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US DEPARTMENT OF DEFENSE SUPPORT OF CIVILIAN VECTOR CONTROL OPERATIONS FOLLOWING NATURAL DISASTERS

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ABSTRACT. The United States Department of Defense (DoD) employs advanced-degreed entomologists as Preventive Medicine and Public Health Officers in the Army, Navy, and Air Force. While the primary objective of military entomologists is service member health and readiness ("force health protection"), military entomology resources can provide support to civil authorities as directed by the President or Secretary of Defense through Department of Defense Directive 3025.18, Defense Support of Civil Authorities (DSCA). The employment of DSCA is complex and involves the consideration of such factors as the proper request process, funding, legality, risk, appropriateness, and readiness. Once approved and mobilized, however, military preventive medicine assets can be of significant help to civil authorities when dealing with emergency vector control. This paper will address some of the policy issues surrounding the use of DSCA, outline the resources available from the individual military services, and provide examples of DoD contingency vector control support to civil authorities.

KEY WORDS Defense support of civil authorities, emergency vector control, natural disaster

INTRODUCTION

The mission of the Department of Defense (DoD) is to provide the forces necessary to deter war and to provide for the security of the USA. An important aspect of maintaining a ready force is force health protection (US Department of Defense 2018). Historically, disease nonbattle injuries (DNBI) have caused more casualties than combat, and DNBI caused by arthropod vectors have impacted almost every major military operation (Pages et al. 2010). Notable examples are yellow fever during the Spanish-American War and malaria in the Pacific Theater during World War II (Kitchen et al. 2008). For this reason, the Army, Navy, and Air Force commission officers with advanced degrees in entomology and maintain mission-specific preventive medicine units. Preventive medicine units are tasked with preventing DNBI (including food-, water-, and vector-borne disease) in deployed forces (Department of the Navy Issuances 2012b, APD 2013, US Air Force Doctrine 2015). Under the right circumstances, military preventive medicine assets, including vector control, may also be deployed to assist civilian agencies to protect the affected populace in the event of natural disasters.

Following natural disasters outside of the USA and its territories, military preventive medicine units may mobilize in support of stability or emergency operations when assistance is requested by the affected nation. In many cases, preventive medicine units will be deployed alongside engineers or clinicians to provide environmental health and field hygiene support for both US military and partner nation personnel. Additionally, preventive medicine assets may be deployed to a partner nation to help prepare for future emergencies and provide direct support to military and/or civilian agencies as part of global health engagement missions.

Within the USA and its territories, the DoD's role in preparation for or response to a natural disaster or disease outbreak is different. Preventive medicine personnel will provide support to military installations and the personnel living and working on DoD installations, but do not have the authority to directly support local, state, or federal governmental organizations unless requested. The role of the DoD in civil support and the mechanisms by which DoD assistance is requested are often not well understood, even by those within the DoD or civilian emergency response organizations. Several different laws govern when and how the DoD may respond, and the laws differ whether the response is within or outside of the USA. While there is likely to be added complexity and expense involved with requesting military assistance, the DoD has many unique capabilities, a large number of skilled personnel, and the ability to operate in the austere environments often encountered after a major natural disaster. This article will describe the DoD assets capable of providing vector control following natural disasters and discuss the policies and procedures required to mobilize those assets for civil support.

PREVENTIVE MEDICINE ASSETS IN THE DoD

For pest and disease vector control, the DoD coordinates the development of policy, training, pesticide applicator certification, and equipment

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through the Armed Forces Pest Management Board (Office of the Under Secretary of Defense for Acquisition and Sustainment). While each branch of the military shares common preventive medicine goals, each Service has unique preventive medicine and vector control assets tailored to their primary support missions. The DoD medical assets are scalable and flexible, and the support provided can range from a single subject matter expert to an entire deployable unit and all the associated equipment as the mission dictates.

Army

Army medical capabilities are usually described in terms of "roles of care" (APD 2013). Roles of care range from I to V and facilitate medical care, including preventive medicine, at all levels of military operations from the battlefield to rehabilitation and redeployment. In the Army, vector surveillance and control services are the responsibility of preventive medicine units.

Role I is the unit or individual level of preventive medicine and medical care. A significant amount of vector-borne disease prevention occurs at this level. Individuals and unit commanders are responsible for the correct implementation of the DoD Arthropod Repellent System (AFPMB 2015). That is, uniforms are treated with permethrin and worn properly, topical repellent is applied to exposed skin, chemoprophylaxis is taken as prescribed, and bed-nets are used appropriately. Field sanitation teams (FST) are an example of an Army asset that falls within the Role I level of care. Field sanitation teams are a 2-person team capable of performing basic preventive medicine tasks (i.e., latrine placement and rodent control) for an Army company. Two soldiers are selected from the company to receive FST certification training, and the team is supplied with a basic set of pest management equipment, including simple pest control tools such as a 2-gal pressurized sprayer and preformulated insecticides (APD 2000, 2014a).

Role II preventive medicine support is provided by area support units such as medical companies within brigade support battalions (BSB). The BSB medical companies often have a preventive medicine section that consists of an environmental science and engineering officer (ESEO) and a preventive medicine noncommissioned officer (APD 2014b). The preventive medicine section generally focuses on training and basic field sanitation, but also has limited capability to survey for vectors, identify threats, and perform pest management (APD 2009). As this type of preventive medicine support is usually attached to a brigade combat team, it is more likely that these units would be deployed in support of units conducting other types of response activities following natural disasters.

Role III preventive medicine support is provided by preventive medicine detachments (PMDETs) and echelons above brigade (APD 2016). The PMDETs fall within multifunctional medical battalions and can provide area support to units without organic preventive medicine assets upon request (APD 2013, 2016). A PMDET is made up of 12 soldiers—a commanding officer, an executive officer, and 10 enlisted preventive medicine soldiers. The officers are an environmental health and engineering officer and an entomologist, usually one of each. Either may be in command. The PMDETs are capable of performing basic entomological activities such as vector surveillance, threat assessment, uniform repellent treatments, and vector control (APD 2009). A PMDET is more flexible and has greater pest surveillance and control capabilities in comparison to Role II assets. Vector control equipment available to a PMDET can include 2-gal pressurized sprayers, fan-operated backpack applicators, and truck-mounted pesticide dispersal equipment. Vector surveillance equipment available to PMDETs includes Centers for Disease Control and Prevention miniature light traps, tick drags, larval dippers, and rodent traps. A PMDET may be more likely to be deployed within the USA and territories in support of natural disaster recovery efforts.

Role IV preventive medicine support is provided by the 1st Area Medical Laboratory (1st AML). The 1st AML serves as a mobile laboratory for an entire area of operations. In addition to an entomologist, the 1st AML typically has several other specialized officers that may include an ESEO, veterinarian, and preventive medicine, infectious disease, or occupational health doctor. This unit also includes enlisted laboratory technicians. The 1st AML is capable of performing identification and threat assessment for vectors and vector-borne pathogens and provides area support to lower echelons of preventive medicine services (APD 2009). Pest management capabilities are more limited. In addition, the 1st AML is capable of splitting into smaller subunits to cover a larger area of operations (Cardile et al. 2016). The 1st AML is often deployed in situations where extensive mobile laboratory capabilities are required, such as the 2014 West African Ebola outbreak (Cardile et al. 2016).

Preventive medicine support at Role V is provided by the Army Public Health Center (APHC), which provides confirmatory analysis of environmental samples provided by deployed preventive medicine personnel and installation pest managers. The APHC may also provide preventive medicine assistance visits to installations with a special medical readiness capability team. Regional Public Health Commands in Germany, Japan, Hawaii, Texas, Maryland, and Washington State provide preventive medicine support within their geographic area (e.g., APHC Central in Texas provides support to installations throughout the central USA). While APHC does not directly engage in pest management, they provide training, health communication services, data management, and laboratory analyses for preventive

medicine assets and installation pest managers throughout the Army (APD 2009).

Navy

The capabilities and distribution of Navy preventive medicine assets are a bit more complex depending on the type of unit (surface ship, installation, United States Marine Corps [USMC], etc.) being supported. Regardless of the unit type, however, the coordination point for policy and guidance is the Navy and Marine Corps Public Health Center (NMCPHC) in Portsmouth, VA. The NMCPHC has a variety of field activities stationed around the globe, with vector diagnostic and control capabilities centered at Navy Environmental and Preventive Medicine Units (NEPMUs) in Virginia, California, Hawaii, and Spain, and the Navy Entomology Center of Excellence (NECE) in Florida. The NEPMUs and NECE have medical entomologists and preventive medicine technicians at each location that provide support to fleet units and installations within their geographic area. In addition, NEPMUs maintain the Navy's primary preventive medicine capability, the Forward Deployable Preventive Medicine Unit (FDPMU) (Department of the Navy Issuances 2012a). The FDPMUs are modular and scalable and include vector surveillance, pathogen diagnostics (vector only), and limited vector control capabilities. They specialize in providing real-time disease risk assessments and recommendations for risk communication and mitigation. From a vector control equipment standpoint, they are designed for small-area (i.e., military encampment) operations with capabilities ranging from compression and motorized backpack sprayers to handheld cold and thermal foggers and truck-mounted ultra-low volume pesticide sprayers. The vector component of an individual FDPMU team is composed of 1 medical entomologist and 2 preventive medicine technicians.

Navy personnel also provide all medical support for the USMC, and are technically USMC assets that fall outside of direct NMCPHC control but typically coordinate with NMCPHC for disease control response. Navy medical entomologists are part of the Medical Battalion Preventive Medicine Units (PMUs) found within the Marine Logistics Group of the Marine Expeditionary Force. The PMUs have personnel and equipment that are scalable for the required mission similar to the FDPMUs, but have less diagnostic capability and a more robust vector control inventory, including truck-mounted ultra-low volume and hydraulic sprayers.

Navy and Marine Corps installations and the units serving there are the primary customers for Navy preventive medicine assets following a natural disaster or potential disease outbreak within the USA. Each installation maintains an integrated pest management plan that guides their daily pest surveillance and control operations, and included in this is an emergency vector control plan. Evaluation and refinement of these plans is supported by civilian entomologists employed by the Naval Facilities and Engineering Command, which may request support from medical entomologists assigned to the units described above. The best way to think about Navy and USMC installations during a natural disaster or vector-borne disease outbreak is of a small city within the surrounding community. The installation has its own stand-alone plan for response but included in that plan is close coordination with the surrounding governmental agencies generally and with mosquito control operations specifically. It should also be kept in mind that while a specific installation may be augmented by one of the aforementioned Navy preventive medicine assets, individual installation mosquito control is typically a contracted service provided by private pest control businesses with little to no surge capacity for the surrounding community.

Air Force

Theater Epidemiology Team: The Theater Epidemiology Team (TET) was established in 1996 and is designed for rapid deployment in order to support contingencies worldwide (Concept of Operations for the Theater Epidemiology Team, United States Air Force Aerospace School of Medicine). The TET is composed of a highly specialized, 5-member team, which, in the standard form, includes a public health officer (can be an entomologist), bioenvironmental engineer, and a preventive medicine physician, along with 2 supporting enlisted positions. This 5-member team is the core concept for epidemiological support of military Air Force members operating in a theater of war. The main capability revolves around the concept of gathering and analyzing data and subsequently generating recommendations for health protection. This team can analyze the risk of contaminants from food, water, and soil. Among other capabilities, this team can assess the threat of endemic infectious diseases, conduct insect surveillance, and identify arthropod-borne pathogens. This small but skilled team is deployed to perform a basic preventive medicine assessment pertinent to the operating environment and mission and does not have the capacity for detailed laboratory analyses.

While it is clear that the TET concept was created to protect military members across a broad spectrum of potential threats, the fundamental idea behind this preventive medicine model is flexibility in scope and function and the ability to sculpt the team to match the need. Therefore, while a TET has never deployed specifically to support DSCA vector control operations, it has also never been specifically requested.

RED HORSE and Prime BEEF: The Rapid Engineer Deployable Heavy Operational Repair Squadron Engineers (RED HORSE) is a large and diverse program capable of deploying up to 404 individuals with specialized equipment, and can

Table 1. Examples of past US Department of Defense support operations for disaster response.

Year	Location	Threat	Activity
2004	Indonesia	Tsunami	Vector and pest control
2005	Louisiana, Texas	Hurricanes Katrina and Rita	Aerial applications for mosquito control
2008	Louisiana	Hurricanes Gustav and Ike	Aerial application for mosquito control
2010	Haiti	Earthquake	Vector and pest control
2014	Liberia	Ebola outbreak	Vector control for deployed units
2017	Texas	Hurricane Harvey	Aerial application for mosquito control

carry out virtually all civil engineering tasks, from large-scale construction projects to pest management operations (AFDPO 2019a). This capability is specifically adapted to operate in the type of contingencies encountered following natural disasters and was a part of vector control operations after Hurricane Andrew in southern Florida and Hurricane Katrina in Louisiana. The Prime Base Emergency Engineer Force (Prime BEEF) is a subset of the RED HORSE function, and the smaller footprint means they can respond quickly and operate farther out in an area with reduced infrastructure (AFDPO 2019b). Both of these assets include 2 DoD certified pesticide applicators. Since the teams are scalable, multiple pairs of applicators could be requested for a specific vector control support project. The team also needs to coordinate specialized equipment that may or may not be at their home base location. Therefore, requests for these assets should include the type of equipment required (e.g., truck-mounted ultra-low volume sprayer or backpack sprayer).

If a request was made to the Federal Emergency Management Agency (FEMA) and military assets were already part of the response, a TET or Prime BEEF team could potentially respond. These teams could provide a stopgap measure, conducting mosquito surveillance, testing mosquitoes for pathogens, and applying appropriate control measures to lower the threat of vector-borne disease until the local resources had recovered. However, the inertia for such a deployment would historically follow a pattern for these teams to join a Joint Task Force and protect military members. Therefore, a specific request for an augmented team would need to be made indicating the requirement for equipment for trapping mosquitoes, identifying mosquitoes, and testing collected mosquitoes for pathogens.

Aerial spraying: The Air Force also maintains a fixed-wing, large-area, aerial pesticide application capability to control disease vectors in combat zones and in response to declared emergencies (ESD 2008, AFDPO 2019c). A need for a military capability in aerial spraying for controlling mosquitoes hails from experience with malaria in the Pacific Theater during World War II (Dowell 1965). While used in the Korean War to control mosquitoes, the Air Force has not sprayed for mosquitoes in a combat zone since Vietnam (Cecil and Young 2008). In contrast, the Air Force Aerial Spray Unit (AFASU) has responded to DSCA requests multiple times (Table 1). Aerial sprays are considered the fastest method to quickly reduce the number of mosquitoes over a large area and, subsequently, lower the threat of vector-borne disease and physical discomfort that can commonly be present following natural disasters such as hurricanes (Breidenbaugh and Haagsma 2008, Breidenbaugh et al. 2008, Qualls and Breidenbaugh 2020). The Air Force Aerial Spray Mission is carried out with specially modified C-130 aircraft and the Modular Aerial Spray System (MASS), based at Youngstown Air Reserve Station, Ohio. This is a unique capability within the DoD and with the Air Force Reserves (AFRC). Unlike Active Duty, the AFRC does not typically move their members every few years and this allows aircrews to develop a strong skill set necessary to conduct aerial spraying. The unit trains for its wartime mission by engaging with integrated mosquito management programs at military installations and various communities, operating in 10 states with approximately 24 separate off-station deployments each year.

The AFASU has 6 spray systems ready for deployment on individual aircraft along with their associated aircrew. Along with the aircrew, the AFASU will also deploy an entomologist, who is a DoD certified applicator who serves onboard the aircraft to ensure proper and lawful application of pesticides. Additionally, entomologists have often participated as liaisons with the requesting state public health decision-makers. Historically, FEMA has requested up to 3 aircraft for most mosquito control responses. The MASS is capable of a range of configurations but can only dispense liquid formulations. Liquid larviciding is an option with the MASS capable of carrying 2,000 gal, so relatively large areas can be treated. The unit normally applies *Bacillus thuringiensis* var. *israelensis* (*Bti*) or methoprene larvicides. Following the discovery of autochthonous Zika in Florida and Texas in 2016 (Likos et al. 2016), the unit began developing the capability to deliver *Bti* as an ultra-low volume aerial spray targeting container-breeding *Aedes* spp. with a droplet size of 110 μm and a swath width of 150–300 ft. The AFASU MASS has an ultra-low volume mosquito adulticide capacity of 1,000 gal and may treat up to a quarter million acres per sortie. However, in practice, the shape of the spray area, distance to the spray area, and weather conditions limit applications to 100,000 acres per sortie. While the possibility for multiple sorties per aircraft per

night exists, historically, the size of the Air Force response, multiple C-130 aircraft, and the extent of the damage have pushed the operating location far afield to the application sites, making multiple flights difficult. In short, 100,000 acres per airplane per night is an appropriate number for planning purposes. It is not uncommon to expect significant reductions in mosquito densities following mosquito adulticide applications, and a reduction >90% should be the minimum level for such applications to be considered successful (Breidenbaugh et al. 2008).

Pesticide application: Regardless of their Service, all military and government civilian personnel who apply pesticides on DoD property must be a certified DoD pesticide applicator. Pest control operators contracted by installations do not necessarily need to be DoD certified, but must have the appropriate state certifications and be supervised by certified DoD pest managers (ESD 2008).The DoD pesticide applicator certification meets the requirements of the Federal Insecticide, Fungicide, and Rodenticide Act (ESD 2008, US House of Representatives 2020a). The DoD pest control operators may become certified in Forest Pest Control; Ornamental and Turf Pest Control; Aquatic Pest Control; Right-of-Way Pest Control; Industrial, Institutional, Structural, and Health-Related Pest Control; Public Health Pest Control; and Aerial Application Pest Control. Certifications must be renewed every 3 years. When DoD entomologists apply pesticides at the request of local authorities in the USA, they first request reciprocity with the state-level authority for the appropriate license for the application of pesticides.

REQUESTING SUPPORT FROM THE DoD

In almost all cases, the DoD is prohibited by law from providing unsolicited assistance in support of civil authorities. There are many different policies and laws guiding DoD response activities domestically and internationally, including the Robert T. Stafford Disaster Relief Emergency Assistance Act; Department of Defense Directive 3025.18 (ESD 2010), Defense Support of Civil Authorities; Department of Defense Directive 5100.46, Foreign Disaster Relief ESD 2012; Army Doctrine Publication 3-28 (ADP 2019); and the Foreign Assistance Act of 1961 (US House of Representatives 1961).

The Stafford Act allows the federal government to plan for and respond to domestic emergencies. Title IV §403 provides for the utilization of DoD resources as directed by the President during domestic emergencies. Under this section the Stafford Act limits assistance to no more than 10 days (US Federal Emergency Management Agency 2018). The Foreign Assistance Act provides the authority for the US government to direct resources to assist partner nations as this in turn promotes the security and well-being of the USA. Section 503 (22 U.S.C. 2311) of the Foreign Assistance Act allows the President to direct the DoD to provide noncombat assistance to partner nations (US House of Representatives 1961).

The DoD response efforts begin with a request from a US civilian authority or foreign government. In the case of natural disasters in the USA, a state or territorial governor may be the requester. Requests for assistance from states or territories are made through FEMA. Requests for assistance from partner nations are often made through the Department of State or a US ambassador. The request is then authorized by the President or the Secretary of Defense, provided the request meets the standards of "legality, lethality, risk, cost, appropriateness, and readiness" as defined by Department of Defense Directive 3025.18 (ESD 2012). In other words, the Secretary of Defense must consider whether the request will adversely impact the DoD mission, pose significant risk to DoD forces or their ability to be ready to defend the USA, pose any potential risks to civilian populations, and whether the request complies with applicable laws. Some of the legal considerations surrounding defense support to civil authorities for vector control are the Economy Act and Title 10 of the United States Code. The Posse Comitatus Act prohibits the use of federal military forces for civilian law enforcement (US House of Representatives 2020b) while Title 10 of the United States Code governs the ability of the federal government to call Reserve and National Guard forces to active federal service (US House of Representatives 2019). The Economy Act requires that the DoD be reimbursed for direct and indirect costs incurred relating to the assistance provided (US House of Representatives 2020c).

The DoD is not a humanitarian organization and thus is not the federal agency in charge of disaster and humanitarian relief efforts. The FEMA (part of the Department of Homeland Security) leads domestic disaster relief efforts while the US Agency for International Development (USAID) leads international disaster relief efforts via the Office of Foreign Disaster Assistance. In other cases, such as disease outbreaks, the DoD may coordinate with other federal agencies such as Health and Human Services or the Department of Agriculture, and the DoD has liaison officers stationed at many of the agencies and vice versa. When a support request is received, the Office of the Secretary of Defense works with FEMA, USAID, or another requesting agency to determine what type of support is being requested and how the DoD can best meet the requirements. Once approved, the cognizant Geographic Combatant Commander (in a domestic response that would be Northern Command or NORTHCOM) will coordinate the DoD response and request specific capabilities from the individual Services. Active Duty and Reserve units may only be mobilized by the federal government. However, while National Guard units are part of the DoD, they are under both federal and state control and therefore may be mobilized by their state governor.

The single exception to requesting support through official channels is the immediate response authority guidance in the DCSA (ESD 2012). Immediate response authority is granted to commanders within their area of operations when local civil authorities request assistance, there is imminent threat to human life or risk of significant property damage, and insufficient time to receive approval from a higher authority. When all 3 of these conditions are met, commanders may use the resources directly at their disposal to aid local civil authorities during natural disasters and similar emergencies. This authority ends after 72 h, or when sufficient civilian resources become available (ESD 2012). While vector control and pest management save lives and preserve property, it is unlikely that any emergency vector control response would fall under the immediate response authority except in the most extreme circumstances.

CONCLUSION

Implementing vector control after a natural disaster is an important step in the prevention of disease outbreaks and can support debris removal and restoration of services such as electricity by reducing mosquito biting pressure. Department of Defense entomologists and preventive medicine units have assisted with a number of foreign and domestic natural disasters (Table 1). Natural disasters will always be a part of our environment, and the best approach for dealing with the unknown extent of future disasters is preparation. Public health officials can be better prepared by educating themselves on proper procedures for making such requests. Knowing where the regional FEMA offices are and participating in regional disaster preparedness drills can build effective working relationships before disasters strike. Furthermore, participation in regional and national professional vector ecology and mosquito control conferences provide important networking opportunities and exchanges in cutting-edge technologies. The DoD follows all applicable laws and policies when determining a response and when making pesticide applications. An effective response from the DoD requires a chain of command and logistical support for units providing assistance, and helps prevent duplicity of action when conducting contingency vector control. While the primary mission of DoD preventive medicine personnel and units is force health protection, the military represents a unique repository of expertise, particularly in mosquito control operations, that may be able to assist state and local governments following a natural disaster or emerging disease threat. Ranging from the relatively small-area surveillance and control capabilities found in the Army and Navy to the massive aerial spray platforms maintained by the Air Force, the DoD stands ready to protect the USA from all enemies (including mosquitoes) foreign and domestic. This discussion has attempted to capture the various capabilities of the DoD that may be available to civilian agencies when their regional resources are temporarily disabled.

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