals less force available to Governors to respond to disaster relief missions in a Title 32 status. I recommend the status quo approach to force structure as it leaves adequate forces in place for all missions and avoids a large political battle that will divert focus from preparing for the nation's security threats.

HSC needs to drive the interagency process as directed in HSPD-5 and complete the implementation plan for pandemic influenza. Current departmental levels of activity will cover the major events of a pandemic. But an efficient and effective, coordinated response is still not realized. If the interagency process and clear command and control issues can be resolved before the next pandemic, the American people will be the beneficiaries.

Endnotes

[1] *Merriam-Webster Online Dictionary*, available from http://www.m-w.com/dictionary/pandemic; Internet; accessed 15 December 2005.

[2] The Center for Disease Control Internet Page on Pandemic Influenza, available from http://www.pandemicflu.gov/general/whatis.html, Internet; accessed 20 February 2006.

[3] George W. Bush, *National Strategy For Pandemic Influenza*,(Washington D.C.: The White House, November 2005), 1.

[4] Molly Billings, "The Influenza Pandemic of 1918"; Stanford University, Human Virology Website, available from http://www.stanford.edu/groups/virus/uda/; Internet; accessed 6 October 2005.

[5] Ann H. Reid and Jeffery K. Taubenberger, "The Origin of the 1918 Pandemic Influenza Virus: A Continuing Enigma," *Journal of General Virology* (September 2003): 2285.

[6] Jeffery K. Taubenberger and Scott P. Layne, "Diagnosis of Influenza Virus: Coming to Grips With the Molecular Era," *Molecular Diagnosis,* Vol. 6 No. 4 (2001): 299.

[7] *The* Center for Disease Control Home Page at "Key Facts About Avian Influenza (Bird Flu) and Avian Influenza A (H5N1) Virus," available from http://www.cdc.gov/flu/avian/gen-info/facts.htm; Internet; accessed 10 October 2005.

[8] Ann H. Reid and Jeffery K. Taubenberger, "The Origin of the 1918 Pandemic Influenza Virus: A Continuing Enigma," *Journal of General Virology* (September 2003): 2285.

[9] World Health Organization, "Cumulative Number of Confirmed Human Cases of Avian Influenza A/ (H5N1) Reported to WHO," available from http://www.who.int/csr/disease/

avian_influenza/country/cases_table_2006_02_13/en/index.html; Internet; accessed 16 February 2006.

[10]World Health Organization, "Cumulative Number of Confirmed Human Cases of Avian Influenza A/ (H5N1) Reported to WHO," available from http://www.who.int/csr/disease/avian_influenza/country/cases_table_2006_02_13/en/index.html; Internet; accessed 16 February 2006.

[11] "Bird Flu Kills 13th Victim in Thailand, Spreads to Taiwan," Associated Press, Foxnews.com, available from http://www.foxnews.com/story/0 ,2933,172852,00.html; Internet; accessed 20 Oct 2005.

[12] World Health Organization, *WHO Global Influenza Preparedness Plan* (Geneva, Switzerland: Department of Communicable Disease, World Health Organization, May 2005), 7.

[13] *Merriam-Webster Online Dictionary*, available from http://www.m-w.com/dictionary/vaccine; Internet; accessed 15 Dec 2005.

[14] William Winkenwerdner, Jr., MD, U.S. Assistant Secretary of Defense – Health Affairs, *"Department of Defense Guidance for Preparation and Response to an Influenza Pandemic caused by the Bird Flu (Avian Influenza),"* memorandum for the Assistant Secretaries of the Military Departments and Director of the Joint Staff, (Washington D.C.: 21 September 2004).

[15] U.S. Department of Health and Human Services, *HHS Pandemic Influenza Plan,* (Washington D.C.: U.S. Department of Health and Human Services, November 2005), D-20.

[16] "Joint Position Statement of the Infectious Diseases Society of America and Society for Healthcare Epidemiology of America on Antiviral Stockpiling for Influenza Preparedness," 31 October 2005; available from http://www.shea-online.org/Assets/files/Oseltamivir_Stickpiling_Position_Paper.pdf; Internet; accessed 12 December 2005.

[17] Todd Zwillich, " Bush Unveils U.S. Flu Readiness Plan", United Press International, 1 Nov 2005, available online from http://www.upi.com/HealthBusiness/view.php?StoryID=20051101-013729-8939r; Internet; accessed 16 February 2006.

[18] David S. C. Chu, U.S. Under Secretary of Defense for Personnel and Readiness, *"Policy for Release of Tamiflu (Oseltamivir) Antiviral Stockpile During an Influenza Pandemic,"* memorandum for the Secretaries of the Military Departments, Chairman of the Joint Chiefs of Staff, (Washington D.C.: 10 January 2006).

[19] U.S. Department of Health and Human Services, *HHS Pandemic Influenza Plan,* (Washington D.C.: U.S. Department of Health and Human Services, November 2005), F-36.

[20] U.S. Department of Health and Human Services, *HHS Pandemic Influenza Plan,* (Washington D.C.: U.S. Department of Health and Human Services, November 2005), F-40.

[21] U.S. Department of Health and Human Services, *HHS Pandemic Influenza Plan,* (Washington D.C.: U.S. Department of Health and Human Services, November 2005), F-41.

[22] U.S. Department of Health and Human Services, *HHS Pandemic Influenza Plan,* (Washington D.C.: U.S. Department of Health and Human Services, November 2005), B-6.

[23] U.S. Department of Health and Human Services, *HHS Pandemic Influenza Plan,* (Washington D.C.: U.S. Department of Health and Human Services, November 2005), 4.

[24] U.S. Department of Health and Human Services, *HHS Pandemic Influenza Plan,* (Washington D.C.: U.S. Department of Health and Human Services, November 2005), B6-7.

[25] William Winkenwerdner, Jr., MD, U.S. Assistant Secretary of Defense – Health Affairs, *"Department of Defense Guidance for Preparation and Response to an Influenza Pandemic caused by the Bird Flu (Avian Influenza),"* memorandum for the Assistant Secretaries of the Military Departments and Director of the Joint Staff, (Washington D.C.: 21 September 2004).

[26] George W. Bush, *Homeland Security Presidential Directive/HSPD-5*, (Washington D.C.: The White House, 28 Feb 2003), paragraph (4).

[27] George W. Bush, *Homeland Security Presidential Directive/HSPD-5*, (Washington D.C.: The White House, 28 Feb 2003), paragraph (4).

[28] Tom Ridge, Secretary of Homeland Security, *"National Response Plan",* (Washington D.C.: Department of Homeland Security, December 2004).

[29] Tom Ridge, Secretary of Homeland Security, *"National Incident Management System,"* (Washington D.C.: Department of Homeland Security, 1 March 2004).

[30] The Department of Homeland Security Home Page, available from http://www.dhs.gov/dhspublic/interapp/press_release/press_release_0456.xml; Internet; accessed 2 Feb 2006.

[31] Robert T. Stafford Disaster Relief and Emergency Assistance Act, U.S. Code, Title 42, Section 5121 (1988).

[32] Public Health Service Act, U.S. Code, Title 42, Section 247d, Public Health Emergencies, (2005).

[33] The Center for Disease Control Home Page, at "Strategic National Stockpile'" available from http://www.bt.cdc.gov/stockpile/; Internet; accessed 15 February 2006.

[34] "Joint Position Statement of the Infectious Diseases Society of America and Society for Healthcare Epidemiology of America on Antiviral Stockpiling for Influenza Preparedness," 31 October 2005; available from http://www.shea-online.org/Assets/files/Oseltamivir_Stickpiling_Position_Paper.pdf; Internet; accessed 12 December 2005.

[35] , "NIAID Initiates Trial of Experimental Avian Flu Vaccine," National Institute of Health, news release, 23 March 2005; available from http://www3.niaid.nih.gov/news.newsreleases/2005/avianfluvax.htm; Internet; accessed 2 February 2006.

[36] "FDA Approves New Laboratory Test To Detect Human Infections With Avian Influenza A/H5 Viruses," Department of Health and Human Services, news release 3 February 2006,

available from http://www.hhs.gov/news/press/2006pres/20060203.html; Internet; accessed 4 February 2006.

[37] U.S. Congress, House of Representatives, Committee on Appropriations, Subcommittee on Defense, Statement by Paul McHale, Assistant Secretary of Defense for Homeland Defense, 109th Cong., 28 September 2005, 4-7.

[38] Jim VandeHei and Josh White, "Bush Urges Shift in Relief Responsibilities" *Washington Post,* 25 September 2005 [newspaper online]; available from http://www.washington post.com/wp-dyn/content/article/2005/09/25/AR2005092501224_2.html; Internet; accessed 6 October 2005.

[39] Paul Wolfewitz, Deputy Secretary of Defense, *"Implementation Guidance Regarding the Assistant Secretary of Defense for Homeland Defense,"* memorandum for the Secretaries of the Military Departments and Chairman of the Joint Chiefs of Staff, (Washington D.C.: U.S. Department of Defense, 25 March 2003).

[40] *The U.S. Northern Command Home Page,* available from http://www.northcom.mil/ index.cfm; Internet; accessed 6 October 2005.

[41] William Winkenwerdner, Jr., MD, U.S. Assistant Secretary of Defense – Health Affairs, *"Department of Defense Influenza Pandemic Preparation and Response Health Policy Guidance,"* memorandum for the Assistant Secretaries of the Military Departments, (Washington D.C.: 25 January 2006).

[42] Department of Defense, Joint Chiefs of Staff, Office of the Chairman, *"CJCS Planning Order, Subject: PANDEMIC INFLUENZA (PI) PLANORD,"* DTG: 141224Z NOV 05, (Washington D.C.: U.S. Department of Defense, 14 November 2005).

[43] Posse Comitatus Act, U.S. Code, Title 18, Part I, Chapter 6, Section 1385 (1878):

> "Whoever, except in cases and under circumstances expressly authorized by the Constitution or Act of Congress, willfully uses any part of the Army or the Air Force as a posse Comitatus or otherwise to execute the laws shall be fined under this title or imprisoned not more than two years, or both."

The Air Force was added to the original act in 1956. The Marine Corps and Navy are not listed in the act itself but are subject to it by DoD Regulation 32 C.F.R. Section 213.2, (1992).

[44] Craig T. Trebilcock, Major, US Army Reserve, "The Myth of Posse Comitatus," Journal of Homeland Security (October 2000): 1.

[45] Trebilcock, 1.

[46] National Security Act, U.S. Code, Title 10, Section 375, (1947)

> "Sec. 375. Restriction on direct participation by military personnel. The Secretary of Defense shall prescribe such regulation as may be necessary to ensure that any activity (including the provision of any equipment of facility or the assignment or detail of any personnel) under this chapter does not include or permit direct

participation by a member of the Army, Navy, Air Force, or Marine Corps in a search, seizure, arrest, or other similar activity unless participation in such activity by such member is otherwise authorized by law".

[47] Trebilcock, 2-3.

These examples of exceptions are found in various sections of U.S. Code, Title 10, Sections 371-381; U.S. Code, Title 10, Sections 331-334; The Stafford Act, U.S. Code, Title 42, Section 5121; U.S. Code, Title 10, Sections 382 and 831.

[48] National Guard Organization, U.S. Code, Title 32, Chapter 1, Section 104, (as amended, 26 January 1998).

[49] U.S. Department of Health and Human Services, *HHS Pandemic Influenza Plan,* (Washington D.C.: U.S. Department of Health and Human Services, November 2005).

[50] World Health Organization, *WHO Global Influenza Preparedness Plan* (Geneva, Switzerland: Department of Communicable Disease, World Health Organization, May 2005).

[51] The Center for Disease Control Internet Page on Pandemic Influenza, available from http://www.pandemicflu.gov; Internet; accessed 20 February 2006; The Center for Disease Control Home Page, available from http://cdc.gov; Internet; accessed 20 February 2006.

[52] Sean McCormack, U.S. Department of State Press Statement, *"US Avian Influenza Team to Turkey,"* (Washington D.C.: U.S. Department of State, 13 January 2006).

[53] White House Press Release, Office of the Press Secretary; *"Fact Sheet – Safeguarding America Against Pandemic Influenza*," (Washington D.C.: The White House, 1 November 2005) available from; http://www.whitehouse.gov/news/releases/2005/11/20051101.html; Internet; accessed 15 February 2006.

[54] William Winkenwerdner, Jr., MD, U.S. Assistant Secretary of Defense – Health Affairs, *"Department of Defense Influenza Pandemic Preparation and Response Health Policy Guidance,"* memorandum for the Assistant Secretaries of the Military Departments, (Washington D.C.: 25 January 2006).

[55] Scott Svabek, Lieutenant Colonel, United States Army, Office of the Assistant Secretary of Defense - Health Affairs; e-mail message to author, 15 February 2006.

[56] Paul McHale, Assistant Secretary of Defense - Homeland Defense, Stewart Simonson, Assistant Secretary of Health and Human Services, *"Interagency Agreement Between the Department of Health and Human Services and the Department of Defense For Support of Contingency Medical Material Requirements,"* Washington D.C., 5 May 2005.

[57] The Center for Disease Control Home Page, "Embargo of Birds From Specified Countries," available from http://www.bt.cdc.gov/flu/avian/outbreaks/embargo.htm; Internet; accessed 15 February 2006.

[58] Frances Fragos Townsend, Assistant to the President For Homeland Security and Counterterrorism, *"The Federal Response to Hurricane Katrina, Lessons Learned,"* (Washington D.C.: The White House, February 2006), 94.

[59] "Joint Position Statement of the Infectious Diseases Society of America and Society for Healthcare Epidemiology of America on Antiviral Stockpiling for Influenza Preparedness," 31 October 2005; available from http://www.shea-online.org/Assets/files/Oseltamivir_Stickpiling_Position_Paper.pdf; Internet; accessed 12 December 2005.

[60] U.S. Department of Health and Human Services, *HHS Pandemic Influenza Plan,* (Washington D.C.: U.S. Department of Health and Human Services, November 2005), 20.

[61] U.S. Department of Health and Human Services, *HHS Pandemic Influenza Plan,* (Washington D.C.: U.S. Department of Health and Human Services, November 2005), 37.

[62] Jim VandeHei and Josh White, "Bush Urges Shift in Relief Responsibilities" *Washington Post,* 25 September 2005 [newspaper online]; available from http://www.washingtonpost.com/wp-dyn/content/article/2005/09/25/AR2005092501224_2.html; Internet; accessed 6 Oct 2005.

[63] Gordan England, Deputy Secretary of Defense, *Strategy for Homeland Defense and Civil Support* (Washington, D.C.: Department of Defense, June 2005).

Nature's Agents or Agents of Empire?

Entomological Workers and Environmental Change during the Construction of the Panama Canal

By Paul S. Sutter*

ABSTRACT

This essay examines the role that entomological workers played in U.S. public health efforts during the construction of the Panama Canal (1904–1914). Entomological workers were critical to mosquito control efforts aimed at the reduction of tropical fevers such as malaria. But in the process of studying vector mosquitoes, they discovered that many of the conditions that produced mosquitoes were not intrinsic to tropical nature *per se* but resulted from the human-caused environmental disturbances that accompanied canal building. This realization did not mesh well with an American ideology of tropical triumphalism premised on the notion that the Americans had conquered unalloyed tropical nature in Panama. The result, however, was not a coherent counternarrative but a set of intra-administrative tensions over what controlling nature meant in Panama. Ultimately, entomological workers were loyal not just to the U.S. imperial mission in Panama but also to a modernist culture of science and to the workings of mosquito ecology as they understood them.

IN HIS LAUDATORY "Introduction" to the 1916 book *Mosquito Control in Panama,* L. O. Howard, the chief of the U.S. Bureau of Entomology and longtime permanent secretary to the American Association for the Advancement of Science, celebrated the

* Department of History, LeConte Hall, University of Georgia, Athens, Georgia 30602-1602.

Much of the research for this article was completed while I was a postdoctoral fellow at the Smithsonian Institution, where Jeffrey Stine and Pamela Henson were my able mentors. I presented versions of this essay at the German Historical Institute, the José Martí International Colloquium in Cuba, the Smithsonian Institution, the Latin American Studies Association, the EcoHealth One conference, and the University of Georgia, and I want to thank all those who provided valuable feedback. For their comments and support I particularly want to thank Shane Hamilton, Neil Maher, Gregg Mitman, and Guillermo Castro. Finally, I want to express my gratitude to Bernie Lightman, the three anonymous referees, and the *Isis* staff.

Isis, 2007, 98:724–754

0021-1753/2007/9804-0003$10.00

mosquito control work done by the Isthmian Canal Commission (ICC) during the construction of the Panama Canal. Howard, who supported that effort from a distance, insisted that such work was "an object lesson for the sanitarians of the world and has demonstrated the vitally important fact that it is possible for the white race to live healthfully in the tropics."[1] With this assertion, Howard added his voice to the triumphalist chorus celebrating the U.S. conquest of tropical nature in Panama.

The technological and engineering feats that distinguished the canal—the giant locks and dams, the Bucyrus steam shovels, and the railroad systems that removed spoil from the famed Culebra Cut—were the most common subjects of such celebratory rhetoric. For many Americans of the time, they were the very stuff of progress, made all the more potent as an "object lesson" because they were achieved by an administrative arm of the U.S. government in a hostile natural environment beyond its borders. In an imperial context in which the technological mastery of nature helped define a nation's level of civilization, American observers crowed that their successful construction of a canal across the isthmus set them apart from the world's other great powers, to say nothing of the "primitive" peoples who increasingly occupied the American imagination.[2]

But next to those civil engineering wonders, on a similar plane of importance, many American observers placed the ICC's sanitary engineering—its local eradication of yellow fever and its control of malaria in particular. Scores of prominent Americans joined Howard in celebrating their apparent sanitary conquest of the tropics. Charles Francis Adams, Jr.—Civil War veteran, past president of the Union Pacific Railroad, amateur historian, grandson of John Quincy Adams, and brother of Henry Adams—called it "an epochal event in sanitation." Having taken control of what was "heretofore the most pestilential region on earth," Adams cheered, the U.S. administration had "proven that the adult male can, by following a prescribed mode of life and observing strict precautionary rules, live, and do a man's work, where he could not live safely or work effectively before." And the head of the U.S. sanitary effort in Panama, William Gorgas, engaged in similar rhetoric in his memoir, *Sanitation in Panama.* "The white man, of all the races of the human family, is the most eager in his pursuit of wealth," Gorgas theorized. "As it becomes generally known that he can live in the tropics and maintain his health, necessarily a large emigration will occur from the present civilized temperate regions to the tropics."[3] These were a few of the many voices—in scores of published books and articles on the subject—that toasted the apparent opening of the tropics to white male settlement and development as a result of American sanitary efforts.

But beyond joining this chorus, Howard made a specific case for the important work done in Panama by a diverse group of entomologists and sanitarians working with ento-

[1] L. O. Howard, "Introduction," in Joseph LePrince and A. J. Orenstein, *Mosquito Control in Panama: The Eradication of Malaria and Yellow Fever in Cuba and Panama* (New York: Putnam's, 1916) (hereafter cited as **LePrince and Orenstein, *Mosquito Control in Panama***), pp. iii–v, on p. iv. On Howard see E. O. Essig, *A History of Entomology* (New York: Macmillan, 1931), pp. 658–664; and L. J. Bruce-Chwatt, "Leland Ossian Howard (1857–1950) and Malaria Control: Then and Now," *Mosquito News,* June 1981, *41*(2):215–225.

[2] On technological dimensions of imperialism see Michael Adas, *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance* (Ithaca, N.Y.: Cornell Univ. Press, 1989); and Adas, *Dominance by Design: Technological Imperatives and America's Civilizing Mission* (Cambridge, Mass.: Harvard Univ. Press, 2006). On the American fascination with primitive peoples see Matthew Frye Jacobson, *Barbarian Virtues: The United States Encounters Foreign Peoples at Home and Abroad, 1876–1917* (New York: Hill & Wang, 2000).

[3] Charles Francis Adams, *The Panama Canal: An Epochal Event in Sanitation* (Boston, 1911), pp. 26–27; and William C. Gorgas, *Sanitation in Panama* (New York: Appleton, 1915), p. 289.

mological knowledge, a group I call "entomological workers." The discovery of the mosquito vectors for malaria and yellow fever, confirmed around the turn of the century in several far-flung parts of the globe, separated the successful U.S. effort to build a transisthmian canal (1904–1914) from the French failure two decades earlier. As those discoveries became accepted scientific truth—a messy and uneven process—Howard and his colleagues went to work. First in Cuba and then more thoroughly in Panama, U.S. entomological workers determined the breeding and feeding habits of vector species—for malaria, several species of the genus *Anopheles,* and for yellow fever, the species *Aedes aegypti*—and convinced high-ranking officials that precision mosquito control ought to be the centerpiece of the U.S. sanitary efforts against these diseases. In the process, entomologists became critical actors in the American administration of Panama and other tropical territories. Control of the Panamanian tropics and the vector-borne diseases closely associated with the region, Howard intimated, would not have been as efficient or successful without entomologists' intimate understanding of environmental conditions on the ground. What Howard did not suggest, and what his rhetoric hid, was that that understanding of the ecology of these diseases—in this essay I focus solely on malaria—came into tension with a dominant set of American, indeed Western, assumptions about the hostility of the tropics to white settlement. While most Americans, participants and observers, assumed that they needed to conquer a singular and unalloyed tropical nature to complete the canal, entomological workers discovered that what needed controlling was a debased hybrid landscape.[4]

This essay examines the place of entomological workers in the dynamic interplay between an environmental ideology of tropical triumphalism and the ecology of malaria during the U.S. construction of the Panama Canal. I divide the essay into several parts. First, I situate my effort at the intersection of several historiographies and grapple with theoretical questions arising from this nexus. Next, I briefly outline American thinking about the tropics, particularly emphasizing how this body of thought tended to naturalize diseases such as malaria. Then I examine how mosquito control became a central strategy of U.S. sanitation in Panama and how entomological workers emerged as lead actors in that process. The decision to focus on mosquito control rather than its alternatives, I argue, opened up an ecological line of inquiry that highlighted the tensions between malarial ecology and the logic of tropical triumphalism. Finally, I examine a mundane but telling debate—over how short to cut the grass around workers' quarters—in which these tensions played out. I argue that entomological workers gave voice to a set of environmental conditions that defied American expectations of nature in Panama and that their experiences offer an important model for rethinking the relationship between science, imperialism, and the environment.

HISTORIOGRAPHY AND THEORY

As an environmental historian, I am interested in how the interplay between ideology and ecology shaped the history of canal construction in Panama—and, for that matter, the larger history of U.S. activity in the Latin American, Asian, and African tropics—and in

[4] The best general history of both the French and U.S. efforts to build a canal is still David McCullough, *The Path between the Seas: The Creation of the Panama Canal, 1870–1914* (New York: Simon & Schuster, 1977). On the importance of hybrid landscapes to U.S. environmental historiography see Richard White, "From Wilderness to Hybrid Landscapes: The Cultural Turn in Environmental History," *Historian,* 2004, *66:*557–564.

how scientists influenced and navigated that interplay. Environmental historians of the United States have been slow to move beyond the nation's borders to chart the environmental implications of the United States as a hemispheric and global actor. The strong connections between nature and nation in U.S. historiography have kept us at home, focused on continental colonization and the wilderness discourse that dominated that process.[5] But just as that discourse reached a key transitional moment in the late nineteenth century, Americans entered into a transimperial conversation about the tropics as both a region and a problem to be solved. The tropics thus became the dominant environmental imaginary of extracontinental U.S. expansion, just as wilderness was for continental expansion. An analytical focus on the tropics, then, pulls U.S. environmental historiography in an international direction, putting it in dialogue with another vital historiography.

Students of U.S. empire, influenced by broader developments in colonial and postcolonial historiography, have moved away from monolithic analyses of imperial power, finding and mining veins of local accommodation and resistance, delineating the complex and intimate social and cultural territory of the imperial encounter, charting internal heterogeneity among the colonizers and the colonized, and demonstrating how agents and events on the periphery often reshaped core policies, practices, and cultures.[6] Particularly germane to this essay has been a move away from analyses of discursive and representational practices and toward the material dimensions of imperial control—to a focus on how power has been exercised on the ground.[7] But historians of U.S. empire have only just begun to recognize the centrality of environmental management to the nation's extracontinental expansion, and environment has only rarely been taken seriously as one of those material dimensions shaping imperial power. A central goal of this essay is to apply to American tropical triumphalism a rigorous analysis of what happened when that ideology met the environments that its practitioners sought to describe and control.[8]

[5] For a discussion of these issues see Paul S. Sutter, "What Can U.S. Environmental Historians Learn from Non-U.S. Environmental Historiography?" *Environmental History,* Jan. 2003, *8:*109–129. Richard Tucker's *Insatiable Appetite: The United States and the Ecological Degradation of the Tropical World* (Berkeley/Los Angeles: Univ. California Press, 2000) and John Soluri's *Banana Cultures: Agriculture, Consumption, and Environmental Change in Honduras and the United States* (Austin: Univ. Texas Press, 2006) are important models.

[6] This is a growing literature, though it is well represented in three collections of essays: Gilbert M. Joseph, Catherine C. Legrand, and Ricardo D. Salvatore, eds., *Close Encounters of Empire: Writing the Cultural History of U.S.–Latin American Relations* (Durham, N.C.: Duke Univ. Press, 1998); Amy Kaplan and Donald Pease, eds., *Cultures of United States Imperialism* (Durham, N.C.: Duke Univ. Press, 1993); and Ann Laura Stoler, ed., *Haunted by Empire: Geographies of Intimacy in North American History* (Durham, N.C.: Duke Univ. Press, 2006). Among other important studies in this field are Mary Renda, *Taking Haiti: Military Occupation and the Culture of U.S. Imperialism, 1915–1940* (Chapel Hill: Univ. North Carolina Press, 2001); Kristen Hoganson, *Fighting for American Manhood: How Gender Politics Provoked the Spanish–American and Philippine–American Wars* (New Haven, Conn.: Yale Univ. Press, 1998); Laura Briggs, *Reproducing Empire: Race, Sex, Science, and U.S. Imperialism in Puerto Rico* (Berkeley: Univ. California Press, 2002); and Paul Kramer, *The Blood of Government: Race, Empire, the United States, and the Philippines* (Chapel Hill: Univ. North Carolina Press, 2006). An influential text in the broader historiographical reconsideration has been Frederick Cooper and Stoler, eds., *Tensions of Empire: Colonial Cultures in a Bourgeois World* (Berkeley: Univ. California Press, 1997).

[7] The classic text that set the stage for much of the postcolonial focus on the discursive and representational was Edward Said, *Orientalism* (New York: Vintage, 1979).

[8] Several scholars have recognized the power of tropical thinking to serve an agenda of imperial domination in the same way that racial discourses did, but those analyses have dwelled mostly on its social and cultural dimensions. See David Arnold, "Inventing the Tropics," in *The Problem of Nature: Environment, Culture, and European Expansion* (Cambridge, Mass.: Blackwell, 1996), pp. 141–168; Nancy Leys Stepan, *Picturing Tropical Nature* (Ithaca, N.Y.: Cornell Univ. Press, 2001); Stephen Frenkel, "Jungle Stories: North American Representations of Tropical Panama," *Geographical Review,* 2007, *86:*317–333; and Frenkel, "Geographical Representations of the 'Other': The Landscape of the Panama Canal Zone," *Journal of Historical Geography,* 2002, *28:*85–99. A growing number of scholars have shown how the human subjects of this discourse on tropicality

Such an approach raises a theoretical conundrum that has long plagued environmental historians. How does one, aware of the constructedness of past ideas of nature, give the material environment a voice (or voices) in speaking to those constructions without simply offering a construction of one's own? Environmental historians' most common response to this dilemma has been a pragmatic one: do the best we can with current science, explicating how nature as we now understand it works and using that understanding to expose the fallacious thinking of the past. Such an approach has its merits, but it treats past and present knowledge inconsistently, using current science uncritically while assuming that past science (and the broader intellectual enterprise of thinking about nature) was the constructed political, social, and cultural practice that historians of science have rightly seen it as. Attention to the historiography and sociology of science, then, ought to compel environmental historians to think more critically about how we use current scientific knowledge to portray the environment as an active historical force.

A more satisfying approach to this theoretical problem than using current science pragmatically is to observe how scientific workers in the past integrated their acquired knowledge of environmental conditions with the ideologies that put them into the field—or, in the case of Panama, how entomological workers squared their emerging understanding of mosquito ecology, gained through observation and experimentation, with reigning ideas of tropical nature.[9] Several approaches in the historiography of science are helpful here. One is the route laid out by the historian of science Robert Kohler, who has provided an intriguing model for what we might call the environmental history of science. In several books, Kohler has looked not only at how scientific practice has reworked nature but also at how the material environment has intruded upon and reshaped scientific practice. His work suggests that the environment is not only a mute subject of scientific study but also an intrusive force that contributes to the social construction of scientific activity.[10] Another promising approach is that offered by actor-network theory (ANT). The proponents of ANT offer a model of causation lodged in collective networks of human and nonhuman actors and structures. ANT rejects the categorical dualism of nature and humanity, allowing for the agency of the nonhuman environment while also calling into question the existence

were able to use its logic to bolster, or even construct, local authority, turning tropical identity into a point of pride. See Arnold, *Colonizing the Body: State Medicine and Epidemic Disease in Nineteenth-Century India* (Berkeley: Univ. California Press, 1993); Julyan Peard, *Race, Place, and Medicine: The Idea of the Tropics in Nineteenth-Century Brazilian Medicine* (Durham, N.C.: Duke Univ. Press, 1999); and Stepan, "Tropical Modernism: Designing the Tropical Landscape," *Singapore Journal of Tropical Geography,* 2000, *21:*76–91.

[9] There has been a hearty, if narrow, debate about how science and scientists functioned as agents of imperialism. Some scholars argue that scientists were merely agents of empire, applying an objectifying discourse of natural history exploration and collection in ways that had decidedly instrumentalist results. See, e.g., Lucille Brockway, *Science and Colonial Expansion: The Role of the British Royal Botanic Gardens* (1979; New Haven, Conn.: Yale Univ. Press, 2002); and Mary Louise Pratt, *Imperial Eyes: Travel Writing and Transculturation* (New York: Routledge, 1992). Other scholars, Richard Grove most notably, suggest that naturalists working on the periphery of empire were in a position to witness profound degradation and that their experience gave birth to modern environmental concern; see Grove, *Green Imperialism: Colonial Expansion, Tropical Island Edens, and the Origins of Environmentalism, 1600–1860* (New York: Cambridge Univ. Press, 1995). Stuart McCook's notion of botany in the Spanish Caribbean as a "creole science" is an excellent example of a growing scholarship that rejects this either/or debate; see McCook, *States of Nature: Science, Agriculture, and Environment in the Spanish Caribbean, 1760–1940* (Austin: Univ. Texas Press, 2002).

[10] Robert E. Kohler, *Lords of the Fly:* Drosophila *Genetics and the Experimental Life* (Chicago: Univ. Chicago Press, 1994); and Kohler, *Landscapes and Labscapes: Exploring the Lab–Field Border in Biology* (Chicago: Univ. Chicago Press, 2002). For a similar approach see Joshua Blu Buhs, "The Fire Ant Wars: Nature and Science in the Pesticide Controversies of the Late Twentieth Century," *Isis,* 2002, *93:*377–400; and Buhs, *Fire Ant Wars: Nature, Science, and Public Policy in Twentieth-Century America* (Chicago: Univ. Chicago Press, 2004).

of a singular "Nature" capable of independent action. While ANT sometimes lumps together in networks various agencies and structures—bodies, institutions, technologies, environmental entities and forces—that scholars might want to tease apart, it nonetheless provides an intriguing model for navigating between materialist and social constructivist perspectives. ANT suggests that, rather than seeing "Nature" as an actor apart from humanity, we need to conceptualize and examine hybrid environments as fields of agency and power in which the human and nonhuman intermingle and together shape change over time.[11]

The material environment that I seek to animate in this essay, then, is not a willful agent, a singular actor with intent or clear interests. Rather, it is an agglomeration of forces and structures that can be difficult to read in the service of agency. Environmental historians know full well that "Nature" does not speak for itself in any simple sense, and we have become acutely aware that speaking for nature is, no matter how solid our scientific backing, a subjective and fraught enterprise. Indeed, for some, environmental history has become the practice of documenting competing claims to speak for nature, all of which reveal social power but none of which adequately gets at a material environment beyond our reach. In this essay, and the larger project of which it is a part, I hope to reveal rather than repeat the power that the singular construct "Nature" has had to naturalize human actions and choices. But I am not fully ready to give up on finding and narrating an environment that acts in history beyond human subjectivity. Recent work in the historiography and sociology of science seems particularly helpful, then, in the project of challenging monolithic and naturalizing notions of "Nature" while also maintaining an insistence on material environmental agency.

I want to take these historiographical and theoretical insights and bring them to bear not just on scientific practice, but on the larger field of U.S. colonial administration, to show how the environment intruded upon that experiment as well. In Panama, entomologists worked at a critical juncture between dominant ideas of nature and environmental phenomena; they had intimate experiences with the material environment that had the potential to reinforce or destabilize ruling ideas of nature and to reveal tensions between their positions and those of other imperial actors. They were not mere captives of tropical ideology. My argument is not that scientists give us unmediated access to material environmental agency—that they are, in a sense, nature's agents. Nor do I intend to imply that they are the only group in the imperial field who work across this gap between the material environment and idealized nature. Rather, my aim is to suggest that material environmental influence can be seen quite clearly at the points of tension between ideological predisposition and empirical observation and that scientists are particularly fruitful subjects for examining such tensions. To paraphrase Richard White: the environment not only spoke back in Panama; the goals and methods of entomological workers invited it to do so.[12]

[11] In charting this approach I have been influenced by Gregg Mitman, "Where Ecology, Nature, and Politics Meet: Reclaiming *The Death of Nature,*" *Isis,* 2006, *97:*494–504; Timothy Mitchell, "Can the Mosquito Speak?" in *The Rule of Experts: Egypt, Techno-Politics, Modernity* (Berkeley: Univ. California Press, 2002), pp. 19–53; and Scott Kirsch and Don Mitchell, "The Nature of Things: Dead Labor, Non-Human Actors, and the Persistence of Marxism," *Antipode,* 2004, *36:*687–705. On ANT see Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network Theory* (New York: Oxford Univ. Press, 2005); Latour, *Politics of Nature: How to Bring the Sciences into Democracy* (Cambridge, Mass.: Harvard Univ. Press, 2004); and John Law, "Technology and Heterogeneous Engineering: The Case of Portuguese Expansion," in *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology,* ed. Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch (Cambridge, Mass.: MIT Press, 1987), pp. 111–134.

[12] Richard White, "Discovering Nature in North America," *Journal of American History,* 1992, *79:*874–891, paraphrase drawn from quote on p. 889.

What entomological workers in Panama observed subtly challenged a basic premise of American tropical thinking: that Panama was, by nature, hostile to white people from temperate regions and thus had to be tightly controlled for whites to live healthy lives there. Entomologists in Panama never ceased to be agents of empire; as Howard's opening comment suggests, they were eager triumphalists when highlighting their role in controlling tropical diseases. But to see them merely as agents of empire, and to fail to disaggregate that category, is to miss how the environment they observed, and that acted along with them, led them to a potentially subversive insight: while many lauded the U.S. sanitary conquest of tropical Panama, entomological workers on the ground intimated that the ICC's real sanitary achievement was in overcoming environmental conditions that U.S. canal building had a strong hand in creating.

CONCEPTUALIZING THE TROPICS

When the United States entered the new nation of Panama in 1904, administrators faced a series of discrete engineering and public health challenges that they, like other Western imperial powers, tended to categorize as "tropical." U.S. canal builders, and American observers of that process, were by no means the first to think about the tropics as an environmental space that threatened the enterprises of white peoples from temperate zones. One can trace ideas about the medical and constitutional challenges of warm climates and torrid zones back to the ancient world. But a coherent discourse on the tropics emerged only during the early period of European exploration in the fifteenth century, and it assumed its modern form in the eighteenth and nineteenth centuries. As Nancy Leys Stepan has argued, modern notions of the tropics relied on a rigorous and geographically informed natural history, the development of modern human sciences such as anthropology, and a revival of medical geography. Together these disciplines made sense of the natural, human, and medical tropics, assembling them into a single geographical category at a moment when European powers had turned their imperial attention to these regions. Modern tropical thinking, then, was the product of several coalescing efforts at scientific exploration and categorization in an imperial age.[13]

Europeans led the way in crafting modern representations of the tropics, but, by the middle of the nineteenth century, expansionism of various sorts prompted North Americans to think about the tropics as well—and, influenced by the Prussian scientist and explorer Alexander von Humboldt, the American tropics in particular. Gold rush migrants and government explorers, travel writers and filibusterers, landscape painters and naturalists, capitalists and workers, diplomats and soldiers—all moved into and through the American tropics during the nineteenth century, writing about and representing the region to a substantial domestic audience. Americans also watched intently as the French floundered in their efforts to build a sea-level canal in Panama in the 1880s, losing more than twenty thousand workers to an environment that one prominent Frenchman described as "literally poisoned."[14] By the late nineteenth century, as a similarly diverse set of actors charted the

[13] On ancient notions of the tropics see Clarence J. Glacken, *Traces on the Rhodian Shore: Nature and Culture in Western Thought from Ancient Times to the End of the Eighteenth Century* (Berkeley: Univ. California Press, 1967); and May Berenbaum, *Bugs in the System: Insects and Their Impacts on Human Affairs* (Reading, Mass.: Helix, 1995), pp. 232–233. David Arnold argues for the fifteenth-century origins of tropical thinking in *Problem of Nature* (cit. n. 8), p. 143. On the formative importance of the eighteenth and nineteenth centuries see Stepan, *Picturing Tropical Nature* (cit. n. 8), pp. 16–17.

[14] McCullough, *Path between the Seas* (cit. n. 4), p. 80. For two very different interpretations of Humboldt

wilderness of the American West, parallel activities in Latin America fueled a growing American literature on and set of assumptions about the tropics that would serve U.S. expansion in the wake of the Spanish-American-Cuban War.

Historically, tropical thinking has been deeply ambivalent, with observers alternately portraying the tropics as edenic and hellish. Early European encounters tended to fall into the former category, with explorers depicting the tropics as bountiful and beautiful. But by the late eighteenth century, as it became clear that disease was a considerable obstacle to tropical colonization (and as colonial regimes transformed tropical environments in ways that made them more amenable to disease), what Philip Curtin has called the "terror" of the tropics emerged as an equal partner in the discourse.[15] The balance swung further in a negative direction during the nineteenth century, as Enlightenment ideas about human adaptability to environmental conditions yielded to notions about the impossibility of temperate peoples acclimatizing themselves to the tropics. Increasingly, temperate zone theorists argued, life in the tropics implied physical and moral degeneracy for northern peoples, and they looked on tropical denizens as physically and morally inferior in increasingly racialized ways. While an "affirmative tropicality" lived on in the legacy of Humboldt and other prominent naturalists who studied the tropics, Europeans and North Americans mostly came to see the tropics as a hostile environment and a vexing imperial problem.[16]

Concerns about race and labor informed the tropical thinking of temperate zone observers; their musings about exotic nature easily slid into questions about the attributes of tropical "natives," and vice versa. Why were tropical regions, where nature seemed so bountiful, so undeveloped by Western standards? Was the tropical climate so enervating that civilization could not flower there, or did the natural bounty of the tropics promote slothfulness among the residents? What would happen to the work ethic of white Americans, forged in supposedly edifying temperate climates, under tropical conditions? These were compelling questions for a nation about to undertake a vast and expensive public engineering enterprise in the tropics. And because racial distinctions appeared to mirror the tropical/temperate divide, many saw race as a "natural" way of organizing these ques-

and his influence see Pratt, *Imperial Eyes* (cit. n. 9); and Aaron Sachs, *The Humboldt Current: Nineteenth-Century Exploration and the Roots of American Environmentalism* (New York: Viking, 2006). On the Panama gold rush transit see Aims McGuiness, "In the Path of Empire: Labor, Land, and Liberty in Panama during the California Gold Rush" (Ph.D. diss., Univ. Michigan, 2001); and Brian Roberts, *American Alchemy: The California Gold Rush and Middle-Class Culture* (Chapel Hill: Univ. North Carolina Press, 2000). On American travel writing about Central America during this period see Larzer Ziff, *Return Passages: Great American Travel Writing, 1780–1910* (New Haven, Conn.: Yale Univ. Press, 2001). On American landscape painters in the tropics see Katherine Manthorne, *Tropical Renaissance: North American Artists Exploring Latin America, 1839–1879* (Washington, D.C.: Smithsonian Institution Press, 1989). On the development of tropical agriculture see Tucker, *Insatiable Appetite* (cit. n. 5); and Soluri, *Banana Cultures* (cit. n. 5). On the broader history of U.S. perceptions of Latin American nature and society see Frederick Pike, *United States and Latin America: Myths and Stereotypes of Civilization and Nature* (Austin: Univ. Texas Press, 1992).

[15] Arnold, *Problem of Nature* (cit. n. 8), pp. 144–145; Philip Curtin, *The Image of Africa: British Ideas and Action, 1780–1850* (Madison: Univ. Wisconsin Press, 1964), pp. 58–87; and John McNeill, "Epidemics, Environment, and Empire: Yellow Fever and Geopolitics in the American Tropics, 1620–1825," *Environment and History,* 1999, *5:*175–184.

[16] Arnold, *Problem of Nature,* p. 146; and Stepan, *Picturing Tropical Nature* (cit. n. 8), pp. 35–43. Philip Curtin charted the cost in lives of British attempts to settle the tropics in *Death by Migration: Europe's Encounter with the Tropical World in the Nineteenth Century* (New York: Cambridge Univ. Press, 1989). On the shift from acclimatization to degeneracy see the articles in the special section on "Race and Acclimatization in Colonial Medicine" in the *Bulletin of the History of Medicine,* 1996, *70*(1), including Warwick Anderson, "Disease, Race, and Empire" (pp. 62–67); Mark Harrison, "'The Tender Frame of Man': Disease, Climate, and Racial Difference in India and the West Indies, 1760–1860" (pp. 68–93); and Anderson, "Immunities of Empire: Race, Disease, and the New Tropical Medicine, 1900–1920" (pp. 94–118).

tions about labor efficiency and development. As the quotations with which I began this essay suggest, many saw the tropics as hostile to whites by nature.

Health also was integral to this tropical/temperate binary. White Americans brought with them to Panama deep anxieties about how the tropics would affect their bodies and constitutions.[17] They also wondered why tropical peoples seemed less affected by a climate and suite of diseases that struck white outsiders with a vengeance.[18] These fears were rooted in a miasmatic paradigm whose adherents postulated that emanations—bad air generated by swamps, other forms of putrefying vegetation, or the workings of the tropical climate on human filth—were the agents of tropical fevers such as malaria. While most writers on the subject, from diarists to medical experts, understood that such miasmas were not unique to the tropics, they assumed that tropical regions were uniquely productive of them. Swamps supposedly produced these emanations in abundance, particularly at night, and many feared that the turning over of tropical soils on the scale that would occur during the excavation of the Panama Canal would disinter these poisons and lay low those who were not immune. The miasmatic theory, though it sometimes encouraged careful attention to specific medical topographies, just as often led to a broad indictment of tropical nature and the tropical climate as constitutionally debilitating and disease producing. "When nineteenth-century Europeans wrote about the dangers of a tropical climate," Philip Curtin has written about the African setting, "they meant literally that temperature, humidity, [and] emanations from the soil were the sources of danger."[19] The same can be said for turn-of-the-century Americans, although, critically, they entered Panama with a more precise understanding of where these diseases came from and thus with several new options for understanding and attacking them.

MOSQUITO VECTORS AND NEW SANITARY CHOICES

Because modern Western notions about the tropics as a discrete region were forged within a miasmatic tradition, one might expect the mosquito vector discoveries for malaria and yellow fever to have thrown tropical thinking into flux. Surprisingly, they prompted only

[17] The tropics were in some senses one of the last redoubts of a once-prevalent American mode of thinking that connected the environment and bodily health, a mode that faded with the germ theory. On this mode of thinking see Conevery Bolton Valencius, *The Health of the Country: How American Settlers Understood Themselves and Their Land* (New York: Basic, 2002); Linda Nash, *Inescapable Ecologies: A History of Environment, Disease, and Knowledge* (Berkeley: Univ. California Press, 2007); and Gregg Mitman, *Breathing Spaces: How Allergies Shape Our Lives and Landscapes* (New Haven, Conn.: Yale Univ. Press, 2007). On these anxieties in another U.S. imperial setting see Warwick Anderson, *Colonial Pathologies: American Tropical Medicine, Race, and Hygiene in the Philippines* (Durham, N.C.: Duke Univ. Press, 2006).

[18] Tropical "native" status had long implied that one was nonwhite, disease resistant, and constitutionally suited to working under tropical conditions. These connections were made in the context of North American slavery. See, e.g., Peter Wood, *Black Majority: Negroes in Colonial South Carolina from 1670 to the Stono Rebellion* (New York: Knopf, 1974); and Mart Stewart, *"What Nature Suffers to Groe": Life, Labor, and Landscape on the Georgia Coast, 1680–1920* (Athens: Univ. Georgia Press, 1996). On disease exchanges and the physiology behind perceptions of disease resistance see Kenneth Kiple, *The Caribbean Slave: A Biological History* (New York: Cambridge Univ. Press, 1984); Kiple, ed., *The African Exchange: Toward a Biological History of Black People* (Durham, N.C.: Duke Univ. Press, 1988); Kiple and Virginia H. King, "Black Yellow Fever Immunities, Innate and Acquired, as Revealed in the American South," *Social Science History,* 1977, *1:*419–436; Richard B. Sheridan, *Doctors and Slaves: A Medical and Demographic History of Slavery in the West Indies* (New York: Cambridge, 1985); Philip D. Curtin, "Epidemiology and the Slave Trade," *Political Science Quarterly,* 1968, *82*(3):190–216; Curtin, "Disease Exchange across the Tropical Atlantic," *History and Philosophy of the Life Sciences,* 1993, *15:*329–356; and McNeill, "Epidemics, Environment, and Empire" (cit. n. 15).

[19] Philip Curtin, "Medical Knowledge and Urban Planning in Tropical Africa," *American Historical Review,* 1985, *90:*594–613, on p. 596.

a minor recalibration among most observers. Rather than seeing the tropics as miasmatic, many insisted that the region was uniquely productive of insect life. Others mixed miasmatic and mosquito theories, making little effort to appreciate the challenges these new discoveries posed to miasmatic logic. Still others began the slow process of teasing apart disease investigation—in this case figuring out the discrete etiologies of malaria and yellow fever—from questions about the physiological effects of the tropical climate, a project that would eventually challenge major assumptions about the capacity of white labor in the tropics.[20] But that process took time. While it might be tempting to assume that the vector discoveries, like a flash of light, replaced miasmatic superstition with scientific truth, the reality was more complex. The mosquito control work done in Panama was at the heart of that complexity.

While tropical nature remained definitive of the public health problem in the eyes of most Americans as the United States entered Panama, the mosquito vector facilitated a pernicious link that reframed tropical sanitary choices: for malaria and other vector-borne tropical diseases to survive, there had to be a reservoir of infected people from whom mosquitoes could obtain the parasite or virus before passing it on to others. That notion, a novel product of the vector theory, put the bodies and behaviors of "tropical" peoples under heavy scrutiny.[21] The miasmatic tradition, which largely blamed nature for disease, generally had justified imperial neglect of "native" public health, at least when it came to tropical fevers (contagious diseases were a different story); but the vector discoveries linked the health of natives and imported "tropical" laborers (mostly black West Indians in Panama) with that of white newcomers in important ways. Imperial public health authorities thus faced several options in controlling malaria as they adjusted to the vector theories: they could embrace racial segregation as a sanitary policy that separated vulnerable outsiders from diseased tropical peoples; they could broaden their public health efforts in an attempt to eliminate native disease reservoirs; or they could attempt to control the mosquito link in disease transmission.

Sanitary segregation had its supporters, in Panama as well as in other imperial settings. The approach emerged most clearly in portions of British West Africa, particularly in the work of S. R. Christophers and J. W. W. Stephens of the Liverpool School of Tropical Medicine. In his primer *Mosquito Brigades and How to Organize Them,* Ronald Ross, who had discovered the *Anopheles* vector for malaria, also suggested segregation as an approach in British India, though he was a stronger advocate of mosquito control.[22] Following these leads, several U.S. officials suggested sanitary segregation for Panama. Henry

[20] Weston Chamberlain, "Some Features of the Physiologic Activity of Americans in the Philippines," *American Journal of Tropical Diseases and Preventive Medicine,* 1913, *1*(1):12–32; and Chamberlain, "The Influence of Tropical Residence on the Blood," *ibid.,* 1914, *2*(1):41–55. On Chamberlain's work see Anderson, *Colonial Pathologies* (cit. n. 17), pp. 74–87.

[21] On these issues in other settings see the articles in the special section on "Race and Acclimatization in Colonial Medicine," *Bull. Hist. Med.,* 1996, *70*(1). The best treatments of yellow fever and malaria in the North American setting have been provided by Margaret Humphreys: *Yellow Fever and the South* (New Brunswick, N.J.: Rutgers Univ. Press, 1992); and *Malaria: Poverty, Race, and Public Health in the United States* (Baltimore: Johns Hopkins Univ. Press, 2001).

[22] S. R. Christophers and J. W. W. Stephens, "The Native as the Prime Agent in the Malarial Infection of Europeans," *Further Reports of the Malarial Committee of the Royal Society* (1900), pp. 3–19; Stephens and Christophers, *Practical Study of Malaria and Other Blood Parasites* (London: Univ. Press Liverpool, 1904); and Ronald Ross, *Mosquito Brigades and How to Organize Them* (London: George Philip, 1902). On segregation as a public health measure in India and West Africa see Curtin, "Medical Knowledge and Urban Planning in Tropical Africa" (cit. n. 19); and John Cell, "Anglo-Indian Medical Theory and the Origins of Segregation in West Africa," *Amer. Hist. Rev.,* 1986, *91:*307–335.

Rose Carter, director of hospitals in the Canal Zone, made such a suggestion before a meeting of the Canal Zone Medical Association in 1908:

> To prevent the infection of the mosquitoes which have access to the men we are protecting is simply to segregate the quarters of these men from those of the natives and colored laborers—a source of infection to the insects—a sufficient distance, which thing has been inculcated by the British writers for years. It is what is hardest to accomplish on the Isthmus of any of the measures that we attempt, yet it is fairly important and considerable sickness has been occasioned by failure to observe this principle.

And Charles F. Mason, who later became chief health officer of the Panama Canal, mentioned as a sanitary approach the "segregation of employees, that is, locating the dwellings of non-immunes far apart from the native villages, the inhabitants of which form reservoirs from which mosquitoes obtain their infection." These recommendations certainly fit with the segregationist policies the United States enacted in the Canal Zone, particularly the division of canal workers into "gold" and "silver" categories, with nonwhite "tropical" peoples largely confined to the second employment class.[23] And they certainly resonated with the strong connections between race, ethnicity, and public health then current within the United States. Indeed, as U.S. sanitarians turned their attention to the threat of diseased "natives" in places such as Panama, they had their own deepening reservoir of racialized domestic public health approaches from which to draw.[24] But sanitary records suggest that, during the construction era at least, effective sanitary segregation was difficult to achieve in a landscape of constantly shifting work sites and workers. In the Canal Zone, though the racial segregation of white Americans from the majority nonwhite workforce was everywhere a social and spatial reality, segregation was of secondary importance as a public health measure. Insofar as malaria control was concerned, sanitarians relied more heavily on other approaches.[25]

The ICC, again following other imperial examples, also considered mass quininization. Robert Koch, the pioneering German bacteriologist, was then the best-known advocate for quinine chemotherapy. On the basis of research he conducted in Africa, the Dutch East Indies, and New Guinea, Koch advocated a strict regimen of quinine both to protect work-

[23] Henry Rose Carter, "Malarial Fever Work on the Isthmus," *Proceedings of the Canal Zone Medical Association,* 1908, pp. 102–114, on p. 106; and Charles F. Mason, "Sanitation in the Panama Canal Zone," *Transactions of the International Engineering Congress, 1915,* rpt. in George Goethals, *The Panama Canal: An Engineering Treatise,* 2 vols. (New York: McGraw-Hill, 1916), Vol. 1, pp. 85–115, on p. 95. On segregation in the Canal Zone and the gold and silver rolls see Michael Conniff, *Black Labor on a White Canal: Panama, 1904–1981* (Pittsburgh: Univ. Pittsburgh Press, 1985).

[24] On these sorts of connections within the United States see Judith Walzer Leavitt, *Typhoid Mary: Captive to the Public's Health* (Boston: Beacon, 1996); Nayan Shah, *Contagious Divides: Epidemics and Race in San Francisco's Chinatown* (Berkeley: Univ. California Press, 2001); Natalie Molina, *Fit to Be Citizens? Public Health and Race in Los Angeles, 1879–1939* (Berkeley: Univ. California Press, 2006); and Tera Hunter, *To 'Joy My Freedom: Southern Black Women's Lives and Labors after the Civil War* (Cambridge, Mass.: Harvard Univ. Press, 1997). On the influence of U.S. medical practice in Panama on U.S. public health and eugenics see Alexandra Minna Stern, *Eugenic Nation: Faults and Frontiers of Better Breeding in Modern America* (Berkeley: Univ. California Press, 2005).

[25] As Charles Mason put it, sanitary segregation "has been carried out as far as is practicable, but it has not occupied as prominent a position as have the other measures referred to": Mason, "Sanitation in the Panama Canal Zone" (cit. n. 23), p. 104. In her study of malaria in the United States, Margaret Humphreys argues that sanitary segregation did not occur much in the U.S. South, for a variety of reasons; see Humphreys, *Malaria* (cit. n. 21), pp. 57–62, 73. Stephen Frenkel suggested in his dissertation that sanitary segregation was easier to achieve in Panama once canal construction was complete; see Frenkel, "Cultural Imperialism and the Development of the Panama Canal Zone, 1912–1960" (Ph.D. diss., Syracuse Univ., 1992).

ers from contracting malaria and to reduce the infectiousness of malarial patients. But American officials were skeptical of the effectiveness of quininization. Questioning Koch's advocacy specifically, Carter wrote in 1908, "I doubt if any sanitarian would be willing to attack the problem in the American tropics exclusively from the end of the human host." While the ICC distributed quinine throughout the construction period, to white and nonwhite workers alike, sanitarians never embraced it as a sole route to eliminating malaria. Consistently getting the correct doses to every worker, U.S. sanitary officials insisted, was too daunting a task for quinine to be much more than an individual prophylactic. Ultimately, American officials decided to attack the mosquito strand in the web of malarial transmission, following examples set by British sanitarians such as Ross and Malcolm Watson, who worked in British Malaya, as well as the pioneering work done by Gorgas in Havana.[26]

PURE AND APPLIED ENTOMOLOGY IN PANAMA

For mosquito control to be efficient and effective, U.S. sanitarians needed to understand vector ecology, and to figure out these details in Panama they turned to entomologists. Entomology had been a marginal, largely taxonomic science in the United States before the Civil War, but by serving postwar agricultural expansion entomologists assumed a central place within both the American scientific community and the growing federal agricultural bureaucracy. In the late nineteenth century, a series of high-profile insect threats to farms and forests—from Rocky Mountain locusts and citrus scales to Mexican boll weevils and gypsy moths—prompted a significant rise in federal sponsorship for applied or "economic" entomology, as the migratory nature of these pest species encouraged national and even international approaches to their control. As one historian of entomology put it, "in the latter half of the nineteenth century, it was as if the forces of nature were lobbying Washington on behalf of the entomologists."[27]

Entomologists built their expertise in the late nineteenth century with what might be called an ecological approach to agricultural pest problems. L. O. Howard, entomology's chief institution builder and a champion of its applied value, was at the vanguard of this effort. Howard received his B.S. and M.S. degrees from Cornell University, where he studied entomology with John Henry Comstock, one of the nation's premier entomologists.

[26] Carter, "Malarial Fever Work on the Isthmus" (cit. n. 23), p. 103. On Koch's quinine recommendations see Curtin, "Medical Knowledge and Urban Planning in Tropical Africa" (cit. n. 19), pp. 597–598; and Thomas D. Brock, *Robert Koch: A Life in Medicine and Bacteriology* (New York: Springer, 1988). Regarding the focus on mosquitoes see LePrince and Orenstein, *Mosquito Control in Panama;* and Ross, *Mosquito Brigades and How to Organize Them* (cit. n. 22). Malcolm Watson arrived in the Federated Malay States in 1901 to undertake mosquito control and wrote about it in two books: *The Prevention of Malaria in the Federated Malay States: A Record of Twenty Years' Progress* (London: John Murray, 1911); and *Rural Sanitation in the Tropics: Being Notes and Observations in the Malay Archipelago, Panama, and Other Lands* (London: John Murray, 1915).

[27] Berenbaum, *Bugs in the System* (cit. n. 13), p. 281. On the history of American entomology and its place in the American scientific establishment see Willis Connor Sorenson, *Brethren of the Net: American Entomology, 1840–1880* (Tuscaloosa: Univ. Alabama Press, 1995); A. Hunter DuPree, *Science in the Federal Government: A History of Policies and Activities* (1957; Baltimore: Johns Hopkins Univ. Press, 1985); Hae-Gyung Geong, "Exerting Control: Biology and Bureaucracy in the Development of American Entomology, 1870–1930" (Ph.D. diss., Univ. Wisconsin, 1999); L. O. Howard, "The Rise of Applied Entomology in the United States," *Agricultural History,* 1929, *3*(3):131–139; Jeffrey Lockwood, *Locust: The Devastating Rise and Mysterious Disappearance of the Insect That Shaped the American Frontier* (New York: Basic, 2004); Robert J. Spear, *The Great Gypsy Moth War: The History of the First Campaign in Massachusetts to Eradicate the Gypsy Moth, 1890–1901* (Amherst: Univ. Massachusetts Press, 2005); James Giesen, *The South's Greatest Enemy? The Cotton Boll Weevil and Its Lost Revolution, 1892–1930* (Chicago: Univ. Chicago Press, forthcoming); and Richard C. Sawyer, *To Make a Spotless Orange: Biological Control in California* (Lafayette, Ind.: Purdue Univ. Press, 2002).

Beginning in 1878, he served as an assistant to Charles Valentine Riley, the head of the U.S. Department of Agriculture's entomological work, and then, in 1894, succeeded him. Howard built the entomological division into the Bureau of Entomology, over which he presided until 1927. He insisted that an intricate knowledge of insect bionomics was crucial to controlling pests, as the simplification of modern agroecosystems opened them to invasions and as modern transportation technologies and networks made it easier for insects to move into previously isolated environments. "The enormous expansion of agriculture in North America" in the late nineteenth century, Howard recalled toward the end of his career, "resulted in types of agricultural practice peculiarly favorable to insect increase."[28] By the turn of the last century, under Howard's leadership, American entomologists were no strangers to serving as careful ecological observers of and problem solvers within a colonizing mission. Indeed, they were well prepared to bring their ecological approach to another round of American expansion.[29]

Federal entomologists gained a powerful new rationale for applied entomology with the mosquito vector discoveries.[30] And while malaria and yellow fever persisted in the United States during the early twentieth century, it was the commercial and military expansion of the United States into tropical Latin America and the Asian Pacific that most forcefully connected federal entomological expertise to public health campaigns. Indeed, these imperial campaigns helped to build federal public health capacity and to reframe disease control, traditionally a state responsibility, as a federal issue during the early twentieth century.[31] But to fulfill their roles as disease managers, entomologists first had to generate

[28] L. O. Howard, *A History of Applied Entomology (Somewhat Anecdotal)* (Washington, D.C.: Smithsonian Institution, 1930), p. 3. On Howard see Essig, *History of Entomology* (cit. n. 1), pp. 658–663; and Arnold Mallis, *American Entomologists* (New Brunswick, N.J.: Rutgers Univ. Press, 1971), pp. 79–86. Howard later became known for his martial and alarmist rhetoric about insects, rhetoric that presaged the postwar U.S. commitment to chemical control of insect pests. But for much of his early career he preached an applied ecological approach that was shared by many in the entomological community. Two of Howard's better-known books were *The Insect Menace* (New York: Century, 1931) and *Fighting the Insects: The Story of an Entomologist, Telling of the Life and Experiences of the Writer* (New York: Macmillan, 1933). See also Howard, *History of Applied Entomology (Somewhat Anecdotal);* Edmund Russell, *War and Nature: Fighting Humans and Insects with Chemicals from World War I to* Silent Spring (New York: Cambridge Univ. Press, 2001); and Russell, "L. O. Howard Promoted War Metaphors as a Rallying Cry for Economic Entomology," *American Entomologist,* Summer 1999, *45:*74–78.

[29] Sorenson makes this point in *Brethren of the Net* (cit. n. 27), pp. 258–259. Philip Pauly has argued that USDA scientists were deeply divided over the biological implications of the nation's increasingly global and imperial posture, with Howard and the Bureau of Entomology assuming a nativist or restrictionist position for fear of exotic insect invasions, while Beverly Galloway, David Fairchild, and others within the Bureau of Plant Industry took a more "cosmopolitan" approach to plant and other biotic introductions and exchanges. In the case of Panama, these two approaches seem to have coexisted without much conflict, perhaps because the applied entomology practiced there was medical rather than agricultural. See Philip J. Pauly, "The Beauty and Menace of Japanese Cherry Trees," *Isis,* 1996, *87:*51–73; and Pauly, *Biologists and the Promise of American Life: From Meriwether Lewis to Alfred Kinsey* (Princeton, N.J.: Princeton Univ. Press, 2000), Ch. 3.

[30] Early links between insects and disease transmission, both nationally and internationally, had already put a premium on applied entomological knowledge, spawning the fields of medical and veterinary entomology. In the imperial context, Sir Patrick Manson, the putative father of tropical medicine, figured out in the late 1870s that mosquitoes (*Culex fatigans,* to be precise) hosted and transmitted the filarial worms responsible for elephantiasis, a discovery that led medical officials to seek similar parasite-vector explanations for other diseases. See Roy Porter, *The Greatest Benefit to Mankind: A Medical History of Humanity* (New York: Norton, 1997), p. 467. And in the United States, the 1891 discovery by Theobald Smith that ticks (arachnids, not insects—but the problem was claimed by entomologists nonetheless) spread Texas fever among cattle in the South and West was a formative development. On the history of Texas fever see Claire Strom, "Texas Fever and the Dispossession of the Southern Yeoman Farmer," *Journal of Southern History,* 2000, *65:*49–74.

[31] Yellow fever outbreaks in 1905 in several southern cities were a critical turning point in this regard, as the U.S. Public Health Service (created in 1902 from the Marine Hospital Service) directly intervened with mosquito control efforts modeled on Gorgas's work in Havana and Panama, efforts that showed up ineffective state efforts. A similar if slightly less direct line of influence led from malaria control in Panama to subsequent federal efforts

some knowledge of mosquitoes, which to that point had not been extensively studied. As a first step, Howard put together a USDA Bulletin, *Notes on the Mosquitoes of the United States,* in 1900, and then a primer on the subject, *Mosquitoes: How They Live, How They Carry Disease, How They Are Classified, and How They May Be Destroyed,* in 1901. In the process, he corresponded extensively with leading entomologists and sanitarians throughout the world. Howard was not the first to engage in such transatlantic correspondence; nineteenth-century American entomologists had relied extensively on European collections and expertise. But his international correspondence was distinctive in the set of imperial connections it reflected, an underappreciated aspect of the Progressive Era's transatlantic conversation and one that was formative not just for entomologists but for many other experts within the nascent environmental management state.[32]

The adoption of mosquito control in Panama necessarily transformed the isthmus's mosquitoes from fauna incognita into subjects of close scientific study. Just prior to the U.S. entry into Panama, entomologists had begun the task of identifying and cataloguing the region's Culicidae (mosquito family). Recognizing "the imperfect character of our knowledge and especially the very great need for a competent monograph on the species of Culicidae of North and Central America and the West Indies, both from the biological and from the sanitary points of view," Howard and his colleagues, Harrison Dyar and Frederick Knab, wrote a grant to the newly created Carnegie Institution in 1902 seeking funding to undertake such a systematic study. Dyar was a lepidopterist with graduate degrees in entomology and bacteriology from Columbia, where he was teaching when Howard hired him to curate Lepidoptera for the National Museum of Natural History in 1897. Knab was a Bavarian-born artist and entomologist who would later become the chief curator of Diptera at the National Museum.[33] The three received the grant in 1903 and began assembling a network of collectors and consultants throughout the covered regions to assist in their efforts. Many of these collectors were associated with the nation's new imperial holdings, but the authors also came to rely on Latin American and Caribbean scientists and institutions, such as the Instituto Oswaldo Cruz in Rio de Janeiro. Howard not only tapped into the sort of transimperial circuits that have increasingly occupied the attention of colonial and postcolonial scholars; he and his colleagues also engaged in what

in the U.S. South, where the disease persisted until World War II. See Humphreys, *Yellow Fever and the South* (cit. n. 21), pp. 10–15; and Humphreys, *Malaria* (cit. n. 21), pp. 74–75.

[32] L. O. Howard, *Notes on the Mosquitoes of the United States: Giving Some Account of Their Structure and Biology, with Remarks on Remedies,* Bulletin No. 25, N.S., Division of Entomology, U.S. Department of Agriculture (Washington, D.C.: Government Printing Office, 1900); and Howard, *Mosquitoes: How They Live, How They Carry Disease, How They Are Classified, and How They May Be Destroyed* (New York: McClure, Philips, 1901). For Howard's correspondence during this period see National Archives and Records Administration, Record Group 7, Records of the Bureau of Entomology and Plant Quarantine (NARA RG 7), Washington, D.C., Entry 6, "General Records, Letters Sent, 1896–1908," and Entry 13, "Letters Received Regarding the Mosquito Investigations, 1900–1901." Howard had established himself as an expert on mosquitoes and their control in the 1890s, prior to the vector confirmations, and he carefully followed the vector discoveries and the various imperial sanitary efforts that came in their immediate wake. See Howard, "An Experiment against Mosquitoes," *Insect Life,* 1892, *5*(1):12–14; and Howard, "Another Experiment against Mosquitoes," *ibid.,* 1893, *6*(2):90–92. For the definitive treatment of the transatlantic Progressive Era conversation see Daniel Rodgers, *Atlantic Crossings: Social Politics in a Progressive Age* (Cambridge, Mass.: Belknap, 1998).

[33] L. J. Bruce-Chwatt notes that at the turn of the last century only twenty of the approximately four hundred species of *Anopheles* known today had been described; see Bruce-Chwatt, "Leland Ossian Howard" (cit. n. 1), p. 217. On Dyar see Marc E. Epstein and Pamela M. Henson, "Digging for Dyar: The Man Behind the Myth," *Amer. Entomol.,* Fall 1992, *38:*148–169; "Dyar, Harrison Gray," in Essig, *History of Entomology* (cit. n. 1), pp. 608–610; Mallis, *American Entomologists* (cit. n. 28), pp. 323–326; and Harrison Gray Dyar Papers, Record Unit (RU) 7101, Smithsonian Institution Archives (SIA), Washington, D.C. On Knab see Mallis, *American Entomologists,* pp. 393–394; and Frederick Knab Papers, RU 7108, SIA.

Stuart McCook has aptly called "creole science" by drawing on the expertise of Latin American and Caribbean scientists in ways that challenge stark notions of imperial science and medicine as hegemonic. The eventual result was a massive four-volume study, *The Mosquitoes of North and Central America and the West Indies,* coauthored by Howard, Dyar, and Knab, that appeared between 1912 and 1917. Building on the currency of the mosquito vector theories as well as the U.S. military, engineering, and agricultural expansion into the tropics, these federal entomologists produced a landmark study in mosquito systematics and ecology.[34]

Panama played an important if surprisingly belated role in the production of *The Mosquitoes of North and Central America and the West Indies.* When the Carnegie Institution money ran out after three years, the project was far from complete and in need of supplemental funding. The USDA provided some of that funding, but the authors also had to look elsewhere. Ironically, one of the notable gaps in their knowledge as of 1906 was Panama. During the first several years of the study, which coincided with the American entry into Panama, Howard had asked several amateur observers in the Canal Zone to send along mosquito information and specimens, but they proved unreliable. Sanitarians in Panama were focused on controlling the yellow fever mosquito, *Aedes aegypti,* which bred almost exclusively in artificial containers in and around human habitations. As a result, though broad mosquito control efforts were well under way, there had been little effort to survey the Canal Zone's mosquito fauna or to figure out which *Anopheles* species were responsible for malaria transmission. As it turned out, 1906 was a pivotal year in this regard: as a result of *Aedes aegypti* control, 1906 saw the last case of yellow fever of local origin during the construction era. But it was also a terrible year for malaria, with 21,934 hospitalizations and 195 deaths reported in the official statistics. The need to shift control efforts to *Anopheles* mosquitoes thus meshed neatly with the scientific goals of Howard, Dyar, and Knab.[35]

As the ICC'S Sanitary Department refocused on malaria, Howard and his coauthors arranged for a USDA entomologist named August Busck to visit the region and make a thorough survey of the mosquitoes there. Busck was born and educated in Demark, where he received his doctorate in 1893. He then relocated to the United States and, after a brief stint in the flower business, became an entomological assistant for the USDA. He also served as a specialist in Microlepidoptera for the National Museum, and he had traveled

[34] Leland O. Howard, Harrison G. Dyar, and Frederick Knab, *The Mosquitoes of North and Central America and the West Indies,* 4 vols. (Washington, D.C.: Carnegie Institution, 1912–1917). Information on the history of the project is from Vol. 1, pp. 2–6. Howard cites important Latin American figures in the introduction to his book *Mosquitoes* (cit. n. 32). See also his correspondence in NARA RG 7. On "creole science" see McCook, *States of Nature* (cit. n. 9); Peard, *Race, Place, and Medicine* (cit. n. 8); and Steven Palmer, *From Popular Medicine to Medical Populism: Doctors, Healers, and Public Power in Costa Rica, 1800–1940* (Durham, N.C.: Duke Univ. Press, 2003).

[35] LePrince and Orenstein, *Mosquito Control in Panama,* pp. 23–24. Howard was in touch with several people in Panama from the earliest days of the construction period. In early 1906, he scolded Joseph LePrince for not sending along mosquito samples, making clear that his interests went well beyond the applied: "But really, my dear Mr. LePrince, I have been so disappointed that you have not sent me a large collection of mosquitoes which you possibly might have captured, not in the towns but along the line of the Canal, in the woods or in the swamps. You see my interest is not only the medical and sanitary interest, but the zoological and entomological interest, and my monograph will cover all mosquitoes, whether they carry disease or whether they have not yet proven to have any such capacity. Can you not get some of them for me, and can you not interest other people in the search?" L. O. Howard to Joseph LePrince, 6 Jan. 1906, NARA RG 7, Box 33, Folder "L" [1 of 6]. Bureau of Entomology correspondence also contains letters between Howard and Dr. Arthur Kendall, a sanitary official with the ICC, that find Howard requesting the collection and shipment of Canal Zone mosquitoes as early as March 1905; see, e.g., Howard to Arthur Kendall, 7 Feb. 1906, NARA RG 7, Entry 6. Howard was also in touch with Major Louis LaGarde about mosquito collecting; see Howard to Major Louis A. LaGarde, Medical Department, Ancon, n.d., Box 32, Folder "L" [1 of 3].

extensively throughout Latin America and the Caribbean in the early twentieth century as a member of several scientific expeditions. Busck visited Panama from April to July 1907, which allowed him to collect during the first part of the rainy season. The ICC funded the trip, an indication that they appreciated its sanitary importance. Upon his arrival Busck reported immediately to Gorgas, who arranged for an inspection tour of several days. Then Busck settled into ICC accommodations at the town of Tabernilla, around which he did most of his own collecting. Busck received assistance from Joseph LePrince, the ICC's chief sanitary inspector, and LePrince's assistant, Herbert Canfield. The British-born LePrince had immigrated to the United States and received engineering degrees from Columbia in 1898 and 1899. He served as Gorgas's assistant during the Cuban sanitary campaign before following Gorgas to Panama, where he directed most of the mosquito control work. (After the canal's completion, LePrince went on to work for the U.S. Public Health Service, mostly on malaria-related mosquito control efforts in the U.S. South, where he was a key figure in bringing the mosquito control techniques of Panama back to the United States.)[36] LePrince instructed district sanitary inspectors to pass along samples of collected mosquito larvae to Busck, who then bred out adult mosquitoes. It was largely from these hatched larvae that Busck made his species identifications. He then sent his samples to Dyar and Knab for confirmation, and they made them a part of the Smithsonian's National Insect Collection.

Busck's expedition to Panama was a great success, particularly from a taxonomic standpoint. "Our knowledge of the mosquito fauna of the Isthmus of Panama has heretofore amounted to practically nothing," Dyar and Knab noted in an article about Busck's collecting trip; prior to Busck's survey, only seven mosquito species had been identified within the Canal Zone, but "Mr. Busck returned with more than 90 species, of which 30 were new to science." Busck also was able to recruit and train responsible collectors, including Allan Jennings of the Sanitary Department, who worked as Busck's assistant and went on to serve as an "entomologist" for the ICC.[37] Finally, physicians took note of Busck's presence and exhibited a hunger for entomological knowledge. For example, Dr. Perry Preston of the Empire District wrote the following note to Busck during his Panama stay: "Mr. Goodale, Sanitary Inspector of Empire, has been telling me about your collection of mosquitoes. If it is in no way an imposition on my part I would like very much to call on you in Tabernilla and see them. I have a number of circulars published by Prof. Howard and I would like to bring them with me and have you explain them to me." Beyond charting isthmian mosquito fauna, then, Busck's visit was a critical one for linking entomology and sanitation: it gave sanitarians a deeper appreciation of the entomological landscape; it gave entomologists a thorough look at early mosquito control efforts in Panama; and it trained sanitary workers in the careful arts of larvae collection and hatching, mosquito identification, and the location of breeding grounds.[38]

[36] On Busck see Mallis, *American Entomologists* (cit. n. 28), pp. 326–327; and August Busck Papers, RU 7129, SIA. On LePrince see F. E. Jackson and Son, comps. and eds., *The Makers of the Panama Canal* (Washington, D.C.: Division of the History of Technology, National Museum of American History, Smithsonian Institution, 1911); and Patricia M. LaPointe, "Joseph Augustin LePrince: His Battle against Mosquitoes and Malaria," *West Tennessee Historical Society Papers,* Dec. 1987, *41:*48–61.

[37] Harrison G. Dyar and Frederick Knab, "Descriptions of the New Mosquitoes from the Panama Canal Zone," *Journal of the New York Entomological Society,* Dec. 1907, *15:*197–212, on p. 197. See also Howard *et al., Mosquitoes of North and Central America and the West Indies* (cit. n. 34), Vol. 1, p. 5. Although Jennings became one of the most important entomological workers in the Canal Zone, particularly in relation to malaria control, I have not been able to find biographical information on him.

[38] Perry Preston to Busck, 11 May 1907, Busck Papers, Box 1. For details of Busck's 1907 trip see August

Panama had an extensive mosquito fauna, and to the entomologically uninformed all mosquitoes seemed a threat to public health. Indeed, given how little entomologists knew about mosquitoes, it is not surprising that the Americans failed to differentiate between species in their early control efforts. As Busck noted, aggressive mosquito control efforts were already under way in 1907, with brushing (clearing vegetation around settlements), drainage, oiling of potential breeding areas (covering standing water with a thin sheen of oil to asphyxiate larvae), and screening of quarters being the primary approaches taken. These tactics had been somewhat effective in reducing mosquito numbers, but Busck insisted that public health indictments be handed down only to the guilty species. There were pressures for fiscal efficiency, particularly after George Goethals took over as the ICC's chief engineer in the spring of 1907, and targeted mosquito control efforts promised to be most cost effective. As Busck put it:

> With all due credit to the truly excellent work and the undeniably brilliant results achieved, the work is nevertheless done more or less in the dark, at present, for lack of accurate knowledge of the enemy. It could undoubtedly be made both more effective in some ways and less expensive in others through a more intimate knowledge of the mosquitoes concerned, toward which the present investigation has made but a small beginning.

With his careful cataloguing of Canal Zone species and his attention to the "intimacies" of mosquito ecology, Busck moved the inquiry away from a broad assault on Panamanian nature and toward one that targeted specific species and their breeding grounds.[39]

In his final report Busck did note, as many other knowledgeable observers had and would, that the Panamanian climate and environment were conducive to mosquito life. Consistently high temperatures allowed for year-round breeding, and heavy rainfall during the eight-month rainy season meant that there was plenty of standing water in which mosquitoes might breed, even during the dry season. Moreover, Panama's soils often drained poorly, exacerbating problems with standing water. Panama's various natural bodies of water also supported the prolific growth of algae and aquatic plants, which provided mosquito larvae with food sources and some protection from predacious fish. Finally, tree holes and epiphytic plants in Panama's forests, and crab holes along the coastline, collected water and provided breeding habitat for certain mosquitoes, including several *Anopheles* species. There was much about Panamanian nature, in other words, that supported mosquito breeding.[40]

But Busck also noted that human-induced environmental change was critical to mosquito breeding success in Panama. He noted that "the ever-changing conditions due to the canal work are a continued source of trouble" and that "the progress of each steam shovel or of each of the extensive dumps produces new problems to be solved in the way of

Busck, "Report on a Trip for the Purpose of Studying the Mosquito Fauna of Panama," in *Smithsonian Miscellaneous Collections,* 1910, *52*(1921):49–77. See also Dyar and Knab, "Descriptions of the New Mosquitoes from the Panama Canal Zone"; and Harrison G. Dyar, "The Mosquitoes of Panama," *Insecutor Inscitiae Menstruus,* July–Sept. 1925, *12*(7–9):101–195.

[39] Busck, "Report on a Trip for the Purpose of Studying the Mosquito Fauna of Panama," p. 53. My focus on the term "intimacies" is meant to link this scientist–environment interaction with the sorts of social and sexual interactions upon which Ann Laura Stoler has focused in much of her work. For a discussion of her approach to empire see Stoler, "Empires and Intimacies: Lessons from (Post) Colonial Studies—A Round Table," *J. Amer. Hist.,* 2001, *88:*829–897.

[40] Busck, "Report on a Trip for the Purpose of Studying the Mosquito Fauna of Panama." See also LePrince and Orenstein, *Mosquito Control in Panama,* pp. 19, 22, 30–38.

drainage." More important, he intimated that mosquitoes breeding in these anthropogenic conditions were more likely to be malaria vectors than those breeding under natural conditions. Of the ninety mosquito species Busck identified, nine were Anophelines. He believed *Anopheles pseudopunctipennis* to be the most abundant, followed by *A. albimanus* (later observers would reverse this order). Busck did make a few anecdotal comments connecting particular species with malaria transmission. For instance, he noted that a July 1907 surge in *A. albimanus* around La Boca, the result of prolific breeding in "a temporarily dammed up swamp near the laborers' quarters," had corresponded directly with a spike in malaria among the workers quartered there. But entomologists and sanitarians still were not sure which *Anopheles* species were the critical vectors in Panama and which were less important.[41] Busck had done much to lay out the possibilities, but sanitarians awaited definitive experimental proof.

Samuel T. Darling, Chief of the Laboratory of the Board of Health in the Canal Zone, undertook that experimental work. Darling had received his M.D. in 1903 from the College of Physicians and Surgeons in Baltimore, and he arrived on the isthmus in 1905, where he quickly rose to a position of medical leadership. By 1907 he was not only in charge of the ICC lab but also head of the Canal Zone Medical Association, a group of physicians and sanitarians who met regularly to present tropical medical research; their *Proceedings* provide a thorough primary record of U.S. tropical medicine during the construction era. Darling's lab was part of a sophisticated medical infrastructure created in the Canal Zone that allowed doctors, like entomologists, to pursue both scientific and applied approaches to tropical medicine and public health. Indeed, the Canal Zone was an important incubator for American tropical medicine and public health expertise at a moment when tropical medicine was emerging globally as a distinctively imperial discipline.[42] In early 1908 Darling sought permission to engage in a series of experiments to determine the details of "the mechanical transmission of malarial parasites from man to man by mosquitoes." He was granted permission in early February of that year and proceeded to design a set of experiments using Spanish and West Indian malaria patients.[43]

As they had done for Busck, district sanitary inspectors collected *Anopheles* larvae and sent them to Darling, who bred them to adulthood. He then had these adult mosquitoes bite workers with transmissible cases of malaria. Once they did so the mosquitoes were

[41] Busck, "Report on a Trip for the Purpose of Studying the Mosquito Fauna of Panama," pp. 53, 57. Mosquito taxonomy is complex and fluid. Species names have changed over time with new interpretations of what constitutes a distinct species, and systematists are increasingly uncomfortable with rigid species definitions, now often talking about species complexes and lumping together all sorts of slight variations. Because of these complexities, I have chosen to use the species names assigned by the scientists I am examining, noting the changes over the time period I examine but not divergences with present understanding.

[42] On Darling see Enrique Chaves-Carballo, "Samuel T. Darling: Studies in Malaria and the Panama Canal," *Bull. Hist. Med.,* 1980, *54:*95–100. On tropical medicine's history see Roy Porter, "Tropical Medicine, World Diseases," in *Greatest Benefit to Mankind* (cit. n. 30), pp. 462–492. On the history of tropical medicine in Britain see Michael Worboys, "Manson, Ross, and Colonial Medical Policy: Tropical Medicine in London and Liverpool, 1899–1914," in *Disease, Medicine, and Empire: Perspectives on Western Medicine and the Experience of European Expansion,* ed. Roy MacLeod and Milton Lewis (London: Routledge, 1988), pp. 21–37.

[43] Samuel T. Darling to Superintendent, Ancon Hospital, 30 Jan. 1908, NARA RG 185, Entry 30, Box 253, Folder 37-H-7 (I). Specifically, Darling sought permission to "attempt the infection of certain black laborers by mosquitoes that have previously bitten patients with malarial fever," but his 1910 report suggests that he only went through with experiments that involved mosquitoes biting infected patients, after which the mosquitoes were examined to see if the plasmodia developed within them. Darling's study spoke volumes about the racial thinking and public health inequalities that marked the canal-building era, but for the purposes of this essay I want to focus on his entomological findings. See also William Gorgas to Major D. D. Gaillard, 7 Feb. 1908; Gaillard to Gorgas, 11 Feb. 1908; Executive Officer to Darling, 13 Feb. 1908; and Darling to Chief Sanitary Officer, 7 Oct. 1908: NARA RG 185, Entry 30, Box 253, Folder 37-H-7 (I).

removed and, after a necessary incubation period, dissected to see if malaria plasmodia were in their systems.[44] In March 1909 Darling reported his preliminary results, which he expanded on in a lengthy 1910 report, *Studies in Relation to Malaria.* Of the eleven species of *Anopheles* he studied (he worked with two species that Busck had not identified), he found that only three seemed capable of transmitting malaria. He dismissed the tree-hole and sylvan Anophelines, *A. cruzii* and *A. eiseni,* as malarial transmitters; found solely in forested landscapes remote from population centers, they had little contact with humans and seemed to prefer other blood sources, though he had not been able to disprove definitively that they were capable vectors. He also dismissed *A. malefactor,* a relatively abundant species, as a transmitter of malaria; none of the collected *A. malefactor* (despite their name) became "infected" with malaria. Sanitary inspectors and other entomological workers found several other species in such small numbers that, although Darling could not determine if they were capable vectors, he dismissed their importance. Of the three that did prove capable, Darling determined that *A. pseudopunctipennis* was marginally successful as a transmitter of malaria: only 12.9 percent of them became "infected" after biting malarial patients, and few adults were taken in workers' quarters. Darling did note that *A. tarsimaculata* had a high rate of infection acquisition (60 percent), but he said little about its role as a malaria transmitter beyond noting its capacity. Others would later point out that, because of its limited range (it was found mostly on the Atlantic side, in the vicinity of Colón), it was not particularly worrisome.[45]

By far the most important of Darling's findings was the central role in malarial transmission played by *A. albimanus,* which had an infection rate of 70.2 percent. He wrote: "Anopheles albimanus, the common white footed anopheles, is an extremely hardy, vigorous, rapidly developing adaptable mosquito and is the transmitter of Estivo Autumnal [Falciparum] and of Tertian [Vivax] malarial fever in the Canal Zone at this time. In the efforts at mosquito destruction, the extermination of A. albimanus is of paramount importance."[46] Although some of Darling's conclusions were later challenged, none of those challenges affected his essential public health message: when it came to malaria, *A. albimanus* was the major problem. Discerning the breeding and feeding habits of *A. albimanus* thus became a mosquito control priority.

Entomologists were coming to understand that the world's *Anopheles* species showed a wide variety of preferences when it came to breeding habitat. Some preferred clean water, others dirty water; some preferred water exposed to sunlight with lots of algae, others shady pure water, and still others brackish water; some favored natural bodies of water such as lakes and streams, though most avoided swiftly moving water, while others showed an uncanny attraction to artificial containers; and all larvae did best in habitats that provided protection from fish and other predators. As adults, *Anopheles* also showed varied habits, with the most important questions for sanitarians centering on their feeding preferences, their persistence at entering human habitations, and the distance they could fly. Some *Anopheles*

[44] Samuel T. Darling, *Studies in Relation to Malaria* (Washington, D.C.: Government Printing Office, 1910), pp. 13–23. See also James Stevens Simmons, *Malaria in Panama* (Baltimore: Johns Hopkins Press, 1939).

[45] Darling to Superintendent of Hospital, Ancon, 18 Mar. 1909, NARA RG 185, Entry 30, Box 253, Folder 37-H-7 (II). On *A. tarsimaculata*'s limited range see LePrince and Orenstein, *Mosquito Control in Panama,* p. 51.

[46] Darling to Superintendent of Hospital, Ancon, 18 Mar. 1909. There are four types of malarial parasites, two of which are important for the Panama case: *Plasmodium falciparum* and *Plasmodium vivax.* The former is a virulent strain of African origin that produces fairly high mortality rates; the latter is a milder strain, mostly of European origin.

seemed catholic in their tastes for mammalian blood, taking it where they could get it. But others showed decided preferences for either human or particular nonhuman blood-meal sources, and their choices in turn shaped disease ecology. Various species also exhibited distinct differences in their capacity to invade human habitations and thus pose a threat as disease transmitters. Finally, determining how far species could fly was critical in designing environmental control measures for areas around human habitations.

Where did *A. albimanus* fit in this range of breeding and adult habits, particularly in comparison with other *Anopheles* species? Busck, Darling, and others had already begun to sketch a portrait of *A. albimanus* as an aggressive, flexible species associated with malarial outbreaks, but it was left to other sanitarians and entomologists to fill out this portrait. Entomological workers already knew that *Anopheles* in general were country mosquitoes, not peridomestic ones like *Aedes aegypti.* Although some *Anopheles* inhabited sylvan or "wild" settings, most were found in and around villages in agricultural areas. But as entomological workers looked closely at the habits of *A. albimanus,* they found that it showed a marked affinity for landscapes of human disturbance. Allan Jennings, Busck's former assistant who came to occupy an important place among entomological workers in Panama, described its breeding habits in detail: "preference is shown by the mosquito for stagnant, fairly pure water, exposed to direct sunlight, with a growth of Spirogyra [algae]." "With the exception of foul or swift water," he continued, "they may occur in almost any collection of water, however small or seemingly unsuited to mosquito propagation. Hoof-prints, wheel-ruts, the smallest puddle or thinnest film of water seeping from the ground . . . are points of danger and must be included in the control work." Implicit in Jennings's description was an important point: human activity, even of the most minor sort, created many of the ideal breeding grounds for *A. albimanus.* In most natural bodies of water where such breeding conditions were found, including most swamps, fish predation controlled *Anopheles* larvae with varying levels of effectiveness. Tree holes, crab holes, and the water in bromeliads were important exceptions, though Darling's experiments had already shown that mosquitoes that bred in such natural conditions were not effective vectors in Panama. But fish infrequently found their way into human-produced depressions, and "mosquitoes instinctively avoid places that fish and other enemies reach easily."[47] Its larval preference for direct sunlight, moreover, meant that *A. albimanus* was not a forest species but one more likely to breed in cleared areas where water collected. There was no shortage of such areas in the Canal Zone.

A. albimanus's adult habits also suggested its troublesome nature. They were found to be aggressive biters with a particular taste for human blood, and they proved to be persistent entrants into human habitations. In surveys of *Anopheles* species captured in worker quarters, *A. albimanus* was by far the most prominent. It was also an efficient vector, achieving rates of infection in laboratory settings that were much higher than those seen in other vectors. *A. albimanus,* Jennings and others found, was a mosquito with an intimate connection to humans and their landscapes. Its preference for human blood, its persistence in entering human habitations, its capacity to breed in cleared landscapes, its absence from uninhabited forested areas, and its efficiency as a malaria vector all marked *A. albimanus* as a mosquito with a long coevolutionary history with humans and the malarial parasite.

[47] Allan H. Jennings, "Some Problems of Mosquito Control in the Tropics," *Journal of Economic Entomology,* Apr. 1912, *5:*131–141, on p. 133; and LePrince and Orenstein, *Mosquito Control in Panama,* p. 64. On the distribution of *Anopheles* see, e.g., J. A. LePrince, "Mosquito Destruction in the Tropics," *Journal of the American Medical Association,* 26 Dec. 1908, *51:*2203–2208.

Moreover, extensive human activities in the Canal Zone—the importation of tens of thousands of workers (lots of food) and the transformation of the Canal Zone environment (lots of breeding sites)—may well have favored its propagation over that of other mosquito species, including less dangerous Anophelines. To see this particular mosquito species as merely a pernicious product of tropical nature, Jennings intimated, was to miss both its evolutionary and ecological relationships to humans and the role of canal construction in facilitating its ubiquity. "While not domestic in the same sense as *Stegomyia calopus* [an earlier name for *Aedes aegypti*]," he wrote, "*Anopheles albimanus* is closely associated with man and finds its most congenial surroundings about his habitations and in conditions he creates in the course of agricultural, engineering and other work. This fact is correlated with the highly-developed blood-sucking habit and has been an active factor in its development and in establishing the economic importance of the species."[48] *A. albimanus* was a hybrid creature, difficult to explicate within an intellectual framework that separated tropical nature from U.S. efforts to transform the region. It was a nonhuman agent, to be sure, but its abundance in Panama is better seen as the product of a network of human and natural agencies and structures at work in the Canal Zone.

The most detailed case for seeing human contributions in the creation of malarial conditions in Panama came in *Mosquito Control in Panama,* the 1915 book cowritten by LePrince and his assistant, A. J. Orenstein. Orenstein, only in his mid-twenties when he first arrived in Panama in 1905 to work under Gorgas and LePrince, was an M.D. with degrees from the Jefferson Medical College in Philadelphia. Their mosquito control work led them to conclude that malaria "develops most rapidly when the soil is disturbed by large and extensive excavations and fills accompanied by the introduction of non-immune labor housed near the site of their work."[49] Here was not only a succinct summary of the potential for canal building to exacerbate malarial outbreaks but also a partial vindication of the discredited miasmatic theory's contention that turning over and disturbing soil would contribute to disease in Panama. Excavation had caused disease, but not because it exposed poisoned soil and let loose malarial emanations. Rather, it amplified the breeding success of the mosquitoes most productive of malarial transmission in Panama.

But LePrince and Orenstein went further. Building on the accumulated observations of district inspectors, they mapped out specific aspects of the Canal Zone's engineered landscape that had contributed to vector breeding.[50] For instance, ICC officials relied on a serpentine and ever-shifting network of rail lines for the rapid removal of materials excavated from sites such as the Culebra Cut. As a result, the construction landscape became riddled with corduroy-like rail-tie depressions that, when filled with rain, became ideal vector breeding places. Spoil dumping was also a problem, as it often blocked watercourses and drainage paths, creating new swamplands that entomological workers then identified as troublesome breeding sites (see Figure 1). District inspectors frequently complained of

[48] Jennings, "Some Problems of Mosquito Control in the Tropics," p. 133.

[49] LePrince and Orenstein, *Mosquito Control in Panama,* p. 39. After serving in Panama, Orenstein moved to South Africa, where he spent most of the rest of his long life (he died in 1972) working to improve public health, with a particular focus on the respiratory diseases that plagued the mining industry. See "Obituary: Major-General Alexander J. Orenstein," *Transactions of the Royal Society of Tropical Medicine and Hygiene,* 1972, *66:*815–817; and Randall Packard, "The Invention of the 'Tropical Worker': Medical Research and the Quest for Central African Labor on the South African Gold Mines, 1903–36," *Journal of African History,* 1993, *34:*271–292.

[50] The Canal Zone was divided into a series of sanitary districts, each with its own sanitary inspector and staff. These inspectors made regular reports to LePrince, who was the chief sanitary inspector, that were filled with accounts of mosquito breeding sites and conditions. These reports and related correspondence can be found in NARA RG 185, Entry 30, Boxes 242–244. There are individual folders for each sanitary district.

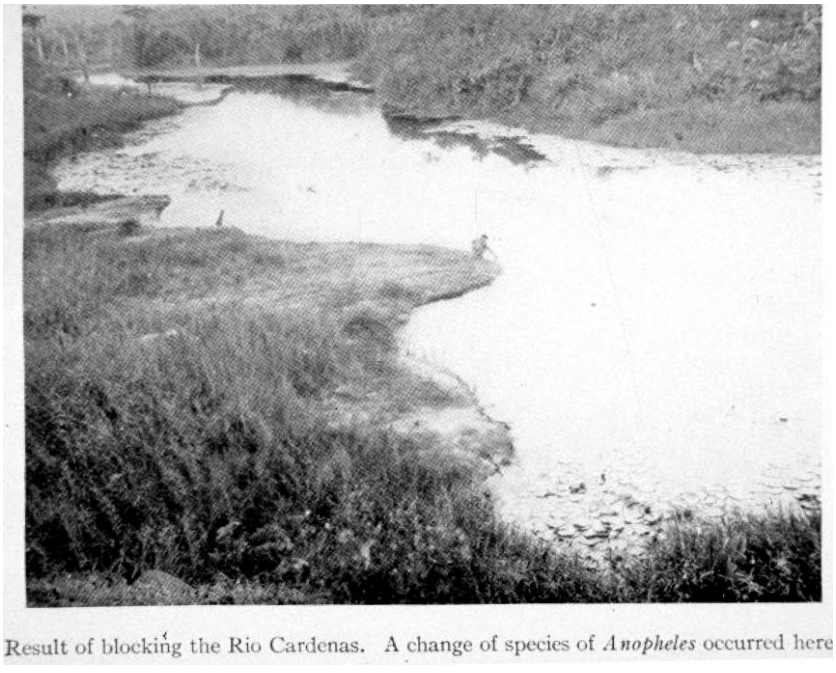

Result of blocking the Rio Cardenas. A change of species of *Anopheles* occurred here

Figure 1. *This was one of several photographs that LePrince and Orenstein included in their book to illustrate the ways in which the blocking of rivers and other watercourses as a result of spoil dumping and other construction activities could create new mosquito breeding habitat. In this case, they note a shift in* Anopheles *species as a result of the altered conditions. (From LePrince and Orenstein,* Mosquito Control in Panama, *opposite page 72.)*

spikes in *Anopheles* numbers and corresponding malarial outbreaks that coincided with the creation of these new wetlands. Extensive excavation also caused frequent landslides that similarly disturbed hydrological patterns, and as the canal cut went deeper it too began to collect water in ways that supported vector breeding (see Figure 2). One of the most vexing engineered breeding grounds, LePrince and Orenstein suggested, was a result of dredging. At various sites along the canal route, the ICC used hydraulic dredges that scoured the canal bottom and pumped tons of muddy slurry onto lands adjoining the canal. When the surface mud on these slurry fields began to dry it cracked, and water collected in the cracks. These watery crevices, exposed to sunlight but difficult for fish to reach, were ideal for *A. albimanus* breeding, and they were exceedingly difficult to mitigate, as workers who attempted to walk on the slurry fields would be quickly swallowed up by the mud (see Figure 3). Finally, the filling of Lake Gatun and Miraflores Lake, the two major reservoirs along the canal route, also proved troublesome from a mosquito-breeding standpoint, as these reservoirs created shallow edge environments, littered with flotsam, that favored vector breeding. All these various aspects of canal construction, then, created specific landscapes of breeding success.[51]

Even mosquito control efforts could, if not executed properly, be more of a problem

[51] These details are from LePrince and Orenstein, *Mosquito Control in Panama,* particularly pp. 43–78. Margaret Humphreys documents similar problems in the U.S. South as hydropower lakes filled and malarial rates increased there in the early twentieth century. See Humphreys, *Malaria* (cit. n. 21), pp. 88–92.

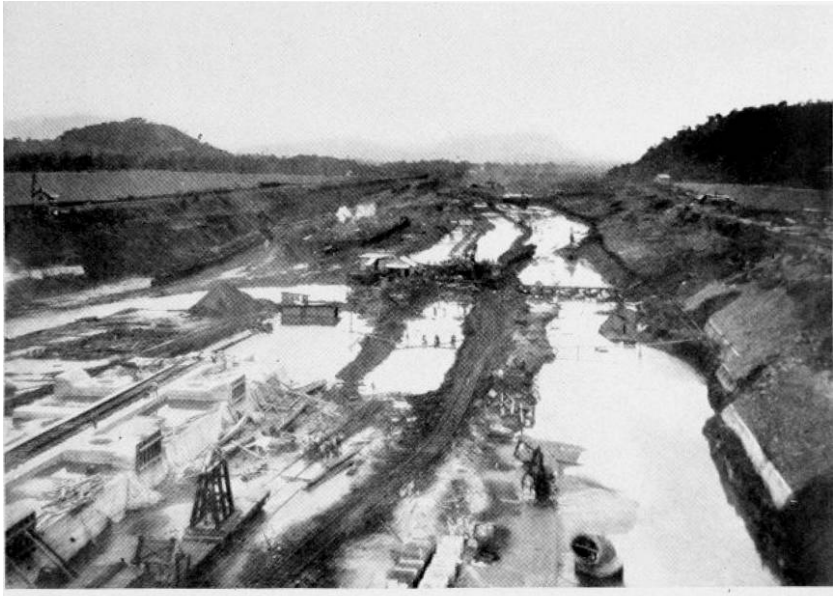


Figure 2. *The canal cut itself often held standing water and created new breeding sites for* Anopheles albimanus. *(From LePrince and Orenstein,* Mosquito Control in Panama, *opposite page 38.)*

than a solution. One of the most important mosquito control tactics was drainage. U.S. sanitarians cut ditches, laid tile, and sometimes even paved culverts in areas of persistent standing water. When well constructed and maintained, these drainage works could reduce mosquito breeding substantially. But when poorly constructed or maintained, they often exacerbated the problem. If, for instance, vegetation built up in the ditches, or if they were not of a sufficient grade, water could collect in pools, again providing favorable breeding conditions (see Figure 4). And such drainage problems were frequent; improper construction and maintenance of drainage systems was one of the biggest concerns voiced by the entomological workers who monitored mosquito breeding.[52]

LePrince and Orenstein concluded their lengthy summary by noting: "The topography, meteorological conditions, and constant changes due to the construction work, together with the character and constant moving of the population and their dwellings, and social conditions, were particularly unfavorable to the control undertaken."[53] This measured conclusion, implicating as it did the work of canal construction in exacerbating *Anopheles* breeding, stands in sharp contrast to the facile rhetoric of tropical conquest that many Americans engaged in. And while this nuanced perspective, gained by paying careful attention to the material environment, did not lead entomological workers to confront that rhetoric head on, it did create some revealing tensions among American administrators. Entomological workers constantly had to track down and apply control methods to new

[52] LePrince and Orenstein, *Mosquito Control in Panama,* pp. 71–72.
[53] *Ibid.,* p. 218.

Figure 3. *Hydraulic fill lands adjoining the canal route were among the most troublesome vector breeding grounds, as they were tremendously difficult for mosquito control workers to mitigate. (From LePrince and Orenstein,* Mosquito Control in Panama, *opposite page 120.)*

breeding grounds created by canal construction, and, as sanitary records reveal, they frequently scolded other ICC officials who took little heed of these anthropogenic hazards. LePrince and Orenstein also intimated that entomological workers considered "social conditions" and their relations to mosquito control, though they did so only in a shallow way. While entomological workers often resorted to racialized generalizations about the habits of nonwhite workers, whose alleged sanitary carelessness and moral failings threatened not only their own health but that of white Americans, thorough mosquito control also necessitated that they look carefully into mosquito breeding wherever it threatened worker health in the Canal Zone. In ways both expansive and limiting, the strategy of mosquito control privileged biological over social explanations, but it did not completely ignore the latter.

THE GREAT GRASS-CUTTING DEBATE

Tensions between entomological workers and other ICC administrators came to the fore in an unlikely debate over how short to cut the grass in the Canal Zone. Controlling adult mosquito populations was a critical aspect of the U.S. sanitary program, and the most important step taken here was brushing and grass cutting around work sites, homes, and barracks. Entomological workers had shown that such environments provided adult mosquitoes with daytime resting places and protection from wind and other elements and that, in some cases, long grass hid watery areas ideal for breeding. Eliminating such conditions in the immediate vicinity of work sites and human habitations reduced mosquito numbers substantially. Casual observers of this brushing and grass-cutting work often couched it in the language of conquest, as an effort to control the jungle's constant predatory advances

Figure 4. *Ditches of various sorts were critical to draining wet or swampy lands that bred mosquitoes in the Canal Zone. But when they were inadequately constructed or maintained, they could also themselves be troublesome breeding sites. This photo shows weeds retarding water flow, which could create pools of water ideal for vector mosquito breeding. (From LePrince and Orenstein,* Mosquito Control in Panama, *opposite page 20.)*

on human settlements. Indeed, sanitary clearing intersected in important ways with a larger landscaping effort in the Canal Zone, which sought to control and domesticate tropical vegetation as a symbol of American environmental mastery. But grass cutting also led to conflict between entomological workers, interested in the specifics of mosquito ecology, and those workers more concerned about the landscape aesthetics of environmental, and imperial, control.

The controversy began in 1908, during George Goethals's reorganization of the ICC and his efforts to streamline operations. During the first several years of canal construction, brushing and grass-cutting responsibilities were divided between the Department of Sanitation, which focused on mosquito control, and the Department of Labor, Quarters, and Subsistence, which cleared brush and cut grass around worker quarters for aesthetic reasons. When he became ICC chairman Goethals insisted, for the sake of efficiency, that all such work be brought under the control of the renamed Quartermaster's Department (QMD), with sanitary inspectors making specific requests to the QMD when sanitary cutting was necessary. Gorgas immediately raised several concerns about this new system.

He disliked the idea of putting mosquito control work in the hands of a department that did not appreciate its urgency or understand its specifics. He also questioned whether the QMD would carry out sanitary requests quickly and carefully, and he worried, presciently, that constant and often urgent requests from his department would become an irritant.[54]

Gorgas's sanitary grass-cutting goals were quite different from those that drove the QMD's work. Sanitarians did not worry until grass grew to a foot or more in height, the point at which it effectively harbored mosquitoes. This meant that they cut less often, focused their cutting in areas that served as critical mosquito habitat, and determined the areas to be cleared, usually a perimeter of 100–200 feet around housing and work sites, on the basis of observations of how far vector mosquitoes could fly. Under pressure to be cost efficient, entomological workers let their observations of mosquito behavior determine the extent of their brushing and cutting. Aesthetics were beside the point. Conversely, the QMD was more interested in neatly trimmed lawns in and around ICC facilities, particularly those that served and housed white American workers and their families, whether they were critical to mosquito control or not. While sanitarians trumpeted the need for precision mosquito control based on an intimate knowledge of Panama's malaria vectors, they feared that ignorant administrators were more interested in the aesthetic symbolism of unruly jungle giving way to finely cropped lawn.[55]

Gorgas's fears soon were realized. Within months of the reorganization, district sanitary inspectors complained that the QMD attended to requested sanitary cutting slowly, if at all; was sloppy in its execution—allowing, for instance, grass cut in and around ditches to block water flow; and gave excessive attention to cutting grass short near gold (white) married quarters while neglecting other important sanitary cutting in areas that bred and harbored vector mosquitoes. Indeed, whereas entomological workers seemed determined to provide thorough mosquito control, the QMD mostly manicured white American settlements, ignoring those areas where silver roll workers lived, which were often near disturbed and watery environments conducive to mosquito breeding. Moreover—most exasperatingly to Gorgas—the charges to the Sanitary Department for grass cutting had increased considerably since the reorganization, even as the QMD did the work less effectively. Indeed, Gorgas discovered that the QMD had taken to charging all grass cutting to his department under the assumption that its purpose was mosquito control, even though Gorgas thought that little of it was of any sanitary value.[56]

By 1910, two years after Goethals initiated his reorganization, Gorgas was ready to call the arrangement a failure. In a frank letter to Goethals, he explained: "Formerly grass cutting for sanitary purposes was done by the Sanitary Department, and that around the quarters, whose object was aesthetic, was done by the Quartermaster's Department. At present it is all done by the Quartermaster's Department from sanitary funds. The tendency of the local quartermaster, therefore, is to concentrate his attention upon grass cutting around quarters, and neglect that for sanitary purposes." Gorgas was quick to note that the QMD had "no especial knowledge of mosquito work," making it clear how tied he had become to seeing entomological expertise as proprietary, a part of what made entomolog-

[54] For correspondence outlining this controversy see NARA RG 185, Entry 30, Boxes 241–242, Folders 37-B-7 (I–V).

[55] The beginnings of this debate are laid out in Chief Sanitary Officer [Gorgas] to Chairman, Isthmian Canal Commission [George Goethals], 21 July 1908, NARA RG 185, Entry 30, Box 242, Folder 37-B-7 (I). Succeeding correspondence in this and following folders fills out the story.

[56] The billing situation is laid out in a series of letters and memos written in the fall and early winter of 1908: NARA RG 185, Entry 30, Box 241, Folder 37-B-7 (I).

ical workers both effective and necessary. "As I go about," he continued, "I am daily impressed, in all the details of execution, with the advisability of having the men in immediate charge of the work educated more or less in the habits of the mosquito so that they can carry out the measures understandingly." The QMD had few such men—and the results showed it, as official malaria rates for the critical months of June through August, in decline from 1906 to 1909, had risen again in 1910. Such recidivism, Gorgas believed, was the result of mosquito control work having been taken away from the entomologically informed.[57]

Goethals responded to Gorgas's concerns by creating a commission to study the issue. After hearings and extensive testimony, the commission recommended several changes to the system—including a better method to account for who ought to be billed for particular grass-cutting jobs. But the commission's final report nonetheless supported the reorganization, suggesting that there was not enough statistical evidence to prove that the shift in responsibility had been detrimental to public health in the Canal Zone—and particularly to the health of white American workers. Ultimately, Goethals refused to buy Gorgas's argument that, almost regardless of cost, sanitary work must be in the hands of those experts best equipped to limit mosquito breeding. That was insult enough. But then, in inquiring about the sanitary value of the QMD's obsessive grass cutting near gold quarters, Goethals revealed just how tenacious miasmatic perceptions could be: "Do you think the relief from mists gained by close grass cutting," Goethals asked Gorgas in a 1911 letter, "is of any sanitary or hygienic value?" "The only knowledge I have that short grass decreases mist," Gorgas responded with barely concealed exasperation, "is the statement in your letter to that effect. But accepting your statement that such is the case, I do not think that down here the presence or absence of mists is of any hygienic importance."[58]

This grass-cutting debate, however mundane, raised important tensions of empire, in the realms of discourse and practice. The battle over grass cutting provided a concrete example of how the dominant U.S. ideology of tropical conquest, manifest here as a landscape aesthetic, came into conflict with the perceived ecological dictates of mosquito control. For many American officials, closely manicured grounds not only reflected environmental mastery, the subjugation of a tropical jungle and its apparent threats to the health and enterprise of temperate white people; such a landscape *reproduced* the very distinction between hostile tropical nature and human mastery that informed its creation. As the canal neared completion, the journalist Albert Edwards celebrated this appearance of mastery: "On the sides of the hills," he wrote, "you see villages—clusters of homes, well-kept lawns where all that is beautiful in the jungle has been separated from what is noxious."[59] Here was the mainspring of the tropical ideology in the Canal Zone—a landscape of settlement that segregated the malignant tropics, environmentally and socially, from the benign and bountiful tropics (see Figure 5). The irony, of course, is that the white American landscape that Edwards celebrated—one that included well-built and well-

[57] Chief Sanitary Officer to Chairman, ICC, 21 Oct. 1910, NARA RG 185, Entry 30, Box 242, Folder 37-B-7 (I). On page 5 of this letter Gorgas cited yearly malarial hospitalization rates for the months of June–August, pointing out that the rate in 1909 had been 219 per 1,000 and that it had risen to 344 per 1,000 in 1910. But figures for the entire year showed a slight decline in malaria hospitalizations from 1909 to 1910. For a complete run of those statistics see W. C. Gorgas, *Report of the Department of Sanitation of the Isthmian Canal Commission for the Year 1913* (Washington, D.C.: Government Printing Office, 1914).

[58] Goethals to Gorgas, 9 Oct. 1911, NARA RG 185, Entry 30, Box 242, Folder 37-B-7 (III). On the larger controversy see NARA RG 185, Entry 30, Box 242, Folders 37-B-7 (III, V); and Gorgas to Goethals, 23 Oct. 1911, NARA RG 185, Entry 30, Box 242, Folder 37-B-7 (III).

[59] Albert Edwards, *Panama: The Canal, the Country, and the People* (New York: Macmillan, 1913), p. 512.

Types of screened houses: Colon Hospital grounds

Figure 5. *This photograph of the Colón Hospital grounds illustrates the landscape that the QMD grass-cutting operations aimed to create around gold quarters and other critical U.S. facilities. (From LePrince and Orenstein,* Mosquito Control in Panama, *opposite page 204.)*

screened houses and clean, orderly streets as well as close-cropped lawns and other domesticated tropical plants—intersected only obliquely with the landscape of mosquito control. The grass cutting of the QMD was designed less to solve a discrete public health problem than to reinforce an environmental ideology of tropical conquest. Or, perhaps more accurately, many in the ICC assumed that pursuing their landscape aesthetic was an adequate approach to protecting a narrowly defined public health.

Entomological workers upset this logic at a couple of levels. Gorgas, their voice in this debate, argued that there were not only differences but real tensions between the QMD's landscape aesthetic and the work of mosquito control. There was no doubt that the work the QMD did around white quarters provided some protection against mosquitoes, but its expense and limited extent made it inadequate to the larger goal of eliminating vector mosquitoes wherever they threatened worker health. If the primary goal was improved public health, then much of the grass cutting accomplished by the QMD was either useless or inefficient, Gorgas argued. Moreover, entomological workers produced a landscape of mosquito control that was barely legible to those looking for an aesthetic of imperial environmental mastery. Their sanitary landscape was spotty and ragged; in it, the wild and tamed tropics could not be so easily separated and discerned. In this sense, it mirrored the ecology of *A. albimanus* breeding it was designed to mitigate. The unkempt sanitary landscape to which the QMD implicitly objected, then, was an apt symbol of how attending to vector ecology in Panama had made murky not only the aesthetic boundaries between tropical nature and its conquest through modernization, but also those between natural and human agency.

But that was not the only boundary that entomological workers, in their focus on mosquito control, softened and complicated. Their approach was also less beholden to another dichotomy critical to the logic of tropical triumphalism: that between the settlements of white gold employees—"the men we are protecting," to borrow Henry Rose Carter's telling phrase—and the areas where those on the silver rolls lived and worked. The QMD's maintenance of nice lawns around white American worker settlements functioned to create and perpetuate a landscape of racial as well as environmental differentiation, though the labor (much of it nonwhite) and expense that went into producing such manicured American enclaves was often obfuscated by a logic of differing racial capacities and drives. To many white observers, such lawns seemed like natural expressions of their racial superiority. Entomological workers' grass-cutting strategies worked at cross-purposes with this symbolic project. Critically, their attention to mosquito ecology did *not* lead entomological workers into a reasoned critique of the sharp racial and civilizational taxonomies so central to tropical thinking at the time. But their single-minded goal of eliminating vector mosquitoes did lead them to extend their work beyond white quarters to take account of breeding places wherever they threatened worker efficiency.

Because nonwhite workers were more likely to live near disturbed work sites in substandard housing where mosquitoes thrived, entomological workers had to pay some attention to the relationship between those "social conditions" and mosquito breeding. Though they often chalked up the persistence of a malarial reservoir among nonwhites to particular racial habits, sanitary inspectors and other entomological workers nonetheless worked to prevent and mitigate breeding conditions in and around silver quarters as well as in some "native towns," existing settlements in the Canal Zone that had swelled with the arrival of tens of thousands of workers and their dependents. By seeing mosquitoes as the problem, and by suggesting that landscape change had as much to do with malaria as tropical nature *per se,* entomological workers pursued a *relatively* color-blind course—not because they were critical of the racial logic behind the American tropical ideology or the medical and environmental inequalities everywhere evident in the Canal Zone, but because the taxonomies that interested them were less racial or civilizational than entomological. Entomological workers' relative color-blindness thus cut several ways. Compared to other U.S. officials, they were less likely to trace an effective sanitary perimeter atop the color line. But they were also largely blind to the broader set of power relations and networks of agency that tended to put nonwhite workers in harm's way.

Entomological workers' attention to mosquito ecology thus could be as reductive and compartmentalizing as it was challenging to tropical triumphalism. For them, the presence of particular *Anopheles* species *meant* the presence of malaria, and vice versa. Their attention to vector species in no way constituted a full or objective view of malaria and the forces that produced it. They came to know intimately only part of the malarial cycle, the part that occurred in mosquito bodies and the environments they required to breed and subsist. They paid less attention to what happened once malaria was in workers' bodies and to the socioeconomic determinants of malarial demography—low pay, crowded and substandard housing, and objectionable food among them. While their ecological focus encouraged entomological workers to attack mosquito breeding throughout the Canal Zone, not just in white areas, it also limited their capacity to look beyond the blinders of their ecological expertise to contend with the other social, economic, and racial dimensions of malarial parasitism and transmission.

Entomological workers' reductive focus on mosquito control also opened them to administrative critiques. While it might be tempting to portray the grass-cutting debate as

one pitting heroic purveyors of nature's truths against ignorant senior administrators focused on expediency, it is important to recognize that entomological workers had a goal several layers removed from that of Goethals. For entomological workers, success was the elimination of vector mosquitoes; for Goethals, success was a completed canal, and mosquito control was only a means to that end. He was not going to pursue every last vector mosquito unless it was cost efficient to do so. Thus, while entomological workers gave voice to the material conditions that produced vector mosquitoes in Panama, they did so only by blocking out other voices and considerations. To know the "nature" of the problem was not to know it all.

CONCLUSION

The most important achievement of entomological workers in Panama was to control vector mosquitoes, which helped to eliminate yellow fever and greatly reduce malaria within the Canal Zone. The official malaria morbidity rate declined from a peak of 821 per 1,000 in 1906, just before Busck's trip and the beginnings of precision mosquito control, to 76 per 1,000 in 1913, as the canal neared completion.[60] Entomological workers, through careful observation and experimentation, came to understand that protecting workers against malaria necessitated not the control of tropical nature *per se* but, rather, the management of particular hybrid landscapes to which American enterprise substantially contributed. Where the logic of tropical triumphalism naturalized U.S. interventions in Panama and suggested that modernization was the surest path to unlocking the promise of the tropics, entomological workers noted that the environmental impacts of modernization-in-process were at the heart of the "tropical" threat to public health and that mosquito control in Panama involved conquering a nature that Americans helped to make.

Entomological workers were both critical *to* U.S. imperial success in Panama and, at times, implicitly critical *of* the environmental ideology that naturalized that success. Given that, how do we make sense of the positions and roles of these scientific workers as imperial actors? Were they agents of empire whose accomplishments served the goal of American imperial control, or were they critics of empire whose pursuit of truth challenged the fallacies of American tropical ideology? Neither characterization fits. Entomological workers had much to gain, in terms of professional status, by serving American expansion, a formula that had already built for them a central place in the federal scientific establishment. But entomological workers were not entirely captured by the instrumentality of the U.S. administration in Panama. Indeed, they insisted that their ecological expertise was built on a loyalty to nature and its workings, not solely to the U.S. mission or its animating environmental ideology. Just as important, entomological workers were loyal to the modernizing logic of science itself—the notion that science was a path to truth, administrative efficiency, and progress—and they increasingly identified with an international and trans-imperial community of scientists and sanitarians who saw themselves as crucial to controlling the tropics. While this could put them at odds with other national-imperial actors, as the grass-cutting debate suggests, it also meant that they were strongly inclined to an interventionist developmentalism that made their work to correct fallacies in tropical thinking its own kind of conquest. Finally, their loyalty to nature limited how far they could push into the world of the hybrid, for they still defined themselves as experts on nature

[60] Gorgas, *Report of the Department of Sanitation of the Isthmian Canal Commission for the Year 1913* (cit. n. 57), p. 6.

and thus avoided fully facing the "social conditions" that also contributed to malaria in Panama.

The scientific sensibility of entomological workers in Panama made them imperial agents of a particular kind, at once dutifully contributing to the goal of imperial control and developing an independent streak that made them agents for change. Their motives, like those of many imperial actors, emerged from competing identities, and their experiences on the ground challenged their ideological presuppositions. That men like Howard and Gorgas joined the triumphalist chorus when the canal was finished is not surprising. Claiming that mosquito control conquered the tropics for white northerners was a more satisfying and succinct boast than claiming that it resolved a set of problems created by a large-scale engineering project that relied on huge labor importations and massive disturbances under a particular set of environmental and social conditions. But to listen only to their triumphalist words would be to privilege their discourse over the material dimensions of imperial control to which they paid such close attention.

By carefully following entomological workers through the Panamanian environment that was their laboratory, we see environment intruding as a causal force, obliquely and in a networked form but also distinctly. The practitioners of American tropical triumphalism often misconstrued the nature that they sought to make culpable not only for disease but also for underdevelopment. That is something current science can certainly help us to explain, as we work with a more expansive knowledge base and a different set of cultural filters when we think and write about the tropics today. But it is more theoretically satisfying, if one's goal is coherently to link the material and the discursive in the imperial moment, to show how scientists contemporary to canal construction and engaged in an intimate reading of the environment themselves gave voice to a hybrid nature that talked back in confounding ways. In narrating the story of entomology in Panama in this way, I have tried to avoid the pitfalls of insisting that current science is the only route to a material environmental analysis. By attending to vector ecology, entomological workers learned that there was no simple nature to be conquered in Panama. Rather, they had to manage a series of environmental processes and entities so interlocked with human agency and action that they defied the dichotomies of tropical theorizing. American tropical triumphalism persisted, then, not in ignorance of a body of scientific knowledge yet to be constructed, but because its practitioners clung to useful binaries and ignored existing evidence to the contrary.