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Vaccines for military use

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ABSTRACT

Vaccines have long been used by military forces in order to prevent communicable diseases and thereby preserve the fighting force. A tradition that began with the mass vaccination of the Continental Army against smallpox during the War of the American Revolution in the late 18th century continues today with routine and deployment-based vaccination of military forces against potential pathogens of nature and biological weapon threats. As their role has expanded in recent years to include humanitarian and peacekeeping missions, the military's use of vaccines against infectious diseases has concomitantly broadened to include civilian populations worldwide. The emergence of new threats and the recognition of additional global challenges will continue to compel the development and promotion of vaccines to combat infectious diseases of military significance.

Disease prevention is a critical component of the military's doctrine of force readiness. Although the impact of infectious diseases in military venues has progressively decreased over the past century, it still accounts for the majority of morbidity there [1]. Because prevention of these diseases is best accomplished through the use of vaccines, the military has been a major force in both the development and the use of vaccines throughout modern history [2] (Table 1). In some instances exigencies have stimulated vaccine research on infectious diseases of mission-specific relevance; in others, the military has functioned as a high-volume consumer of routine immunizations.

Modern military forces are not solely involved in combat operations; they also function as peacekeepers, police, humanitarian relief workers, and disaster assistance personnel [3,4]. These roles potentially expose them to a wide array of environments throughout the world and may alter the primary mission from force preservation to the protection and treatment of civilians, including children [5], potentially predisposing forces to an expanded array of pathogens. Risks include infections that are prevalent in developing nations lacking widespread routine childhood vaccination programs; those that are endemic to only select regions of the world and tend to cause sporadic infections or outbreaks in deployed military personnel; and pathogens that may cause outbreaks of common diseases in enclosed populations. Recruit training represents the latter scenario, in which numerous young adults reside in confined living conditions for extended periods of time and are subjected to intense physical, emotional, and immunologic stressors placing them at increased risk of communicable illnesses [6]. Additionally, deployed military members harboring infections may serve as vectors of disease upon their return. To guard against the plethora of infectious diseases that may assail a military in any of its many, expanded, modern functions, a variety of vaccines is widely deployed (Table 2).

1. Smallpox

Smallpox immunization, beginning with the first large-scale inoculation of a military force, Washington's Continental Army in 1777, by variolation [2] or via vaccination with live orthopoxviruses has been used by the military for more than two centuries. Vaccinia products distantly related to Jenner's continued to be routinely administered to new recruits until 1990, nearly twenty years after the cessation of routine civilian use of the vaccine, when it had become clear that the risk outweighed any potential benefits [7–9].

Despite the eradication of smallpox as a cause of natural human disease in the 1970s, the U.S. government reinitiated large-scale military vaccination using live vaccinia in December 2002 in response to the perceived threat of bioterrorism involving smallpox. The military has since vaccinated over 1.7 million individuals [10]; of note has been the identification of myopericarditis, at a rate of approximately 1.2 cases per 10,000 vaccinees [11,12], as a serious cardiac complication of live vaccinia. Currently, a second-generation, tissue-culture derived, smallpox vaccine, also associated with a risk of myopericarditis, is given to select U.S. military units that will potentially deploy to areas considered to be at "high risk" due to the threat of biological weapons expo-

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Table 1
U.S. military contributions to vaccines against infectious diseases.

Disease/Agent	Dates	Military Relevance	Military Contribution	Key Personnel
Smallpox	1777	Highly contagious scourge of troops; tactical advantage to immune troops	First large-scale inoculation of an army	Gen. George Washington, Dr. Benjamin Rush
Yellow fever	1900	Epidemic disease associated with high mortality in American-occupied areas	Demonstrated that the etiologic agent was a filterable virus transmitted by *A. aegypti* mosquitoes, leading to disease control through vector eradication and eventually, through vaccination	Maj. Walter Reed, Maj. James Carroll, Aristide Agramonte, Jesse Lazaer, Col. William Gorgas
Typhoid	1909	Communicable cause of outbreaks among deployed troops	Development of killed typhoid vaccine that became mandatory for all Army and Navy personnel in 1911 and greatly reduced the morbidity and mortality of typhoid among military personnel	Maj. Frederick F. Russell
Pneumococcus	1945	Prominent respiratory pathogen among troops	Tested first multivalent polysaccharide vaccine at the Army Air Base, Sioux Falls, S.D. (under auspices of the Armed Forces Epidemiological Board), reduced incidence of pneumonia and the pneumococcal carrier state	Dr. Colin MacLeod, Dr. Michael Heidelberger, Lt. Richard Hodges
Hepatitis A	1945; 1985–1990	Cause of major outbreaks among troops in setting of military conflict	1945 Demonstrated that passive immunization with pooled normal human Immunoglobulin could prevent or attenuate disease; 1980s–1990 Investigated safety and immunogenicity of inactivated vaccines and directed a pivotal efficacy study of inactivated HAV vaccine in ~40,000 Thai children	Col. Charles Hoke, Lt. Col. Bruce Innis, Dr. Len Binn, Dr. Stanley Lemon
Adenovirus	1952–1969	Major cause of acute respiratory disease in recruits, disruptions in training, economic losses	Isolated causative agent, later named adenovirus, at Ft. Leonard Wood; described epidemiology and clinical spectrum of adenovirus infections; developed killed bivalent vaccine; recognition of SV40 contamination; developed oral, attenuated, multi-valent vaccine	Dr. Maurice Hilleman, Col. Edward Buescher, Maj. Franklin Top, Col. Phillip Russell
Influenza	1957	Epidemic and pandemic disease impede military readiness and fighting force	Described antigenic drift and shift; developed surveillance system for epidemic disease	Dr. Maurice Hilleman
Rubella	1961	Consequences of disease in pregnancy affects military families	Isolated the causative virus after noting interference with enteroviral growth in African green monkey kidney cell cultures; led to development of a safe and effective vaccine using this virologic technique	Cpt. Paul Parkman, Cpt. Malcolm Artenstein, Lt. Col. Edward Buescher
Meningococcal disease	1966–1972	Epidemic meningitis in basic training settings causes significant morbidity and mortality among troops	Described immunologic responses to the bacteria and identified protective responses; developed first polysaccharide vaccine and proved its efficacy in clinical trials	Dr. Malcolm Artenstein, Dr. Irving Goldschneider, Dr. Emil Gotschlich, Maj. Ronald Gold
Japanese encephalitis	1950s; 1980s	Epidemic neurologic disease in Asia; outbreaks in American forces in Korea; potential for impacting deployed troops throughout Asia	Early attempts at vaccination (WWII); significant contributions to the epidemiology and ecology of the virus in the 1950s–60s; pivotal field trial of inactivated vaccine in Thailand	Dr. Joseph Smadel, Dr. Albert Sabin, Cpt. Edward Buescher, Cpt. William Scherer, Col. Charles Hoke
Hepatitis B	1970s–early 1980s	Blood-borne and sexually transmitted disease	Demonstrated protective effect of antibodies	Dr. Saul Krugman, Col. William Bancroft, Dr. Maurice Hilleman

sures [10]. Newer generation vaccines continue in development [13]. Other developed nations, such as Canada and Great Britain, have not adopted policies of vaccinating large groups of military personnel against smallpox.

2. Vaccines used routinely and in recruit training settings

Routine childhood immunizations, including those against tetanus, diphtheria, pertussis, measles, mumps, rubella, varicella, and polio are consistently applied to service members early in recruit training to ensure complete penetrance of immune protection against these preventable pathogens. As most young adults have received basic immunizing doses in childhood, these vaccines are generally either given as booster doses to sustain immunity or based on the results of serologic screening; subsequent doses are given at intervals as recommended by the Advisory Committee on Immunization Practices (ACIP) [8].