THE UNITED STATES ARMY MEDICAL DEPARTMENT

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Perspectives

Commander's Introduction

MG Philip Volpe

Throughout history, battles, campaigns, and even wars have been won and lost due to a factor having nothing to do with force organization, combat doctrine, fire and maneuver, superior weapons, inspired leadership, or logistics support, but rather because of the collective health of the single essential element, the Warfighters. Field commanders had long struggled with the loss of combat effectiveness due to the ravages of diseases and other debilitating physiological problems among their forces. There were few answers as to causes, and even fewer for remedies, until the second half of the 19th century when, as COL Stephen Craig explained in the *AMEDD Journal* in 2006:

> Bacteriology, developed by Koch, Pasteur, and others, and the nascent science of immunology were establishing a foundation for public health practice that was being effectively applied by innovative physicians in state and metropolitan public health departments.[1]

Army medical leaders were also recognizing that these new approaches to explaining the causes and prevention of diseases were potentially of great value to military capabilities and readiness. In 1893, The Army Surgeon General, BG George Sternberg, established the first Army Medical School. However, the purpose of the school was not to teach medicine and surgery. As BG Sternberg wrote to Daniel Lamont, the US Secretary of War:

> There is no need to teach medicine and surgery to graduates of our medical colleges, but there are certain duties of an Army medical officer—for which the college course has not prepared them—which are more important than the clinical treatment of individual cases of disease and injury…. A special education is needful to prepare a military man to undertake the protection of the public health. The course at the army medical school will prepare him to cope with the questions of practical sanitation that will be presented to him at every turn in his military career.[2]

That profound insight in 1893 established that the tenets of public health were basic to military medicine. From that beginning, the science and practice of public health disciplines in the military have become recognized as essential to the achievement of a relevant and ready force and the sustainment of combat power. That evolving realization has resulted in top-down emphasis, policies, and regulations to institutionalize public health as an integral part of garrison management and the planning and execution of training and operational deployments. The creation of the US Army Public Health Command in 2011 formally established public health as a distinct, major component of the Army Medical Department.

The scope of AMEDD's commitment to public health is impossible to convey in a few short paragraphs, or even an entire issue of the *AMEDD Journal*. Fortunately, for each of the past 7 years, COL Mustapha Debboun, Chief of the Academy of Health Sciences Department of Preventive Health Services, has assembled articles from preventive medicine and public health professionals for a dedicated issue of the *Journal*, providing exposure for the diversity and complexity of their responsibilities and their work. That continues with this eighth issue, with articles covering a spread of public health and force health protection concerns, from extensive research studies and surveillance, to solutions for problems and threats. As with those past issues, this *AMEDD Journal* clearly conveys the breadth and depth of this vital work and vigilance that are never-ending, mostly behind the scenes. Because of the preventive and environmental nature of their work, the success of the Army's public health professionals is often not noticed in our everyday lives, but it is absolutely reflected in an absence of disease and injury, and the improved health of us all. For this, these medical professionals have truly earned our respect and gratitude, both for what they have done and what they will do to protect our most valuable asset, the Warriors who defend our nation and our way of life.

1. Craig SC. The evolution of public health education in the US Army. *US Army Med Dep J*. April-June 2006:7-17.
2. *Annual Report of the Army Surgeon General, 1893*. Washington, DC: US War Department; 1893:15.

EDITOR'S PERSPECTIVE

As the understanding of the value of information relating sicknesses, diseases, and deaths to geographic locations and time expanded and matured, the United States has increasingly regarded the threat of wide-spread, uncontrolled diseases as a national security concern. Following World War II, the military took the lead in implementing world-wide disease and vector surveillance and analysis, initially for its own strategic purposes, but also to complement the growing initiatives and activities across the civilian public health sectors. Quantum leaps in the sophistication of analysis, communications, and data management have made such disease surveillance an indispensable tool for both military and civilian public health professionals throughout the world. The Defense Department (DoD) established the Global Emerging Infections Surveillance and Response System (GEIS) in 1997 to centralize coordination of surveillance efforts of the overseas DoD medical research laboratories. Over the years, the GEIS network has expanded to include international collaborations with various agencies and organizations in numerous countries. In an excellent article providing insight into the capabilities, scope, and value of the functions performed by GEIS, Navy CDR David Blazes and his team of coauthors detail the extensive activities and accomplishments of the GEIS network for one year, 2011. Their article clearly conveys the enormity, gravity, and especially the importance of the work that GEIS has done, and will do in the future.

The world was stunned at the destruction and loss of life suffered by Japan following the earthquake and tsunami which struck the main island of Honshu in March 2011. As happens for most major disasters, an international relief effort was quickly mobilized, with the military leading the way. The US has considerable military resources located in Japan, and the rapid employment of those assets in partnership with Japanese forces was clearly evident in the media coverage. However, the immediate and sustained involvement of the US military preventive medicine, veterinary, and radiological defense personnel was largely overlooked, a normal circumstance for these public health professionals who perform their important functions in the background of large operations. Nolan Watson's article reveals this aspect of disaster response that was absolutely essential for execution of the US military's contingency plans. Ranging from immediate water and food sampling and analysis, to evacuation of military personnel's pets from Japan, to extensive radiological sampling and testing following the nuclear reactor malfunctions, these professionals provided the US and Japanese authorities with almost continuous data vital to their decisions and planning. Mr Watson's article is not only an eye-opening presentation of what these military personnel do, but their dedication and pride in their work is clearly evident, a well-deserved tribute to the military public health professionals upon whom we all depend, whether we realize it or not.

The nutrition needs of recruits and combat Soldiers, primarily infantry, have been studied for years, and military nutrition programs and field rations are tailored to those needs. However, scant attention has been given to the nutrition requirements of deployed personnel who do not normally experience the same physical activity and stress levels of those involved in combat operations. 1LT Ashley Carlson and her coauthors investigated the diet, physical activity, and bone mineral density of a group of combat service support Soldiers before and after deployment to detect any indicators that their nutrition needs may be different. Their article clearly describes the carefully designed study, presents the data, and discusses it within the context of results from similar studies of combat Soldiers. This is an interesting first look at whether there may be value in tailoring nutrition to specific populations in varying deployment environments.

In this time of nearly unrestricted access to information, often of suspect accuracy, and nearly universal connectivity among individuals, sometimes a bit of information is interpreted and/or applied incorrectly, but that interpretation is spread without further investigation or verification, and sometimes achieves a life of its own. This may be particularly true with subjects of health and illness, as uninformed, unverified, and incomplete opinions and statements can easily fuel a sense of paranoia and fear, especially when the subject is cancer. Occasionally, however, such information may indeed be accurate, and fears justified. Jessica Sharkey and Veronique Hauschild have contributed an article which discusses how the US Army Public Health Command (USAPHC) deals with one area of such concern, the cancer cluster. The Centers for Disease Control and Prevention have formally defined cancer clusters, and have established a set of scientifically-based guidelines to evaluate reports to determine if a cancer cluster investigation is indeed warranted. The guidelines include carefully established criteria with which to judge the reported cancers, including frequency, the type(s) of cancer involved, the geographic area, and the time period of the onsets. Their article is a succinct, clearly presented explanation of how the US military addresses reports of perceived concentrations of cancer cases which ostensibly may be related to environmental or other external conditions.

The central component of The Army Surgeon General's System for Health initiative is the Performance Triad of activity, nutrition, and sleep. Activity and nutrition as part of good health have long been promoted both in health literature and the public media. In recent years, researchers have increasingly been examining sleep as an equally valuable counterpart of an overall healthy lifestyle. One aspect of sleep research looks at the quality of the sleep to be as important as the quantity, and the factors that affect sleep quality. Army medicine is currently involved in several ongoing sleep research projects and collaborative efforts. LTC Sandra Escolas and her team of researchers examined the sleep of post-deployed military service members from the perspective of an individual's ability to relate to others, known as attachment theory, and how it may affect the type of sleep, quality and quantity, that an individual experiences. This excellent article reports the results of their carefully designed, extensively researched study, and how those results correlate with the literature of civilian studies in this area. This is an important contribution to the growing area of research into sleep as an essential component of one's overall health.

Dr Coleen Baird has contributed two earlier articles to the *AMEDD Journal* exploring various aspects of how exposure to burn pits may affect the long-term health of military and civilian personnel deployed to combat theaters. She has kept us current on the potential hazards, the research, the findings and conclusions, and the responses of military and veterans' healthcare agencies. Her article in this issue discusses the most recent legislative action which places burn pit exposure into a category on par with radiation exposure from World War II tests, Agent Orange exposure, and the 1991 Gulf War undiagnosed symptoms and diseases. The Department of Veterans Affairs maintains a registry for personnel potentially exposed to environmental hazards in each of those circumstances. New legislation effective January 10, 2013, directs the establishment of a registry for those potentially exposed to toxic chemicals and fumes from open burn pits during deployments. Such registries are important because they allow personnel to be listed as eligible for medical assistance should their exposure lead to illness. Such symptoms and diseases often do not present for a number of years following exposure, at which time it may be difficult to verify eligibility and receive care. Dr Baird's article is an excellent and informative presentation which synopsizes burn pit exposure actions to date, explains the registries, and details what was involved in the creation of this registry dedicated to potential victims of those exposures.

The Consumer Products Safety Commission is charged with ensuring that the public in the United States is protected from unreasonable risks of injury or death from use of the thousands of products under their jurisdiction. The military has a similar responsibility to those who use the thousands of items that are specifically developed and procured for use by military service personnel and civilians, especially weapon systems. In 1981, The Army Surgeon General established the Health Hazard Assessment Program (HHA) to evaluate the potential health effects of operating military weapon systems. Following the DoD-wide adoption of the HHA concept in 1983, the Army HHA was formally established in what is now the USAPHC. In their article, Dr Timothy Kluchinsky and his team use the responsibilities of the HHA in the testing of joint weapon systems under development to describe the parameters that USAPHC must consider and evaluate, the standards that must be applied, and the various other considerations that are involved in their work. This article is a detailed, informative discussion of another very important function of Army medicine that works quietly and efficiently in the background, and is vital to protect our Warfighters from preventable, unnecessary injury, or worse.

In 2011, Dr Hikmet Jamil, Dr Bengt Arnetz, and a team of researchers contributed a report of their study of the health effects on Iraqi civilians and military personnel resulting from environmental exposure to multiple biologic and chemical substances during the 1991 Gulf War. Dr Arnetz and Dr Jamil return to the *AMEDD Journal* with another team of researchers to report the results of a second study concerning environmental exposures during that conflict. The focus of this research effort was the relationship of such exposures and adverse birth outcomes among Iraqis. As in their previous study, the research was complicated by several factors including availability of specific exposure data, sample selection after a period of intervening years, and the availability of proper comparison groups. There were also a number of cultural factors to consider since data collection involved direct interviews to discuss often sensitive issues. Therefore, this group of experienced researchers had to carefully design and plan the study to mitigate the recognized deficiencies, strictly follow the plan during data collection, and meticulously examine and analyze that data to account for nonrelevant influences or corrupting factors. The results of their study are presented in a clear, organized manner that completely supports their conclusion. Their work is an example of important research that should stimulate further investigation into this side effect of warfare, which may have broader applications for similar peacetime exposures to comparable substances.

As we have learned from hard experience over the last 110 years, some of the most pernicious threats to our

Soldiers are posed by the smallest of adversaries—mosquitoes, ticks, sand flies, fleas, mites, and other arthropods—which cause problems directly through bites and irritation, and, more importantly, vector some of the most virulent disease pathogens that afflict humans and other mammals. The battle to counter those threats is never-ending, pursued not only by the best resources of the US military, but also by governments, foundations, and corporations worldwide. Some of the arthropod threats are regional, perhaps existing in areas of low human population density, thus lowering the priority for attention from meager public health resources available in most undeveloped countries. However, for the US military, the challenge of preparing for such threats is exacerbated by the potential of deploying forces to virtually any location on the globe, so military medical professionals must always be prepared to address any of the potential arthropod threats, often on very short notice. Research across the spectrum of threats, therefore, is constant. Dr Abdel Zayed and a diverse team of researchers have investigated efficacy of residual insecticides against an arthropod pest of the desert environment that is particularly difficult to control, the Old World sand fly, a source of significant nuisance bites and an important vector of cutaneous leishmaniasis. Their article reports the results of the study examining the effectiveness and duration of 3 residual insecticides on the 2 types of tent materials used in the current combat theaters, cotton duck and vinyl. The study involved several environmental parameters to which each material/insecticide combination was exposed, and data was gathered over a period of months. This interesting article is another excellent example of a well designed, professionally executed scientific study that yielded positive, usable results for the improved protection of our Warfighters.

Another group of arthropods that can cause serious illness and even death among humans are filth flies. Unchecked, their ability to transmit viral, bacterial, and protozoal pathogens, including dysentery and cholera, can rapidly degrade the combat capability of a fighting force. Such flies populate almost every climate and geographic area, including the deserts of the world, often in great numbers. There are many measures employed to control filth flies, including aggressive sanitation controls, insecticides, and baited traps. All of those measures have limitations, especially within deployed environments. Baited traps, in particular, while initially very effective at collecting large numbers of flies, quickly lose effectiveness as the containers fill and additional flies cannot enter. In their article, Navy LT James Dunford and his collaborators describe a research project conducted by the Navy Entomology Center of Excellence in which they investigated increasing the kill potential by placing a coating of residual insecticide on the outside surface of the trap to deliver a lethal dose to those flies who land, but do not enter the trap container. While such a concept may seem fairly straightforward, the complexity of collecting valid, robust data and the parameters which must be considered for a field research project quickly complicate its planning and execution. Because of the comparative purpose of the data collected at the various locations and times, planning and design are especially crucial, and collection of data and maintenance of the traps must follow the plan exactly. Although each of two collection periods were roughly one week in length, the team collected an enormous amount of flies and attendant data, and then had to carefully organize and analyze everything. The article clearly demonstrates the thoroughness, attention to detail, and dedication of those involved in finding answers for threats to our health and well-being.

Since the development of the first truly effective topical insect repellent by the US Army in 1946 (deet (N,N-diethyl-3-methyl benzamide)), the use of such a repellent has been the first line of personal defense against biting insects. Over the years, many commercial topical products of varying effectiveness have been developed and marketed, but the more effective of those still share some measure of cosmetic disadvantages, including oily residue, unpleasant smell, and/or dermal irritation. Additionally, there is the inherent inconvenience of application, and reapplication, especially when heavy perspiration or water immersion in encountered. Although the US military has for years required use of a personal protection measure system which includes deet application to exposed skin, surveys show that actual use of deet, even when the hazards of vector borne diseases in the area are understood, has been confirmed by only around 50% of deployed military personnel. The commercial market has encountered similar ambivalence towards the use of topical repellents, and has pursued development of repellent devices that do not require application to either skin or clothing, collectively known as spatial repellents. In another research effort by the Navy Entomology Center of Excellence, Aaron Lloyd and his team of researchers evaluated 4 commercial, off-the-shelf consumer spatial repellent products for effectiveness as an insect repellent, as well as reliability, suitability for the tactical environment, and supportability. Their article describes another excellently designed and executed field research project, requiring precision and attention to detail to ensure that the resulting data and derived conclusions solidly support the conclusions. Although the currently available products may not be completely suitable for combat applications, this research study could lay the foundation for the concept of individual

Soldier spatial repellent devices, and stimulate further research and development in this area.

Arthropods not only cause harm to human health with bites, venom, and as disease vectors, they also can be severely destructive to the food chain, not only for humans, but for many grazing animals. This has been recognized throughout history, as records from ancient civilizations describe locust infestations destroying fields of crops throughout regions, caterpillars stripping crops and forests, and, in more recent times, insect infestations rendering entire stores of grain and other food products inedible. The US military procures, transports, and stores huge amounts of food products at locations throughout the world. Protection of those products in transport and especially in storage is a challenge requiring constant surveillance monitoring and immediate corrective actions. Dr Choe Hyon Chong has contributed an article describing actions by Army public health professionals in the Republic of Korea to optimize control measures for the Indian meal moth, a persistent and greatly harmful pest involved in the destruction of stored dry food products in many areas of the world. The focus of this research project were the Army's food storage warehouses. His article describes a well-conceived approach to first understanding the dynamics and parameters of the infestations at the specific location of concern, followed by application of the most effective control measures at the optimum times for their use. The plan began with period of surveillance trapping to determine the moth's seasonal cycles at various locations in the warehouse, then implementation of control treatments, and continued surveillance to evaluate the results. In addition to active control measures, the researchers were able to recommend changes to warehouse management policies and procedures, as well as physical changes to the warehouse itself, both of which complemented the control treatments, resulting in a much more efficient overall control program. Dr Choe's article is an excellent example of the nature of many public health studies and projects. To be truly effective, many such studies require an extended timeline, careful planning, patience and attention to detail in execution, and vigilance to events and changes in the study environment.

The US military routinely conducts medical assistance missions into developing countries around the world, usually providing medical capabilities for the population that may be scarce, or nonexistent, in those areas. Such missions serve many purposes, the highest of which is the humanitarian benefits for the patients served, but the military medical personnel greatly benefit from encounters with health problems and conditions which they may never actually experience within more developed societies, such as the United States and Europe. These experiences could be invaluable during operational deployments with units into remote, undeveloped areas where the local populace may have never seen a trained healthcare professional, much less any medical equipment. Over time, the local people realize that their new neighbors, the deployed forces, do in fact have the capability to offer them medical care rarely available in their area, and reluctance to seek assistance fades, especially when they face a medical emergency. At that time, they may present conditions or illnesses similar to those encountered during medical outreach missions, unfamiliar but to the most experienced medical personnel. In their article, LTC Jennifer Gurney and her colleagues describe one such condition encountered on several occasions in Afghanistan, and how the Army combat support hospital was able to respond. Circumcision of young male children, even infants, is a common practice in that country. Unfortunately, it is usually practiced absent any local medical capabilities, neither in training nor facilities or equipment. As should be expected, the results of such practice can be devastating, causing lifelong deformation and often permanent injury to the urinary and reproductive systems of the children. Over the years of US presence, Afghans have been bringing such injured boys to our military facilities to receive care for this injury. LTC Gurney et al present the case studies of 2 boys, one infant and one aged 4 years, who were severely injured during the traditional, primitive, local procedure in the village. Both children required unique reconstructive surgery and several days of inpatient care to resolve their injuries. The article clearly depicts the knowledge, skills, resourcefulness, and total dedication to patient care that is inherent in our military medical professionals. It is an eye-opening source of experience-based advice, ideas, and hints about how to successfully contend with this injury which is rarely seen among the US populace. This article should be must-reading for all military medical personnel preparing for deployment into the third world environment, whether with an operational unit, or with a medical assistance mission.

An understanding of the transmissibility of disease dates back many centuries, as indicated in early religious writings describing rules for isolating lepers. Examples of mandated separation of the healthy from the sick can be found in the Roman empire. The formal system of quarantine began years later as port cities imposed rules restricting personnel to remain aboard newly arriving ships for a period of time to provide the opportunity to detect any diseases that may be among them. Of course we have come a long way in our ability to detect diseases, understand the mechanisms of infection and transmission, anticipate outbreaks and the potential scope of their spread, and institute preventive action, including vaccinations and sanitation and hygiene measures. However, legally imposed quarantine and isolation remain tools for public health authorities when a disease outbreak threatens to overwhelm other control measures and spread unchecked. The same option is available to a military commander as the responsible authority for the health and safety of the military installation, facility, or organization under his or her command. The military commander may isolate and quarantine personnel and property on a military installation when a threat is imminent. Such action may be implemented either to prevent military personnel from contracting a disease that is infecting the civilian population in the area, or to quickly contain spread of serious disease detected among military personnel aboard the installation. In either case, the commander must understand the various options available before the imposition of involuntary quarantine may be required, and must clearly understand the governing rules and regulations for such actions. MAJ Joseph Topinka has contributed an excellent article clearly and succinctly providing a thorough, detailed overview of the legal aspects of a military commander's authority in such situations. The breadth of a commander's authority as well as the limitations are clearly explained, and the references list provides a ready source for locating the specific directives, instructions, and orders pertaining to these situations. This article is an ideal primer to introduce a military commander or staff to this complex and unusual responsibility. As MAJ Topinka states so well in closing his article, "Considering the potential magnitude of an epidemic or other medical crisis, the value of understanding the laws, regulations, and guidance in this article cannot be overstated."

The Spanish philosopher George Santayana wrote in 1905, "Those who cannot remember the past are condemned to repeat it."* That well-known (but too often misquoted) maxim is applicable in almost every facet of human existence, and medicine is no exception. It is especially applicable in the area of public health, where so much of the benefits to health and well-being have been obtained by constant attention to environmental and sanitation standards and practices, most of which are conducted in the background of daily life. Unfortunately, from that perspective, another old adage is also too often proven true—out of sight, out of mind. It has been proven time and again that a reduction in emphasis or resources involved in public health activities will eventually result in a decline in the health of those residing in the area. COL Barry Graham's excellent, absorbing article describes a classic sequence of events occurring during the American Civil War that clearly proves and emphasizes these points. His article focuses on two very different approaches in addressing one of the scourges of the period, yellow fever, and the tragic results. The differences between Union Army actions in occupied New Orleans, Louisiana, and New Bern, North Carolina, could not have been more stark, and the resulting differences in yellow fever infections and death were dramatic. Compounding the tragedy is the fact that the success in suppressing yellow fever in New Orleans preceded the epidemic in New Bern by 2 years, and had been recognized and publicized throughout the Union states. Unfortunately, the actions that led to the success was not given any emphasis within the Union Army, and the deadly New Bern epidemic of 1864 was the result. However, the observant reader of COL Graham's article will quickly recognize an even greater tragedy from failure to "remember the past." As he points out, only 11 people died of yellow fever in New Orleans between 1862 and 1865 under Union Army occupation. After occupation ended and civil authority resumed in 1866, 185 people died; in 1867 there were 3,107 deaths; and more than 4,000 died of yellow fever in 1878. Indeed, the people of New Orleans were immediately "condemned to repeat" the past because it had been so quickly forgotten.

The *AMEDD Journal* is pleased to present COL (Ret) Brian Lukey's introduction of a new volume of the Borden Institute's Textbook of Military Medicine Series, *Military Quantitative Physiology*. COL (Ret) Lukey provides an informative overview of the book, and describes its contents as the most complete amalgamation of many years of research into the physiology of military operational medicine printed to date. His presentation should stimulate interest in this book as an extremely valuable resource for medical practitioners and researchers involved in helping Warfighters contend with the physiologic stressors of the military operational environment.

*Santayana G. *The Life of Reason*. New York, NY: C Scribner's Sons; 1905:82.

Contributions of the Global Emerging Infections Surveillance and Response System Network to Global Health Security in 2011

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ABSTRACT

In its 15th year, the Global Emerging Infections Surveillance and Response System (GEIS) continued to make significant contributions to global public health and emerging infectious disease surveillance worldwide. As a division of the US Department of Defense's Armed Forces Health Surveillance Center since 2008, GEIS coordinated a network of surveillance and response activities through collaborations with 33 partners in 76 countries. The GEIS was involved in 73 outbreak responses in fiscal year 2011. Significant laboratory capacity-building initiatives were undertaken with 53 foreign health, agriculture and/or defense ministries, as well as with other US government entities and international institutions, including support for numerous national influenza centers. Equally important, a variety of epidemiologic training endeavors reached over 4,500 individuals in 96 countries. Collectively, these activities enhanced the ability of partner countries and the US military to make decisions about biological threats and design programs to protect global public health as well as global health security.

BACKGROUND

The mission of the US Department of Defense's (DoD) Armed Forces Health Surveillance Center Global Emerging Infections Surveillance and Response System (AFHSC-GEIS) Division is to develop, implement, support, and evaluate an integrated global emerging infectious disease (EID) surveillance and response system that contributes to enhancement of US forces' health, the military health system, and the global public health community. Force health protection of US and allied service members remains the strategic focus of our efforts. Equally important and well-aligned with its primary focus of global public health security is the recognition that adequate health allows for country-level security, and thus regional stability—one of the stated strategic goals of the DoD.

During fiscal year (FY) 2011, AFHSC-GEIS supported a network of 33 partners in 76 countries (shown in Figure 1) contributing to global EID surveillance and capacity building efforts. Key partners continued to be the 5 DoD overseas research laboratories:

- US Naval Medical Research Unit Number 2 (NAMRU-2) (Hawaii)
- NAMRU-3 (Egypt)
- NAMRU-6 (Peru)
- Armed Forces Research Institute of Medical Sciences (AFRIMS) (Thailand)
- US Army Medical Research Unit-Kenya (USAMRU-K)

These laboratories operate regional disease surveillance networks centered in Cambodia, Egypt, Peru, Thailand, and Kenya, respectively. Additionally, support was provided to DoD reference laboratories at the Naval Health Research Center (NHRC), the Walter Reed Army Institute of Research, and at the USAF School of Aerospace Medicine to conduct disease surveillance in military and nonmilitary associated populations. A key goal of the network continued to be the enhancement of host-country capacity in support of integrated disease surveillance as mandated by the World Health Organization's (WHO) *International Health Regulations (2005)* (*IHR (2005)*).[1]

The strategic goals through which AFHSC-GEIS achieves its mission provide a holistic approach to public health, and constitute the foundation of our global surveillance efforts across all EID surveillance goals including: (1) surveillance and response; (2) training

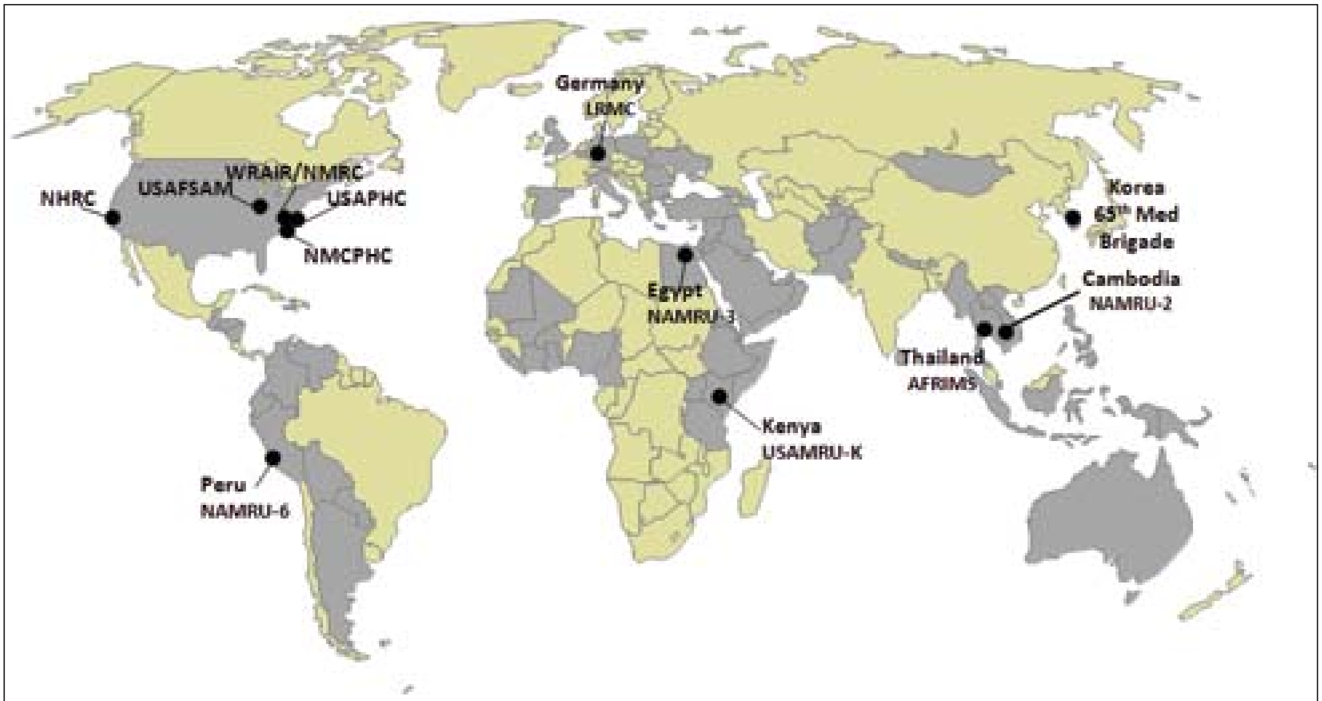

Figure 1. AFHSC-GEIS network and major laboratories, fiscal year 2011. Note: GEIS partner countries are shaded gray.

Glossary:

AFRIMS – Armed Forces Research Institute of Medical Sciences
LRMC – Landstuhl Regional Medical Center
NAMRU – Naval Medical Research Unit
NHRC – Naval Health Research Center
NMCPHC – Navy & Marine Corps Public Health Center
NMRC – Naval Medical Research Center
USAFSAM – USAF School of Aerospace Medicine
USAMRU-K – US Army Medical Research Unit-Kenya
USAPHC – US Army Public Health Command
WRAIR – Walter Reed Army Institute of Research

and capacity building; (3) research, innovation and integration; and (4) assessment and communication of value added. This article provides a summary of the accomplishments for each of these in FY2011 and presents future challenges being addressed by our network. We also update AFHSC-GEIS system accomplishments of FY2009 which were previously published,[2] and further evaluate contributions of this network towards global health security in 2011.

SURVEILLANCE AND RESPONSE INITIATIVES

As surveillance and response activities are central to the overall mission of the AFHSC-GEIS, human and animal disease surveillance activities were supported in 76 countries. Outbreak response is an integral part of partner collaborations with host country health systems, and in FY2011, network partners assisted in a total of 73 investigations and outbreak response efforts, shown in Table 1. The most salient of these investigations included:

1. NAMRU-3's response to a large outbreak of over 1,500 dengue-like cases in Yemen's west coast October 2010-January 2011, leading to its first chikungunya case confirmation and successful *Aedes aegypti* (L.) vector control implementation.[3,4]
2. NAMRU-3's response to a request from the Egyptian Ministry of Health for the conduct of a retrospective freezer study of human samples to determine whether Egypt was the main source of a very large foodborne outbreak in Germany from May to July 2011. The outbreak affected over 4,000 patients and was associated with a Shiga toxin-producing enterohemorrhagic *Escherichia coli* (Migula) O104:H4. No evidence from any of the samples in this retrospective study demonstrated the outbreak strain.
3. USAMRU-K's diagnostic and entomologic assessment support for a dengue serotype 3 outbreak among the African Union Mission in Somalia military peacekeepers and civilians in northeast Kenya along the Kenya-Somalia border, September to October 2011.

A number of country-specific surveillance programs also achieved notable accomplishments in FY2011, including the following highlights. Researchers from AFRIMS conducting acute febrile illness surveillance in Nepal detected the first known chikungunya infections in the country and defined the genetic diversity among hantaviruses in Nepal.[5] The researchers also identified enteroaggregative *E.coli* and *Campylobacter* spp. as the two most commonly isolated enteric pathogens from a cohort of Nepalese children aged less than 2 years. Investigators from USAMRU-K have continued to expand their acute febrile illness and arbovirus surveillance program throughout Kenya and identified strains of Crimean-Congo hemorrhagic fever virus in *Hyalomma* spp. ticks,[6] as well as 9 additional as yet unidentified mosquito-borne arboviruses isolated in cell culture.

Surveillance projects supported by AFHSC-GEIS utilizing the DoD Serum Repository were vital in identifying infectious disease exposures during deployments and other military service. A study conducted by the AFHSC and NHRC investigated the seroprevalence of and seroconversion to 7 respiratory pathogens among service members deployed to Afghanistan from 2004 to 2007.[7] The study found that 30.1% of service members seroconverted to at least one pathogen and *Bordetella pertussis* (Bergey et al) seroconversion was 2 to 4 times higher than that reported for the general US population. A second Serum Repository-based study found a Q fever incidence of 4.2 cases per 1,000 person-years among Army veterinary officers from 1989 to 2008 (K.G.V., unpublished data). Preliminary findings indicate that 13.8% of these Army veterinary officers were seropositive upon entry into the military. Thus, *Coxiella burnetii* (Derrick) (the causative agent of Q fever infections) appeared to be common among veterinarians that enter the military. This estimate was similar to seroprevalence estimates of 22.2% among civilian counterparts reported in a 2006 study among US veterinarians, the only other large, well-studied veterinary population to date.[8]

Country and pathogen-specific prevalence studies were conducted by several partner laboratories. Surveillance for sexually transmitted infections was conducted in Djibouti (NAMRU-3), Kenya, and Peru, retrospectively focusing on *Neisseria gonorrhoeae* (Neisser) antibiotic resistance and *Chlamydia trachomatis* (Busacca) prevalence in high-risk civilian (commercial sex workers, men who have sex with men) and local military populations.[9] Large, enteropathogen-focused cross-sectional studies involving over 3,500 stool samples conducted in those 3 countries demonstrated that norovirus was the most common viral etiology found among US military personnel at Camp Lemonier, Djibouti, whereas *Shigella* spp.

Table 1. AFHSC-GEIS outbreak response actives (listed by partner) during fiscal year 2011.

Partner	Number of Outbreaks	Countries	Pathogens/Conditions
AFME	2	Kenya, USA	Adenovirus, Rift Valley fever
AFRIMS	4	Cambodia, Nepal	Cholera, influenza
NAMRU-2	3	Cambodia	Dengue, leptospirosis, malaria
NAMRU-3	4	Egypt, Pakistan, Yemen	Crimean-Congo hemorrhagic fever, Dengue, E. coli
NAMRU-6	21	El Salvador, Peru	A. baumanii, Bell's Palsy, dengue, E. histolytica, gastroenteritis, influenza, K. pneumonia, leishmaniasis, leptospirosis, pneumonic plague, rabies (animal), tuberculosis, varicella,
NASA	3	Afghanistan, Botswana, Kenya, Namibia, Somalia, South Africa	Crimean-Congo hemorrhagic fever, dengue, Rift Valley fever
NHRC	11	Costa Rica, USA	Adenovirus, group A beta-hemolytic streptococci, influenza, norovirus, pneumonia
USAPHC	1	USA	Group A beta-hemolytic streptococci
USAPHCR-Europe	4	Afghanistan, Germany, United Kingdom	E. coli, influenza, rabies
USAFSAM	1	USA	Norovirus
USAMRIID	1	Kenya	Rift Valley fever
USAMRU-K (& GVF)	15	Cameroon, Kenya, Somalia	Acute febrile illness, cholera, dengue, transboundary animal diseases of regional concern, yellow fever
WRAIR	3	Kenya, Peru, USA	Crimean-Congo hemorrhagic fever, Orthobunyavirus spp., Rift Valley fever

Glossary:
AFME – Armed Forces Medical Examiner (formerly Armed Forces Institute of Pathology)
AFRIMS – Armed Forces Research Institute of Medical Sciences
GVF – Global viral forecasting
NAMRU – Naval Medical Research Unit
NASA – National Aeronautics & Space Administration
NHRC – Naval Health Research Center
USAFSAM – USAF School of Aerospace Medicine
USAMRIID – US Army Medical Research Institute of Infectious Diseases
USAMRU-K – US Army Medical Research Unit-Kenya
USAPHC – US Army Public Health Command
USAPHCR – US Army Public Health Command Region
WRAIR – Walter Reed Army Institute of Research

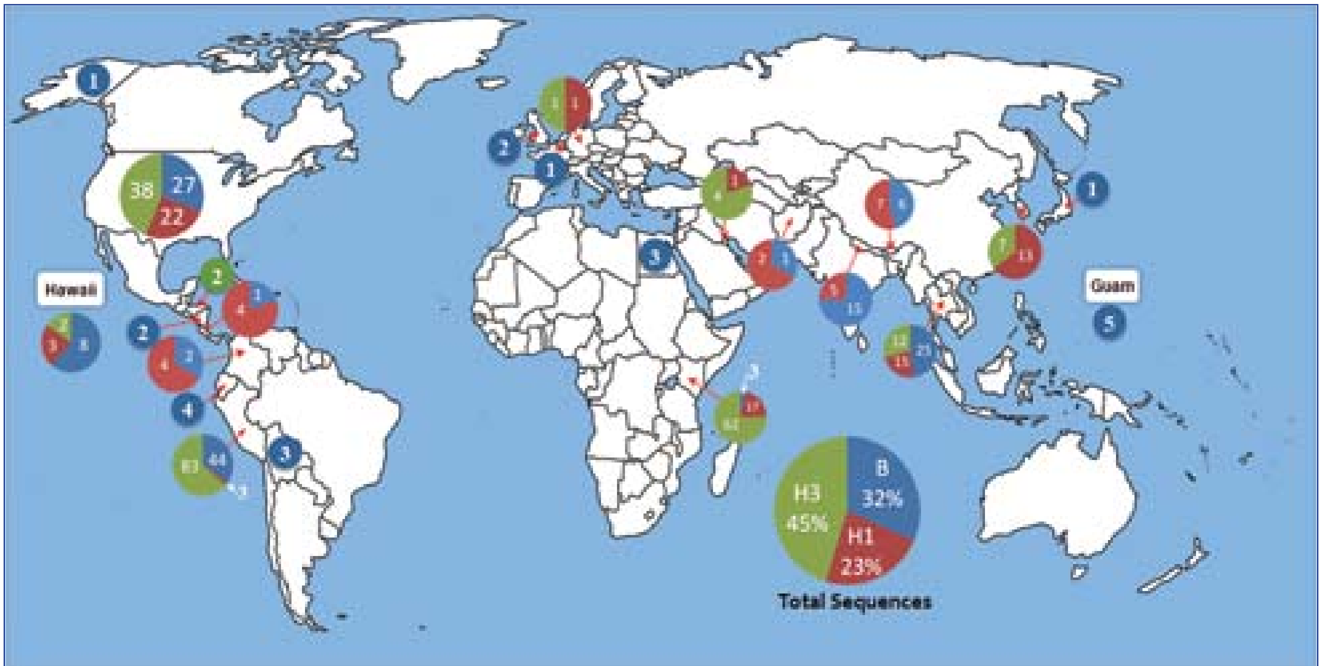

Figure 2. Sequenced influenza subtype A(H1N1)pdm09, subtype A(H3N2) and subtype B strains, DoD laboratories, by country, 2010-2011. Pie charts represent distribution of the 3 influenza subtypes within the countries indicated.

H1 – A(H1N1)pdm09 subtype H3 – A(H3N2) subtype

B – B subtype

were the most prevalent bacterial pathogen in Kenya,[10] and *Campylobacter* spp. the most frequently identified bacterial pathogen associated with diarrhea in Peru.[11] Acute diarrheal diseases continued to represent one of the largest disease and nonbattle injury threats in the US military. The study findings will aid military planners in defining more specific preventive and treatment countermeasures for US forces deployed to these areas.

Several antimicrobial-resistant organism surveillance initiatives were undertaken to inform and improve treatment options and policies for military service members both in the United States and in deployed settings. Antimalarial resistance surveillance efforts by NAMRU-2 detected an unexpectedly high rate of *Plasmodium falciparum* (Welch) multidrug resistance gene amplification in the south-central region and on the eastern border of the country; a finding which may represent evidence of the regional spread of mefloquine resistance in Southeast Asia. In Egypt and Jordan, NAMRU-3 scientists established hospital-acquired infection (HAI) surveillance, which has since found that ≈70% of *E. col*i isolates in that region were producers of extended-spectrum betalactamase (ESBL), an enzyme that confers resistance to many common penicillin and cephalosporin antibiotics, and about 50% of *Staphylococcus aureus* (Rosenbach) isolates were resistant to methicillin. A similar HAI surveillance effort by NAMRU-6 scientists in Peru documented similar, or even higher rates, of methicillin resistant *S. aureus* and ESBL-producing *Klebsiella pneumonia* (Schroeter).

In the United States, the DoD's Multidrug-resistant Organism Repository and Surveillance Network, initially established in June 2009, continued to provide the military health system with a unique centralized pathogen identification and resistance profiling resource for advanced characterization of multidrug resistant organisms. Over 300 isolates were characterized by pulsefield gel electrophoresis which resulted in identification of the emergence of colistin-resistant *Acinetobacter*, vancomycin-resistant *Enterococcus*, and the first report of a New Delhi metallo-beta-lactamase isolate in the military health system. These identifications were performed as part of the DoD's component of the Infectious Diseases Society of America's global ESKAPE (*Enterococcus faecium* (Orla-Jensen), *S. aureus*, *Klebsiella* spp., *Acinetobacter baumannii* (Bouvet and Grimont), *Pseudomonas aeruginosa* (Schroeter) and *Enterobacter* spp.) genomics project, which receives isolates from 13 military medical treatment facilities, five of which are from war zones in Iraq and Afghanistan.[12]

Investigators from NHRC continued to monitor antibiotic resistance of group A *Streptococcus*, a persistent respiratory bacterial pathogen in recruits and advanced

Table 2. Major laboratory capacity building initiatives, by geographic region, fiscal year 2011.

Geographic Region (Supporting DoD Laboratory)	Major Laboratory Capacity Building Initiative	Countries Supported
Southeast Asia (AFRIMS, NAMRU-2)	NIC and military influenza lab equipment, reagent & training support; EID laboratory diagnostics and disease surveillance systems	Bhutan, Cambodia, Lao People's Democratic Republic, Nepal, Thailand, Vanuatu & Solomon Islands
Far East (AFRIMS)	NIC and military influenza lab equipment & reagent support; EID laboratory proficiency and equipment support; disease surveillance systems	Philippines
East & Central Africa (USAMRU-K)	NIC and VHF lab equipment, reagent and training support; EID laboratory diagnostics	Cameroon, Kenya, Tanzania, Uganda
West Africa (NAMRU-3, USAMRIID)	NIC and MoH influenza lab equipment, reagent and training support; VHF lab diagnostics & military EID lab diagnostic testing capacity	Burkina Faso, Cote d'Ivoire, Djibouti, Ghana, Liberia, Libya, Nigeria, Sierra Leone
North Africa, Middle East, Southwest Asia (NAMRU-3, WRAIR)	NIC lab equipment, reagent and training support	Afghanistan, Bahrain, Egypt, Jordan, Qatar, UAE, Yemen
Central Asia (NAMRU-3, University of Florida, USAMRIID)	EID and influenza lab equipment, reagent and training support	Azerbaijan, Georgia, Mongolia
Europe (NAMRU-3, PHCRE, University of Florida)	Military and academic influenza lab equipment, reagent and training support	Bulgaria, Poland, Romania, Ukraine
North, Central, South America (NAMRU-6, PHCRS)	NIC and MoH influenza lab equipment, reagent and training support; leishmania military reference lab equipment, reagent and training support	Argentina, Bolivia, Colombia, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Venezuela

Glossary:
EID – Emerging infectious diseases
MOH – Ministry of health
NIC – National influenza center
PHCRE – Army Public Health Command Region-Europe
PHCRS – Army Public Health Command Region-South
VHF – Viral hemorrhagic fever

individual training units at 9 US military medical treatment facilities serving these trainees. Moderate resistance was seen against erythromycin and clindamycin. In addition, an important influenza-related collaboration between NAMRU-6, USAF School of Aerospace Medicine, NHRC, and the Walter Reed Army Institute of Research led to the identification of an A(H1N1)pdm09 virus subclade possessing a reemergent HA D222N mutation that was found to be associated with increased respiratory illness severity among patients in Ecuador, Mexico, and Washington, DC.[13]

In the Middle East, scientists at the Global Disease Detection Regional Center of the US Centers for Disease Control and Prevention partnered with NAMRU-3 staff and regional medical officials to conduct severe acute respiratory illnesses (SARI) surveillance at 22 hospitals in 6 countries (Egypt, Jordan, Djibouti, Yemen, Oman, and Qatar). This effort, named the Eastern Mediterranean Acute Respiratory Infection Surveillance network in September 2011, is expanding to 8 additional hospitals in Iraq and Afghanistan. Its main objectives include: (1) establishing and monitoring baseline trends for SARI; (2) describing the seasonality of influenza in each country; (3) providing an early warning system for epidemics; and, (4) monitoring high-risk patients (very young, old, and those with comorbidities) who may be at greater risk of SARI.

Partnering with National Influenza Centers (NICs) in South America, the US Army Public Health Command Region-South initiated military participation in national respiratory surveillance programs in El Salvador, Guatemala, and Honduras, while USAMRU-K established a regional genetic sequencing capability at the Kenya NIC to support influenza surveillance network activities in 4 partner countries (Kenya, Uganda, Tanzania, and Cameroon). The AFHSC-GEIS continued to support a comprehensive worldwide effort in influenza surveillance that monitors circulating strains and subtypes, and contributes to the yearly evaluation of seasonal and pandemic vaccines. A geographical summary of isolates sequenced is provided in Figure 2.

FY 2011 outbreak response and disease surveillance efforts have contributed to the understanding of infectious diseases pertinent to the DoD as well as to partner countries. Through effective data collection and timely reporting, the AFHSC-GEIS partner network continued to provide disease situational awareness to inform decision-makers on prevention, treatment, and outbreak response actions to address force health protection and global disease burdens.[14]

CAPACITY BUILDING AND TRAINING INITIATIVES

The AFHSC-GEIS supported a broad array of capacity building projects in coordination with US military, foreign military and civilian government officials. Major laboratory capacity-building initiatives were undertaken with 48 foreign health, agriculture, and defense ministries, as well as with other US government entities and international institutions, including numerous NICs and other country-specific and regional EID reference laboratories worldwide, as shown in Table 2. The objective of the GEIS capacity-building strategy continued to be improvement of the ability of deployed US military forces and partner governments to effectively engage in biosurveillance activities through enhanced laboratory and human resource capacities, as well as improved electronic disease surveillance systems.

The AFHSC-GEIS partners made significant enhancements to laboratory capacities by providing equipment to host country reference laboratories in Afghanistan, Bulgaria, Burkina Faso, Cote d'Ivoire, Egypt, Ghana, Kenya, the Republic of Georgia, Tanzania, and the Ukraine. In addition to the training that is normal with new equipment, basic and advanced training in laboratory methods and biosafety were commonly performed by our network partners in other countries such as Cambodia, Lao People's Democratic Republic, and Sri Lanka. A significant capacity building engagement by NAMRU-3 included the conduct of training and provision of supplies and equipment to enhance EID laboratory diagnostic, vector surveillance, safety, and biomedical capacity in Afghanistan. This resulted in the analysis of nearly 3,000 clinical samples and 8,000 arthropods and enabled this country to better implement its health policy obligations under the WHO's *IHR (2005)*.[1] Additionally, collaborations between the Naval Medical Research Center and NAMRU-6 resulted in the establishment of a DoD Clinical Laboratory Improvements Program (CLIP)-certified and College of American Pathologists-accredited laboratory to support the diagnosis of infectious diseases among US personnel stationed in the Latin American region. The USAMRU-K and Walter Reed Army Institute of Research scientists were also directly involved in similar improvements that will eventually lead to CLIP accreditation of DoD laboratories in Kenya and Afghanistan, respectively.

Many significant contributions were made to the enhancement of electronic disease surveillance systems through the AFHSC-GEIS network. Scientists from AFRIMS, in collaboration with Royal Thai Army (RTA) medical officials, continued support for the Unit-Based Surveillance (UBS) tool with integration of components of the Suite for Automated Global Electronic bioSurveillance (SAGES). The program included training of approximately 600 personnel and expansion to 113 reporting units in 16 surveillance clinics/hospitals throughout Thailand. The diligent, efficient efforts of the Thai members of the AFRIMS and RTA medical team who worked on the UBS project were recognized with presentation of the prestigious RTA Innovation Award in September 2011, the only medical project to earn such an honor. Additionally, NAMRU-6 and NAMRU-2 assisted the Peruvian and Cambodian military forces, respectively, with installation of SAGES disease surveillance capacity.

The AFHSC supported training activities for over 4,500 individuals from 96 countries as shown in Table 3. Overall, 203 training events were conducted in 42 countries. A total of 3,691 (81%) trainees from 49 countries were directly supported by AFHSC-GEIS funded partners. Significant expansion of training initiatives has occurred since our FY 2009 report.[15] One of the highlights in this area is the University of Florida's Certificate Program in Emerging Infectious Disease Research which enrolled 30 students, 22 of whom completed the program in FY 2011. Another highlight is the Uniformed Services University of the Health Sciences (USUHS) Tropical Medicine Program which supported 39 US military medical students and physicians in FY2011. During the training program which involved tropical medicine practical experiences in Kenya, Peru, and Thailand, US military tropical medicine practitioners obtained the practical experience they needed to recognize, diagnose, and treat US military personnel, coalition partners, and civilians during deployments.

Military-to-military partnerships and surveillance exchanges among global network partners and foreign military counterparts, shown in Table 4, continued to be an area of high interest and priority for AFHSC-GEIS in FY2011. Military partnerships in 20 countries resulted in a number of collaborative response activities that supported foreign military partners as well as multinational peacekeepers in joint exercises and missions. Specific efforts included electronic surveillance systems and disease reporting support, outbreak training and response support, laboratory capacity building, and computerized data analysis and training capacity.

RESEARCH, INNOVATION, AND INTEGRATION INITIATIVES

The AFHSC-GEIS continued to introduce innovative methods in disease surveillance activities, mainly through a variety of research efforts targeted to improve timely and accurate surveillance. These included advanced characterization of pathogens to better understand genetic variability across strains, improvements in diagnostic products, and evaluation of diagnostic and transportation media in forward deployed settings. Consideration was given to how proposed research and innovation activities are adding value to standard surveillance.

In collaboration with the Joint Project Executive Office for Biological and Chemical Defense, AFHSC-GEIS supported expansion of an influenza detection panel for use by the Joint Biological Agent Identification and Diagnostic System (JBAIDS). Funding was provided to achieve US Food and Drug Administration (FDA) 510K clearance for a field-expedient five-target assay (Influenza A, Influenza B, Influenza A/H1, Influenza A/H3, and Influenza A/H1/2009 (swine lineage)).[16,17] After completing clinical studies and receiving FDA clearance for the JBAIDS Expanded Influenza Panel in September 2011, panel kit deliveries to forward deployed US Central Command sites and Navy large deck ships started in November 2011, allowing for more timely access to novel strains that may be needed in support of WHO's Global Influenza Surveillance and Response System vaccine development efforts.[18,19]

The AFHSC-GEIS continued to support historical analyses of influenza pandemics among military populations in an attempt to inform current epidemic risk and identify potential patterns of spread. Continued analysis of the 1918 pandemic mortality among Australian, British, Canadian, New Zealand, and US forces was conducted by collaborators at the Australian Army Malaria Institute and AFHSC in FY 2011.[20-22] Epidemiologic research examining the genetic variability of human adenovirus (HAdv) strains, prospective surveillance for vaccine-targeted HAdv-4 and HAdv-7 strains, and early detection

Table 3. Statistics for AFHSC-GEIS funded training initiatives by geographic area, fiscal year 2011

US Combatant Command	Training Initiatives	Countries	Trainees*
Africa Command	55	17	1,668
Central Command	74	18	1,310
European Command	15	15	496
Northern Command	16	10	376
Pacific Command	20	22	462
Southern Command	23	14	233
Total	203	96	4,545

*If exact figures are not known, estimates of number of trainees are provided.

Table 4. Military-to-military partnerships in 20 countries, fiscal year 2011.

Country	Collaborative Focus	Collaborative Area of Exchange
Afghanistan	Human resource development	Laboratory capacity
Burkina Faso	Avian influenza surveillance	Laboratory and disease reporting capability
Cambodia	Influenza sentinel surveillance	Influenza laboratory capacity and electronic reporting
Cameroon	Influenza sentinel surveillance	Sentinel site support and data sharing collaboration
Cote d'Ivoire	Avian influenza surveillance	Laboratory and disease reporting capability
Ecuador	EID surveillance	Electronic surveillance system and outbreak training support, laboratory capacity for antimicrobial resistance testing
El Salvador	Influenza sentinel surveillance	Influenza surveillance capability
Ghana	Avian influenza and sentinel surveillance	Laboratory and disease reporting capability
Guatemala	Influenza sentinel surveillance	Influenza surveillance capacity
Honduras	Influenza sentinel surveillance	Influenza surveillance capacity
Kenya	Malaria and influenza surveillance	Laboratory capacity, microscopy training, electronic surveillance system, sentinel site support and data sharing collaboration
Liberia	Malaria and other FVBI vector surveillance	Vector collection training laboratory capacity
Nigeria	Malaria surveillance	Laboratory and disease reporting capability, microscopy training, electronic surveillance system
Paraguay	EID surveillance	Electronic surveillance system
Peru	EID surveillance, outbreak response, ILI surveillance, enterics surveillance, hospital acquired infection surveillance, antimicrobial resistance, TB diagnosis and reporting	Electronic surveillance system and outbreak training support, laboratory capacity for antimicrobial resistance testing
Philippines	Influenza sentinel surveillance	Influenza laboratory capacity
Poland	Influenza sentinel surveillance & EID laboratory capability	Influenza laboratory capacity
Singapore	Influenza sentinel surveillance	Influenza surveillance capacity
Tanzania	Malaria and influenza sentinel surveillance	Laboratory capacity, microscopy training and influenza surveillance capacity
Thailand	Influenza sentinel surveillance and outbreak detection	Laboratory capacity and outbreak training support

Glossary:
EID – Emerging infectious diseases
ILI – Influenza-like illness
FVBI – Febrile and vector-borne infections
TB – Tuberculosis

of vaccine breakthrough infections continued to be implemented by scientists at the Lovelace Respiratory Research Institute and NHRC. Retrospective (2006-2011) characterization of over 500 vaccine-targeted HAdv-4 and HAdv-7 strains was also achieved with identification of a new genomic variant of HAdV-4, tentatively designated HAdv-4a6 and exhibiting a novel Xho I profile, from a case of influenza-like illness in a recruit at the Marine Corps Recruit Depot, San Diego in 2006.

Diagnostic tools were also developed and improved for several other pathogens in FY2011. A novel fluorescence resonance energy transfer-based reverse transcriptase polymerase chain reaction (RT-PCR) assay to simultaneously diagnose and speciate *Leishmania* spp. was developed and validated by NAMRU-6, and NAMRU-3 developed the capacity to conduct RT-PCR for the rapid quantitative detection of *Plasmodia* spp. in blood from humans. Preliminary results from experiments in the standardization and validation study phases have provided results concordant with those obtained from a previously established PCR test. This work is being expanded to a rapid quantitative multiplex RT-PCR for the simultaneous detection of *P. falciparum, P. vivax* (Grassi and Filetti)*, P. malariae* (Grassi and Filetti)*,* and *P. ovale* (Grassi and Filetti) and will be evaluated for use in malaria diagnostics.

Timely processing of samples is important to any surveillance activity. To this end, AFHSC-GEIS supported efforts in the development of new specimen collection methods and rapid diagnostic assays. The 65th Medical Brigade at the Brian Allgood Army Community Hospital in Seoul, Republic of Korea (RoK), conducted a validation study of a 12-pathogen respiratory virus multiplex assay and used the assay to characterize viral diseases during a US-RoK joint exercise. Investigators at the San Antonio Military Medical Center (SAMMC) developed and field tested a simple filter-card diagnostic system for leptospirosis, a disease spread to humans from the urine of infected animals by bacteria that can survive in the environment for weeks to months. Likewise, and in support of norovirus shipboard surveillance efforts, scientists at the Naval Environmental Preventive Medicine Unit Number 2 validated the use of FTA Elute (Whatman, Inc, Florham Park, NJ) filter paper as a medium for stool sample transport as an alternative to viral transport medium currently provided in surveillance kits, eliminating the need for cold chain and thereby alleviating logistical obstacles which have prevented ships from participating in such surveillance. Preliminary validation testing suggests there is no decrease in PCR detection when samples are collected and stored on FTA Elute filter paper compared to classic methodology of sample acquisition and storage. Once validation is complete, this method can be integrated in other norovirus surveillance efforts in the US military.

Transportation media for handling multidrug resistant bacteria were also evaluated by SAMMC. Two swab types at 2 time points and 3 temperatures were assessed to see if bacteria were viable after varying parameters possibly associated with transporting isolates. This study found that swabs held at room temperature had the highest chance of yielding bacteria with both swabs held for as long as one or 4 weeks. Finally, in an entomological surveillance study to evaluate presence and population size of *Ae. aegypti* in 3 countries around the Red Sea, investigators found that RNA*later* (Life Technologies Corporation, Grand Island, NY), a commercial tissue storage reagent, is a viable medium to transport nucleic acid from virus-infected mosquitoes, especially from countries lacking liquid nitrogen. The method provides flexibility in the delay of sample transportation and, above all, does not compromise results.

Integration of surveillance efforts is a complex and challenging task, one that requires constant adaptation and adjustment. The AFHSC-GEIS continued its efforts to integrate disease specific surveillance activities to develop a more robust surveillance network, generating comparable data across regions. Standardization of malaria surveillance protocols across DoD partners on 3 continents was initiated and acute gastroenteritis surveillance was established among recruit and shipboard populations. These efforts have helped to improve the quantification of the burden of illness and will serve as a platform for development of malaria/enteric diagnostics. These and similar efforts will serve to enhance DoD's capacity to conduct therapeutic and/or prophylactic drug studies as well as better inform vaccine developers and other stakeholders.

ASSESSMENT AND COMMUNICATION OF VALUE ADDED INITIATIVES

Assessment of findings and timely communication of their importance and public health impact are key components of effective surveillance programs. This communication is essential for keeping public health leaders and officials properly informed so they can, in turn, make recommendations and enact measures that reduce disease risk and prevent or respond to disease outbreaks. Surveillance findings are routinely provided to the respective health, agriculture, and defense ministries of host countries, and all AFHSC-GEIS partners are highly encouraged to present and publish their findings.

In FY2011, participants in the network published 152 manuscripts in peer-reviewed journals and delivered 136 posters and oral presentations at scientific conferences. The importance of these papers and presentations in describing the risk regarding disease transmission and severity, as well as disease prevention, is best exemplified by the selection of 2 NAMRU-6 articles by the Peruvian Society of Emerging and Tropical Infections in 2011 as important infectious disease articles in Peru.[23,24]

Surveillance findings and information were also communicated to DoD leadership and the public health community through the development and publication of disease prediction models. In FY2011, USUHS collaborated with investigators in the ROK and AFRIMS to develop and refine ecological niche models for predicting mosquito densities and Japanese encephalitis transmission. The information obtained from these models was used by the DoD Joint Preventive Medicine Policy Working Group for their Japanese encephalitis vaccination policy review. The models also contributed to disease transmission risk assessment products such as VectorMap, an example of which is shown in Figure 3.

The AFHSC-GEIS is also responsible for assessing disease surveillance findings from across the network as a whole. Through review of these programs, the AFHSC and its partners detected a decrease in vaccine effectiveness for the live-attenuated vaccine, especially with regards to the A(H1N1)pdm09 vaccine component.[25] These findings were presented at the annual FDA's Vaccine and Related Biological Products Advisory Committee (VRBPAC) meeting in February 2011, prior to the decision on seasonal influenza vaccine production for the United States and the northern hemisphere. Subsequent studies of the serologic responses among vaccinated recruits found modest differences between the live-attenuated and inactivated vaccines.[26] More importantly, the later studies also found evidence of decreased antibody-mediated immunity against the currently circulating A(H1N1)pdm09 influenza strains in 2011 when compared to 2009 strains, possibly due to genetic drift which could have negative implications during subsequent influenza seasons if there is significant mismatch with circulating A(H1N1) strains.[26]

The assessment and communication of the aforementioned surveillance activities, as well as those in the preceding subsections of this article, play a critical role in protecting military and global public health. As discussed earlier, assessing the meaning of surveillance findings and conveying the importance of these findings

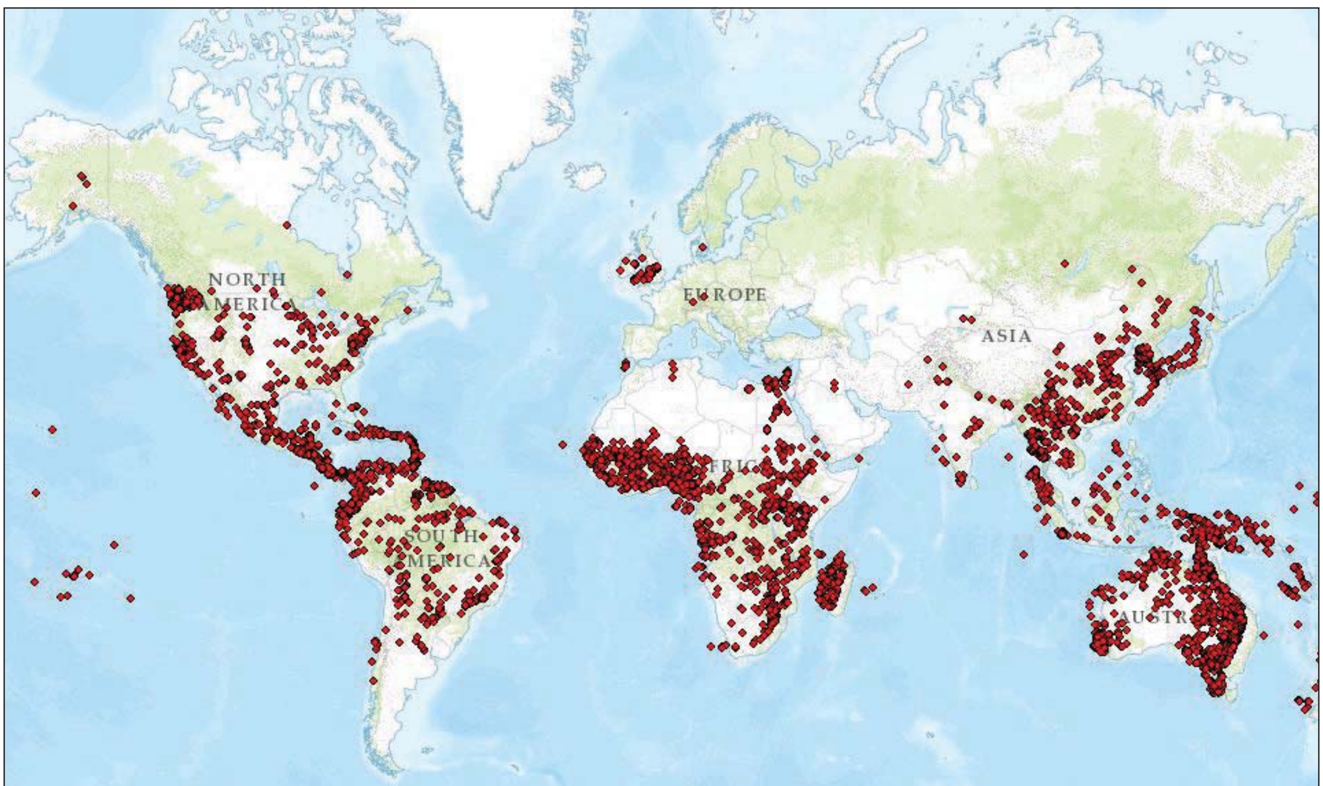

Figure 3. VectorMap mosquito distribution overlays for determining locations where vectors are present and risk of disease transmission to US forces. Each maroon dot represents a location of vector population data, including vector species.

to the global community are key requirements for promoting public health. By effectively communicating this information to public health leaders, AFHSC-GEIS continued to support informed decision making in support of global public health.

CONCLUSIONS AND CHALLENGES

In its 15th year of existence, the AFHSC-GEIS continued to make significant contributions to global public health and emerging infectious disease surveillance worldwide. Significant progress was attained in maturation, standardization, and unification of worldwide EID surveillance and response initiatives in FY2011 through support of the 4 strategic goals outlined earlier. Routine program evaluation through quarterly assessment of project milestones and metrics was implemented in accordance with previously-established, nationally recommended public health response guidelines.[27] Expansion and standardization of genetic and molecular-based testing platforms (for example, PCR-based assays and genomic sequencing capability) was coordinated across the network of partners as recommended in our FY2009 capacity building report,[28] and expansion of electronic surveillance systems, such as SAGES, was undertaken. Collectively, these activities enhanced the ability of partner countries and the US military to make decisions about biological threats and design programs to protect both global public health and global health security.

Standardization of methodological approaches to EID surveillance continued to be a challenge. As part of our AFHSC-GEIS strategy, establishment of disease-specific or pillar-specific steering committees for respiratory infections, febrile and vector-borne infections, malaria, enteric infections, and sexually-transmitted infections was accomplished in FY2011. Similar committees were established in FY2012 to guide efforts in antimicrobial resistance surveillance and capacity building. Strategic guidance for each of these committees were formulated, including goals, objectives, and external review functions.

The greatest challenge to our work continued to be the provision of meaningful and sustainable host country infrastructure and human resource capacity to ensure full compliance with *IHR (2005)*[1] competencies as outlined previously in the AFHSC-GEIS FY2009 outbreak response report.[14] The AFHSC-GEIS disease surveillance network is positioned to detect the emergence of new and reemerging human and zoonotic pathogens[29]; however, we must continue to provide innovative and cost effective approaches to disease surveillance in these times of fiscal constraint. For example, recognizing that zoonoses constitute over 70% of EIDs, increased zoonotic surveillance efforts will be undertaken in future years in order to develop local capacity focusing on high-risk populations at the human-animal interface.

There are various other challenges AFHSC-GEIS faces in conducting timely and effective disease surveillance. Optimizing collaborations within the DoD and other US government agencies to minimize duplication of efforts continues to be a priority. Establishment of data sharing agreements between and among countries within the network is another major challenge. AFHSC-GEIS hopes to address these challenges by the introduction of a "disease surveillance dashboard" that aims to maintain sovereignty of data, while making useful information available to decision makers in a timely fashion. The importance of health security cannot be overemphasized and the role that military public health officials play continues to require clarification in many settings.

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We thank the numerous individuals who perform surveillance as part of the AFHSC-GEIS global network, including all individuals in the health, agriculture, and defense ministries of our partner nations whose efforts have contributed to the success of the network. We also express our appreciation to the AFHSC staff, especially Dr Luther Lindler and Dr Julie Pavlin, for their assistance with manuscript edits and editorial suggestions.

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US Army Public Health and Veterinary Support in Japan Following the Tōhoku Earthquake and Tsunami, March-April 2011

Nolan A. Watson

BACKGROUND

This article is a brief summary of the activities of the Public Health Command Region – Pacific and the Japan District Veterinary Command following the March 11, 2011 earthquake, tsunami, and nuclear reactor explosion in northeastern Japan.

The information used in this article was primarily gathered by the Special Army Medical Command Response Capability-Medical History Team (SMRC-MHT) based at Fort Sam Houston, Texas, which consists of historians from the Army Medical Department Center of History and Heritage's Office of Medical History. Team members for the Japan 2011 mission were an active duty military historian and the author. In Japan, the Commander, Public Health Command Region-Pacific (PHCR-PAC), and the Commander, Japan District Veterinary Command (JDVC),* provided invaluable insight and information. They were also extremely helpful in assisting the SMRC-MHT members in travel and conducting interviews with personnel.

During the week July 9 through July 15, 2011, the SMRC-MHT traveled to Camp Zama, Japan and recorded the activities of the PHCR-PAC and the JDVC related to the March 2011 earthquake, tsunami, and resulting nuclear crisis. Information concerning immediate disaster response and the later formal Army and United States Forces–Japan (USFJ) support during Operations Tomodachi, Pacific Passage, and Pacific Homecoming† was also collected.

The team was able, through discussion, interviews, and personal interaction, to develop a greater understanding of the challenges faced by and achievements of the Soldiers and civilians of the PHCR-PAC and the JDVC. Trained through simulated disasters and performing constant travel related to testing and support, the personnel of these units were prepared to operate under unusual circumstances. Although these organizations operated within a joint environment during the recovery and support efforts, the focus of this document is US Army operations.

EVENT 1: EARTHQUAKE

> We'd feel earthquakes every now and then because we get quite a few every year, but it started off just a normal earthquake, and then it got bad and cars were shaking and alarms were going off and people were screaming.
>
> SPC Donald Lewis, PHCR-PAC

On Friday, March 11, 2011, a magnitude 9.0 earthquake, one of the largest in recorded history, struck off the northeastern (Tohoku) coast of the main Japanese island of Honshu, near the city of Sendai. Initial reactions were for safety and accountability at various levels. Communication was difficult due to power and telephone line damage. Additionally, the size of the units' regions of responsibility further hampered accountability efforts. Internet connectivity remained to varying degrees, and, in many cases, contact was made through Skype and Facebook social networking sites when government telephone lines were inoperable. Contact was established with all personnel before midnight, March 11.

The PHCR-PAC normally tests a wide variety of environmental and industrial samples during routine, steady-state operations. After the earthquake, one of its first tasks was to test Camp Zama's water supply. The tremors had shaken water pipes and agitated visible sediment which concerned the residents of Camp Zama. Initial testing confirmed that there was no danger, and after

*When information for this article was collected, PHCR-PAC and the JDVC were under separate command structures. On July 22, 2011, the US Army Veterinary Command was deactivated and all Department of Defense veterinary services were assumed by the Army Public Health Command. In Japan, the JDVC was integrated into the Camp Zama-based PHCR-PAC. On August 31, 2011, the JDVC was reconstituted as Public Health Command District-Japan. The PHCR-PAC includes 3 veterinary command districts: Japan, Guam, Hawaii.

†Operation Tomodachi included both humanitarian assistance (direct) and consequence management (indirect) support of the Japanese people through combined US and Japanese military aid and assistance following the actual disaster events, and was continuing when this article was written (January 2012). Operation Pacific Passage refers to the voluntary departure of military family members from Japan. Operation Pacific Homecoming is the converse of Operation Pacific Passage, with voluntary departees returning to Japan.

The March 11, 2011 earthquake and tsunami devastated the northeast coastline of the Japanese island of Honshu. The area around the city of Sendai, pictured here, was especially hard hit. Photo courtesy of the US Army.

approximately 24 hours of rumors and misinformation about storing water, fears abated and the issue subsided.

During the early hours of recovery following the first event, the JDVC* shifted to emergency operations. Power outages and potential structural damage posed immediate food safety concerns, including the primary US military storage and staging food warehouses on Honshu. Food inspectors called, drove, or walked as needed (sometimes for miles) to reach all affected facilities and conduct refrigeration failure procedures and evaluate the potential affect on food safety of any physical damage.

Within 24 hours of the earthquake, after initial food and animal facility assessments at 10 sites supported by the Zama, Yokosuka, and Misawa branches, the Veterinary Services Branches began preparing installation command channel messages. The messages addressed food safety during power outages and provided continued refrigeration failure information and support to government food facilities.

Military Working Dog kennels, stray facilities, and installation boarding and care kennels were contacted to determine physical status and address any animal injury/care issues. An increased food surveillance laboratory testing program was initiated due to increased food sanitation-related concerns. The Misawa Veterinary Services Branch and its Veterinary Treatment Facility (VTF) at Misawa Air Base near the northern tip of Honshu lost power, heat, and telecommunications while dealing with snow and freezing temperatures. Its personnel labored to continue operations under extreme adverse conditions for the next 2 weeks.

*The JDVC consisted of 5 Veterinary Service Branches supporting 34 installations, the 7th Fleet (USN), the 5th Air Force, USFJ, and the US Embassy. The branches were Misawa (supporting 2 installations), Zama (supporting 8 installations, 5th Air Force, US Embassy, and USFJ Headquarters), Yokosuka (supporting 8 installations/sites and the 7th Fleet), Iwakuni (supporting 4 installations/sites and 7th Fleet units at Sasebo), and Okinawa (supporting 15 installations and the III Marine Expeditionary Force).

EVENT 2: TSUNAMI

> The tsunami was the major cause of damage from the 3/11 events. When I traveled through Sendai, there was some building damage from the earthquake, but the tsunami damage was incredible and absolute, sparing almost nothing in its wake.
>
> COL Michael Brumage, Commander, PHCR-PAC

As the tremors and aftershocks from the large earthquake continued while decreasing in magnitude, another threat appeared. The earthquake caused a vast tsunami along the east coast of Japan, which was particularly damaging to the Sendai area and roughly 400 km of the Tohoku coast, obliterating many towns and cities in the affected area, resulting in approximately 20,000 deaths. Breaking through a lowered coastline caused by the earthquake, the waters crushed countless walls and buildings, and damaged the Fukashima Daiichi nuclear power plant. Personnel from the Yokosuka Veterinary Services Branch (animal care, JDVC food inspectors, and a JDVC noncommissioned officer assigned to the Navy Food Management Team) stationed on Yokosuka Naval Base had to withdraw for a short time due to fears of the tsunami, which fortunately crested at 2 m near Yokosuka, rather than the height of 9 m near Sendai, approximately 160 km to the north. In the tsunami's aftermath, PHCR-PAC provided support in testing water supplies, air samples, and other items for radiological, biological, and chemical contaminants to assure the safety of the working environment where US personnel were assisting the Japan Self-Defense Force.

The tsunami also directly and indirectly impacted Japanese commercial food plants normally audited by the JDVC. The JDVC's immediate post-tsunami actions included communicating with those plants and determining the physical damage, power supply, proximity to affected areas, and state of operations. This was essential to determining food safety decisions for USFJ.

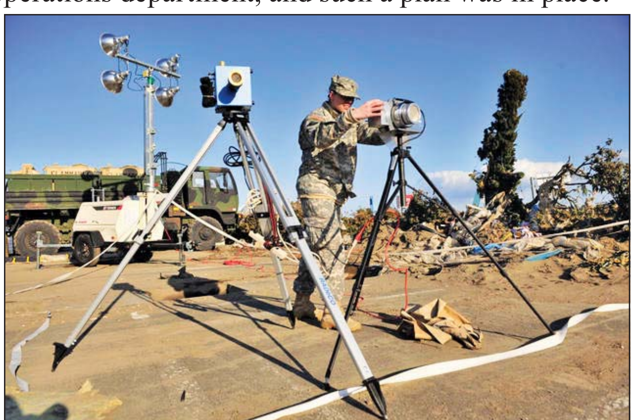
Concurrent with the other contingency actions, search and rescue (SAR) dogs from the United States, the United Kingdom, and Australia required veterinary support to be allowed entry into Japan, a rabies-free country, to assist in recovery efforts. The strict animal quarantine requirements of the Japanese government were met largely through the efforts of the JDVC.

EVENT 3: CRITICALLY DAMAGED NUCLEAR REACTOR

> I didn't really think it touched home for most of the personnel here on what the seriousness of the situation was, until the incident with the nuclear reactor started up and then it became real.
>
> CPT Brian E. Vencalek, PHCR-PAC

Monday, March 14, brought more challenges as requests for assistance and support increased, and the situation at the Fukashima Daiichi power plant came under close scrutiny. The condition of the nuclear reactors at the power plant continued to deteriorate, and public concern in connection with a potential nuclear accident was greatly heightened. Rumors had detrimental effects on PHCR-PAC operations. While Facebook aided communication immediately following the initial events, it now impeded progress as its postings spread and heightened unfounded fears. Similarly, American news media compounded anxiety and fear by incessantly publicizing possible nuclear concerns. Community-level risk communication became a de facto mission of PHCR-PAC.

In order to field questions and assist with their expertise at a higher level, some health physics personnel at PHCR-PAC were detailed to the US Army-Japan and Joint Security Forces–Japan staffs. Also, PHCR-PAC was later augmented with health physics personnel from the Army Public Health Command's Army Institute of Public Health (AIPH), who arrived in Japan before any other military radiation detection unit. As the tempo increased within PHCR-PAC, the newly formed operations cell increased from an operations officer and one noncommissioned officer to several personnel with varying augmentations, all working very long hours over the next month. Fortunately, a training exercise prior to the events had demonstrated the value and need for a larger operations department, and such a plan was in place.



A US Army public health specialist from the Institute of Public Health, Aberdeen Proving Ground, MD, checks radiation levels at the Sendai Airport, Japan, on March 27, 2011. Photo courtesy of the Department of Defense.

When reactor Unit #3 at the Fukashima nuclear power plant exploded on March 14, new fears emerged, and PHCR-PAC dispatched teams to collect data to determine the effects of the explosion and measure the amount of possible radioactive contamination. The teams collected air and water samples from Army bases in the Kanto Plain (Tokyo area) as well as from areas where US personnel were working in the vicinity of Sendai. Coordination and cooperative testing was conducted with the US Air Force Radiation Assessment Teams, which arrived in Japan one week after the AIPH team. Also, Occupational and Environmental Health Surveillance Assessment teams were sent for an extended time to the Sendai Airport area where US and Japanese Forces were concentrated during humanitarian relief operations.

POSTDISASTER OPERATIONS

Japan District Veterinary Command

The JDVC became concerned that Military Working Dogs might require preventive radiologic protection with administration of potassium iodine or KI tablets. The JDVC addressed those concerns to the USFJ Surgeon, then worked with the Department of Defense (DoD) Military Working Dog Veterinary Service to determine a dosage and dosing scheme. The JDVC then quickly coordinated with the US Army Medical Department Activity, Japan, to obtain the medications and finalize the dosage plan, in case it was needed. Dosage and methods of dispersal were quickly identified and relayed, but fortunately the need to administer the medications did not materialize.

The VTFs at Camp Zama, Yokosuka, Yokota, and Misawa began to experience increased visitation by military dependents, steadily at first, then increasing very rapidly. Dependents and DoD civilians had concerns for their safety and were voluntarily leaving Japan, but all pets had to receive health certifications before they could depart. The stream of people increased and often nearly overwhelmed the staff of the VTFs. The workload reached particularly high levels after official notification of voluntary assisted departures for dependents and their pets was announced, and Operation Pacific Passage began on March 22. This operation involved the examination, certification of health, and transportation of over 2,700 pets.

The VTFs succeeded through the dedication and flexibility of their personnel. Supplemental personnel were primarily available food inspectors from the Yokosuka and the Camp Zama Veterinary Service Branches. But there were also enthusiastic volunteers, such as Military Working Dog handlers, and a newly arrived JDVC Animal Health Technician destined for the Sasebo VTF who had not yet processed from arrival. A surgeon waiting with his pet in the Misawa VTF line expressed a wish to help and was given a stethoscope and a crash course on animal physical exam basics, and put to work in an exam room. Very long days and nights combined with some emotional military dependents to add to the challenges faced by the VTF staffs.

The JDVC developed and initiated a novel program for radiological surveillance that continues today. The program information was requested by the Department of Veterinary Science at the AMEDD Center and School (AMEDDC&S) for instructional purposes. Supplemented with additional radiation meters received from AMEDDC&S and USAPHC Veterinary Services, the program provided daily radiological surveillance monitoring of up to 68 different animal and food related facilities and conveyances on 14 different installations for all military service branches within USFJ, with over 7,000 readings as of July 2011. The monitoring provided assurances to commands and the public of no health threat to installation level food supplies from radiation. Health physicists from PHCR-PAC reviewed the data daily and confirmed the absence of a health threat, and provided supplemental equipment training and refined the JDVC-developed program. They were also essential in facilitating JDVC efforts with additional handheld radiological monitoring equipment that was vital to the program.

With the public announcement of radiological contamination of Japanese food products, JDVC immediately initiated working relationships with the Government of Japan (GoJ) to receive testing results; Defense Logistics Agency and the Defense Commissary Agency personnel regarding normally exempt product origin; and the Food and Drug Administration (FDA) representative who had been dispatched to the US Embassy in Japan. The JDVC food inspectors also began conducting surveys at the installation level. The results were rapid responses to USFJ and JDVC to provide assurances that contaminated products had not reached USFJ installations. Command channel messages were sent with each newly researched product announcement. Although time consuming, it was very important to ensure announcements and news media events addressed food safety concerns.

The Commander, JDVC, described the food inspection mission in detail:

> By the next Monday after the quake, we initiated conducting commercial food plant assessments. Within 10 days, we had recommended suspension of the first commercial food plant previously approved for DoD procurement due to proximity of the primary damage sites and our inability to reach them. Within 15 days of 3/11, we had finished our initial evaluation with additional suspension recommendations, and worked with USAPHC Veterinary Services, DoD Veterinary Services Activity, FDA, USDA [US Department of Agriculture], ASD/HA [Assistant Secretary of Defense/Health Affairs], USFJ, etc, with the result being an historical ALFOODACT [all food activities alert] 004-2011 issued on April 1, 2011, with suspension of DoD food procurement from 13 different prefectures, with a few individual plant exceptions, due to concerns of compromised food safety from radiological, seismic activity damage, and resupply/transportation or power outages resulting in potential microbiological, chemical, physical, or radiological contamination. JDVC then developed an enhanced auditing program first enacted later in April 2011 that included sending a team with a CWO [chief warrant officer] 640A, veterinarian, and 68R food inspectors to the plants to conduct onsite radiological surveillance, bioluminescence surveillance, determination of raw ingredient origins, HAACP [hazard analysis and critical control points] and production/processing methodology reassessment, etc. We also gathered onsite water and food product samples for microbiological [tested by the JDVC Food Surveillance Laboratory], chemical [DoD food analysis and diagnostic laboratory], and radiological [food, FDA US based laboratory; water, AIPH testing]. In addition, JDVC met with GoJ [agencies] to obtain GoJ and prefectural radiological testing results, to discuss radiation testing methodologies, and to determine complementary efforts to avoid any needless duplication. This will be an ongoing mission for the next 2 years [estimated], with continued surveillance for several years to come.
>
> LTC Margery Hanfelt, Commander, JDVC

Although JDVC served as the food safety lead and primary responder for all USFJ during Operation Tomodachi, it was not spared from other tasks. The JDVC faced part two of the dependent animal care mission, Operation Pacific Homecoming, when returning family members required documentation to expedite bringing their pets back into Japan. Working with the GoJ, this effort was accomplished in a short amount of time. The accomplishment was made possible through meticulous record-keeping and an atmosphere of great trust between the JDVC and the GoJ. The JDVC also enacted a "hotline" connecting veterinary teams with GoJ Animal Quarantine Service officials at Narita Airport, and received pets at designated US military installation sites.

Public Health Command Region–Pacific

> We were getting a lot of people who were engineering and veterinary specialties filling in, trying to do as best as they possibly could. But it was many, many long days. I think that the first day we got off was about 60 days after the actual earthquake.
>
> MAJ William Whitaker, PHCR-PAC

The testing site distance and monitoring schedule (every 4 hours during the first weeks) added to logistics issues within PHCR-PAC. For the remainder of March and through most of April, teams and trucks were almost continuously en route to testing sites, performing a test, or returning with data for interpretation. Assisting in testing were augmentees from the 296th Army Band, the 78th Signal Battalion, and the 441st Military Intelligence Battalion. Personnel within PHCR-PAC were also trained outside of their normal scope of duties to assist in the monitoring mission. Additional assistance for PHCR-PAC missions was also later received from USAPHC, and the 9th Area Medical Laboratory based at Aberdeen Proving Ground, MD.

The operations cell of PHCR-PAC grew as it received assistance for its staff members. Long hours increased as the unit gathered and disseminated information to USARJ and USAPHC. The public health section of the BG Crawford F. Sams Hospital (Camp Zama) also continued to work closely with PHCR-PAC, providing information and testing requests.

A small testing team was sent to the operations center at Ishinomaki near the Sendai Airport. The US military used Ishinomaki Camp, near the devastated area of Sendai, as a staging area. From there, Army, Marine Corps, and Air Force personnel supported the Japanese Ground Self-Defense Force as it provided humanitarian relief and rescue operations. Because of the proximity of the destruction and the large congregation of personnel, the PHCR-PAC team monitored for potential hazards. The team provided particulate matter sampling of the air, water, and soil. Heavy metal and vapor air sampling was conducted, as well as water quality analysis.

Housing areas for US military personnel and their dependents were also of primary interest for testing. These testing areas included Camp Zama; the nearby Sagamihara Housing Area, Sagami Depot, and Atsugi Naval Air Station; Yokohama's North Dock facilities; and Hardy Barracks (downtown Tokyo). Reaching the Yokohama North Dock and Hardy Barracks areas was difficult because of constant heavy traffic congestion and the maze of streets. Yet dedicated drivers, mostly Japanese civilians, successfully navigated the city streets to transport Soldiers to the areas requiring testing.

Not surprisingly, operations during the heavy sampling period of March, April, and May 2011 increased dramatically. The logistics of the sampling and survey mission, including translation and continually providing information, were complex. Similarly, the materials required for collecting the samples and their transport presented more challenges. "Normal" operations for PHCR-PAC before the disasters required numerous testing items and transport at great expense. Such expenses increased substantially as the monitoring efforts expanded. Material gathered by air, water, and soil sampling arrived at either the Camp Zama or USAPHC laboratories for testing. Some of the materials were shipped to contractors to perform the testing. Many of the Japanese vendors were sympathetic and offered free supplies or discounts.

NONCOMBATANT EVACUATION OPERATION

Operation Pacific Passage was the first true test of existing plans for the noncombatant evacuation operation (NEO) from Japan in the event of catastrophe or the outbreak of hostilities on the Korean peninsula. Spouses, dependents, US or other foreign national civilian employees, and pets presented a significant challenge. It is understandable that some people were eagerly seeking transit due to the unstable environment. As military personnel and family members pondered courses of action, a town hall meeting was called at Camp Zama where USFJ and garrison command leadership fielded questions and concerns. One issue was the care of personally owned animals (pets). Noting the extreme concern, the Commander, USARJ agreed that pets could be a part of the voluntary departure.

Ultimately, NEO was not activated, but voluntary leave paid by the government was approved. This action eased many dependents' minds, but also significantly increased the workload for VTFs. Though most of the dependents and civilians opted to stay in Japan, a number decided to leave. Volunteers helped to bridge the gap for animal care in the manner of feeding and walking. Also, military exchanges sometimes provided complimentary water and pet carriers. Navy personnel assisted in movement of the pets to the Narita airport near Tokyo. Cooperation continued at the Narita airport as the airport staff and the airlines allowed more animals on aircraft and eased their travel and storage through the airport. The environment of cooperation was necessary as many of the dependents had small children, compounding the already stressful situation.

Denver International Airport and Seattle-Tacoma (Sea-Tac) International Airport were the receiving hubs for voluntary departees. Family members then had to find passage to other parts of the United States. For some, an additional day would be necessary to arrange further transportation. Logistic support was provided by local USMC reserve units and Army and Air Force personnel. Strollers were provided for the large number of young children and the American Red Cross provided showering and baby changing stations.

After 4 to 8 weeks, many of the dependents returned to Japan. Operation Pacific Return, the reverse of Operation Pacific Passage, went smoothly. The ease of the transition in connection with the movement of pets was largely due to JDVC's interactions with the GoJ. The time for animal entry into Japan was significantly reduced due to their good working relationship. The JDVC maintained the required documentation and addressed all questions that satisfied GoJ's requirements.

CONTINUED EFFECTS

> I guess we're at the new normal….We still have some families slowly coming back, so we, I think, have gone to more of what it used to be, where you just got a regular full day of work.
>
> SFC April Smith, JDVC

More than 2 weeks after the March 11 earthquake, concerns about food procurement continued. Radiologic contamination was the most notable concern, but refrigeration and other storage and transportation issues related to the earthquake and its aftermath remained. Veterinary food inspection teams, redirected to assisting in the animal care mission, "re-tooled" to their original function and began another phase of recovery. Although the food safety inspection was an existing mission before the earthquake, it has greatly expanded due to new challenges presented by the unfolding disasters. Newer technology, such as bioluminescent technology to quickly determine some surface contaminations at food production plants, is now used to aid the inspection process.

The Public Health Command District-Japan (PHCD-J) remains busy with food inspection issues. On August 7, 2011, ALFOODACT 010-2011 was issued initiating removal of suspensions of procurement of food products from those designated areas in Japan. Implementation by PHCD-J of those suspension removals will require approximately 2 years of effort. The PHCD-J also established a comprehensive walk-through program for food inspectors at the facility level, which includes radiological and bioluminescence surveillance, surveillance food laboratory testing, and other legacy food inspection programs. Radiological surveillance of food facilities and conveyances will continue for several years.

PHCR-PAC continues to monitor and plot data in connection with air, water, and soil quality, in addition to sustained examination of biological, radiological, and chemical threats. Its laboratory has received additional equipment to perform testing and has gained additional personnel to assist in daily operations. Ambient radiation readings to a minute degree have increased within the tested areas, however, such readings pose no threat to personnel.

CONCLUSION

The Soldiers and civilian personnel of Public Health Command Region – Pacific and the Public Health Command District-Japan (formerly JDVC) were able to rapidly alter daily operations from a garrison structured organization to support field operations and the myriad of challenges in connection with what became a de facto partial NEO. Although no exercise can fully prepare any unit for such a disaster, extensive planning was invaluable in reacting to and contending with the ceaseless demands for assistance and information. The events and actions solidified a solid and cohesive working relationship between the PHCR-PAC and JDVC leaders and staffs, and provided a "proof of concept" for the Army Public Health Command.

Planning and readiness exercises for future Public Health Command District-Japan operations include updating NEO plans to be more realistic in reflecting actual requirements and capabilities, as evidenced by events experienced by the JDVC. Organizational changes and protocols ensuring improved coordination with the GoJ to create and emplace procedures during similar emergencies are in staffing. Part of the JDVC's success was the product of its management of information and prompt identification of incorrect sources. A disaster preparedness exercise conducted 2 months prior to the March 11 earthquake is credited with particularly beneficial results. Key among the lessons learned from that exercise were the need for a robust operations cell with dedicated personnel and communications assets, implementation of which was an essential element in the success of the emergency reaction to such an unprecedented disaster event.

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Diet, Physical Activity, and Bone Density in Soldiers Before and After Deployment

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ABSTRACT

Purpose: To investigate diet, physical activity, and bone mineral density (BMD) in combat service support Soldiers before and after deployment, and to determine if any components of diet or physical activity impacted BMD.

Design: Fifty-three Soldiers participated in the study. The BMD of the femoral neck and lumbar spine were measured using dual-energy x-ray absorptiometry. Diet was assessed using the Block Food Frequency Questionnaire. Physical activity was assessed using the Baecke Habitual Physical Activity Questionnaire.

Results: The BMD of the spine (0.79%; $P=.03$) increased significantly during deployment. Reported physical activity at work (-10.76%; $P=.01$) decreased and vitamin K intake increased (37.21%; $P=.01$). Soldiers did not meet the dietary reference intake for vitamin D and exceeded the dietary reference intakes for all other nutrients. No significant relationships were observed between change in diet or physical activity and change in BMD.

Conclusion: Due to the small sample size, we could not determine if deployment impacted BMD, diet, or physical activity in combat service support Soldiers. Future research should focus on investigating the association between lower levels of physical activity, inadequate diet, and decreased BMD in larger military populations.

Since 2001, over 2 million US military personnel have deployed to Iraq or Afghanistan.[1] Many of these Warfighters have been deployed multiple times for deployments lasting over 9 months. The demands placed on Soldiers during deployments are physically challenging and require them to maintain a high level of physical fitness.[2] In garrison settings, Soldiers typically participate in scheduled physical fitness routines and have access to dining facilities and many other food sources. The variability in mission requirements during deployments may limit routine exercise regimens and food intake, otherwise available in garrison.[3] Additionally, the hot and dry climates associated with deployments promote dermal calcium losses, and, when combined with inadequate dietary intake of calcium and vitamin D, subject military personnel to decreased bone density and place them at risk for musculoskeletal injuries.[4]

Bone-related injuries and stress fractures are a major problem in the military and affect the health and readiness of Soldiers.[5] Risk factors for bone-related injuries include increasing age, female gender, smoking, inadequate calcium intake, poor fitness level, and overtraining.[5] Previous studies have examined the impact of sustained operating environments[3,6] similar to deployments, on bone mineral density (BMD) in infantryman and have presented contradictory results. Nindl et al[3] observed an increase in bone mineral content of the whole body and trunk, whereas Casez et al[6] found an increase in BMD of the tibia and a decrease in BMD of the spine.[6] More recent studies have investigated the effect of deployment on physical activity and body composition. Sharp et al[7] determined that a 9-month deployment negatively impacted aerobic capacity, upper body power, and BMD. Lester et al[8] noted an improvement in upper and lower body strength and a reduction in aerobic performance. Collectively, these results suggest that physical activity, particularly load bearing, may positively impact bone health; however, a deployed setting with inadequate food and rest and periods of prolonged work may negatively impact BMD. Since most studies have investigated infantry Soldiers and recruits, levels of BMD and physical fitness of combat service support Soldiers during deployment are unclear; so it remains unknown if long-term deployments impact bone density in this population.

Nutrient losses from environmental factors combined with inadequate diet subject military personnel to bone-related injuries.[3] It is well known that calcium and vitamin D are important nutrients related to bone metabolism; however, other nutrients such as protein, fat, vitamin K, sodium, magnesium, and phosphorus may play a role in maintaining bone density as well.[9] Previous data from the National Health and Nutrition Examination Survey[10] which indicated age-associated changes in calcium intake suggest Soldiers aged 18 to 40 years may not be consuming the recommended amounts of bone-related nutrients, predominantly calcium. Etzion-Daniel et al[11] examined nutrient consumption by female Israeli

Defense Forces Soldiers during Army basic training and found vitamin D (49%-61%) and calcium (24%-31%) intakes to be well below the military dietary reference intakes (MDRIs).[12] Other studies suggest that intake of vitamin D and calcium greater than the MDRI may reduce the risk of fracture in Soldiers[13,14]; however, most studies focus on female recruits[13-16] and do not consider males or deployment settings. Collectively, these results suggest that female Soldiers do not consume sufficient calcium and vitamin D during basic training. However, the consumption levels of bone-related nutrients in combat service support Soldiers in garrison and deployment settings have not been considered and are unknown.

At present, the interactions between dietary intake, physical activity, and BMD in combat service support Soldiers during long-term deployments have not been investigated. The purpose of this study was to investigate dietary intake, physical activity, and BMD in combat service support Soldiers before and after a 12-month deployment to Iraq. Furthermore, researchers wanted to determine if any components of diet or physical activity impacted BMD throughout the study period.

SUBJECTS AND METHODS

Fifty-three US Army Soldiers were recruited from the 62nd Medical Brigade, Joint Base Lewis-McChord, Washington. Volunteers were eligible to participate if they were active duty male or female Army Soldiers aged at least 18 years, were in good physical and mental health, and scheduled to deploy to Iraq in 2007. Pregnant Soldiers were excluded. The study was a prospective, descriptive, longitudinal design with repeated measures that took place at the Madigan Army Medical Center in Tacoma, Washington. Lifestyle factors, anthropometrics, diet, physical activity, and BMD were collected before and after the 12-month deployment to Iraq. Baseline measurements were taken within 30 to 60 days of deployment. Postdeployment measurements were taken within 60 days of each Soldier's return from Iraq.

DATA COLLECTION

All dependent variables were documented at baseline and after the 12-month deployment. Height was measured at baseline to the nearest 0.1 cm using a Harpenden stadiometer. Body weight was measured at both time points using a calibrated electronic scale and measured to the nearest 0.1 kg with volunteers wearing the Army physical fitness uniform (t-shirt, shorts, and socks). Body mass index (BMI) was calculated as weight (kg) divided by height^2 (m^2).[17] Age, ethnicity/race, and lifestyle habits (family history of bone abnormalities, history of eating disorders, alcohol use, and tobacco use) were collected using a demographic survey.

Bone mineral density of the (L1-L4) spine and femoral neck were measured by a trained, certified technician using dual energy x-ray absorptiometry (Lunar Prodigy Densitometer, GE Healthcare, Madison, WI).

Physical activity was measured using the Baecke Habitual Physical Activity Questionnaire. This tool was validated on male and female subjects with similar age and activity level of study participants, and was designed to assess physical activity during work, leisure, and sports activities.[18] The baseline survey assessed activity during the previous year, whereas the postdeployment survey assessed activity during deployment. Work activity was designed to measure frequency of sitting, standing, walking, lifting, fatigue, and sweating. Questions involving sports were designed to measure frequency, type, and duration of activity for up to 4 different sports, while leisure activities included frequency of sports participation, television watching, walking, and riding a bicycle during off-duty hours. The work and leisure subscales were scored from 1 to 5 on a Likert scale (1=never; 5=always/very often). The sport score was determined by assigning values to certain sports based on their frequency and intensity.[18] Overall, physical activity was determined by adding work, leisure, and sport codes and was described on a scale of 1 to 15 (1=low, 7.5=moderate; 15=high).

The previously validated 2010 Block Food Frequency Questionnaire (FFQ, NutritionQuest, Berkeley, CA)[19] was administered to estimate usual and customary intake of 110 food items. Respondents reported how often (in the past year) they typically consumed each food (never, a few times per year, once per month, 2-3 times per month, once per week, 2 times per week, 3-4 times per week, 5-6 times per week, or everyday), and what their usual intake was on those days. Individual portion sizes were estimated by pictures provided to enhance accuracy of quantification. The questionnaire also contained questions about overall consumption of foods from each food group, beverage intake, and use of vitamin supplements. All completed questionnaires were analyzed by NutritionQuest. Ten nutrients (energy, protein, fat, carbohydrate, calcium, vitamin D, phosphorus, magnesium, sodium, vitamin K) were included in the analysis for this study. All nutrients were calculated as the sum of daily intake from food. Due to the outdated MDRIs[12] typically used for military personnel, energy was compared to the Department of Agriculture's dietary guidelines[20] for Americans' estimated energy intake for males and females aged 18 to 25 years with a moderate physical activity level. All other nutrients were compared to the Institute of Medicine's dietary reference intakes (DRIs).[21]

STATISTICAL ANALYSIS

Study completers were defined as those participants who completed both baseline and postdeployment measurements. Statistical analysis was performed using the SPSS Inc Statistical Package (version 18.0, SPSS Inc, Chicago IL). Descriptive statistics using means±standard deviations were used to describe all data. Independent *t* tests were used to compare those who completed the study and those who did not. Dependent variables were analyzed using a 2-tailed, paired samples *t* test to compare differences in means between baseline and postdeployment. Pearson's correlations were used to compare relationships between changes in physical activity, changes in dietary nutrients, and changes in BMD. Statistical test significance (alpha) was set at $P \leq .05$.

Table 1. Demographic characteristics at baseline (N=19).

Demographic Data	Baseline
Age (years)[a]	23.13±3.4
Gender[b]	12 male 7 female
Height (cm)[a]	173.19±10.8
Weight (kg)[a]	73.27±12.3
BMI (kg/m²)[a]	24.25±2.4
Ethnicity/Race[b]	
Caucasian	13
African American	3
Hispanic	2
Pacific Islander	1
Lifestyle Habits[b]	
Tobacco use	4
Alcohol use	10
Family history of bone disease	3
History of stress fracture	2
History of eating disorder	0

Notes:
a: Expressed as means±SD
b: Number of participants

RESULTS

Nineteen of 53 (36%) study participants returned after deployment to complete all data points. One Soldier did not provide baseline data, another did not provide baseline FFQ data, and 32 Soldiers did not return for postdeployment measurements. No significant differences were observed in age, height, weight, BMI or gender between those who completed the study and those who did not. Demographic data are presented in Table 1. Twelve male and 7 female Soldiers were study completers. Age ranged from 18 to 36 years, with a mean of 23.13±3.4 years. Height ranged from 149 cm to 193 cm with a mean of 173.19±10.8 cm. Weight ranged from 54 kg to 95 kg with a mean of 73.27±12.3 kg. The BMI ranged from 20.07 to 28.49, with a mean of 24.26±2.4. Thirteen Soldiers were white, 3 African American, 2 Hispanic, and one Pacific Islander. At baseline, 4 Soldiers reported tobacco use, 10 indicated alcohol use, 3 noted family history of bone disease, 2 a history of stress fracture, and none a history of eating disorder. During deployment, 4 Soldiers began using tobacco and only 2 Soldiers reported alcohol use. No stress fractures were experienced by either gender during deployment.

Changes in anthropometrics and BMD from baseline to postdeployment are presented in Table 2. No significant differences were observed in weight or BMI. Bone mineral density of the spine increased significantly from baseline to postdeployment (0.79%; P=.03). It is possible that this increase may have been related to bone growth during deployment, since bone accrual may still be taking place in many of these young Soldiers. In contrast to the increase in BMD of the spine, no significant differences were seen in BMD of the femoral neck (-0.87%; P=.09) from baseline to postdeployment. However, it is important to note that even though there were no statistically significant results, 47% of subjects did experience a clinically significant (2% change) decline in BMD of the femoral neck.

Reported work, sport, and leisure activity before and after deployment is presented in Table 2. A significant decrease in physical activity at work (-10.76%; P=.01) was observed. No significant differences were observed

Table 2: Anthropometrics, BMD, physical activity, and dietary intake from baseline to postdeployment in study completers (N=19).

Anthropometrics	Baseline (Mean±SD)	Postdeployment (Mean±SD)	Change (%)[a]	*P* value[b]
Weight (kg)	73.27±12.3	73.52±12.3	0.34	0.76
BMI (kg/m²)	24.25±2.4	24.40±2.9	0.62	0.59
Bone Mineral Density				
Femur BMD (g/cm²)	1.15±0.14	1.14±0.14	-0.87	0.09
Spine BMD (g/cm²)	1.26±0.14	1.27±0.14	0.79	0.02*
Physical Activity				
Work	2.51±0.35	2.24±0.40	-10.76	0.01*
Sport	2.53±0.79	2.55±0.81	0.79	0.91
Leisure	2.51±0.65	2.58±0.80	2.79	0.71
Overall	7.55±1.35	7.37±1.40	-18.01	0.61
Dietary Intake				
Energy (kcal)	3231±2215	3009±1609	-6.86	0.48
Protein (g)	117±90	113±113	-3.94	0.73
Carbohydrate (g)	409±252	387±198	-5.46	0.56
Fat (g)	120±99	120±74	-0.16	0.98
Calcium (mg)	1150±707	1183±431	2.9	0.75
Magnesium (mg)	427±260	413±164	-3.44	0.71
Sodium (mg)	5152±3968	5355±2600	3.95	0.73
Phosphorus (mg)	1722±1104	1847±760	7.25	0.32
Vitamin K (mcg)	208±171	286±287	37.21	0.01*
Vitamin D (IU)	179±126	185±96	3.13	0.81

Notes:
a: Percent change (%)=(Post-Pre)÷Pre×100.
b: *P* values were derived from the paired samples *t* test
*$P \leq .05$ was considered significant.

Table 3. Dietary intake of male (n=12) and female (n=7) Soldiers during deployment compared to the Institute of Medicines's DRIs[a].

	Postdeployment (Mean±SD)	DRI	%DRI[b]
Energy (kcal)[c]	Male 3381±1686	2800	121
	Female 2373±1346	2200	108
Protein (g)	Male 129±53	56	230
	Female 85±39	46	185
Carbohydrate (g)	Male 420±203	130	323
	Female 329±192	130	253
Fat (g)[d]	Male 141±78	108	131
	Female 85±54	77	110
Calcium (mg)	Male 1297±408	1000	130
	Female 990±428	1000	99
Magnesium (mg)	Male 450±172	420	107
	Female 349±139	320	109
Sodium (mg)	Male 6120±2712	1500	408
	Female 4045±1902	1500	270
Phosphorus (mg)	Male 2096±770	700	299
	Female 1421±559	700	203
Vitamin K (μg)	Male 269±169	120	224
	Female 316±252	90	351
Vitamin D (IU)	Male 197±111	600	33
	Female 165±65	600	28

Notes:
a - Dietary reference intake
b - %DRI=(Mean÷DRI)×100
c - Energy for moderately active males and females aged 18 to 25 years derived from the US Dept of Agriculture.
d - Represents 35% of total energy based on the Acceptable Macronutrient Distribution Range (20%-35%).

in sport or leisure activity. After combining work, leisure, and sport activity into one score, no significant differences were observed in reported physical activity. Furthermore, the overall physical activity score during deployment was 7.37. Based on a scale of 1 to 15, this can be categorized between low and moderate.

Data for dietary intake before and after deployment is presented in Table 2. A significant increase was observed in reported vitamin K intake (+37.21%; P=.01) from baseline to postdeployment. No other significant dietary changes were observed. However, after comparing nutrients to the DRIs, it was found that vitamin D intake of males and females were 33% and 28% of the DRI, respectively. Conversely, calcium intake met the DRI in both males (130%) and females (99%). All other nutrients (energy, protein, carbohydrate, fat, magnesium, sodium, phosphorus, vitamin K) exceeded the DRIs as shown in Table 3.

Table 4: Pearson correlation coefficients between change in BMD and change in physical activity and diet variables.

Dietary Intake	Femur BMD	Spine BMD
Energy (kcal)	0.269	0.074
Protein (g)	0.256	0.077
Carbohydrate (g)	0.121	0.057
Fat (g)	0.267	0.013
Calcium (mg)	0.157	0.157
Magnesium (mg)	0.13	0.038
Sodium (mg)	0.18	-0.078
Phosphorus (mg)	-0.32	0.051
Vitamin K (μg)	-0.114	0.262
Vitamin D (IU)	0.022	0.165
Physical Activity		
Work	-0.02	0.176
Sport	0.015	-0.247
Leisure	0.151	0.004

BMD indicates bone mineral density.
Any $P \geq .05$ was considered significant.

Pearson's correlations revealed no significant relationships between changes in dietary nutrients or physical activity and change in BMD of either site ($P \geq .05$). These results are shown in Table 4.

COMMENT

After a 12-month deployment to Iraq, there was a significant increase in spine BMD. Additionally, there was a significant increase in reported vitamin K intake, and a significant decrease in physical activity at work in combat service support Soldiers. However, overall diet and physical activity remained unchanged. No significant relationships were observed between changes in any dietary nutrients or physical activity and change in BMD during the study period. These results may not be representative of all combat service support Soldiers due to the small sample size. Furthermore, diet may vary among Soldiers during deployment based on location and availability of food options from the dining facility, fast food restaurants, and field rations. Physical activity may also vary among Soldiers depending on unit missions, available exercise facilities, and scheduling of routine physical fitness regimens. Therefore, caution must be taken when interpreting these results.

The increase in spine BMD observed in this study differs from the findings of Sharp et al,[7] who noted a significant decrease in BMD (-0.8%; $P \leq .01$) of infantry Soldiers following a 9-month deployment; Nindl et al[3] who detected a decrease in bone mineral content in infantry Soldiers; and Casez et al[6] who found a significant decrease in spine BMD of infantry grenadiers (-2.1±0.4%) and tank drivers (-1.2±0.4%). The increase in BMD of the spine observed in this study may represent normal bone kinetics in young adults, suggesting that deployment did not have a negative impact on BMD as we anticipated.

The reported level of physical activity (7.37±1.4) observed in this study may not be comparable to that of infantry Soldiers; specific job requirements and duties make it difficult to compare results with previous studies.[3,6,7] Due to the nature of deployment and logistical challenges, it was not feasible to conduct specific and repeated measures of physical activity as seen in these studies. However, one study by Lester et al[8] assessed self-reported physical activity in a similar manner and found a decrease in reported physical fitness during deployment, which is similar to the significant decrease in reported physical activity at work observed here. Long-term research investigating duration, intensity, and type of physical activity beyond what was studied here may be beneficial in determining the consequences of decreased physical activity during deployment and BMD. Furthermore, the low to moderate level of self-reported physical activity observed here is of concern, and may potentially impact the maintenance of physical fitness standards required to sustain mission readiness.

Surprisingly, reported intake of vitamin K significantly increased from baseline to postdeployment; however, overall diet including calories, protein, carbohydrates, fat, calcium, magnesium, sodium, phosphorus, and vitamin D did not significantly change. Current literature is lacking on the implications of vitamin K intake and bone health; however, one previous study demonstrated a relationship between low vitamin K intake and lower BMD or higher fracture risk in women.[22] In our study, the increase in vitamin K intake was not related to BMD of either site. It is unknown if Soldiers consumed more vitamin K containing foods while deployed, or if they were taking a vitamin supplement containing vitamin K. More research is needed to determine vitamin K intake of deployed Soldiers and its relationship to BMD.

In this study, female Soldiers consumed 99% of the DRI for calcium, which differed from previous findings of lower intakes of calcium in female military personnel.[11] In contrast, both male and female Soldiers consumed only one-third of the DRI for vitamin D, agreeing with previous observations.[11] Changes in dietary calcium and vitamin D intake during deployment was not correlated with changes in BMD. When interpreting these results, the long-term implications of low vitamin D intake on BMD must be considered.

All other nutrients measured (energy, protein, carbohydrate, fat, magnesium, sodium, phosphorus, vitamin K) exceeded the DRIs, which may place Soldiers at risk for other health conditions beyond what was studied here. Since Soldiers must maintain a high level of physical fitness[2] and weight[17] in order to meet military standards, these results may be of concern to military commanders and health professionals.

This study has multiple strengths and limitations. The repeated measures design and the use of valid and reliable tools to assess diet, physical activity, and BMD added strength to the study. However, the major limitation of the study was the small sample size, typical of military studies because high attrition rates are common due to the highly mobile population. Additionally, the study was descriptive, therefore no comparisons with a nondeployed control group were included. Further, physical activity and dietary intake were self-reported, which may have resulted in reporting bias. Many male Soldiers commented on eating more food than what was offered in the questionnaire, which may have resulted in underreporting. Lastly, no midpoint measures were obtained, making it unclear if BMD, physical activity, and diet were affected at any time during deployment.

CONCLUSION

During a 12-month deployment to Iraq, combat service support Soldiers experienced an increase in BMD of the spine. Additionally, Soldiers indicated an increase in vitamin K intake, and a decrease in physical activity at work; however, overall physical activity and diet were not affected. No components of diet or physical activity were related to changes in BMD; however, Soldiers reported a physical activity level less than moderate, and a vitamin D intake below the DRI. Reported intakes of all other nutrients met or exceeded the DRIs. Due to the small sample size, we could not conclusively determine if deployment impacted BMD, diet, or physical activity in combat service support Soldiers. Military commanders and dietitians should promote routine physical fitness and nutrition education during deployment when unit level training is not feasible. Furthermore, military dietitians are needed in both deployment and garrison settings to prevent both overnutrition and undernutrition, mitigate future health conditions, and maintain the mission readiness of Soldiers.

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Addressing Cancer Clusters in the US Army

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When subject matter experts in the Environmental Medicine Program of the US Army Public Health Command (USAPHC) are alerted to a reported "cluster" of cancer cases with a potential environmental exposure, the decision process determining whether the reported situation warrants a cancer cluster investigation should follow the scientific guidelines set forth by the Centers for Disease Control and Prevention (CDC) for investigating clusters of health events. However, in reality, the high degree of concern and lack of trust among those perceiving and reporting the existence of such a cluster have often been driving factors in the decision to proceed, with the associated commitment of time and resources. It should be noted that, to date, none of the resulting investigations have confirmed the existence of an identified group of cancers that is causally linked or related to military specific operations or hazards. To ensure clarity of and confidence in the process, proper risk communication is often one of the most important elements in the process of investigating a purported cancer cluster. This article provides background and information regarding the procedures that are used to scientifically evaluate a potential cancer cluster while ensuring proper risk communication is accomplished.

Potential cancer clusters investigated by the US Army Public Health Command.

Cancer	Presumed Environmental Cause/Risk Factor	Conclusions
Acute myelocytic leukemia	Potential burnpits (volatile organic compounds), benzene	Unrelated cases; latency–timeframe between disease and exposure of concern are too short to be supported by science.
Breast cancer	Unknown workplace (building) hazards	Unrelated cases/no connections; limited exposure time
Brain cancer	Unknown environmental cause associated with location (installation)	Unrelated types of cancers; no unique or related exposure experiences
Thyroid cancer	Radiation source in work environment (unknown and/or irradiated mail)	Inadequate evidence of exposure of concern

BACKGROUND

To date, several published studies have shown higher rates of cancer in the US military when compared to the general population. This finding was described by Zhu et al, who found significantly higher incidence rates of breast and prostate cancers in both white and African American service members when compared to data from the National Cancer Institute.[1] Using US national incidence rates as a reference, Yamane found significantly higher rates of cervical, prostate, and vulvar cancers among active duty Air Force personnel.[2] When compared to age-specific rates in the general population, Rennix et al reported significantly elevated incidence of breast cancer in enlisted Army women aged 35 years or younger.[3]

Given the results discussed earlier, it is unsurprising that there be concern regarding an increased risk of cancer among US Army beneficiaries. Soldiers and Army civilians alike may attribute clusters of cancer to occupational and/or environmental exposures related to military service or presence on a military installation. Examples of large-scale military investigations of potential cancer clusters include investigation of skin and respiratory cancers associated with exposure to mustard agents during World War II testing programs,[4-6] various cancers due to ground water contamination involving contaminants like benzene and volatile organic compounds at Camp LeJeune, NC,[7,8] the risk of developing cancer after exposure to Agent Orange in the Vietnam War,[9-13] and risk of cancer mortality after exposure to radiation during nuclear weapons testing.[14,15] Examples of smaller-scale investigations of potential cancer clusters completed by the USAPHC include those presented in the Table.

Because these are small investigations of limited numbers of cancer cases, they cannot be evaluated as a quantified epidemiological investigation. Instead, the approach recommended by the CDC has been used.

APPROACH

Defining the Problem

In cases that have been investigated by USAPHC, concerns are raised by anecdotal reports of small numbers of persons who have been diagnosed with cancer.

Regardless of the potential relationship of the cancer to an external environmental exposure, these cases involve people with a serious medical condition. Proper risk communication and empathy, discussed later in this article, are critical elements, even at the earliest interactions. Part of the initial communications should ensure an understanding of what constitutes a cluster, as well as the investigative process that will be used.

According to the CDC:

> A cancer cluster is defined as a greater-than-expected number of cancer cases that occur within a group of people in a geographic area over a period of time.[16]

The hallmark characteristics of particular cancers often vary from patient to patient, making cancer cluster investigation a difficult task. However, the CDC has established several criteria a group of cancer cases must meet in order to be considered a cluster[16]:

- a greater-than-expected frequency;
- a single type of cancer, or multiple types of cancer that have been scientifically linked to the same cause;
- a carefully defined geographic area from which the cases are derived; and
- a clearly defined time period during which the cases occurred.

It is important to acknowledge that a group of cancer cases meeting all the cluster criteria previously identified may be a product of chance, inaccurate designation of expected cases, inconsistent case definitions between actual cases and expected cases, as well as known or unknown causes of cancer. Use of the specific guidelines described in the following sections help identify and minimize such instances.

Specific Investigation Guidelines

Although every investigation has unique challenges that require some flexibility to account for intricacies of the particular health outcome of concern or the amount of resources and information available, the CDC guidelines[17] suggest a 4-stage systematic approach, portrayed in the Figure, when managing an investigation of a possible cancer cluster. Each stage includes a major component of conducting a comprehensive investigation, from initial contact to final response.

Stage 1: Initial Contact and Response

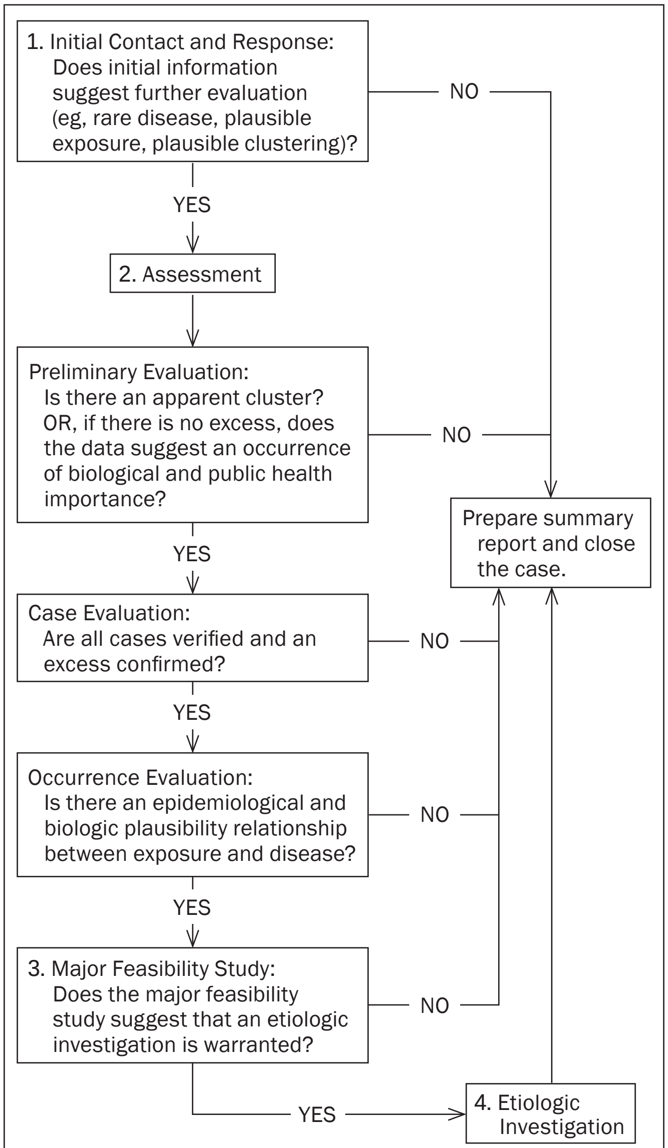
Per CDC recommendations, the first thing that should be accomplished is the collection of all available information regarding the potential cluster through initial contact with the reporting individual or entity. Crucial information includes type(s) of cancer involved, suspected environmental exposure(s) of importance, geographic boundaries, and the time over which cases occurred. Detailed contact and demographic information for those involved should also be recorded. In addition to obtaining as much information as possible, communicating initial impressions with the concerned party is also appropriate; different types of cancer outcomes, cancer cases occurring in older individuals, and brief exposure and latency periods are less indicative of true cancer clusters. However, a single type of cancer that is rare and occurs in an unusual segment of the population warrants further investigation.

Stage 2: Assessment

During the assessment phase, a comparison of observed versus expected occurrence is reviewed in order to determine if cases exist in excess of normal conditions. First, a case definition must be established, including geographic and time restrictions. A suitable reference group must then be selected to represent the expected occurrence. If the threshold of expected occurrence is not exceeded but there appears to be an argument for biologic plausibility or much public health interest, investigators must use their best judgment when deciding if further investigation is warranted. If these efforts reflect a greater-than-expected occurrence, further investigation, case validation in particular, should be conducted. If case validation confirms an excess in occurrence, a field investigation should be conducted in order to further define epidemiologic characteristics of the potential cancer cluster. At this time, an in-depth review of available literature and databases should be done so that the likelihood of an exposure-outcome relationship can be evaluated. If the complete assessment results indicate an excess without a probable environmental exposure, or if the excess is not confirmed, the investigation should be concluded at this point. If the complete assessment yields information suggesting epidemiologic and biologic plausibility in a greater-than-expected occurrence of cancer cases, the investigation should proceed to the next step.

Stage 3: Major Feasibility Study

The third stage of a cluster investigation focuses on determining if an epidemiologic study designed to assess the relationship between environmental exposure(s) and cancer outcome(s) is feasible. The major feasibility study should include a more detailed literature review focused on scientifically established causes for the type(s) of cancer involved, considerations for resources needed, determination of proper data collection on cases and controls as well as appropriate data analysis techniques, and an assessment of the levels of concern from



Process diagram for Centers for Disease Control and Prevention guidelines for investigations of clusters of health events.

all stakeholders. The information gathered during this phase may suggest that a major etiologic investigation is not needed, in which case a report of findings should be written and the investigators should relay all relevant information to everyone involved. The major feasibility study may also indicate that an etiologic investigation is warranted, and therefore, investigators should proceed to the next step.

Stage 4: Etiologic Investigation

If the first 3 stages indicate, an etiologic investigation should be performed to evaluate the link between health outcome(s) and possible exposure(s). The information gathered during the first 3 phases of the cluster investigation should serve as a guide for developing an appropriate research protocol. Ultimately, the purpose of such a study is to gain public health knowledge and determine if any associations can be found between the cancer(s) and environmental exposure(s) of concern. Whether or not rates are determined to be greater-than-expected indicating a true cluster of cancer cases, the results of the etiologic investigation should be relayed to all stakeholders to ensure that any concerns that the suspected cluster may have generated are addressed.

Health Risk Communication

Risk communication is defined as a science-based approach for communicating effectively in high-stakes, emotionally charged, controversial situations. In most cancer cluster investigations, risk communication has played a major role. The 3 fundamental challenges of effective risk communication are: (1) ensuring stakeholders pay attention to what you have to say; (2) convincing stakeholders to believe what you tell them; and (3) delivering the message in such a way that stakeholders remember what you have said long enough for them to act on it. Effective risk communication not only helps to establish good working relationships with stakeholders and engage organization leaders in active participation, but it also creates rapport and credibility with concerned community members, which can minimize undue concerns and ease challenges inherent in potential cancer cluster investigations. In a world where perception equals reality and risk perception often does not match risk reality, lack of trust in the source of information being provided, a lack of scientific understanding, distortion of the facts by media outlets, misconceptions about the truth the public may hold, and fear of the unknown greatly reinforce the need for effective risk communication.[18,19]

Clearly, cancer is a serious, high-stakes, and emotionally charged issue. Given risk perceptions and assumptions that may exist, particularly among Soldiers and beneficiaries due to higher rates of cancer in the military when compared to the general population, risk communication should always be part of the overall cancer investigation process. Within the USAPHC, the Health Risk Communication Program serves as the Army's center of risk communication expertise for both the Department of the Army and the entire Department of Defense. This program can be used to assist with cancer investigations.

RECOMMENDATIONS AND CONCLUSIONS

Army personnel concerned about potential clusters of cancer should review the guidelines described above. These concerns should not be ignored as proper risk communication at the earliest stages can help to ensure that accurate information is understood in later stages of a technical investigation. Assumptions should be avoided and rapid collection of necessary information will facilitate a successful investigation. In many cases, support from subject matter experts and risk communication specialists such as from the USAPHC can be useful to both bolster technical confidence and minimize perception of bias.

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The Effect of Attachment Style on Sleep in Postdeployed Service Members

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ABSTRACT

This study examined the effects of attachment style on subjective sleep outcomes in a population of service members (N=561 (403 male, 157 female)). Active duty, postdeployment service members completed questionnaires including two measures of adult attachment and two measures of subjective sleep. Results confirmed the central hypothesis: secure attachment style is associated with better sleep, followed by dismissing, fearful, and preoccupied, respectively. Gender differences were also found for prevalence of attachment style patterns. This is the first study incorporating attachment style and sleep outcomes within a military population, and provides the basis for future research in this area.

INTRODUCTION

In the field of social work and the related social and psychological sciences, there is a renewed interest in the application of attachment theory to a variety of biopsychosocial outcomes and populations.[1] Similarly, there is a surge of interest in sleep hygiene, sleep behaviors, and the overall implications of good sleep for human development and optimal performance, particularly within special populations, such as military service members.[2] More recently, these two areas of research have merged to shed light on the underpinnings of both positive and negative sleep symptoms and behaviors. The recent literature on attachment style suggests a positive relationship between secure attachment, lower levels of anxiety and depression, and good sleep hygiene.[3] Although our understanding of this attachment relationship is still nascent, there is no doubt that the factors of anxiety, depression, and sleep hygiene have a strong impact on well-being and performance outcomes in high-stress populations, such as military service members.[4] Additionally, recent research suggests that aspects of secure attachment experiences in veterans, such as the perception of unit support, can mitigate mental health outcomes and sleep problems.[5] This study is the first to investigate the direct relationship between attachment style and sleep behaviors in a population of active duty service members.

ATTACHMENT THEORY: ATTACHMENT STYLE

The attachment theory of John Bowlby[6] has been a seminal foundation to understanding human growth and development for several decades.[7] Bowlby's theory has informed the way social workers, psychologists, psychiatrists, and counselors have conceptualized healthy development from infancy, through childhood, and across the lifespan.[8] Attachment theory, while influential to the behavioral sciences and clinical practice from its inception in the 1950s, has continued to expand its contribution in the field to the present day.[9] The idea of "a secure base" has become a central framework for understanding the breadth of the human experience—the development of the "self," human behavior in relationship to important "others" from birth to death, and how this system of attachment impacts the totality of our experience from the biopsychosocial perspective.[10]

According to Bowlby:

> Attachment theory regards the propensity to make intimate emotional bonds to particular individuals as a basic component of human nature, already present in germinal form in the neonate and continuing through adult life into old age.[6(p120-121)]

Bowlby describes how an internal system, called a "working model," exists as a biological function in the human nervous system as a result of developmental experiences with our primary caregiver. He further explains that this working model not only establishes the system by which we relate to important others, but it is also the system by which a person understands the "self."[8] Bowlby describes the attachment relationship as a back-and-forth dynamic between care-giving and care-seeking, and the nature of this exchange shapes who we are and how we relate to important others, particularly in close, intimate relationships and social bonds.[9]

Bowlby[6] outlines the 3 basic patterns of attachment that were first described by his protégé and colleague Mary Ainsworth.[11,12] The first pattern, "secure" attachment, describes a confident individual and a caregiver who is responsive and supportive, particularly when the individual is fearful. This confidence combined with sufficient support and protection allows the individual to explore the world feeling secure. The second pattern, "anxious resistant" attachment, describes an individual who is uncertain if his or her caregiver will be responsive in times of need or danger. Due to his or her uncertainty regarding the caregiver, this individual will tend to cling to the caregiver and also be too anxious to explore the world freely. The third pattern is "anxious avoidant" attachment that describes an individual who believes that he or she will be refused support and protection from his or her caregiver, and therefore does not seek closeness or protection through close bonds with others.[6,9]

We now know through extensive longitudinal studies that these patterns of attachment, described as attachment styles, are, for the most part, stable and enduring across the lifespan.[7] The working model that informs how we understand ourselves in relation to important others, and our attachment style and behaviors towards these others, persists throughout development. As such, our attachment style determines how we interact with peers, how we interact in romantic relationships, and how we perceive and approach the world more broadly.[8] As a result of continued research, we have learned that our attachment systems become "activated" and are particularly salient for us in times of threat.[9] As such, attachment styles inform the way we cope with stress, and how we engage with our important interpersonal support systems, especially when we need help and protection. As a result, attachment style also impacts some of our most important physical and mental health outcomes, such as levels of anxiety and depression, and quality of sleep.[13]

ATTACHMENT STYLE AND SLEEP

A growing body of recent literature in the area of attachment and health outcomes reveals an important relationship between attachment style and quality of sleep across the lifespan.[14] Just as the attachment literature reveals a positive relationship between secure attachment styles and good health, sleep research reveals that quality sleep is essential to human development and functioning from infancy to older adulthood.[15] Beyond rest and restorative factors, sleep also integrates learning and memory, and provides resources for emotion-regulation/self-regulation that is necessary for coping with stress.[16] It is not surprising then that quality sleep has been found to have a strong relationship with a wide array of physical and psychological health outcomes including metabolism,[17] body mass index,[18] self-regulation and self-control,[16] and depression and anxiety.[13] Conversely, sleep disruptions and sleep disorders are directly associated with and symptomatic of several mental health conditions in children and adults, such as posttraumatic stress disorder (PTSD),[19] depression and other mood disorders, and anxiety.[20]

In addition to the separate findings, there are also conjoint findings between attachment styles, sleep, and important health outcomes and performance behaviors.[3] Neurological studies reveal that the anatomy of the attachment system in the brain overlaps the anatomy of REM sleep, which is essential to overall healthy sleep.[21] It is important to note that regular sleep patterns in infancy and childhood have been a core standard by which we measure overall healthy development in the early years of life.[22] Early sleep patterns appear to be interconnected with the early attachment experiences, which are largely dependent on the mother's, or caregiver's, attachment style.[23] As such, attachment style and sleep have been conceptualized as a transactional system of early development that informs later developmental outcomes and life experiences.[24] Researchers have identified relationships of early childhood attachment styles and sleep patterns/disruptions with academic functioning[24]; adolescent depression[25]; childhood and adolescent trauma, PTSD, and anxiety.[22]

ATTACHMENT STYLE, SLEEP, AND MILITARY SERVICE MEMBERS

There is a growing body of research conducted with military service members in the area of attachment style within the context of trauma, specifically PTSD.[27] Importantly, it has been found that PTSD in combat veterans is associated with insecure attachment styles.[28] Several studies have also shown that the attachment measures of marital functioning and couple adjustment are salient for veterans and Soldiers with PTSD.[29,30] Two recent studies show that the attachment measure of marital satisfaction plays an important role in lower symptom severity for veterans with PTSD.[31,32]

There is also a new and growing body of research in the area of sleep quality and sleep disruptions with veterans and service members. It has been found that sleep disturbances are a common factor among veterans with major diagnoses, such as PTSD, traumatic brain injury (TBI), and anxiety disorders.[4] The attachment variable of perceived unit support may be helpful in reducing sleep difficulties in this population.[5] These findings speak to the transactional model of attachment style and sleep with respect to health outcomes for veterans. The possible impact of secure attachment and good sleep as mediating variables in major diagnoses such as PTSD, TBI, anxiety, and depression suggest the need for further research in this area. As such, this study examined the relationship between attachment style and sleep in a population of service members.

HYPOTHESES

1. The first set of hypotheses examined the relationship between the two adult attachment measures.
   a. Those who endorse secure and dismissing attachment styles will report less relationship anxiety as compared with fearful and preoccupied attachment styles. By contrast, those who endorse preoccupied and fearful attachment categories will report more relationship anxiety as compared with secure and dismissing attachment styles.
   b. Those who endorse secure and preoccupied attachment categories will report less relationship avoidance as compared with fearful and dismissing attachment styles. By contrast, those who endorse fearful and dismissing attachment categories will report higher avoidance scores as compared with secure and preoccupied attachment styles.
   c. It is expected that there will be no gender differences on attachment categories.

These hypotheses are in line with other findings between these two types of adult attachment measures, and consistent with the literature on adult attachment patterns.

2. The second set of hypotheses examined the relationships between two measures of attachment style and two measures of sleep.
   a. It is predicted that individuals who endorse secure attachment styles (secure attachment category, low relationship anxiety, and low relationship avoidance) will have more regular sleep routines as compared with insecure attachment styles (dismissing, preoccupied, fearful attachment styles, high relationship anxiety, and high relationship avoidance).
   b. It is also predicted that individuals who endorse secure attachment styles (secure attachment category, low relationship anxiety, and low relationship avoidance) will have less sleep activity as compared with insecure attachment styles (dismissing, preoccupied, fearful, high relationship anxiety, and high relationship avoidance).
   c. We predicted these relationships between secure attachment styles and good sleep outcomes to stand irrespective of gender.

Again, these hypotheses are consistent with the extant literature on attachment styles and sleep outcomes in nonmilitary populations.

METHOD

Participants

Among the 561 respondents, 403 were male, 157 were female, and one with no response on the gender selection. The ethnicity of the sample was 12.3% Hispanic and 86.6% non-Hispanic, and the racial profile was 65.6% Caucasian, 19.6% African American, 5.9% Asian/Pacific Islander, and 8% "Other." In terms of age, 8% were 25 years and younger, 23% were in the 26-30 year age range, 48.5% were in the 31-40 year age range, and 21% were 41 years and over. With respect to marital status, 69% were married or living with a partner, and the remaining 31% were never married/single/divorced/no partner. The branch of service and rank demographic were 62% Army and 37% Air Force; 54% SGT, SSG or SFC and 23% LT to CPT. This population was well educated, with 22% having a master's degree or higher, 30% with a bachelor's degree, and 44% having some college. All participants had deployed at least once. Participants self -reported how long they have been deployed in their career, resulting in an average of 1.90 years (1 year, 10.8 months) with a range from one month to a maximum of 14 years of total time deployed.

Procedure

Data were collected as part of a quantitative, cross-sectional study examining attachment, temperament, and resilience as protective mechanisms for posttraumatic stress. Data were collected on anonymous questionnaires distributed on Fort Sam Houston and Lackland Air Force Base in San Antonio, Texas, from May 2010 to June 2011. In order to participate in this study, the participants must have been deployed for at least 30 days or more, aged 18 years or older, and on active duty. The study was reviewed and received an exemption determination from the Brooke Army Medical Center Institutional Review Board. For this study, the independent variables were 2 measures of adult attachment (one categorical and one continuous measure) and the dependent variables were 2 measures of sleep: activity-level sleep and rhythmicity sleep. Additionally, the relationship between the 2 adult attachment measures was examined in hypotheses 1. The categorical measure of attachment was the independent variable (secure, fearful, preoccupied, and dismissing) and the continuous measure was the dependent variable (relationship related anxiety and relationship related avoidance).

MEASURES

Attachment

Adult attachment was measured 2 ways: one with the Bartholomew and Horowitz Relationship Questionnaire,[33] a 4-item categorical adult attachment variable; the other with the Fraley et al Experiences in Close Relationships [scales]-Revised,[34] which creates 2 continuous anxiety and avoidance attachment variables. Figure 1 illustrates the hypothetical relationship between the 2 measures.

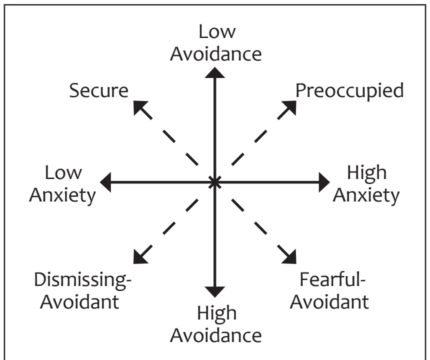

Figure 1. Representation of the relationship of the 4 attachment categories (secure, dismissing, fearful, preoccupied) to attachment related anxiety and avoidance. For example: low avoidance+high anxiety=preoccupied attachment; high avoidance+low anxiety=dismissing attachment. Adapted from Fraley[35] with permission.

Experiences in Close Relationships Revised[34] is a measure of adult attachment. This is a 36-item self-report instrument designed to measure attachment-related anxiety and avoidance. Participants are asked to reflect on their close relationships, without focusing on a specific partner, and rate the extent to which each item accurately describes their feelings in close relationships, using a 7-point scale ranging from "not at all" (1) to "very much" (7). Eighteen items tap attachment anxiety and 18 items tap attachment avoidance. Internal consistency reliability tends to be 0.90 or higher for the 2 ECR-R scales.[34] Mean scores range from 1 to 7 on each dimension and higher scores suggest higher levels of relationship anxiety and relationship avoidance with overall scores ultimately mapping onto a categorical quadrant to delineate an individual attachment style, as shown in Figure 1.

Relationship Questionnaire[33] is a self-report adult attachment measure which includes a series of 4 statements that represent secure, preoccupied, fearful, and dismissing adult attachment styles. Participants are instructed to read the statements and indicate which is most consistent with how they view themselves. Next, the volunteers are asked to rate each of the above relationship styles to indicate how well or poorly each description corresponds to their general relationship style on a Likert-type scale from disagree strongly to agree strongly. Test-retest reliabilities of the RQ subscales ranged from 0.49 to 0.71 as were reported by Scharfe and Bartholomew.[36] Schmitt, with the assistance of over a hundred colleagues, validated the attachment questionnaire in 62 cultures, suggesting that people worldwide fall into one of the 4 attachment patterns, and there are cultural differences that suggest societal norms influence one's resulting attachment pattern.[37] Responses from this assessment are presented as one of 4 categorical outcomes that are indicative of the attachment style reported by the participant (Figure 1).

Sleep

Permission to use the Dimensions of Temperament Survey Revised[38] (DOTS-R) measure was granted by Dr Michael Windle (oral communication, March 27, 2009). The DOTS-R is a 54-item questionnaire for adults that measures 10 temperament dimensions: (1) activity level-general, (2) activity level-sleep, (3) approach-withdrawal, (4) flexibility-rigidity, (5) mood quality, (6) rhythmicity-sleep, (7) rhythmicity-eating, (8) rhythmicity-daily habits, (9) distractibility, and (10) persistence. Two subscales of this assessment were selected for use as they relate to sleep; activity level sleep and rhythmicity sleep. Activity level sleep was created by summing 4 items that describe the amount of activity when in bed (for example: I move a great deal in my sleep; I move a lot in bed)—less sleep activity is associated with better sleep. Rhythmicity sleep was created by summing 6 items that describe the regularity in sleep activities (for example: I wake up at different times; I usually get the same amount of sleep each night)—more stable, routine rhythmicity is associated with better sleep. Windle and Lerner[38] reported internal consistency coefficients (Cronbach α) for a sample of 300 young adults corresponding to the 10 factors listed above:

(1) 0.84	(2) 0.89	(3) 0.85	(4) 0.78	(5) 0.89
(6) 0.78	(7) 0.80	(8) 0.62	(9) 0.81	(10) 0.74

DATA ANALYSIS

The data analysis was conducted using SPSS version 18 (SPSS, Inc., Chicago, IL). A multivariate analysis of variance (MANOVA) was used to test the first hypothesis, which examined the relationship between the 2 adult attachment measures. The independent variable is the categorical measure of adult attachment (the Relationship Questionnaire (RQ) attachment category) and the dependent variable is the continuous measure of adult attachment (the Experiences in Close Relationships Revised (ECR-R) attachment-related anxiety and attachment-related avoidance scores). A MANOVA was also used to test the second set of hypotheses, which examines the relationship between the RQ and the sleep variables. The least squared differences (LSD) method was used for the follow-on contrasts comparing the attachment categories of secure, fearful, preoccupied, and dismissing. Separate stepwise regressions were used to examine the relationships between the 2 attachment dimensions of relationship anxiety and relationship avoidance with the 2 sleep measures of activity level sleep and rhythmicity sleep. Regarding the third set of hypotheses, a χ^2 test was used examine gender differences on the categorical measure and an analysis of variance (ANOVA) was used to search for gender differences on the continuous measure of adult attachment and the sleep measures.

RESULTS

Descriptive Statistics

The RQ is made up of 4 possible attachment categories; secure, fearful, preoccupied, and dismissing. In our sample, 39.3% selected secure, 24% fearful, 7.2% preoccupied, and 29.5% dismissing as their attachment style. The ECR-R creates 2 measures of attachment; relationship anxiety and relationship avoidance. The mean scores on each subscale were 2.7932 for anxiety and 2.7891 for avoidance with SDs of 1.20544 and 1.14693 respectively. The two measures of sleep, activity level sleep and rhythmicity sleep, resulted in means of 10.84 and 14.76 with SDs of 3.40 and 3.99 respectively. Higher scores on sleep activity indicate more sleep activities or lower quality of sleep, whereas higher scores on sleep rhythmicity indicate more sleep regularity or better quality of sleep.

Attachment Style Categories and Relationship Anxiety

The overall MANOVA, using the RQ as the independent variable and the ECR-R as the dependent variable, resulted in a significant findings for RQ and anxiety, $F_{3,505}$=28.91, *P*=.000, and a significant finding for RQ and avoidance, $F_{3,505}$=22.60, *P*=.000. The means (M) and SDs for the RQ measures on anxiety resulted in secure (M=2.37, SD=1.00), fearful (M=3.49, SD=1.3), preoccupied (M=3.40, SD=1.09) and dismissing (M=2.66, SD=1.4). The secure attachment category was associated with significantly less anxiety, then fearful, preoccupied, and dismissing. Fearful was associated with significantly more anxiety than secure and dismissing, but not preoccupied. Preoccupied was found to be significantly more associated with relationship anxiety than secure and dismissing, but not fearful. Dismissing was found to have significantly more relationship anxiety than secure, but significantly less relationship anxiety than preoccupied and fearful. Thus, with respect to relationship anxiety, the results were as predicted in the hypotheses: secure and dismissing have lower levels of relationship anxiety, and preoccupied and fearful have higher levels of relationship anxiety. Moreover, relationship anxiety was associated most highly with fearful and preoccupied attachment categories, with meaningful significance levels for all groups (Figure 2).

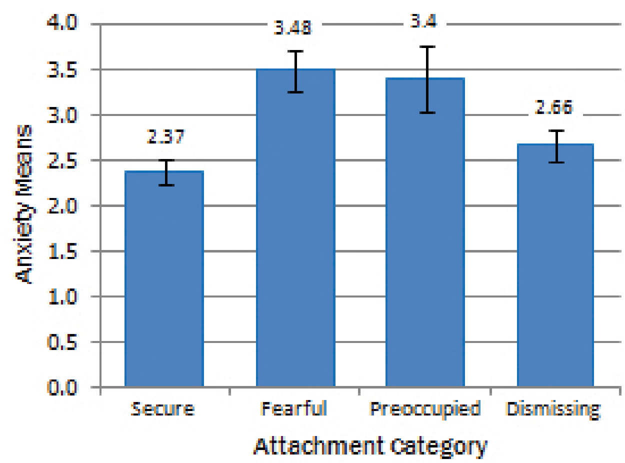

Figure 2. Relationship anxiety (mean) plotted against adult attachment categories. MANOVA yielded significant differences of relationship anxiety among the categories: $F_{3,505}$=28.91, *P*=.000. Line segments show confidence intervals at the 95% level for relationship anxiety means.

The means and standard deviations for the RQ measures on avoidance resulted in secure (M=2.35, SD=0.93), fearful (M=3.34, SD=1.2), preoccupied (M=2.72, SD=0.90), and dismissing (M=2.96, SD=1.148). Secure was significantly less associated with avoidance as compared with both fearful and dismissing, though not significantly different from preoccupied. Fearful was significantly more associated with avoidance as compared with secure, preoccupied, and dismissing. Preoccupied was more associated with avoidance as compared with secure, though not significantly so, and is significantly less associated with avoidance as compared with both fearful and dismissing. Dismissing is significantly more associated with avoidance as compared with secure, and significantly less associated with avoidance as compared with fearful, though not significantly different from preoccupied. These results support the hypothesis that fearful and dismissing are more associated with relationship avoidance than secure and preoccupied (Figure 3).

Attachment Style Categories and Sleep

A MANOVA was performed using the categorical measure of attachment style (secure, fearful, preoccupied and dismissing) as the independent variable and the 2 sleep measures as the dependent variables; sleep rhythmicity and activity level sleep. The model resulted in significant findings for attachment category with activity level sleep, $F_{3,509}$=10.71, *P*=.000 (Figure 4), though the findings for rhythmicity sleep were not significant, $F_{3,509}$=2.01, *P*=.111 (Figure 5). The LSD method was

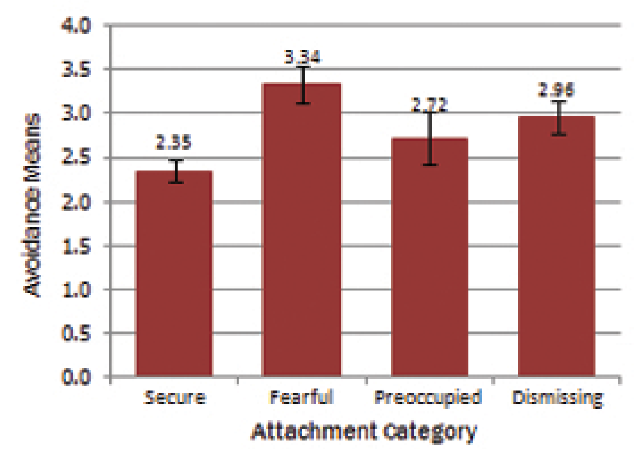

Figure 3. Relationship avoidance (mean) plotted against adult attachment categories. MANOVA yielded significant differences of avoidance means among the categories: $F_{3,505}$=22.60, P=.000. Line segments show confidence intervals at the 95% level for avoidance means.

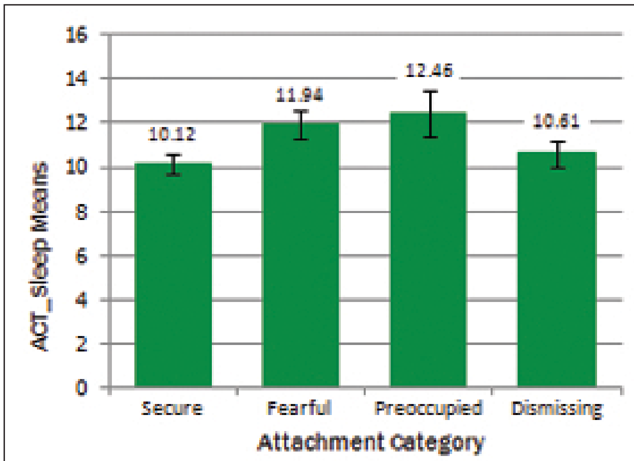

Figure 4. Activity level sleep (mean) plotted against adult attachment categories. MANOVA yielded significant differences of activity sleep means among the categories: $F_{3,509}$=10.71, P=.000. Line segments show confidence intervals at the 95% level for activity sleep means.

used for the follow-on contrasts. Among the activity level sleep variables, secure was found to be significantly different from fearful and preoccupied, fearful from secure and dismissing, preoccupied from secure and dismissing, and dismissing from fearful and preoccupied. According to our sample, individuals who endorse secure attachment styles have the lowest sleep activity levels, followed in order by dismissing, fearful, and preoccupied. Although the overall F score was not significant for the rhythmicity sleep variable, the LSD was conducted. The only significant difference was found for secure and fearful individuals. Secure individuals report more regular sleep activities followed by dismissing, fearful and preoccupied.

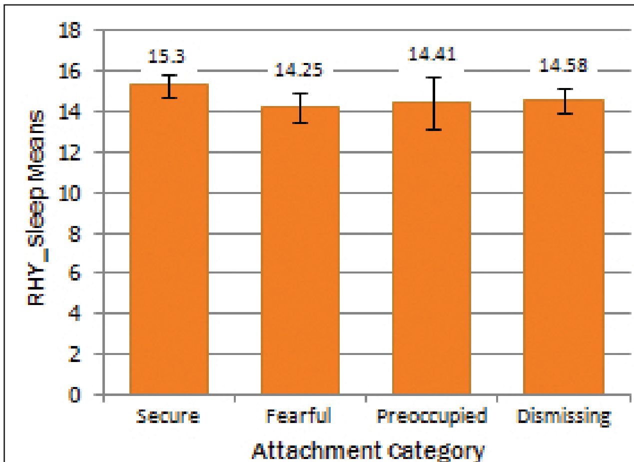

Figure 5. Rhythmicity sleep (mean) plotted against adult attachment categories. MANOVA did not yield significant differences of rhythmicity sleep means among the categories: $F_{3,509}$=10.71, P=.111. However, LSD follow-on contrasts showed a significant difference between secure and fearful attachment categories and rhythmicity sleep. Line segments show confidence intervals at the 95% level for rhythmicity sleep means.

Attachment-Related Anxiety and Sleep

Two stepwise multiple regressions were conducted to analyze the relationship between attachment-related anxiety and avoidance with activity level sleep and rhythmicity sleep. Fraley[39] recommends using multiple linear regression for analyzing ECR-R data. The independent variables and the dependent variables are significantly correlated with each other as shown in the correlation matrix presented in the Table.

The first regression had attachment-related anxiety and avoidance entered as predictors and activity level sleep entered as the dependent variable. The stepwise regression excluded attachment-related avoidance from the equation leaving attachment-related anxiety as the only predictor for activity level sleep (ACT_Sleep=9.66+0.433×ECR_Anxiety). The results of the regression indicated the predictor explained 2.4% of the variance (R^2=0.024, $F_{1,540}$=13.06, P=.000). The second regression used relationship anxiety and relationship avoidance as predictors for rhythmicity sleep. This stepwise regression excluded relationship anxiety from the equation, leaving relationship avoidance as the only predictor for rhythmicity sleep. (RHY_Sleep=16.624-0.667×ECR_Avoidance). This regression analysis found that relationship avoidance predicts 3.6% of the variance for rhythmicity sleep (R^2=.036, $F_{1,548}$=20.733, P=.000).

Gender Differences in Attachment Style and Sleep

Although gender differences are not widely reported on attachment style categories in the general population, Correlations for relationship anxiety, relationship avoidance, and the sleep measures. Cell information shows correlations, significance level, and number of responses within each attachment category of relationship anxiety and relationship avoidance, and the 2 sleep measures of activity sleep and rhythmicity sleep.

		ACT_SLEEP	RHY_SLEEP	ECR_ANXIETY	ECR_AVOIDANCE
ACT_SLEEP	Pearson Correlation	1	-0.268*	0.153*	0.143*
	Sig. (2-tailed)		0.000	0.000	0.001
	N	553	553	543	542
RHY_SLEEP	Pearson Correlation	-0.268*	1	-0.173*	-0.191*
	Sig. (2-tailed)	0.000		0.000	0.000
	N	553	561	551	550
ECR_ANXIETY	Pearson Correlation	0.153*	-0.173*	1	0.603*
	Sig. (2-tailed)	0.000	0.000		0.000
	N	543	551	551	550
ECR_AVOIDANCE	Pearson Correlation	0.143*	-0.191*	0.603*	1
	Sig. (2-tailed)	0.001	0.000	0.000	
	N	542	550	550	550

*Correlation is significant at the 0.01 level (2-tailed).

we examined gender differences within our military population in the interest of parity. A χ^2 test was used on the categorical measure which resulted in χ^2=11.120, P=.011 (Figure 7). An ANOVA was used to find gender differences on the continuous measure of adult attachment (relationship anxiety F=1.412, P=.24, relationship avoidance F=.004, P=.95) and the sleep measures (sleep activity F=.88, P=.349; sleep rhythmicity F=1.26, P=.26).

Although the ANOVA suggested there were no significant differences on sleep outcomes by gender, the χ^2 test revealed important gender differences on attachment style categories. Specifically, female respondents had a smaller proportion of secure and dismissing attachment styles and a greater proportion of preoccupied and fearful attachment styles as compared with male respondents. Most remarkably, female respondents were far more vulnerable to fearful attachment styles as compared with men (by close to 15%).

COMMENT

The findings from this study are consistent with the related literature on attachment and sleep in nonmilitary populations; secure attachment may be associated with better sleep.[3] Additionally, this study offers a preliminary sketch of the attachment style types that may be found within a military population; nearly 40% of this population endorses secure attachment and 30% dismissing. Therefore, a full 70% of this population endorses attachment styles that are associated with greater resilience.[22] Our findings regarding attachment styles support the idea that secure attachment styles afford less relationship anxiety as compared with dismissing, fearful, and preoccupied attachment styles. These findings also highlight the particularly compelling differences between dismissing attachment styles and fearful and preoccupied ones. Dismissing attachment styles are perhaps more resilient than preoccupied and fearful ones as they are also associated with less relationship anxiety. Regarding attachment style and sleep behaviors, our findings provide further support

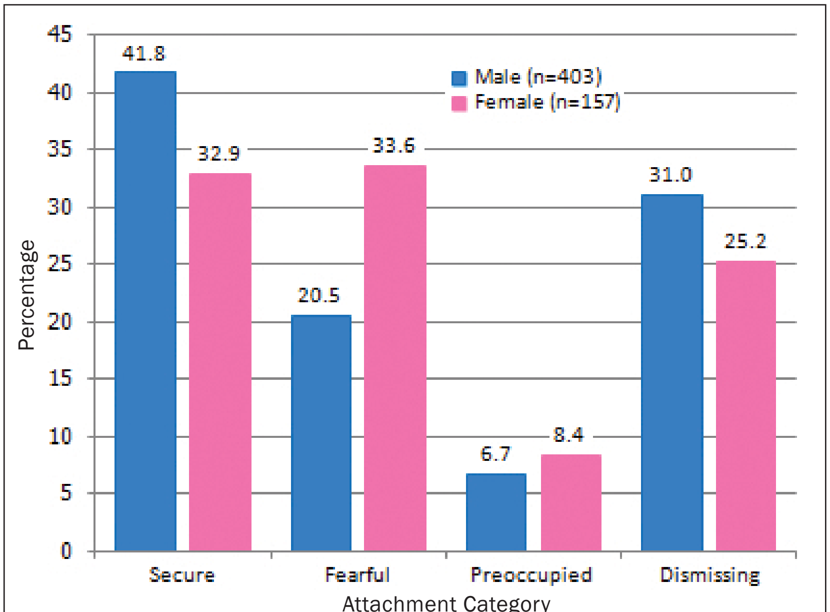

Figure 6. Percentage of respondents by gender per adult attachment category. A 2×4 χ^2 test (χ^2 =11.120, P=.11) shows significant differences between attachment category percentages and endorsements by gender.

for the idea that secure attachment styles afford better sleep; secure attachment styles are associated with uninterrupted and sound sleep, and perhaps more regular, routine sleep activities. As seen earlier, secure attachment, followed by dismissing attachment styles, enjoy better sleep as compared with fearful and preoccupied attachment styles. Interestingly, gender differences were found with respect to prevalence of attachment style between gender groups. Moreover, women had a greater prevalence of fearful and preoccupied attachment styles (less resilient) and men had a greater prevalence of secure and dismissing attachment styles (more resilient). These findings have important implications specific to our military population.

Our findings for attachment style, relationship anxiety, and sleep outcomes provide some insight into the resiliency versus risk profile for service members. Secure attachment is associated with lower levels of anxiety, depression, and fewer sequelae of trauma, such as PTSD.[28] Similarly, low relationship anxiety affords greater interpersonal and social support in addition to other protective resources,[22] whereas high relationship anxiety not only impedes access to these protective factors but also promotes further risk factors, such as isolation.[40] Of course, better sleep is associated with improved outcomes in a plethora of areas from work performance to physical and mental health.[16] Thus, secure and dismissing attachment styles may be more resilient, especially considering the potential stressors and demands of military service and the active duty military context, which includes individual work performance expectations, military group and cultural expectations, and lifestyle necessities. Moreover, active duty service members must achieve an overall biopsychosocial level of fitness in order to thrive, despite constant variability and change, unique teamwork expectations (horizontal relationships), and leadership pressures via chain-of-command (vertical relationships). Active duty service members must endure constant change both at work and at home, where intimate and familial relationships are also challenged by extended separations, moving locations, and a continued sense of uncertainty about the future. As such, individual attachment styles may be more salient for military personnel as compared with their civilian counterparts. Additionally, female service members may be more vulnerable to less resilient attachment styles as compared with male service members, a difference that is not conspicuous in the general population. Perhaps female service members are simply more likely to endorse fearful and preoccupied attachment patterns as compared with men in the military due to gender expectations and identity formation within the culture (such as hypermasculinity and invincibility). The lack of significant differences in sleep outcomes by gender, despite these differences in attachment patterns, suggests a possible conflict with subjective measures of attachment and other constructs, perhaps in the area of self-concept, within this population. While these gender differences within the military population require further investigation, these findings provide a basis for continued consideration.

APPLICATIONS

Attachment styles, relationship styles, and sleep patterns are important considerations for military service members who can be addressed at various levels of intervention, from the individual, couples, family, and community to the larger system and culture. For example, attachment styles may be helpful to individual assessment protocols and clinical interventions for anxiety, depression, PTSD, problems with sleep, and other intrapersonal problems, perhaps even substance abuse. Military healthcare providers, particularly social workers, can work to bolster secure attachment patterns through the process of the therapeutic relationship. Moreover, secure attachment styles can be developed with time and effort through stable, corrective relationships and alternative support figures, a process known as "earned secure attachment."[41] Conversely, relationship factors may be used to assess internal resources of individual wellness and resilience in service members. For example, clinicians may alternately take a more strengths-based approach to working with secure individuals on their presenting concerns. Attachment factors may also provide insight into interpersonal problems that can have an impact on significant family relationships, professional relationships, and performance outcomes for service members. Again, appropriate attachment-related interventions may be useful to address these interpersonal and social concerns. Providers may help service members develop self-awareness of their personal attachment pattern by reflecting on early, seminal attachment experiences, and current interpersonal dynamics. Couples and family issues are particularly salient for service members who tend to rely, perhaps more strongly, on their marriage and family relationships for support and well-being as compared with their civilian counterparts. Thus, social workers can work to improve attachment style patterns in military couples and families in the interest of greater resilience and positive outcomes for service members, their significant relationships, and their families.

At the community level, military cadres, squadrons, and units may benefit from cultivating secure attachment behaviors within their groups—both horizontally between peers and vertically between commanders and their unit members—as compared with traditional fear-based norms and contingencies. As such, cultivating secure attachment styles, secure relationship styles, and also healthy sleep behaviors may be essential to future training programs for service members, and not far afield from the current emphasis on buddy systems, unit cohesion, family-friendly unit environments, and resiliency training. Finally, individual and group attachment and relationship patterns may be an important consideration to the military at the organizational level.[42] These factors may be essential to both individual and group potentialities for certain performance outcomes, those based on a deep-seeded trust in others and the world-at-large. Moreover, secure attachment styles may provide a sense of personal safety that is necessary for optimal performance within the military system and culture.

LIMITATIONS

There are several limitations to our study that warrant attention. First, the data were not longitudinal assessments of participants across time points and were based upon self-reported data. Second, we collected a convenience sample of Army and Air Force service members, and it is unknown how well our findings generalize to other military personnel. With respect to methods used for this study, one central limitation must be considered and improved upon in future studies: the measures for sleep outcomes were embedded in a larger questionnaire designed to assess temperament and not sleep per se. Future studies of this kind may find more nuanced and sensitive results from an instrument designed and validated to measure sleep outcomes, such as the Pittsburgh Sleep Questionnaire (http://www.sleep.pitt.edu/content.asp?id=1484), or even objective sleep measures taken within the sleep laboratory. With respect to findings, the regression analyses depict significant relationships between sleep measures and attachment style although the magnitude of accounted variance is small. Relationship anxiety is found to predict activity sleep, such as waking and movement, whereas relationship avoidance is found to predict rhythmicity sleep, such as bedtime routines and consistent hours. In dealing with military populations, several factors may moderate these effects, which include situational factors such as variability of schedules, presence of interfering factors such as health factors including physical or emotional pain and changes in sleep environments; the potential use of sleep aides, and the study's undetermined nature of the quality of sleep such as sleep duration, physical restoration and integrity of sleep architecture. Limitations notwithstanding, our study makes several important contributions. To our knowledge, this was the first study to assess the relationship between attachment and sleep in military personnel.

FUTURE DIRECTIONS

The present data provide preliminary support for the importance of understanding an individual's attachment style within the context of the military. Further research should also examine the relationship between attachment, sleep symptoms, and combat stress. A better understanding of factors contributing to development and/or maintenance of attachment patterns and sleep behaviors could mitigate the consequences of combat stress and PTSD in addition to other concerns. With respect to internal demographics, the literature in the area of attachment style does not show established gender differences with respect to overall attachment measures and outcomes. However, future studies may continue to parse potential gender differences in the relationships between attachment styles, relationship anxiety, and sleep outcomes among service members. This same approach may also apply to observations of other discrete groups within the military, such as age, culture, rank, branch of service, or occupational specialty, as these important intrapersonal factors may show significant differences on salient attachment and sleep measures. For example, does attachment style and position or rank of the patient have an impact on perceived outcomes of treatment? Or, are secure attachment styles easier (that is, more compliant) or actually better (more effective, more resilient) with respect to military training and organization? If so, can we increase secure attachment through systematic methods and within the requisite 8 to 10 sessions of therapy as it stands? Can we increase secure attachment through leadership styles and policies? Linking attachment theory with clinical practice has posed a long-standing question: what practice approach best supports and enhances mechanisms of secure attachment? Future studies must address these important questions that arise from across the spectrum of behavioral healthcare fields that serve the total military system, its personnel, and families.

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Considerations Regarding a Burn Pit Registry

Coleen P. Baird, MD, MPH

The issue of health concerns potentially associated with open burning to dispose of trash (burn pits) remains a concern. Both the Senate and the House of Representatives passed legislation, signed into law on January 10, 2013,[1,2] requiring the Department of Veterans Affairs (VA) to establish a registry of those exposed. The burn pit issue has been discussed in 2 earlier articles in the *AMEDD Journal*.[3,4] The first article[3] discussed the environmental sampling and health risk assessment—including the implications and limitations—conducted at Joint Air Base Balad, the location of the largest burn pit in Iraq. The second article[4] discussed a review of the potential long-term health risks associated with burn pits conducted by the Institute of Medicine (IOM) of the National Academy of Sciences.[5] The review was conducted at the request of the Department of Veterans Affairs to address the potential for subsequent health conditions among Veterans. While neither the health risk assessment nor the IOM review identified specific health concerns, the plausibility was acknowledged and a variety of stakeholders remain concerned that there are health implications. These stakeholders called for the creation of a "burn pit registry," a list of all military personnel exposed to burn pits.[6,7] This article discusses how such a registry might be established and some of the implications involved.

BACKGROUND OF THE HEALTH RISK ISSUE

Before incinerators or alternate forms of waste disposal became available, open-air burn pits were used by the US military to dispose of solid waste during Operations Enduring Freedom and Iraqi Freedom.[3] The Department of Defense (DoD) defines a burn pit as:

> …an area, not containing a commercially manufactured incinerator or other equipment specifically designed and manufactured for [the] burning of solid waste, designated for the purpose of disposing of solid waste by burning in the outdoor air at a location with more than 100 attached or assigned personnel and that is in place longer than 90 days.[8]

At some deployment locations, burn pit emissions likely contributed to the total burden of pollutants to which deployed personnel were exposed and may have included particulate matter, volatile organic compounds, metals, and polycyclic aromatic hydrocarbons.[9] However, exposure to burn pit emissions likely varied by the size and location of the burn pit, as well as meteorological conditions. Technical guidance for field waste management was available, specifying that "engineers will manage the disposal of all categories of wastes (except medical waste) in a theater of operations."[10(p4)] The guidance suggests burial, or segregation and recycling when possible.[10] However, disposal of collected recycled material was impractical for many locations in an active theater of combat. For this reason, in areas without host nation or contractor support, burning was considered a preferred alternative, but only for short periods until incinerators became available. Landfills are a method also suggested, but there is some risk in transporting trash from the base to a distant location. At many camps, establishing the burn pit downwind (140 m downwind of personnel and living areas, if possible) as recommended, would minimize exposure. Additionally, individual exposure would vary by location, type of duty, and activities; for example, a guard at a burn pit site versus an individual who spent most time indoors while deployed. Some base camps were large and incinerators were purchased, but logistical issues concerning contracts for personnel to use and maintain the incinerators delayed their use. This included Joint Air Base Balad (JBB), a very large base camp in Iraq with as many as 25,000 people at its peak base loading. In the United States, it is estimated that each person generates 4 to 6 pounds of solid waste per day. By 2008, it was estimated that JBB was generating several hundred tons per day.[3]

More waste was generated during this conflict in comparison to previous operations due to the almost universal use of bottled drinking water in a desert climate, increased capability to purchase items from internet sites, which use a lot of packaging, and the omnipresent personal electronic devices that are usually discarded if nonfunctional. Additionally, Styrofoam packaging was heavily used in dining facilities and carry-out food sources. I observed attempts to have service members segregate food from Styrofoam plates and plastic tableware at dining hall exits in Afghanistan, which produced spotty success at best. Joint Base Balad was one of the camps where incinerators were available at a site that was generating a considerable volume of waste, but, for reasons discussed earlier, did not become operational until 2008. To address health concerns at JBB in 2008 prior to the activation of the incinerators, preventive medicine personnel conducted air sampling for targeted expected emissions to include particulate matter, volatile organics, metals, polycyclic aromatic hydrocarbons, and polychlorodibenzodioxins/furans (dioxins and furans).[9] The burn pit at JBB covered 10 acres, but not all areas were burning at the same time. Sampling locations were selected to represent typical and maximum exposure levels for the general population. The samples were collected over multiple 24-hour periods to account for some of operational and meteorological variability in exposure levels. A total of 163 samples were collected resulting in 4,811 individual analyte results. The data from the sampling effort was used in a quantitative screening human health risk assessment. Using this methodology, both noncancer and cancer risks were "acceptable" or "safe" as per the Environmental Protection Agency classification of the level of potential exposure to each individual analyte. A "moderate" operational risk from particulate matter and a potential for short-term, reversible noncancer effects were noted. The Defense Health Board (DHB), an independent board comprised of experts from private industry and universities, reviewed the conclusions of the initial screening health risk assessment.[11] The DHB agreed with the conclusion that no long-term health effects should be expected due to dioxin or the analytes measured and used in the risk assessment. However, that statement did not dismiss the potential for long-term health risk. Conclusions regarding long-term risk were limited by the short term and intermittent nature of the sampling event, and because not all possible contaminants of concern were sampled.[4] It was not feasible to test for some contaminants due to the difficulty of using certain equipment in a field setting.

The military gave additional emphasis to burn pits in 2009, and the Multinational Coalition, Iraq, issued specific guidance on burn pits with checklists in an environmental standard operating procedure. As discussed in the IOM report,[5] Congress also became interested in military burn pit use and safety in 2009, and held hearings including testimony from both military officials and Veteran's groups. These hearings discussed the screening health risk assessment, and Veterans and other medical and environmental professionals who served in Iraq testified about the presence of noxious smoke on the base at Balad. Some individuals "attributed a range of medical problems to smoke from burn pits, including asthma, joint pain, cancer, nausea and vomiting, burning lungs, and Parkinson's disease."[5(p13)] Respiratory symptoms by redeploying personnel were also discussed. Bills were introduced in 2009 and 2010 to sharply curtail the use of open-air burn pits, and HR 2647, the National Defense Authorization Act for Fiscal Year 2010, prohibited the use of burn pits for hazardous and medical waste except in conditions where there is no alternative, as well as placing a number of other requirements on the DoD related to burning trash.[5] The DoD published a directive on the use of open air burn pits in contingency operations in 2011.[8]

In 2010, the Veterans Benefits Administration published a training letter for claims examiners addressing, among other things, environmental hazards in Iraq and Afghanistan, particularly burn pits. It listed all chemicals detected in burn pit sampling regardless of whether they were detected at levels below health concern levels.[12] Also in 2010, the VA asked the IOM to examine the long-term health consequences of exposure to burn pits in Iraq and Afghanistan.[5]

In 2011, the IOM committee concluded that:

> ...in light of its assessment of health effects that may result from exposure to air pollutants detected at JBB and its review of the literature on long-term health effects in surrogate populations, the committee is unable to say whether long-term health effects are likely to result from exposure to emissions from the burn pit at JBB. However, the committee's review of the literature and the data from JBB suggests that service in Iraq and Afghanistan—that is, a broader consideration of air pollution than exposure only to burn pit emissions—might be associated with long-term health effects, particularly in highly exposed populations (such as those worked at the burn pit, or susceptible populations (for example, those who have asthma) mainly because of the high ambient concentrations of PM from both natural and anthropogenic, including military, sources. If that broader exposure to air pollution turns out to be sufficiently high, potentially related health effects of concern are respiratory and cardiovascular effects and cancer.[5(p7)]

Although the IOM recommended a broader consideration of air pollution, SB 3202 (The Dignified Burial of Veterans Act of 2012)[1] mandating the establishment of an open pit burn registry was signed into law (Public Law No. 112-2601) on January 10, 2013. Title II, §201 of the Act specifies that:

> Not later than one year after the date of enactment of this Act, the Secretary of Veterans Affairs [SVA] shall
>
> (A) establish and maintain an open burn pit registry for eligible individuals who may have been exposed to toxic chemicals and fumes caused by open burn pits;
>
> (B) include any information in such registry that the SVA determines necessary to ascertain and monitor

the health effects of the exposure of members of the Armed Forces to toxic airborne chemicals and fumes caused by open burn pits;

(C) develop a public information campaign to inform eligible individuals about their eligibility, including how to register and the benefits of registering; and

(D) periodically notify individuals about significant developments in the study and treatment of conditions associated with exposure to toxic airborne chemicals and fumes caused by open burn pits.[1]

The law also requires the Secretary of Veterans Affairs (SVA) to enter into an agreement with an independent scientific organization (such as the IOM) to develop, within 2 years after establishment of the registry, a report which assesses the effectiveness of the actions taken by the Secretary to collect and maintain information on the health effects of exposure, recommendations to improve collection and maintenance of such information, and using established and previously published epidemiological studies, recommendations regarding the most effective and prudent means of addressing medical needs of eligible individuals with respect to conditions likely to result from exposure to open burn pits. There is also a requirement for an update to the report 5 years following the original report that assesses whether and to what degree the registry is current and scientifically up-to-date. This is similar to the current process in the Agent Orange Registry.[13] This bill also requires the DoD to cooperate with the Secretary of Veteran's Affairs, and provide all possessed or obtainable data relevant to the reports.

WHAT DOES THIS ACT REALLY MEAN?

To address the eligibility requirement, it will be necessary to identify individuals who were "exposed." The Act defines an "eligible individual" as:

any individual who, on or after September 11, 2001

(A) was deployed in support of a contingency operation while serving in the Armed Forces; and

(B) during such deployment, was based or stationed at a location where an open burn pit was used.[1]

Accordingly, anyone at a location with an open burn pit regardless of their location relative to the burn pit would be eligible. Further, the Act defines "open burn pit" as follows:

The term "open burn pit" means an area of land located in Afghanistan or Iraq that

(A) is designated by the Secretary of Defense to be used for disposing solid waste by burning in the outdoor air; and

(B) does not contain a commercially manufactured incinerator or other equipment specifically designed and manufactured for the burning of solid waste.[1]

Where other methods of waste management were not available, open burning of trash was a common occurrence to limit accumulation that would attract vermin and potentially create a public health hazard. If a listing of locations where trash was burned, along with where and when incinerators were instituted, was generated and provided to the Deployment Manpower Data Center, base camp rosters for relevant time periods could be generated. However, this assumes or implies that all individuals assigned to a base camp with a burn pit were exposed to "airborne toxic chemicals and fumes," and without further information would consider them all equally exposed. In reality, in ideal situations, a burn pit site is selected with a consideration of prevailing winds, and located such that most personnel would be upwind of the burning. Considering all individuals at locations with burn pits equally exposed could result in misclassification, as well as an inability to assess dose-response trends if the registry information is used for epidemiological purposes.

The second requirement authorizes the Secretary of Veterans Affairs to determine what information should be included in the registry to monitor the health effects of those included. This could include physical examinations with specific testing, periodic self-report of all or specific conditions, or as of yet undetermined information. Self-reported exposure information could also be collected in an attempt to classify exposure level, although this is not necessarily a valid measure of actual exposure.[14,15] The public information campaign to inform eligible individuals about their eligibility, how to register, and the benefits would be easily accomplished, once the eligibility was established, as the VA has done for a number of other exposures or conditions.[16] The VA must also periodically notify individuals about significant developments in the study and treatment of conditions associated with these exposures. According to the Department of Veterans Affairs Office of Public Health, the VA currently maintains several health registry evaluation programs to track the health of Veteran's exposed to environmental hazards during military service. These are included in the Ionizing Radiation Registry[17] which addresses radiation exposure, most notably from atomic weapons use and testing in World War II; the Agent Orange Registry[13] which addresses herbicide exposure in the Vietnam War; and the Gulf War Registry[18] which is not related to a specific exposure but covers undiagnosed symptoms and illnesses following service during the 1990-1991 Gulf War, Operation

Desert Shield, Operation Desert Storm, Operation Iraqi Freedom, and Operation New Dawn. Note that the last 2 listed operations are the recent and ongoing conflicts. The VA also maintains the Depleted Uranium Follow-up Program[19] which addresses all conflicts included in the Gulf War Registry and service in Bosnia with potential depleted uranium exposure, and the Toxic Embedded Fragments Registry[20] for Veterans who have or likely have an imbedded metal fragment. These registries differ in terms of what is offered or included, and Veterans can be eligible for one or several, and do not need to be enrolled in VA health care to be included. The information from the evaluations is maintained in VA databases and is part of the VA medical record. However, the registry examinations are not compensation examinations, nor do they serve as a claim for VA benefits. For some of these registries, actual exposure data is lacking. One possibility for a burn pit registry would be the expansion of eligibility for the Gulf War Registry[18] specifically to include participation in Operation Enduring Freedom (Afghanistan). In this way, eligible participants would be added to the currently existing registry and the information gathered on members might be modified to address burn pit concerns. The model for the registry is most likely to be the Agent Orange Registry.[13] Created in 1978 due to concerns of Vietnam veterans that their exposure to the herbicide mixture (colloquially called Agent Orange because it was stored in drums with orange stripes) was causing health problems, it was the first VA registry. Registrants received an examination and a series of baseline tests. No specific test for exposure is conducted, and there is no way to determine if any specific illness or symptom is "caused" by Agent Orange exposure. However, those who enrolled receive the "Agent Orange Review," a newsletter which provides information regarding developments related to Agent Orange.[21] This information includes health conditions identified as service-connected to Agent Orange exposure or service in Vietnam based on recommendations in a review by the IOM.

The Act requires the SVA to enter into an agreement with an independent scientific organization (such as the IOM) to develop reports which assess the effectiveness of the actions taken, generate recommendations to improve the collection and maintenance of the information, and use established and previously published epidemiological studies to evaluate "conditions that are likely to result from exposure to burn pits." These reports would be due at 2 and 5 years following enactment of the bill, which occurred January 10, 2013. In all likelihood, the requirement for reports from an independent scientific organization will parallel the current relationship between VA and IOM to assess the potential health implications of exposure to Agent Orange. In 1991, Congress passed the Agent Orange Act of 1991 (Pub L No. 102-4, 105 Stat 11, February 6, 1991) which directs the SVA to request that the IOM perform a comprehensive evaluation of scientific and medical information regarding the health effects of Agent Orange. The first comprehensive review was conducted in 1994 and updates have been published every 2 years. These reports review the available scientific evidence regarding the "statistical association" between exposures to dioxin and other chemicals in the herbicide and various health outcomes. Statistical association means that reviewed studies have demonstrated a statistical association—a statistically significant association between the disease and exposure. The categories of findings following review are noted in the Table. The limited/suggestive evidence category is used when bias and chance could not be ruled out, and this category is often used when at least one high quality health study shows a positive association, but other studies produce conflicting results. This category is often sufficient for presumption; examples from the Agent Orange presumptions include prostate cancer and type –II diabetes.[23]

Since the original report, 14 diseases have been considered presumptively related to service in Vietnam.[24] This means that individuals who served on land in Vietnam from 1962 to 1975 are eligible for "service connection" for these diseases and are eligible for compensation without "proving" an association between an exposure during their time of service and these diseases. Some of the more recent additions, such as ischemic heart disease, prostate cancer, and type-2 diabetes are common in aging populations irrespective of exposure. According to Samet et al,[24] estimates from fiscal year (FY) 2010 noted that VA now provides disability compensation to approximately 3 million veterans and 342,000 beneficiaries (survivors of those who died as a result of their condition), at a cost of $41 billion annually. Costs have increased from $19 billion in FY 2000 to an estimated $43 billion in FY 2010. This is because the Vietnam veterans have aged, the list of diseases which qualify for Agent Orange compensation has lengthened, and Gulf War veterans have become ill and filed claims in the 20 years since that conflict. The Gulf War registry compensates Gulf War Veterans with "medically unexplained illness" and some infectious diseases (ie, leishmaniasis).[25] If a condition is diagnosed, it is no longer "medically unexplained."

The DoD and the VA recognized the need to address burn pit exposure as well as other exposure effects on pulmonary function and disease. Joint meetings and symposiums were held in 2011 and 2012. It has been considered that organ systems other than the pulmonary

Categories of evidence for disease presumption in association with Agent Orange.

Category of Evidence	Evidence Requirements	Presumption Examples	Estimated Population Prevalence
Sufficient evidence of an association	Multiple, high quality studies with statistically significant findings after chance, bias, and confounding are ruled out.	B-cell leukemia Chloracne	Low
Limited/suggestive evidence of an association	Evidence is suggestive of an association but is limited because chance, bias, and confounding could not be ruled out with confidence. May be one positive (statistically significant) study.	Prostate cancer Diabetes	High, increasing with age
Inadequate/insufficient evidence to determine whether an association exists	Available epidemiological studies are of insufficient quality, consistency, or statistical power to permit a conclusion regarding the presence or absence of an association due to confounding, inadequate exposure assessment, or failure to address latency.	1994 assessment for type II diabetes, moved to limited/suggestive in 2000. Bladder and other cancers Hearing loss and "eye problems" recently added.	High for diabetes, Variable for cancers High for hearing and vision problems with aging
Limited/suggestive evidence of no association	Requires several adequate studies which cover the full range of human exposure to fail to show an association and, even then, category is valid only for the conditions/exposures/length of observation in those studies.	One single health outcome: spontaneous abortion after paternal exposure to dioxin.	
Sufficient evidence of a causal association	This category reflects consideration of the "Hill Criteria"[22] concerning causation.	Has not been used for Agent Orange.	

system may be affected by some of the chemicals emitted with burn pit smoke at sufficient levels, although there is no sampling to indicate that these levels have occurred.[9] Additionally, there are other potential airborne exposures, such as particulate matter.[5,26] The DoD and VA now consider deployment-related airborne hazards a more appropriate focus than burn pits. A joint action plan addressing those hazards is now being prepared by the 2 agencies.

The first studies by the US Armed Forces Health Surveillance Center used sites in the Central Command area of operations.[27] Four sites, two with burn pits and two without burn pits, were chosen to allow comparisons between sites where individuals were potentially exposed to burn pit smoke and individuals who were not exposed to burn pit smoke, but were potentially exposed to other pollution sources such as particulate matter and pollution from local industry. The studies evaluated cardiovascular diseases, signs, symptoms, respiratory diseases, and ill-defined conditions. The main finding was that for nearly all health outcomes measured after personnel returned from deployment, the incidence for these health conditions was either lower or about the same as for those who had not deployed or those who had deployed outside the area of a documented open air burn pits. One exception was for personnel deployed to a site without a burn pit (Camp Arifjan, Kuwait) where a measurable increase in the rate of signs, symptoms and ill-defined conditions was noted. For health outcomes occurring during the deployment period, Air Force personnel at Joint Base Balad had a higher proportion of respiratory encounters. However, this was not noted among Army personnel at the same location or service members at the other burn pit sites that were studied. The overall findings when examining populations of personnel exposed to burn pit smoke indicate no substantial or consistent effect of possible exposure to smoke at the bases examined in these analyses when compared to other deployed personnel. These studies have a number of strengths and some limitations. Depending on the individual studies, strengths included the use of comprehensive electronic medical records to examine postdeployment medical visits and hospitalizations, the ability to evaluate many different health outcomes, and large populations which allowed for high power to detect findings. Some limitations included an inability to adjust for confounding exposures such as smoking, lack of individual exposure data, and limited population data, and short follow-up time at the time of the study. The choice of comparison group in this study, US-based military personnel, may not be an ideal comparison group as those not deployed may be ineligible for deployment due to medical conditions, potentially making rates of disease higher in this nondeployed population. This is known as the "healthy warrior" effect.[28] Because of the likelihood of some exposure misclassification which may limit the detection of slight increases in risk and other limitations inherent in the data, the DoD is cautious of the interpretations of these findings and continues to examine the possibility that there may be a limited number of service members who may have experienced, or may eventually experience adverse health effects after exposure to burn pit smoke.[29] Continued follow-up of these cohorts will provide information regarding deployment-related exposures in addition to burn pits, and any health condition can be included in the analysis. These studies are currently underway.

Although there has not been conclusive evidence of disease associated with burn pit exposures, Veterans' groups support a registry, noting that "a registry will enable Veterans to receive healthcare specific to their special needs and will enable VA to research further causes of these illnesses."[7] However, given that the IOM concluded that ambient air pollution may pose greater health risks than chemicals emitted from military burn pits, mandating a registry of those exposed to burn pits might not target individuals at risk of health outcomes. While it may be true tha registries enable medical follow-up and outreach efforts, a registry and subsequent studies limited to those who self-report exposure to burn pits may miss identifying adverse health effects in those exposed to wider pollution sources. According to the IOM report,[5] there are no illnesses specifically associated with burn pit exposure and therefore no specific markers for medical follow-up. However, the IOM report also concluded that the broader question of deployment-related inhalational exposures and health outcomes deserves continued study.

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The Health Hazard Assessment Process in Support of Joint Weapon System Acquisitions

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The Army Surgeon General established the Health Hazard Assessment (HHA) Program in 1981 to evaluate the potential health effects of operating military weapon systems. The *Department of Defense Directive 5000.1** issued in 1983 directed all uniformed services to consider HHA as an integral part of their respective materiel acquisition processes. *Army Regulation 40-10*,[1] which formally established the Army HHA Program, was published in October 1983. In 1995, The Army Surgeon General designated the US Army Center for Health promotion and Preventive Medicine, which evolved into the US Army Public Health Command (USAPHC) in 2011, as the lead agent of HHA with the primary goal of identifying and eliminating or controlling health hazards associated with the life cycle management of weapons, equipment, clothing, training devices, and other materiel systems. This article focuses exclusively on the HHA process for joint weapons systems being acquired by the US Army (Figures 1-3). For the purposes of this discussion, the term "weapon system" does not include the nonweapon-related aspects of vehicles or platforms such as engines, transmissions, chassis components, etc.

The HHA Program recently began assessing Joint weapon systems as a member of the Army Weapons System Safety Review Board (AWSSRB). The AWSSRB provides safety and occupational health consultation to the Joint Weapon Safety Working Group† which advises the Assistant Secretary of Defense for Research and Engineering and the Deputy Under Secretary of Defense for Installations and Environment regarding the conduct of efficient and effective joint weapon system reviews. The HHA Program typically evaluates the following 5 hazards when assessing joint weapon systems:

1. Impulse noise
2. Blast overpressure
3. Chemical substances
4. Recoil
5. Musculoskeletal trauma (lift and carry)

*Obsolete, replaced by the *DoD Directive 5000.01* series effective May 12, 2003.

†The charter of the Joint Weapons Safety Working Group was signed on October 11, 2012.

IMPULSE NOISE

Definition

Impulse noise is generally and in its most basic sense considered to be a high-level, short duration pressure wave disturbance of less than 0.5 seconds at levels that can immediately cause acoustical trauma.

Data Requirements, Initial Recommendations, Comments

Collect impulse noise data in accordance with *Military Standard (MIL-STD) 1474D*, Requirement 4,[2(p35)] at all personnel-occupied areas (operator, crew, passenger, and maintenance personnel). Collect appropriate data to determine the 140 dB noise contour. The *MIL-STD-1474D*

Figure 1. XM25 Counter Defilade Target Engagement System. Photo provided by USAPHC.

requirements may differ from those described in local test operations procedures, and the HHA project officer can help resolve the discrepancies.

Provide system operations information to fully characterize daily impulse noise exposures for all affected personnel. Operational information for components (such as cartridges or ancillary equipment) should include a listing of the weapon systems with which the materiel is used, and any acoustically significant attributes of their use. For example, provide model designations for rifles using a new cartridge, and describe pertinent silencer, muzzle brake, and barrel length characteristics for the rifles listed. Operational information for weapon systems that may be fired in different ways during the course of a day should also be provided. For example, it should be specified what shooter positions (prone, kneeling, standing, from a foxhole, etc) are anticipated for a rifle system, and the mix of firing conditions (azimuth, elevation, charge) anticipated for a howitzer or mortar should be specified.

Assessments may sometimes be done by analogy in lieu of obtaining data. There is little benefit in redoing an assessment if the materiel under investigation incorporated only changes applied to an older design that did not affect acoustics. In such a case, we often just apply the original conclusions for the older design. However, even in such cases, the situation should be reviewed because there could be new medical criteria that must be applied to the old data.

Eliminate impulse noise associated with materiel and support design to the maximum extent feasible to reduce the reliance upon hearing protection devices for hearing conservation; reduce aural signatures; reduce the range of detectability.

Figure 2. M777A2 Howitzer in Afghanistan. Photo provided by USAPHC.

All personnel exposed to hazardous noise must wear hearing protective devices (HPDs). *Department of the Army Pamphlet 40-501*[3] lists HPDs approved for Army use. The devices must be fitted for size by properly trained personnel (if preformed earplugs or helmets), adequately maintained, and properly worn.

Double hearing protection consisting of approved earplugs in combination with an ear muff, headset, or noise-attenuating helmet may be used to increase firing allowances.

Additional use restrictions (firing allowances or doctrinal use practices) may also apply in order to mitigate the hazard.

Health Effects

Elevated sound levels can cause trauma to the hearing mechanism. The mechanical damage caused by the acoustic trauma may cause permanent hearing loss. This can also be accompanied by ringing (tinnitus) in the ears.

Medical Criteria

Impulse noise greater than 140 peak decibels is considered hazardous.[2,3] Repeated, unprotected exposure to hazardous impulse noise will cause permanent hearing loss.

BLAST OVERPRESSURE

Definition

An instantaneous change in air pressure, typically emitted by an explosive device when it detonates, that imparts mechanical energy to contacted objects.

Data Requirements, Initial Recommendations, Comments

Conduct blast overpressure testing on the materiel in accordance with the guidance for Blast Overpressure Analysis and Test Operations Procedure (TOP) 4-2-831.[4,5] After the test is completed, send the properly formatted data and a description of the test to the USAPHC for analysis.

Health Effects

Blast waves encountering human tissue yield mechanical stresses that can injure if they are of sufficient intensity and/or frequency. Although many organs are susceptible to injury, the eardrum and air containing organs such as the heart, lungs, esophagus, stomach, and intestines are particularly vulnerable. Possible negative health outcomes include mild, transient cognitive dysfunction, visceral injury, and death. Although it was previously thought that the absence of eardrum rupture could indicate sparing of damage to the viscera, this notion has recently been challenged. Blast overpressure injury risk is related to the mechanics of the pressure wave and the physical properties of the tissue contacted.

Medical Criteria

Extensive study by the Army Medical Research and Material Command has yielded an algorithm that describes the relationship between the intensity of a blast recorded by a blast test device and lung injury.[6] This algorithm resides within the Blast Overpressure Health Hazard Assessment software used by the USAPHC to assess the risk of lung injury to Soldiers exposed to blast. Due to the complexity of factors found in the blast environment and variations in the intensity and pulse duration of blast waves, it is not possible to express blast overpressure injury risk as a simple numeric threshold value. However, as a general rule, risk of blast injury to visceral organs is considered to be minimal when the blast falls under the Z limit described in *MIL-STD-1474D*.[2]

CHEMICAL SUBSTANCES

Definition

For the purposes of this discussion, chemical substances are those substances that are released as a gas, vapor, fume, or smoke as a result of firing a weapon system. They do not include combustion products or other chemicals that are released from vehicles or other ancillary equipment associated with the system.

Data Requirements, Initial Recommendations, Comments

Provide detailed information on the chemical composition of any propellants to the USAPHC for a definitive HHA on weapon combustion products. Sampling for weapon combustion hazards should follow test guidelines in TOP 2-2-614.[7]

Provide the material safety data sheets (MSDS), composition, purpose, and quantity of any miscellaneous chemicals used in the operation and maintenance of the materiel to the USAPHC. Provide MSDSs to users and maintainers, including information on specific use, handling, storage, and disposal requirements in appropriate technical manuals.

Figure 3. M3 Carl Gustaf Recoiless Rifle. Photo provided by USAPHC.

Eliminate or reduce the number of miscellaneous toxic/hazardous chemicals used by design or substitution to the maximum extent feasible. The Army Institute of Public Health's Toxicity Evaluation Program performs toxicity clearances and evaluations for chemicals used by the Army.

Health Effects

Weapon combustion products are a primary source of potential toxic gas exposures. Soldiers can suffer a variety of health effects based upon the physical form of the chemical, route of entry, and duration of exposure.

Depending on the duration and level of exposure, Soldiers can suffer a variety of health effects resulting in a range of outcomes from performance decrement to death. Irritants or corrosive chemicals can cause inflammation, burns, or blisters, fibrogenic materials lead to a loss of lung function, allergic reactions can lead to asthma-type diseases, or dermatitis. Carcinogenic materials can cause cancers in affected organs or tissues, possibly leading to death. Poisonous chemicals can lead to cell death, and asphyxiants will affect the body's ability to use oxygen.

Medical Criteria

Health-based exposure limits for chemical substances adhere to guidelines published by the Occupational Safety and Health Administration Permissible Exposure Limits,[8] American Conference of Governmental Industrial Hygienists Threshold Limit Values,[9] or military unique criteria outlined in *MIL-STD-1472G*.[10] These limits formulate a level of exposure that the typical worker can experience during a lifetime without adverse health effects. The risk determination process considers levels of exposure for a traditional 8-hour workday in a 40-hour work week, time weighted average concentrations for 15-minute exposure durations, and a ceiling limit that should not be exceeded during any part of the workday exposure.

RECOIL

Definition

Recoil is a specific type of mechanical shock that occurs when the reactive force from discharge of a firearm propels the weapon backwards and imparts mechanical force to the point of contact with the Soldier's body. The magnitude of recoil force delivered to the user is dependent upon several factors including the design of the weapon and firing technique.

Data Requirements, Initial Recommendations, Comments

Data requirements for recoil are currently being developed. It is anticipated that data requirements will necessitate conducting a weapon kinetics study, similar to that described in TOP 3-2-504.[11] Specific data items required to assess the risk of musculoskeletal injury from recoil will likely include measurements of weapon acceleration, weapon speed, and displacement along the axis of the weapon that aligns with the anatomical point of contact with the operator. In addition, the data items described in TOP 3-2-504 to calculate recoil energy will be needed: weights of weapon, propellant, and bullet. Required information about the mission scenario includes a description of the intended operators (gender), the anticipated number of rounds fired on a typical training day, duration of training, and the anticipated total number of rounds fired on a training activity.

This assessment, like other musculoskeletal assessments, will employ a systems approach. Exposure to recoil force will be evaluated within the context of the other items in the Soldier's ensemble. The Soldier, uniform, personal protective equipment and other equipment carried on his/her body will be assessed as a unitary system that considers the interactions between all components. Therefore, recoil assessment will also require a description of wearable items such as individual body armor. Finally, since firing technique influences recoil transmission, descriptions as to how the weapon is held and firing postures will be required.

Until specific medical criteria dictate otherwise, initial recommendations to mitigate injury include enforcing the firing limitations described in the Table, as found in TOP 3-2-504.[11] This includes limiting exposures from shoulder-fired weapons to less than 60 ft-lbs (81.4 J) of recoil force.

Health Effects

Exposures to mechanical recoil force that occur as a consequence of normal use of a weapon can result in soft tissue injury such as contusion or laceration. High dosages of force directed at the anterior shoulder may also produce tendonitis, focal bursitis, nerve injury, or fracture of the clavicle. Due to the fact that there is little opportunity to alter the anatomical contact point with a shoulder-fired weapon, repeated exposures may increase the probability and/or severity of operator injury. Common symptoms of injury include pain, superficial ecchymosis or deep tissue hematoma, whereas signs of injury include pain, minor reduction in active range of motion of the shoulder, or slight decrement in lifting capacity probably secondary to trauma of the anterior shoulder tissues.

Firing limitations for test weapons.[11]

Computed Recoil Energy	Limitations on Rounds
Less than 20.34 ft-lb (20.3 J)	Unlimited firing
15 to 30 ft-lb (20.3 to 40.7 J)	200 rounds/day/man
30 to 45 ft-lb (40.7 to 61.0 J)	100 rounds/day/man
45 to 60 ft-lb (61.0 to 81.4 J)	25 rounds/day/man
Greater than 60 ft-lb (81.4 J)	No shoulder firing

Medical Criteria

Currently, no medical criteria have been identified for recoil exposures. Personal factors that increase susceptibility to injury include the thickness of soft tissues (particularly the thickness of the pectoral muscles overlying the more vulnerable soft tissues in the pocket of the shoulder). Therefore, anthropometrically smaller individuals with ectomorphic body types are at higher risk of injury. The Table displays the TOP 3-2-504[11] recommended design standards for firing limitations for test weapons.

The validity of these design criteria as a basis for medical criteria for HHA has not been substantiated. A preliminary study conducted by Blankenship et al[12] questioned applying the firing limits proposed by TOP 3-2-504[11] for the 45 to 60 ft-lb (61 to 81.4 J) range as medical criteria while shooting a shoulder-fired weapon with a shoulder covered only by a uniform. They recommended additional studies to obtain the data needed to develop a more definitive characterization of recoil exposure.

MUSCULOSKELETAL TRAUMA (LIFT AND CARRY)

Definition

Obviously, every item in the Army inventory has weight, including weapon systems. Musculoskeletal trauma may occur if excessive weight is lifted by a Soldier either once or over a series of repetitions.

Data Requirements, Initial Recommendations, Comments

Identify the physical demands of the task and lifting requirements (manual or mechanical lift) and determine warning label requirements in accordance with *MIL-STD-1472G*[10] for each of the system components.

Provide data for analysis as identified on the HHA Lifting Analysis Worksheet to support the completion of an HHA on this potential health hazard concern.

Apply the design guidance for efficient handling contained in paragraphs 5.8.6.3 and 5.9.11 of *MIL-STD-*

1472G[10] to the materiel design to the maximum extent feasible. Place emphasis on heavy items that require manual lift/adjustment.

Health Effects

A potential source of exposure to musculoskeletal trauma is the lift/carry of heavy components or equipment. Some components may require multiple personnel to lift, carry, and/or install. Manual handling and lifting are a major cause of work-related lower back pain (LBP) and impairment, and shoulder or arm pain. The LBP can occur by direct trauma, a single exertion (overexertion), or as a result of multiple exertions (repetitive trauma). The LBP and impairment are also associated with other work-related factors such as pushing and pulling activities, extreme postures such as forward flexion, and cyclic loading.

Medical Criteria

Although medical criteria for musculoskeletal injury from lifting and carrying do not exist, human performance design criteria from paragraph 5.8.6.3 of *MIL-STD-1472G*[10] can be applied. This standard considers various factors that are related to manual material handling injury risk such as gender, lift height, lift frequency, object mass, object size, carry distance, and lift team composition. Each of these should be considered when requiring Soldiers to perform lift, carry, and push and pull tasks during use of the materiel and its components.

Each item required to be manually lifted/carried should be labeled with their weight and lifting requirements according to paragraph 5.8.6.3.12 of *MIL-STD-1472G*.[10] Hoist and lift points shall be provided and clearly labeled where mechanical or power lift is required.

SUMMARY

Since 1981, the Army's HHA Program has provided an invaluable service to combat developers and materiel program managers by providing recommendations designed to eliminate or control health hazards associated with materiel and weapon systems. The program has consistently strived to improve its services by providing more meaningful and efficient assistance to the acquisition community. In the uncertain fiscal times ahead, the Army's HHA Program will continue to provide valuable and cost-effective solutions to mitigate the health risks of weapon systems.

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1991 Gulf War Exposures and Adverse Birth Outcomes

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ABSTRACT

We studied 1991 Gulf War (GW)-related environmental exposures and adverse birth outcomes in Iraqis. A random cross-sectional sample of 307 Iraqi families that immigrated to the United States responded to a structured interview covering socioeconomics, lifestyle, environmental exposures, and birth outcome. Data per each family was collected either from the man or the woman in the respective family. The respondents were divided into those that resided in Iraq during and following the GW (post-GW, n=185) and those that had left before (pre-GW, n=122). The primary outcome was lifetime prevalence of adverse birth outcomes, ie, congenital anomalies, stillbirth, low birth weight, and preterm delivery and its relationship to GW exposures. Mean number of adverse birth outcomes increased from 3.43 (SD=2.11) in the pre-GW to 4.63 (SD=2.63) in the post-GW group ($P<.001$). Mean chemical (Ch) and nonchemical (NCh) environmental exposure scores increased from pre-GW scores of 0.38 units (SD=1.76) and 0.43 (SD=1.86), respectively, to post-GW scores of 5.65 units (SD=6.23) and 7.26 (SD=5.67), $P<.001$ between groups for both exposures. There was a significant dose-response relationship between Ch environmental exposure ($P=.001$), but not NCh exposure, and number of adverse birth outcomes. Exposure to burning oil pits and mustard gas increased the risks for specific adverse birth outcomes by 2 to 4 times. Results indicate that Gulf War Ch, but not NCh exposures are related to adverse birth outcomes. Pregnancies in women with a history of war exposures might benefit from more intensive observation.

BACKGROUND

Exposures to chemical (Ch) and nonchemical (NCh) (psychosocial factors) environmental stressors have in some, but far from all studies been associated with nonoptimal pregnancy outcomes.[1-7] Nonchemical environmental exposures such as violence and socioeconomic strain have also been associated with adverse birth outcomes.[5,8,9] Prenatal exposure to air pollutants such as sulphur dioxide, nitrogen dioxide, fine (diameter$\leq$2.5 μm) and coarse (diameter$\leq$10 μm) particulate matter might contribute to suboptimal birth outcomes through a range of mechanisms, including inflammatory reactions in the lung, contributing to systematic release of proinflammatory cytokines, DNA adduct formation, and lipid peroxidation.[5,10]

Prior studies of reproductive health effects from exposure to war conflicts have reported an increased prevalence of severe congenital anomalies, neural tube defects, perinatal mortality and preterm delivery, and decreased birth length and weight.[11-15] The 1991 Gulf War (GW) is a more recent example of sustained war with severe implications for Iraqi civilians in terms of complex environmental exposures. Studies of reproductive effects from the GW have predominantly concerned United Kingdom and US veterans reporting an increased risk for spontaneous abortions and congenital birth defects.[16,17] A small study of civilians residing in Kuwait during the early phase of the conflict reported an increased prevalence of children with low birth weight and stillbirth.[18]

Studies of reproductive risks from war typically lack detailed exposure information. However, the US General Accounting Office reported that during the GW up to 21 reproductive environmental hazards, such as depleted uranium and smoke from oil-burning fires, were dispersed into the environment.[16,19] In studies of GW veterans, "exposure" was defined simply as "deployment to the Gulf region."[20] A void of reliable environmental exposure data limits our ability to assess war-related environmental reproductive risks. Major shortcomings of reproductive health studies from war are the lack of (*a*) samples based on random selection, (*b*) Ch-specific and NCh-specific exposure data, and (*c*) proper comparison groups.

Reproductive health effects studies from war characterized by intense and sustained exposure to environmental pollutants, such as the GW, might also contribute mechanistic understandings to studies of sustained but low-intensity urban exposures in general.

OBJECTIVES

The objectives of this cross-sectional study were to determine whether adverse birth outcomes for fathers or mothers exposed to the GW are worse than for non-GW exposed persons.

The following hypotheses were tested:

1. Exposure to the GW is associated with increased risk for adverse birth outcomes.
2. Participants residing in Iraq during the GW report higher exposures than those that had left before the outbreak of the war.
3. There is a dose-response relationship between Ch and/or NCh exposures and adverse birth outcomes.
4. Specific environmental exposures, such as smoke from burning oil wells, are predictive of increased adverse birth outcome risks.

METHODS

Setting

In 2005, an elaborate community-based project was initiated to identify Iraqis residing in the region of metropolitan Detroit, Michigan, which has one of the largest populations of Iraqi immigrants and refugees in the country. The project was announced in Arabic and English using several means of communication, such as the Arabic radio and television. Flyers with project information were distributed at various Arab and Chaldean-American community centers as well as faith-based facilities, convenience stores, restaurants, gas stations, hair salons, and community centers. The local Iraqi directory was also used to identify potential participants.

Participants

This recruitment drive resulted in a list of 5,490 addresses from which a random sample of 411 (7.5% of the entire sample) was selected for study inclusion. This allowed for a statistical power of 0.90, with a 2-sided P=.05 to detect a 30% difference between the 2 groups in the total number of adverse birth outcomes, assuming a mean of 1.5 adverse birth outcomes in the non-GW exposed group. The inclusion criteria were that participants were Iraqi-born and aged 18 years or older at the time they emigrated from Iraq. We chose one person from each household, irrespective of gender, based on the first eligible person we contacted in that household. Of 411 addresses selected, 44 had no residents who fit the study criteria. Of a total of 367 eligible candidates, 17 (4.6%) declined participation. The reasons were lack of time (n=9), lack of interest in the study (n=7), or no reason provided (n=1). A total of 350 qualified families, each represented either by a man or woman, representing a response rate of 95%, accepted to take part in the study. Of these, 43 did not attempt a pregnancy during the period of interest, leaving a final study group of 307 persons.

Participants who came to the United States from Iraq before 1991, and thus not exposed to the Gulf War, were classified as "pre-GW." Those arriving in 1991 or later who had been exposed to the Gulf War were classified as "post-GW."

Variables

The survey instrument used was initially created through a joint effort of the Iowa Persian Gulf Study Group and the Centers for Disease Control and Prevention to evaluate a broad range of health concerns among US Gulf War veterans, and was adopted and used in studies of Iraqi civilians and military.[21-23]

Data Source

Data was collected using the structured interview carried out in Arabic, typically in the participant's home, by a team of female and male Iraqi-born obstetric and gynocology specialists.

Exposure Assessment

The respondents were asked in detail about their GW-related exposures. The GW-specific environmental Ch and NCh factors included agents reported to be associated with symptoms of the "Gulf War Syndrome" reported by many GW veterans.[24] Questions began with the following stem: "During the Gulf War did you have direct contact with any of the following exposure?" The respondents were asked about the following 16 environmental exposures (Ch):

- Smoke from oil burning fires
- Exhaust from heaters or generators
- Diesel or other petrochemical fumes
- Burning trash or burning feces
- Diesel or other petroleum fuel on their skin
- Chemical agent resistant compounds (such as paint)
- Other chemicals such as solvents or petroleum substances
- Depleted uranium
- Direct skin contact with pesticides (creams, sprays, flea collars)
- Pesticides on clothing or bedding

- Nerve gas
- Mustard gas or other blistering agents
- Food contaminated with smoke or oil or other chemicals
- Local food other than food provided by the armed forces
- Bathe in or drink water contaminated with smoke oil or other chemical
- Bathe or swim in local ponds, rivers, or the Persian Gulf

Respondents were also asked to respond about their experiences with 9 war-related NCh (stress exposures):

- Exposure to dead animals
- Hearing chemical alarms
- Scud missiles exploding in the air or on the ground within one mile
- Artillery, rockets or mortars (anything other than Scud missiles) explosions within one mile
- Subjected/exposed to small arms fire
- Seeing dead bodies
- Seeing maimed or seriously injured people
- Witness someone dying
- Any other war-related exposure the participant deemed to be harmful or stressful

These exposures were considered to be of sufficient severity to fulfill the exposure criterion A for posttraumatic stress syndrome in the *Diagnostic and Statistical Manual for Mental Health Disorders*.[25]

The Ch environmental score was calculated by aggregating respondent's answers to the 16 environmental questions. For each specific Ch measure, the exposure status variable was multiplied by exposure duration (none, less than 5 days, 6 days to 30 days, more than 31 days: coded as 0, 1, 2, and 3 respectively) to calculate the cumulative exposure Ch dose. The cumulative NCh stress scale scores were created using the same method. This allowed us to calculate the respective doses of Ch and NCh exposures.

The mean Ch environmental exposure was 3.56 units (SD=5.68, SE=0.32). The actual maximum Ch exposure score observed was 29 of a theoretical high of 48. Based on the mean, Ch exposure scores above 3.56 was classified as high exposure, and below as low exposure. The mean for the NCh exposure scale was 4.58 (SD=5.68, SE=0.32) and an actual maximum of 23 (theoretical high of 27). An NCh exposure above 4.58 was classified as high exposure and below 4.58 as low exposure. The Cronbach α for both scales was greater than 0.75.

OUTCOMES

Adverse birth outcomes were classified as congenital anomalies, stillbirth, low birth weight, and preterm delivery. Stillbirth was defined as fetal death at 20 weeks gestation or greater; low birth weight as less than 2,500 grams; and preterm delivery as delivery of the fetus before 37 weeks gestation.

Since the primary outcome was cumulative numbers of adverse birth outcomes, the 4 adverse birth outcome categories were combined into a composite adverse birth outcome scale score. In addition, each of the 4 adverse birth outcomes was separately analyzed against Ch and NCh exposure histories.

We examined reproductive health effects as a function of (*a*) whether respondents reported having lived in Iraq or not during the war, and (*b*) using the more complex Ch and NCh exposure scales. We used both specific adverse birth outcomes and aggregate adverse outcomes when determining the exposure-outcome association.

STATISTICAL ANALYSES

Nonpaired student's *t* test was used to compare mean Ch and NCh exposures in the pre- and post-GW groups, respectively, as well as comparing scores across both groups on the adverse birth outcome scale. Student's *t* test was also used for comparing mean number of each of the 4 adverse birth outcomes by GW status. Levene's test for equality of variance was checked for all these comparisons, and the appropriate *t* statistics were used. Mann-Whitney U tests were also used to compare groups. Both tests yielded the same results, therefore only student's *t* tests are reported. The Ch and NCh scale scores were analyzed with one-way ANOVA. The Duncan multiple-range test was used to determine which of the total adverse birth categories were different from one another. Multiple linear regression analysis was used to study the relationship between dependent factors and independent Ch and NCh exposure scales, while controlling for gender, ethnicity (Arabic versus Chaldean), education, and smoking status. We checked the normal P-P plot of regression of standardized residuals. Stepwise logistic regression analysis was used to determine the relative contribution of each of the individual environmental items in the Ch scale, classified as either present or absent, on each of the 4 adverse birth outcomes. There was no significant association between NCh and outcomes after controlling for Ch and demographics. Consequently, those results are not reported.

Data was analyzed with SPSS for Windows v19.0 (SPSS Inc, Chicago, Ill). A $P<.05$ (2-tailed) was considered statistically significant.

RESULTS

Table 1 depicts the characteristics of the study participants by post-GW and pre-GW exposure status.

Figures 1 and 2 show participants' mean total number of adverse birth outcomes as a function of self-reported Ch and NCh exposures. There was a significant association between increasing Ch exposures and number of adverse birth outcomes.

Figure 3 depicts participants' aggregate Ch and NCh exposure scores versus the period of immigration. Both Ch and the NCh scores were significantly higher in the post-GW group.

Table 2 reveals that the prevalence of specific adverse birth outcomes by period of immigration to the United States is different only for those exposed to the GW, regardless of whether the child was born in Iraq or the United States.

Table 3 reports pregnancy outcomes following adjustment for demographics and smoking. The Ch environmental exposure scale explained 2.1% of the variance in total adverse birth outcomes. NCh exposures did not remain in the model once Ch exposure was added.

Participants with a history of high Ch environmental exposures were more than twice as likely to report adverse birth outcomes as compared to the low Ch exposure group (odds ratio 2.04 (95% CI, 1.12-3.74)). The ethnicity of the respondent (Chaldean versus Arab) was not associated with birth outcomes.

Table 4 depicts the odds ratio between each of the 4 adverse birth outcomes and specific war-related environmental exposures. Exposures to smoke from burning oil wells, water contaminated with petrochemical products, and mustard gas were all related to a significantly increased risk in the reporting of adverse birth outcomes.

Table 1. Demographic characteristics of study participants.*

Demographic Characteristic (N=307)	Post-GW (n_1=185) $\%n_1$	Pre-GW (n_2=122) $\%n_2$	*P* value
Education - more than high school	56.8	69.2	.40
Smoker	30.0	39.3	.11
Employed	40.0	73.3	.00
Female respondents	48.4	38.5	.10
Covered by health insurance	76.3	60.7	.01
Income – higher than $10,000	39.1	14.9	.01

*The data includes both female and male respondents. Each male respondent reported the outcome of pregnancy of his wife. Single men and women were excluded from participation in the survey.

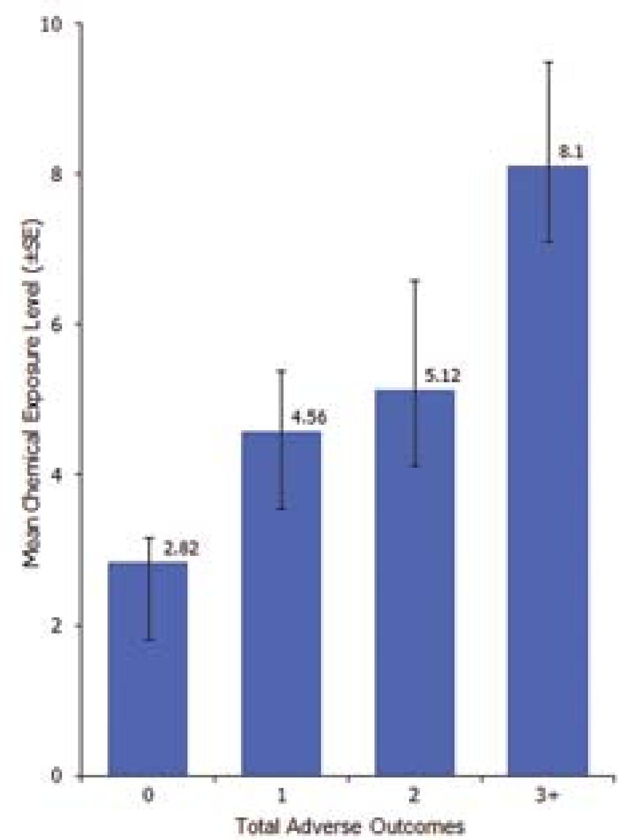

Figure 1. Total number of adverse birth outcomes in relationship to the chemical environmental exposure scale score. For the trend, *P*<.01.

COMMENT

These results support our first hypothesis that the prevalence of adverse birth outcomes is higher in participants having been exposed to the GW as opposed to participants that had left Iraq before the war. As hypothesized, both Ch and NCh exposures were higher in those residing in Iraq during the GW. However, counter to our hypothesis, only Ch, not NCh exposures, exhibited a dose-relationship association with adverse birth outcomes.

Stillbirth exhibited the largest systematically increased risk when comparing the post-GW to pre-GW groups. Exposure to burning oil wells and water and food contaminated with petrochemical products during the GW appeared to be especially related to reproductive risks. This supports our last hypothesis that certain environmental exposures are more closely associated with adverse birth outcomes.

The current study supports the notion that war per se is a risk factor for adverse birth outcomes.[11,12,14-20] One possible environmental culprit revealed in our findings could be the documented exposure to up to 21 potential reproductive toxicants in persons residing in Iraq during

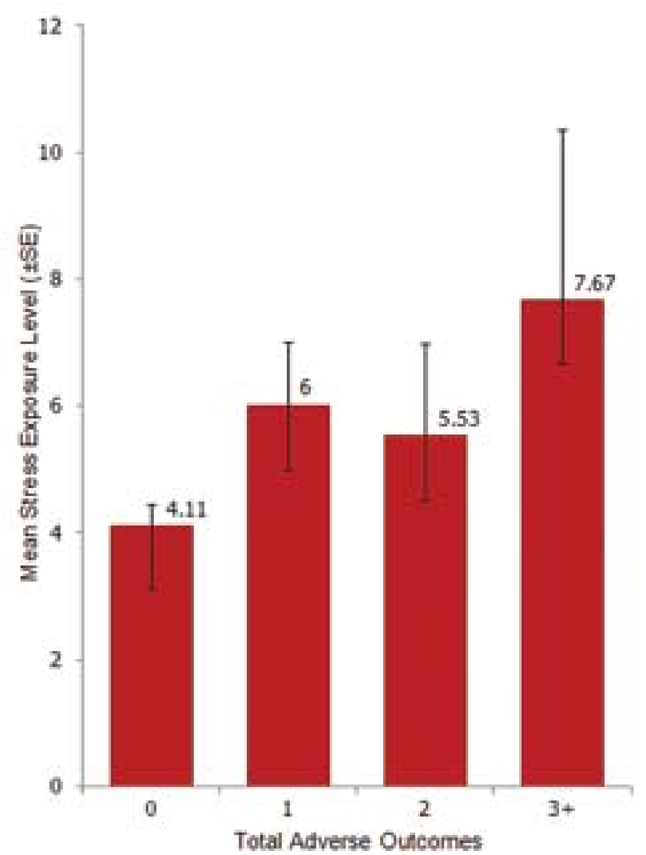

Figure 2. Total number of adverse birth outcomes in relationship to the nonchemical environmental (stress) exposure scale score. For the trend, $P<.01$.

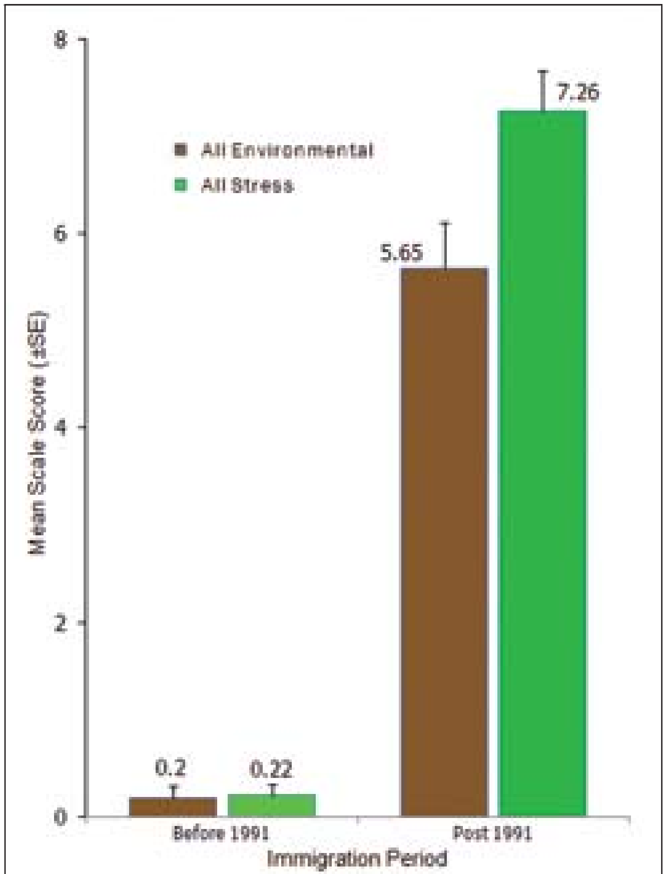

Figure 3. Chemical environmental (all environmental) and nonchemical (all stress) exposure scales presented as functions of the period of the study participants' immigration to the United States relative to the 1991 Gulf War.

the GW.[5,16] The dose-response relationship between Ch exposure and adverse birth outcomes further supports the hypothesis that GW is associated with adverse birth outcomes. Theoretically, it is possible that nonchemical exposures, that is, stress in the post-GW group, contributes to our findings of an increased risk for adverse birth outcomes by means of increased levels of the stress hormone cortisol. However, our findings do not support this theory since NCh exposures were not related to adverse birth outcomes after controlling for Ch exposures and other sociodemographic risk factors.[8,26,27]

These findings extend previous studies conducted in populations exposed to war, such as in Darfur, Kuwait, Bosnia and Herzegovina, and the September 11, 2001 terrorist attacks, as well as nonwar-related exposures in communities that suffer high rates of environmental exposures, such as certain urban and immigrant communities.[12,18,28,29]

The percentage of stillbirth in the current study was higher; 216 per 1,000 births in women exposed to the GW versus 60 per 1,000 births among nonexposed women, as compared to official Iranian 1995 statistics citing 24 per 1000 in 1995.[30] During the war in Darfur from 2003 to 2007, a stillbirth rate of 29 per 1,000 births was reported for the Wad Medani Hospital in Central Sudan.[28] Furthermore, Makhseed et al reported an increased percentage of low birth-weight babies in the Maternity Hospital of Kuwait during Iraq's invasion of Kuwait from 1991 and 1992, as compared to before 1991.[18]

Our finding of an association between Ch exposure and preterm delivery is in line with the report by Fatusić et al,[12] who found an increased rate of preterm delivery during the war in Bosnia and Herzegovina, as compared to pregnancy outcomes after the conflict had subsided.[12,18] However, none of the prior war studies classified type of Ch and NCh exposures.

With regard to specific exposure culprits, air pollution as well as ovarian and uterine irradiation in nonwar community settings has been associated with an increased risk of nonoptimal pregnancy outcomes.[31,32] External exposures to pesticides, both occupational and residential,

Table 2. Specific adverse birth outcomes by date of occurrence and GW exposure category.*

Adverse Pregnancy Outcome	Post-GW (n_1=185) %n_1	Pre-GW (n_2=122) %n_2	*P* Value
Stillbirth - before 1991	11.6	11.1	1.00
Stillbirth - after 1991	21.6	6.0	.00
Congenital anomaly - before 1991	0.0	0.0	N/A
Congenital anomaly - after 1991	2.1	0.0	.30
Low birth weight - before 1991	1.6	2.6	.68
Low birth weight - after 1991	7.4	3.4	.21
Preterm delivery - before 1991	3.2	0.9	.26
Preterm delivery - after 1991	3.4	7.4	.21

*The data includes both female and male respondents. Each male respondent reported the outcome of pregnancy of his female partner.

Table 3. Chemical and nonchemical exposure predictors of aggregate number of adverse birth outcomes.

Variable	Standardized β	*t*	*P* value	R^2
Step 1				
Gender (ref=men[a])	-0.183	-2.797	.006	
Smoker (smoker[a])	0.021	-1.437	.750	
Education (less than high school[a])	-0.086	-1.437	.152	
Ethnicity (Arab[a,b])	-0.185	-2.957	.003	0.112
Step 2				
Chemical exposure scale scores	0.229	2.852	.005	
Nonchemical exposure scale scores	0.024	0.296	.767	0.054
			Total explained variance, R^2=	0.166

Notes:
a. Ref indicates reference category.
b. Iraqi Arab vs Iraqi Chaldeans

have been linked to stillbirth.[26,27] Nonchemical related stress, as measured through maternal salivary cortisol and self-reports, has been associated with shorter pregnancies, although not necessarily preterm birth in a sample of nonwar-exposed persons.[26]

There are a number of limitations to the study that should be considered. The original survey was designed to cover a range of exposures and health outcomes, not just reproductive health. We lacked objective exposure and birth outcome measures. We also asked subjects to report on birth outcomes and exposures a number of years after the GW. This could attenuate true associations. Participants could also be unaware about personal exposures to "invisible" agents such as depleted uranium. Finally, the age of the participants when they were pregnant and the birth order of children remain unknown, factors that could possibly play some role.

CONCLUSION

The prevalence of adverse birth outcomes is increased in participants who resided in Iraq during the Gulf War as opposed to those that had left prior to the GW. Moreover, there is a dose-response relationship between war-related environmental exposures and total number of adverse birth outcomes. Certain chemical exposures appear to be more closely related to adverse birth outcomes. The study points to the importance of considering reproductive risks in pregnant mothers with a history of exposure to war.

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Table 4. Statistical relationships of specific adverse birth outcomes to environmental-specific exposures.

Adverse Birth Outcome	Reported Environmental Exposures	Odds Ratio	95% CI	*P* Value
Congenital birth defects	Diesel and other petrochemical fumes	17.00	1.50; 192.76	.021
Low birth weight	Contact with/exposure to smoke from oil well fires	3.00	1.25; 7.18	.017
	Exhaust from generators/ kerosene heaters	2.59	1.01; 6.69	.063
	Contaminated water in local pond, river or the Gulf	3.87	1.30; 11.58	.028
Pre-term birth	Contact with/exposure to smoke from oil well fires	3.26	1.34; 7.92	.012
	Exhaust from generators/ kerosene heaters	3.50	1.38; 8.87	.013
	Drinking water contaminated by smoke, oil or other chemicals	3.33	1.27; 8.74	.022
	Contaminated water in local pond, river or the Gulf	4.12	1.37; 12.38	.022
Stillbirth	Contact with/exposure to smoke from oil well fires	2.38	1.32; 4.27	.005
	Exhaust from generators/ kerosene heaters	2.84	1.48; 5.44	.002
	Diesel fumes/other petrochemical fumes	2.60	1.24; 5.45	.014
	Burning trash/feces	2.91	1.154; 7.331	.028
	Mustard gas	2.548	1.24; 5.23	.013
	Ingested food contaminated by smoke, oil, or other chemicals	2.20	1.28; 3.78	.013

Note: CI indicates confidence interval.

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Efficacy and Duration of Three Residual Insecticides on Cotton Duck and Vinyl Tent Surfaces for Control of the Sand Fly *Phlebotomus papatasi* (Diptera: Psychodidae)

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ABSTRACT

This study evaluated the toxicity and duration of 3 residual insecticides against the Old World sand fly, *Phlebotomus papatasi*, an important vector of cutaneous leishmaniasis, on 2 types of tent material used by the US military in Afghanistan and the Middle East. Vinyl and cotton duck tent surfaces were treated at maximum labeled rates of lambda-cyhalothrin (Demand CS, Zeneca Inc, Wilmington, DE), bifenthrin (Talstar P Professional, FMC Corporation, Philadelphia, PA) and permethrin (Insect Repellent, Clothing Application, 40%), then subsequently stored in indoor, shaded spaces at room temperature (60%-70% relative humidity (RH), 22°C-25°C), and under sunlight and ambient air temperatures outdoors (20%-30% RH, 29°C-44°C). Insecticide susceptible colony flies (F110) obtained from the insectary of US Naval Medical Research Unit No. 3, Cairo, Egypt, were exposed to treated tent surfaces for 30 minute periods twice monthly for up to 5 months, then once monthly thereafter, using the World Health Organization cone assay. Lambda-cyhalothrin treated cotton duck tent material stored indoors killed *P. papatasi* for 8 months, while the complementary sun-exposed cotton duck material killed adult flies for 1 month before the efficacy dropped to less than 80%. Sand fly mortality on permethrin- and bifenthrin-treated cotton duck decreased below 80% after 2 weeks' exposure to sunlight. Shade-stored permethrin and bifenthrin cotton duck material killed more than 80% of test flies through 5 months before mortality rates decreased substantially. Vinyl tent material provided limited control (less than 50% mortality) for less than 1 month with all treatment and storage regimes. Lambda-cyhalothrin-treated cotton duck tent material provided the longest control and produced the highest overall mortalities (100% for 8 months (shaded), more than 90% for 1 month (sunlight-exposed)) of both cotton duck and vinyl tents.

Sand fly control is essential for reducing the risk of human infection with *Leishmania* parasites, the etiological agents of visceral and cutaneous leishmaniasis (VL, CL, respectively). Across the Middle East and north Africa, phlebotomine sand flies occur in large numbers and with such a widespread distribution that transmitted *Leishmania* parasites cause an average of 350,000 cases of CL annually, representing 12% of the global burden.[1] Despite this sizeable number, CL in that region is believed to be largely underreported and thus expected to be even more prevalent. Even in the absence of CL, large sand fly populations have produced biting rates in excess of 1,000 bites per night on military bases in Iraq. The impact of this quantity of bites significantly degrades the quality of life and operational readiness of deployed personnel.[2]

Conflicts with Soviet invaders, Taliban, and tribal groups have resulted in the destruction of the Afghan public health infrastructure, and mass migration of displaced persons, some with prior infection, from rural to urban areas where living conditions are inadequate. As a result, the incidence of CL in Afghanistan has been increasing for several decades and the increased presence of sand flies is conducive to greater numbers of CL cases.[3] Kabul's population is presently estimated at 3.9 million people, up from about one million in 1980 just after the Soviet invasion.[4] As of 2002, there were an estimated 200,000 CL cases in Kabul alone.[5] Such large numbers of CL cases put deployed service members at increased risk of infection.

Integrated methods of sand fly control in desert environments include insecticide applications, habitat modification (destruction of mammal reservoirs and their burrows), use of personal protective measures, such as insecticide-treated bed nets (ITNs), and topical- and clothing-applied arthropod repellents.[6] Ultra low volume

(ULV) space sprays, thermal fogging, and residual insecticide treatments comprise the chemical control methodologies for sand fly control, and are used by military preventive medicine personnel to provide quick relief from biting insects.[7,8] Insecticide treatment of immature sand flies is not practical, as large areas must be treated with backpack sprayers, and larval habitat is in many cases unknown. Rapid control of biting, adult female sand flies is more practical and critical to both reduction of nuisance biting and disease risk. Adult control is partly reliant upon space sprays and residual insecticide treatment of surfaces on which the flies rest. Habitat modification, useful in some circumstances for long-term sand fly control, requires continuous monitoring and environmental manipulation, is expensive and time consuming, and in general is only applicable for bases which will be in place for many years. Habitat modification is not useful for decreasing biting insect pressure on more temporary bases, most often cost prohibitive, and in some cases illegal if protected wildlife is present or the host-nation will not allow it.[9]


Figure 1. Vinyl extendable modular personnel tents used for transitional billeting, Kuwait, August, 2009.

Ultra low volume space spraying is the standard Department of Defense (DoD) response for control of biting sand flies. Some measure of control has been achieved with space spraying in the Middle East, however, ULV applications are not successful in providing long-term biting relief and effective disease control.[10,11] Adult populations rebound quickly despite a lack of evidence that indicates resistance development to adulticides in Egypt. No documented instances of sand fly resistance exists in the Middle East or Afghanistan.[2,12]

Residual insecticide treatment of sand fly resting areas, especially on surfaces that shelter humans, offers longer lasting protection from biting sand flies than does ULV space spraying or application of topical and clothing repellents. Further, the residual insecticide treatments are simple to implement, due to the presence of insecticides and application equipment typically available to deployed preventive medicine personnel. As with ITNs, a surface treated with insecticide can deliver a lethal dose to host-seeking insects that rest on those surfaces. Advantages of residual insecticide applications over space spray measures (ULV and thermal fog) include long-term protection from a single treatment, serendipitous use of human odors as a means to draw sand flies toward treated surfaces, and savings in manpower and insecticide costs associated with not needing to perform repeated, nonresidual space spraying.[7]

Presently, over 180,000 US and NATO personnel are now serving in *Leishmania*-endemic areas in Afghanistan and the Middle East. Many of these troops are quartered in temporary shelters, often in tents (Figure 1). Recent model tents provide better protection from the environment than older tents because they are equipped with better flooring, screened windows and doors, and are often air conditioned. Cotton duck material was used for military tents several decades ago, but modern tents are constructed of vinyl due to improved protection from sunlight, wind, dust, and rain. Greater numbers of deployed personnel are now living in modular or hardened quarters than were at the beginning of Operations Enduring Freedom and Iraqi Freedom, when troops were originally quartered in tents lacking air conditioning or flooring, or simply slept under open sky. This may explain, in part, the increase of CL cases in Iraq and Afghanistan at the start of those wars, with a subsequent drop in the number of cases through the present.[13] In situations where tents are used in place of buildings or containerized modules, "rubber" (vinyl) tents are most often used by deployed forces as command posts, dining facilities, administrative spaces, medical clinics, and for billeting in both permanent bases and smaller forward observation bases. Although cotton duck tenting is seldom used currently, it was the DoD tent mainstay prior to the introduction of vinyl tents and is still commonly used by rural populations and in refugee centers. Cotton duck liners are still present in the supply system along with general purpose, Tent, Extendable Modular Personnel (TEMPER), and Arctic tents that do not have vinyl surfaces.[14]

This study was designed to evaluate the efficacy and longevity of 3 insecticides, stocked by DoD and available to deployed forces, used as residual treatments on cotton duck and water-repellent vinyl tent material. Colonized (susceptible) *Phlebotomus papatasi* (Scopoli) sand flies were exposed for 30 minutes to treated tent material every second week for 20 weeks, then once monthly, encompassing an 8-month period using the World Health Organization (WHO) cone bioassay in an attempt to determine which of 3 DoD-stocked pyrethroid insecticides was most useful for killing these flies and how long they lasted on cotton and vinyl tent surfaces before retreatment became necessary. This research is intended to benefit people living or working in tents who are concerned about protecting themselves from biting sand flies and *Leishmania* infection in desert environments common to much of the Middle East and Afghanistan.

MATERIALS AND METHODS

Sand Flies

A laboratory population of *P. papatasi* sand flies was used to study the effectiveness of insecticide-treated tent material. The flies (F110) were reared in the Vector Biology Research Program insectary, US Naval Medical Research Unit No. 3 (NAMRU-3), Cairo, Egypt. Flies were colonized by the procedure of Modi and Tesh,[15] at 27°C±2°C, 80%±10% RH, and a light:dark photo period of 12:12 throughout their development. Adults were offered 30% sugar solution daily, and provided blood meals on hamster, *Pachyuromys duprasi* Lataste for egg production. Three to five-day old sand fly females were used in this study.

Insecticides

Three insecticides were applied to tent materials at their highest labeled rates for residual fly control: Demand CS (9.7% lambda-cyhalothrin, National Stock Number (NSN) 6840-01-428-6646) (Zeneca Inc, Wilmington, DE), Talstar P Professional (7.9% bifenthrin, NSN 6840-01-525-6888) (FMC Corporation, Philadelphia, PA) and Insect Repellent, Clothing Application (40% permethrin, NSN 6840-01-334-2666). Although classified and used as a repellent in the DoD supply system, permethrin is also an insecticide and is formulated for adult mosquito control as a ULV spray. The insecticides were chosen based on recommendations from the Armed Forces Pest Management Board's "Standard Pesticides Available to DoD Components" list* and are used by preventive medicine personnel and pest control contractors.

Insecticide Stock Solution Preparation

Demand CS was mixed at the rate of 12 mL per 3.79 L (one gal) of water to produce a 0.03% solution for application to 92.9 m^2 (1,000 sq ft) of surface area. The resultant applied surface concentration was 1.2 µg/cm^2 lambda-cyhalothrin. Talstar P Professional was mixed at the rate of 30 mL per 3.79 L of water to produce a 0.06% solution for application to 92.9 m^2 of surface area and produced a surface concentration of 1.9 µg/cm^2 bifenthrin. Insect Repellent, Clothing Application was mixed at the rate of 75 mL active ingredient per 3.79 L of water to produce a 0.5% solution, designed specifically for thorough treatment of 4 combat uniforms (half the rate of the 150.8 mL bottle developed for use with a 7.57 L (2-gal) sprayer). Cotton duck tent material was sprayed 3 times, producing a moist and darkened surface without runoff, as recommended by the label. This treatment produced a surface concentration of approximately 94 µg/cm^2, or ¾ of the recommended cotton battle dress uniform finished concentration of 125 µg/cm^2.

Tent Material and Applications

Vinyl and cotton duck tent material were used for this study. Vinyl tent material was obtained from a desert TEMPER tent (NSN 8340-01-185-2628). These tents are comprised of 13.5 oz polyester duck and are standard use tenting for deployed US forces. The material is naturally water-repellent and is factory treated with a flame retardant. Due to the flame retardant finish, insecticide application on vinyl tenting is not recommended.[14] However, we chose to treat vinyl tenting with insecticide to determine if any residual protection could be obtained. The cotton duck tent material was collected from a Tent, General Purpose, Medium (NSN 8340-543-7788) made from 9.85 oz cotton duck. In preparation for testing, the vinyl tent material was washed with soap and water. The cotton duck tent material was dry cleaned twice at a commercial cleaner using perchloroethylene to remove any insecticide residues from prior treatment.

Environmental treatments included shade-stored and sunlight-exposed treated tent. Shade-stored (sun protected) cotton duck and vinyl tent was kept on shelves inside the Vector Biology Research Program's storage locker. Air conditioning resulted in consistent temperatures ranging from 22°C-25°C for the duration of the study. Sunlight-exposed test material was set on the roof of the Vector Biology Research Program building from June 2, 2009, through February 25, 2010, and exposed to temperatures ranging from 9°C-44°C.

Insecticides were applied with a 3.79 L compressed air sprayer (NSN 3740-00-191-3677) at a pressure of 50 psi to 55 psi while wearing appropriate personal protective equipment (vented goggles, half-face respirator with organic vapor cartridges, long sleeve shirt, neoprene gloves), to simulate insecticide application under field conditions using equipment and insecticides readily available to military personnel. Tent material was cut into 30.5 cm by 61 cm strips, representing 1/500 of a 92.9 m^2 treatment area (per label directions) (Figure 2). These two 1,860.5 cm^2 strips were sprayed with 1/500 of 3.79 L of solution (7.4 mL of finished product). To calibrate, 3.79 L of tap water was added to the 3.79 L sprayer, pressure brought to 50 to 55 psi with the nozzle inserted in a 100 mL graduated cylinder, and water sprayed until 7.4 mL of water was collected. Three replications averaged one second to obtain the required 7.4 mL sample. During tent treatment, the nozzle was swept the length of 61 cm in one second to produce the desired concentration. At an application distance of 30.5 cm to 38.1 cm, the fan nozzle covered a width of slightly more than 30.5 cm, the width of test strips. Both vinyl and

*http://www.afpmb.org/sites/ default/files/pubs/standardlists/dod_pesticides_list.pdf cotton tent material were treated on horizontal concrete surfaces and allowed sufficient time to air dry before packaging and shipping. Samples were treated at the US Department of Agriculture facility in Gainesville, FL, individually bagged in laminated cambric sample bags (Hubco, Hutchinson, KS), wrapped in duck 5 inch W stretch wrap, film extensible (Lowe's Home Improvement), and shipped to NAMRU-3. Testing commenced about a month after tent treatment, the time necessary to clear samples from airport inspectors and prepare the laboratory for sand fly testing.

Bioassays

These assays followed the method described by WHO,[16] in which 4 WHO plastic cones were fastened to the treated tent liner. A batch of 60 flies per tent type/insecticide combination was tested, in 4 replicates of 15 non–blood-fed female sand flies per cone. All flies were held in the cones for 30 minutes. After exposure, flies were placed in 150-ml plastic cups (15 individuals per cup), with a 30% sucrose solution provided, and maintained in a climatic chamber for 24 hours at 27°C±2°C and 80%±10% RH. Percentage mortality was scored after 24 hours, according to WHO cone assay criteria.[16] All tests were performed with the same tent material/insecticide combination tent samples. Cone test sites were randomly selected on the same treated tent samples throughout the study.

Figure 2. Vinyl tent strips (61 cm by 30.5 cm) used for residual insecticide efficacy studies against the sand fly *Phlebotomus papatasi*, a vector of cutaneous leishmaniasis in Afghanistan and the Middle East.

RESULTS

Cotton Duck, Sunlight-Exposed

Lambda-cyhalothrin applied at maximum fly control rates produced the highest level of mortality in sand flies. Sand fly mortality remained above 80% for 4 weeks (93.3% mortality at week 4) before dropping off quickly to 65% at week 6, and declining to 41.6% at week 8 when testing was stopped. Permethrin-treated cotton duck killed 78.3% of test flies on week 2, declined to 65% mortality on week 4, and slowly receded to 33.3% morality on week 10 when testing was stopped. Bifenthrin-treated cotton duck killed 91.6% of test flies on day 0, 66% on week 2, and fell to 40% on week 6 at which time testing ended (Figure 3).

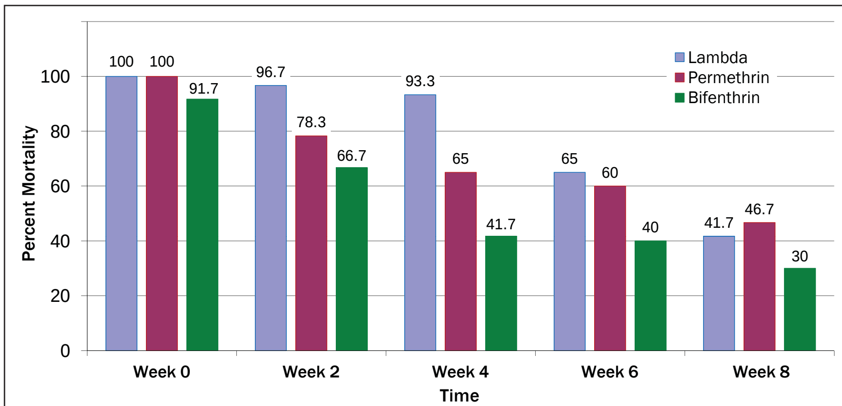

Figure 3. Mortality rates of *Phlebotomus papatasi* to lambda-cyhalothrin-, permethrin-, and bifenthrin-treated, sunlight-exposed cotton duck tenting after initial treatment, May-July 2009.

Cotton Duck, Shade-Stored

Shade-stored (sun-protected) cotton duck was kept on shelves inside the Vector Biology Research Program's storage locker. Air conditioning was kept between 22°C-25°C for the duration of the study. Lack of high temperatures with no sun exposure greatly extended the life of insecticides. Lambda-cyhalothrin treated cotton duck continued killing 100% of all test flies through the end of week 38, providing complete protection well into 8 months. Permethrin-treated cotton duck provided 100% mortality for test flies through week 8, killed 86.6%, 91.6%, and 90% of flies on weeks 10, 12, and 14 respectively, and killed all flies between weeks 16 and 24. Mortality then rapidly dropped off to 10% on week 28 and finally 5% on week 32, when testing stopped. Bifenthrin provided 100% control of test flies through 6 weeks, killed between 90% and 96.6% of flies between weeks 8 and 16, and killed all test flies between weeks 18 and 22 before mortality rates dropped off quickly to 18.3%, 13.3%, and 15% on weeks 26, 30, and 36, respectively. Time-mortality rates of sand flies exposed to shade-stored, insecticide-treated cotton duck tenting is shown in Figure 4.

Vinyl, Sunlight-Exposed

TEMPER (vinyl) tenting treated with candidate insecticides did not produce high mortality rates beyond the initial test day (day 0), and treatment efficacy wore off quickly. Sunlight-exposed, Lambda-cyhalothrin-treated vinyl killed 94% of test flies on day 0, 18.4% on week 2, and 17.5% on week 4 when testing ended. Permethrin-treated vinyl killed 12.2% of test flies on day 0, 2.4% on week 2, and none on week 4, effectively ending that test. Bifenthrin-treated vinyl killed 10.2% of test flies on day 0, 37.5% on week 2, and 11.1% on week 4 at which time testing ended. Time-mortality rates of sand flies tested on sunlight-exposed, insecticide-treated vinyl tenting is shown in Figure 5.

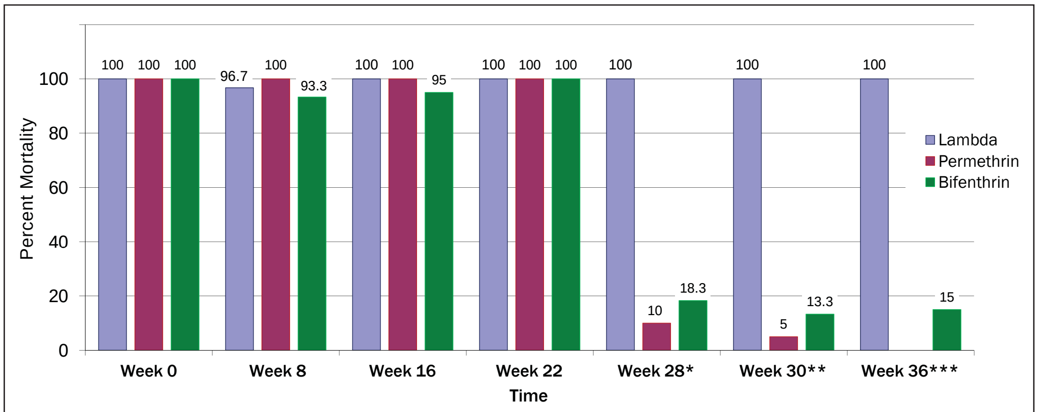

Figure 4. Mortality rates of *Phlebotomus papatasi* to lambda-cyhalothrin-, permethrin-, and bifenthrin-treated, shade-stored cotton duck tenting after initial treatment, May 2009-June, 2010.
Notes:
*Week 28 result for permethrin only. Week 26 results of lambda-cyhalothrin and bifenthrin included in week 28 chart (no data on week 28).
**Week 30 results for lambda-cyhalothrin and bifenthrin. Permethrin result for week 32 included in week 30 graph (no data on week 30).
***No week 36 data for permethrin.

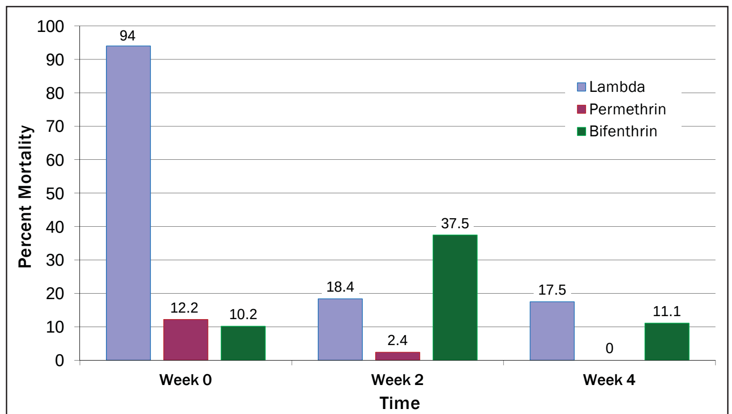

Figure 5. Mortality rates of *Phlebotomus papatasi* to lambda-cyhalothrin-, permethrin-, and bifenthrin-treated, sunlight-exposed vinyl tenting after initial insecticide application, May-June, 2009.

Vinyl, Shade-Stored

Vinyl tenting treated with insecticide and stored on shelves in work space conditions (no sunlight, 22°C-25°C ambient temperatures) provided higher mortality in sand flies than did sunlight-exposed vinyl tenting (Figure 5). Lambda-cyhalothrin-treated vinyl killed all test flies on day 0 and 59% on week 2 before falling off to 37.5% on week 4, the final test date. Permethrin-treated vinyl killed 29.3% of test flies on day 0, 11.1% on week 2, and 10% on week 4, when testing ended. Bifen-thrin-treated vinyl killed 11.1% of test flies on day 0, 26.1% on week 2, and 6.5% on week 4, the final test date. Time-mortality rates of sand flies tested on shade-stored, insecticide-treated vinyl tenting is shown in Figure 6.

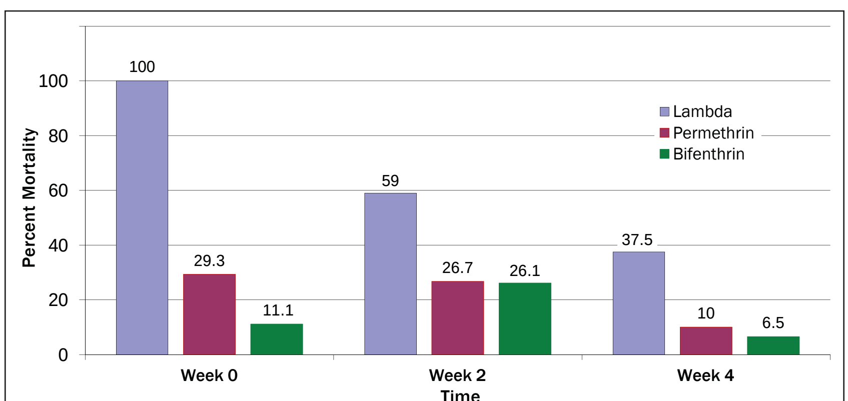

Figure 6. Mortality rates of *Phlebotomus papatasi* to lambda-cyhalothrin-, permethrin-, and bifenthrin-treated, shade-stored vinyl tenting after initial insecticide application, May-June, 2009.

COMMENT

The application of residual insecticides on insect resting surfaces is an important component of programs designed to protect humans from disease-carrying arthropods. In troop deployment situations, displaced persons, or refugee camps, or on short-term contingencies or emergencies in which minimal preparation is afforded those tasked to respond, residual insecticide application to berthing and work spaces takes on increased importance. It has been found that in high temperature, low humidity desert climates common to North Africa, the Middle East, and much of Afghanistan, DoD-stocked residual insecticides can provide long-term protection from sand flies if applied to shaded, indoor surfaces.[2,6]

Lambda-cyhalothrin, permethrin, and bifenthrin are the active ingredients in many commonly used insecticides in the United States and overseas, and are often used as residual sprays for controlling arthropod pests. Our results indicated that cotton duck tent material unquestionably provides a better substrate for insecticide retention than does vinyl tent material, and will provide much longer protection against biting sand flies with both indoor and outdoor (sunlight-exposed) treatments. Lambda-cyhalothrin, a second generation pyrethroid insecticide, has an alpha-cyano group side chain that provides additional stability to the compound against ultraviolet degradation and hydrolysis,[17] whereas permethrin and bifenthrin lack this side chain and are more susceptible to environmental photodegradation.[18] Also, lambda-cyhalothrin formulated as Demand CS is microencapsulated, which provides further protection against environmental degradation. The permethrin and bifenthrin test products were not microencapsulated. Residual treatment of shade-stored, cotton duck tenting with lambda-cyhalothrin, (which is representative of a scenario involving the interior walls of a tent in a field setting), provided the longest duration of control of *P. papatasi*, a common sand fly vector of CL throughout most of the aforementioned region. Under this regimen, all exposed sand flies were killed throughout 38 weeks of bioassay testing, although the end point was set at 6 months (26 weeks).

Effective and extended control (greater than 80%) was produced by permethrin on shade-stored cotton duck through 24 weeks of testing. The efficacy dropped rapidly to 10% on week 28 and then to 5% on week 32, when testing was discontinued. Bifenthrin also provided greater than 80% test fly mortality through 22 weeks, then decreased suddenly on week 26, similar to results obtained with permethrin. We concluded that all 3 products are useful as long lasting residuals on cotton tenting, provided indoor surfaces were treated. However, while both permethrin and bifenthrin provided satisfactory control under such conditions, our results clearly indicate that when available for indoor use on cotton duck tenting, lambda-cyhalothrin is the best choice.

Cotton duck tent treated with all test products and exposed to sunlight provided high levels of mortality for only about a month, after which efficacy dropped quickly. Availability of cotton duck military tents is now the exception rather than the rule. Cotton duck tents are sometimes found in material storage buildings on bases and are being replaced with vinyl tents when they reach the end of their service life. However, there are nonvinyl TEMPER tents, arctic tents, and tent liners used by the armed forces. Once residual treatment has been applied, any of the three aforementioned nonvinyl products could provide useful protection against biting sand flies, especially in temperate climates with short sand fly seasons, such as is common in Afghanistan.

Insecticide-treated vinyl tenting exposed to direct sunlight provided no noteworthy protection against host seeking *P. papatasi*. The efficacy of lambda-cyhalothrin dropped from 94% on day 0 to 18.4% on week 2 and 17.5% on week 4 when testing was discontinued. Just over 30 days had elapsed from the time of insecticide application to the beginning of the test, day 0. The 94% kill rate on day 0 demonstrated that the insecticide application had worked, albeit for a very short while once lambda-cyhalothrin was exposed to sunlight. In contrast, sunlight-protected lambda-cyhalothrin-treated vinyl tent killed all test flies on day 0 and 59% on week 2 before falling off to 37.5% on week 4, the final test date. Although protection was less than desirable during weeks 2 and 4 (less than 80%), some short-term protection against biting sand flies was obtained and will supplement other personal protective measures in the field (N,N-Diethyl-3-methyl benzamide (deet) skin repellent, permethrin-treated bed nets and uniforms). Permethrin and bifenthrin-treated vinyl tenting failed to control more than 30% of test flies at any point in time (days 0, 14, 30), regardless of exposure to sunlight.

The Armed Forces Pest Management Board Technical Guide No. 36[14] does not recommend treating vinyl TEMPER tenting with insecticide. The fire retardant added to an already water-repellent vinyl surface impedes the uptake of insecticide, as clearly seen from these tests. However, some protection is gained for approximately a month if the interior surfaces of a TEMPER tent are treated with lambda-cyhalothrin. In areas where biting pressure is very high and bites can exceed several hundred per night, the added value of treating the inside of TEMPER tents for short deployments is obvious.[2]

Our results indicated that, at best, lambda-cyhalothrin-treated vinyl tent provided minimal control (from 100% control on day 0 to approximately 35% control on day 30) of host-seeking *P. papatasi* under shaded conditions (no direct sunlight exposure). Permethrin- and bifenthrin-treated vinyl surfaces offered no appreciable protection against host seeking sand flies. Nonvinyl tent material, if available as cotton duck tent liners or tent surfaces, can greatly aid in protection against sand flies under hot, sunlight-exposed and cooler, shaded conditions. All 3 insecticides gave excellent protection (greater than 90%) for at least 5 months when used indoors. Under short deployment conditions (less than 30 days), Demand CS will enhance proven personal protective measures (deet skin repellent, permethrin-treated bed nets) against biting sand flies when applied to the interior surfaces of vinyl tents.

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Evaluation of Imidacloprid-Treated Traps as an Attract and Kill System for Filth Flies During Contingency Operations

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ABSTRACT

Two field trials were conducted to evaluate if filth fly trap efficacy was increased by augmentation with an insecticide application to the trap's exterior. Four Fly Terminator Pro traps (Farnam Companies, Inc, Phoenix, AZ) baited with Terminator Fly Attractant (in water) were suspended on polyvinyl chloride pipe framing at a municipal waste transfer site in Clay County, Florida. The outer surfaces of 2 traps were treated with Maxforce Fly Spot Bait (Bayer Environmental Science, Research Triangle Park, NC) (10% imidacloprid) to compare kill rates between treated and untreated traps. Kill consisted of total flies collected from inside traps and from mesh nets suspended beneath all traps, both treated and untreated. Each of 2 treated and untreated traps was rotated through 4 trap sites every 24 hrs. In order to evaluate operational utility and conservation of supplies during remote contingency operations, fly attractant remained in traps for the duration of the first trial but was changed daily during the second trial (following manufacturer's recommendations). In addition, ½ strength Terminator Fly Attractant was used during the first trial and traps were set at full strength during the second trial. Flies collected within the traps and in mesh netting were counted and identified. Three species, *Musca domestica* (L.), *Chrysomya megacephala* (F.), and *Lucilia cuprina* (Wiedemann), comprised the majority of samples in both trials. The net samples recovered more flies when the outer surface was treated with imidacloprid, however, treated traps collected fewer flies inside the trap than did untreated traps for both trials. No significant statistical advantage was found in treating Fly Terminator Pro trap exteriors with Maxforce Fly Spot Bait. However, reducing manufacturer's recommended strength of Terminator Fly Attractant showed similar results to traps set at full strength. Treating the outer surfaces may improve kill of fly species that do not enter the trap. Terminator Fly Attractant was also found to be more effective if traps were not changed daily and left to hold dead flies for longer periods.

Adult filth flies pose a health risk to humans by mechanically transmitting a wide variety of viral, bacterial, and protozoal pathogens.[1] Species in the families Muscidae, Calliphoridae, and Sarcophagidae are of particular interest to military vector control specialists because of their ability to rapidly degrade troop health through mechanical transmission of enteric pathogens such as the causal agents of dysentery and cholera.[2-4] Additionally, significant populations create a nuisance that can degrade mission readiness of deployed personnel. Baited fly traps have been used in many filth fly management programs as surveillance devices but seldom as control devices in the United States due to the offensive odor of attractants. They are used as control devices in other parts of the world but the large number of traps required to suppress adult fly populations, their associated odors, and the maintenance necessary to keep these traps operational make them impractical for fly control in the United States.[5]

Fly traps are an integral part of a filth fly management program for US military forces deployed overseas.[4] Traps with baits such as Flies Be Gone* (Combined Distributors, Inc, Jackson, NJ) that capture flies in a bag may not be optimal for success during contingency operations because the traps fill quickly and additional flies cannot be captured. Also, this trap is not designed to be reused and is typically discarded after a single use. There are reusable fly traps in the military supply system, such as the Fly Terminator Pro trap† (Farnam Companies, Inc, Phoenix, AZ), that consistently capture large numbers of flies in field trials.[6] However, this trap must also be routinely emptied and rebaited for maximum effectiveness.

An alternative to the physical capture of flies alone is the "attract and kill" insect control strategy.[7,8] This strategy

*National Stock Number (NSN): 3740-01-523-0708
†NSN: 3740-01-561-9678

combines visual and/or chemical attractants with insecticides to lure target insects to traps and expose them to a lethal dose of insecticide before they can escape. Thus, if a trap is full and cannot physically capture additional flies, the flies that alight on the trap receive a lethal dose of insecticide, increasing the trap kill beyond what can be physically held in the trap. Some of these systems have been previously evaluated against filth flies with varying degrees of success, but additional research is needed to determine the residual efficacy and environmental degradation of the specific insecticides used in attract and kill systems.[9]

Treating a filth fly trap with an insecticide may not result in increased kill. Some plastic trap materials might be difficult to treat with residual insecticides because water-based insecticides often leave little residue on the surfaces of water-repellent plastics. Also, some commonly used pyrethroid insecticides have high excito-irritancy properties that may negate the impact of the trap's attractants,[10] lessening the trap's effectiveness. Several newer insecticides contain attractants, such as Maxforce Fly Spot Bait (Bayer Environmental Science, Research Triangle Park, NC) (active ingredient 10% imidacloprid), a sugar-baited fly insecticide. Imidacloprid is a member of a new class of insecticides (neonicotinoids), and has been shown to have exceptional potency with generally low toxicity to mammals, birds, and fish.[11]

In contingency and rapid deployment military operations, vector control personnel must reduce fly numbers quickly with a minimal amount of material and equipment. The ability to store large amounts of vector control supplies is frequently hindered by limited storage space, and manpower necessary to routinely service and maintain trapping mechanisms is often limited during contingency operations. Ideally, the effectiveness of filth fly traps could be enhanced by treating them with insecticides available to preventive medicine personnel. If this is possible, it would better serve to protect human health from filth fly-borne diseases not only during military field operations, but also in natural disaster operations and in refugee camps, both of which are increasingly involving US military assistance. The objectives of this study were to examine various application techniques using 2 fly control products to improve overall kill, including:

- Evaluate the efficacy and selectivity of fly species captured using a filth fly trap augmented with a fly-specific insecticide under field conditions.
- Determine whether the addition of insecticide to the exterior of this trap increases fly kill over traps used without insecticide.
- Compare fly capture and kill totals of traps in which Terminator Fly Attractant was not changed versus attractant changed daily.
- Determine if reducing the manufacturer's recommended strength to conserve supplies would result in satisfactory kill.

MATERIALS AND METHODS

Traps and Toxicant

The Fly Terminator Pro trap, shown in the mounting assembly in Figure 1, was selected for the field trials because of its simplistic design, durability characteristics, and demonstrated efficacy.[6] The Fly Terminator Pro is a reusable, fairly inexpensive, (one gallon) trap capable of capturing large numbers of filth flies and is baited with a potent chemical attractant (Terminator Fly Attractant). We chose Maxforce Fly Spot Bait* (10% imidacloprid) for our insecticide because it is a sugar-baited fly insecticide with quick knockdown potency that might prove useful in attract and kill systems.

Trap Design

Four Fly Terminator Pro traps were placed on an A-frame structure consisting of 2.54 cm polyvinyl chloride (PVC) pipe joined with 25.4 cm tie bands into a pyramid arrangement with the trap opening set approximately 50 cm below the apex of the pyramid and the trap bottom suspended approximately 50.8 cm above ground as shown in Figure 1. Traps were sheltered from rain with a circular 30.5 cm diameter aluminum pan. White tulle mesh netting was secured to the PVC pipes with binder clips to capture dead or moribund flies that came into contact with imidacloprid on the outer surface of the traps.

Figure 1. Fly trap and stand. Pyramid arrangement enabled use of the rain shield while keeping the trap at a useful height and minimizing ant contamination.

Field Site and Trap Positions

The field site was located at the Rosemary Hill Solid Waste Management Facility, located 16 km west of Green Cove Springs, Clay County, Florida (UTM 17 428643E; 33 18906N). Four trap sites were located around the fenced perimeter of the waste transfer building, which is on an earthen mound about 10 m above the surrounding landscape. Each trap site varied slightly with respect

*NSN: 6840-01-555-9369

to environmental parameters, and each site was at least 20 m from the nearest trap site at the 4 corners of a square configuration as illustrated in Figure 2. Site 1 was located in partial shade closest to the waste transfer building where it was sheltered from the wind. Site 2 was located in a fairly open area between oleander bushes. Site 3 was surrounded by oleander and somewhat sheltered from the wind, while Site 4 was free of vegetation, received the greatest effects of the wind, and was not shaded.

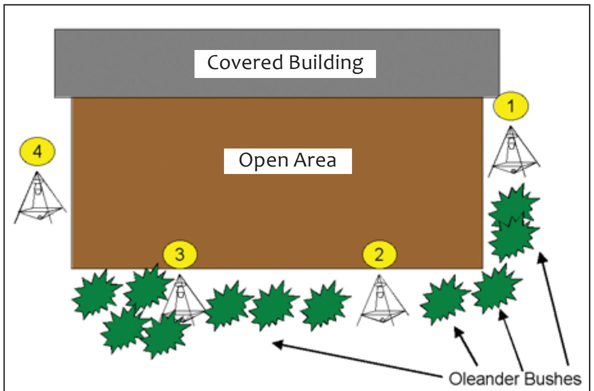

Figure 2. Plan view of fly trap positioning scheme at the Rosemary Hill Solid Waste Management Facility.

Experiment Design

Insecticide application and trapping design comparisons for Trials 1 and 2 are shown in Table 1. For Trial 1, the outer surfaces of 2 of the 4 traps were treated with Maxforce Fly Spot Bait formulated at the label rate (16 fl oz insecticide per gallon (473 mL/3.79 L) of water, prepared at the start of the trial) and applied with a one liter trigger-grip spray bottle until runoff at the beginning of each trial. The interior of each trap was also baited with Terminator Fly Attractant at ½ the manufacturer's recommended strength (0.5 fl oz/gal (14.8 mL/3.70 L) water). The bait was not refreshed during the trial. Treated and untreated traps were placed in an alternating design at sites 1-4, left at the site for 24 hours, and then rotated clockwise to the next site. This was done daily for 7 days from June 18 through June 25, 2008. Following precipitation events, the outer surfaces of 2 treated traps were re-treated with Maxforce Fly Spot Bait on June 19 and June 23 using the same mixture on both dates. Dead flies were collected from the netting daily (9 AM to 11 AM) and the contents of each trap was collected on June 25. A subset of either ¼ or ½ of the total trap catch was collected when the trap catch exceeded transfer container capacity.

The second field trial was conducted from July 29 through August 8, 2008. Traps were placed in the field and rotated as previously described. The outer surfaces of 2 traps were treated daily from July 29-31, and August 4-7 with Maxforce Fly Spot Bait, formulated and applied as described earlier, with new mixtures prepared on July 29 and August 4. Each trap was baited interiorly with Terminator Fly Attractant at full strength per manufacturer label (1 fl oz/gal (29.8 mL/3.79 L) water) and emptied and refreshed with a new mixture of attractant daily from July 29-31 and August 4-7. Dead flies were collected from the traps and netting from 9 AM to 11 AM. Temperature, relative humidity, and rainfall events were recorded daily during both trials.

Table 1. Experimental design and test dates of Trials 1 and 2, Rosemary Hill Solid Waste Management Facility, Clay County, Florida (17 428643E; 33 18906N).

	Trial 1 June 18-25, 2008	Trial 2 July 29-August 8, 2008
Interior trap bait (Terminator Fly Attractant) concentration in water	0.5 fl oz/gal (½ manufacturer's recommendation)	1 fl oz/gal (full manufacturer's recommendation)
Interior bait refresh	Not refreshed during entire trial	July 29, 30, 31 August 4, 5, 6, 7*
Exterior bait (Maxforce Fly Spot Bait) preparation dates (label concentration, 16 oz/gal water)	June 18	July 29 and August 4
Exterior trap surface bait treatments	June 18, 19, 23	July 29, 30, 31 August 4, 5, 6, 7*
Collections	Traps–June 25 Nets–Daily during each visit	Traps–July 30, 31, August 1 Nets–August 5, 6, 7, 8
Trap rotation	Rotated clockwise each daily visit	Rotated clockwise each daily visit

*No traps were set August 1, 2, 3.

Collection and Processing of Samples

For both trials, trap contents were emptied into collection pans and fluid was discarded. Netting samples were placed in vials. All trap and netting samples were returned to the Navy Entomology Center of Excellence (NECE) laboratory at the Naval Air Station Jacksonville, Florida, and stored in a freezer at -29°C until counting and specimen identification could be accomplished. A subset from throughout the entire catch (either ¼ or ½ depending on total trap catch) of flies taken from within the traps was subsequently counted and specimens were identified to species. The total number of specimens counted and identified was then multiplied by the respective number of times that original samples were divided (either by ¼ or ½). Dipterans occurring in small numbers (fewer than 25) were not identified to species. Other insect orders occurred only in very low numbers relative to dipteran species and there was no attempt to

Table 2. The proportion of the 3 primary fly species, *Musca domestica, Chrysomya megacephala,* and *Lucilia cuprina* (with total number of flies from each category in parentheses), attracted and killed by the untreated and treated Terminator® Pro traps during field Trials 1 and 2 (data not log-transformed).

Fly species (N)	Treated trap contents (n)	Untreated trap contents (n)	Net below treated trap (n)	Net below untreated trap (n)	Total (n)
Trial 1					
M. domestica	6.9% (1268)	27.5% (5024)	4.7% (852)	0.02% (4)	39.1% (7148)
C. megacephala	14.9% (2724)	37.8% (6912)	0.5% (91)	0.01% (2)	53.2% (9729)
L. cuprina	0.8% (148)	6.5% (1184)	0.4% (80)	0% (0)	7.7% (1412)
Total % (18,289)	22.6% (4,140)	71.7% (13,120)	5.6% (1,023)	0.03% (6)	
Trial 2					
M. domestica	7.1% (70)	34.1% (335)	40.1% (394)	0.9% (9)	82.2% (808)
C. megacephala	0.8% (8)	3.0% (29)	1.7% (17)	0% (0)	5.5% (54)
L. cuprina	0.8% (8)	4.6% (45)	6.9% (68)	0% (0)	12.3% (121)
Total % (983)	8.7% (86)	41.6% (409)	48.7% (479)	0.1% (9)	

identify those specimens beyond order. Voucher specimens were placed in the NECE insect collection.

Data Analysis

The effects of independent variables (treated/untreated and net/trap) on the number of flies captured were assessed using a mixed model repeated measures ANOVA with data normalized via log (n+1) transformation before analysis (Proc MIXED, SAS 9.2; SAS Institute Inc., Cary, NC). Further analyses (slice option within Proc MIXED, SAS 9.2) were conducted to determine the effects of trap device and insecticide application, and their interaction on fly kill.

RESULTS

It is estimated that nearly 20,000 flies were collected during this study. Three species, *Musca domestica* (L.) (Muscidae), *Chrysomya megacephala* (F.) (Calliphoridae), and *Lucilia cuprina* (Wiedemann) (Calliphoridae), comprised the majority of species collected from the trap units as show in Figure 3. A small number of other dipteran species, including the stable fly *Stomoxys calcitrans* (L.) and eye gnats (Chloropidae), were collected in very low numbers relative to the 3 majority species, but no attempt was made to estimate their numbers. The only nondipteran readily observed in or around the traps was the metallic green histerid beetle (*Saprinus* sp.), which was likely attracted to the fermenting combination of attractant and flies inside the trap. Analyses were conducted only on the 3 dominant fly species previously listed (*M. domestica*, *C. megacephala*, and *L. cuprina*). There was no significant effect on total flies killed due to the position of traps, other than traps located in sheltered positions which did not receive the effects of wind. Site 4 was located in an open, hillside area and received the greatest effects from wind. Flies that were dead in the netting were likely dislodged during stronger winds, therefore skewing downward the numbers collected in the netting at Site 4.

Field Trial 1

An estimated 18,289 of the dominant fly species were collected from the trap units in the first field trial; 17,260 were captured from the traps and 1,029 captured from the nets (Table 2 and Figures 3-6). *Chrysomya megacephala* (53.2%) was the most abundant fly collected, followed by *M. domestica* (39.1%) and *L. cuprina* (7.7%). There were significant differences in the fly kill rate for the untreated vs. treated trap units (F=49.74; *df*=1,28; *P*<.0001), with untreated trap units capturing an estimated 13,126 flies, approximately 3 times more than the imidacloprid-treated traps (n=5,163 flies). When counting trap interior fly catches, no significant difference was found in fly numbers between the treated and untreated traps (F=3.82, *df*=1,28; *P*=.0608). However, there were significantly more flies (n>1,000) collected in nets under the imidacloprid-treated traps than flies (n<10) collected from nets positioned under the untreated traps (F=218.40, *df*=1,28; *P*<.0001).

Field Trial 2

A total of 983 flies were collected from the trap units in the second field trial, shown in Figure 3 and Table 2, nearly 20 times fewer flies than were estimated collected in the first field trial. A comparable number of flies were recovered from the nets (n=488) and traps (n=495), with *M. domestica* (82.2%) and *C. megacephala* (5.5%) being the most and least abundant fly species collected, respectively. Overall, untreated and imidacloprid-treated trap units differed significantly in the fly kill rate (F=40.44; *df*=1,44; *P*<.0001). As with Trial 1, there was no significant difference in the number of flies recovered inside the imidacloprid-treated and untreated traps (F=2.40, *df*=1,44; *P*=.1285), while significant differences were found between the number of flies collected in nets under the imidacloprid-treated traps (n=479) and flies collected from nets positioned under the untreated traps (n=9) (F=55.42, *df*=1,28; *P*<.0001). Interestingly,

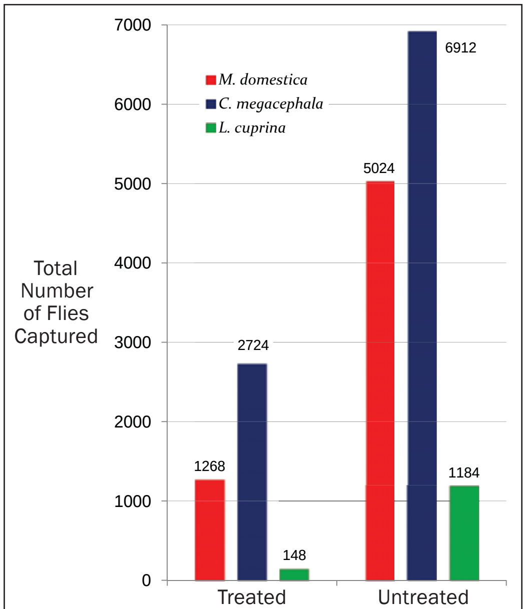

Figure 3. Trial 1, trap data for trap exteriors, untreated and treated with imidacloprid as indicated.

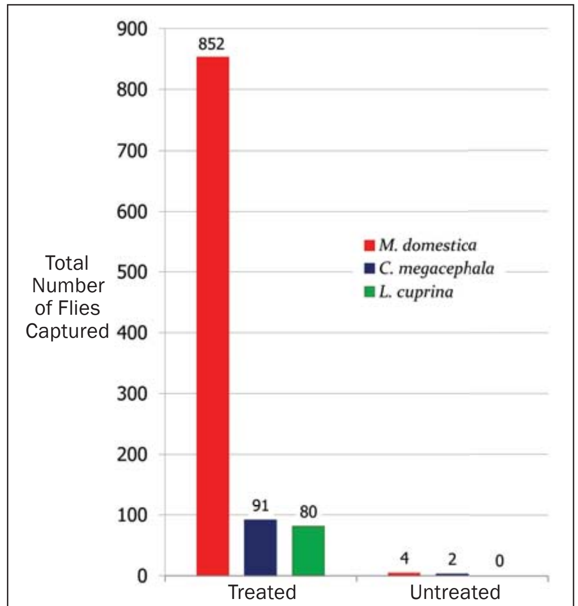

Figure 4. Trial 1, net data for trap exteriors, untreated and treated with imidacloprid as indicated.

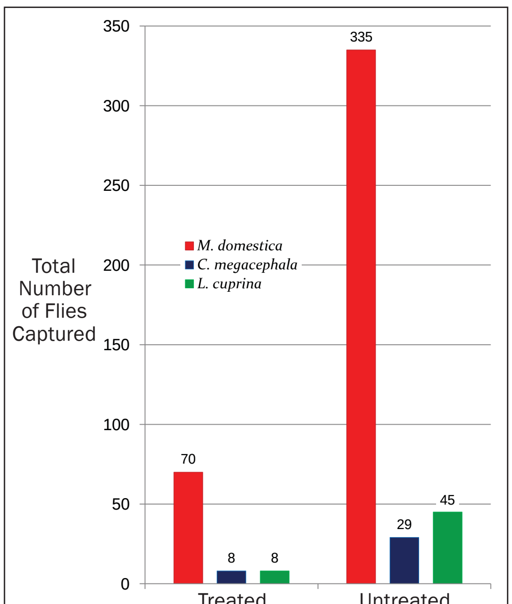

Figure 5. Trial 2, trap data for trap exteriors, untreated and treated with imidacloprid as indicated.

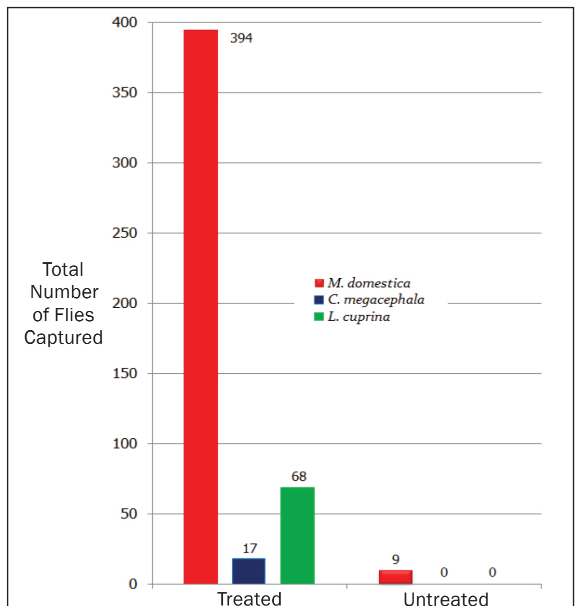

Figure 6. Trial 2, net data for trap exteriors, untreated and treated with imidacloprid as indicated.

similar fly counts were obtained from nets under imidacloprid-treated traps (n=479) and from the interior of untreated traps (n=409).

COMMENT

Depending on how often trap baits are changed, treating the exterior surface of Fly Terminator Pro traps with Maxforce Fly Spot Bait (10% imidacloprid) may not increase overall effectiveness in an attract and kill system. Although more flies were collected from nets placed under imidacloprid-treated traps than untreated traps, untreated Fly Terminator Pro traps collected more flies than the combined totals from interior of treated traps and their nets during both field trials, nullifying the significance of the number of dead flies collected from the netting. However, it is possible that a significant number of moribund flies were able to escape the netting before dying or were displaced by wind or other environmental factors before being collected. In addition, the top portion (lid and handle) of the Fly Terminator Pro traps was not treated, and many flies were observed resting on those surfaces during the study, perhaps not receiving a lethal dose of imidacloprid.

Factors that should be evaluated before implementing fly control methodologies include desired longevity or severity of a fly problem. Environmental conditions and overall purpose will also dictate trap set-up and required maintenance regimens. For longer durations and larger fly populations, the Fly Terminator Pro traps containing attractant and dead flies become more appealing to filth flies, especially to calliphorid filth flies, the longer it is left in traps. There were fewer flies taken during the second trial (N=983) when the trap attractant was changed daily than during the first trial (N≈18,000) when attractant was left in place unchanged. There is likely a synergistic effect of attractant with dead and decaying flies to attract yet more flies to the trap. Numerous *C. megacephala* were observed flying around the inside of the trap after 2 to 3 days during the first field trial, and more *C. megacephala* were ultimately captured within the traps compared to *M. domestica*, as shown in Table 2. In contrast, when the trap contents were changed and refreshed daily during the second field trial, the majority of flies collected inside and outside of the traps were *M. domestica*. This could be attributed to seasonal influences and overall population numbers but could also be due to house fly behavior and physiology (they may land on the outside of the trap before entering and receive a lethal dose of imidacloprid before entering the trap itself). For short durations (less than 2 days), the application of spot bait to the surface of fly traps may increase the effectiveness of control efforts. Maxforce Fly Spot Bait is a wettable powder and will be washed away, especially from plastic surfaces, following precipitation events, making retreatment necessary.

Facility employees commented that fly populations were low during the the second field trial and they did not consider them a nuisance during that period. A major point of contention for these highly attractive traps is whether more flies are being attracted to a given area than would otherwise be found there; thus pre- and postsurveys of fly populations using Scudder grids and similar methods should be made in future studies. However, our assumptions before conducting these trials were that (1) adult fly populations were fairly uniform for a given location during summer months in North Florida, and (2) fly traps attract from a relatively short distance, maybe 30 m to 50 m (oral communication, J. A. Hogsette). No insecticides were applied by county or landfill personnel during these trials. Temperatures and rainfall were typical for north Florida during our trial dates, so we assume that neither weather nor human activities at Rosemary Hill Solid Waste Management Facility impacted fly populations during June, July, and August 2008.

These data indicate that there is potential for combining existing filth fly control products to create a more efficacious attract and kill system, however, expected fly population and control thresholds must first be determined for a given area where filth fly control is warranted. Although overall kill could be increased by treating the outer surface of Fly Terminator Pro traps, based on these data, treating the surfaces must occur daily, especially in areas with high humidity and precipitation. This may not be practical for some fly control programs, especially under contingency circumstances, where available manpower may be limited. Several variables should be more closely examined, such as the residual longevity of the insecticide on the outer surfaces of the traps (to include plastic and paper label on trap) in both hydric and xeric environments, and which kinds of surfaces are more prone to environmental effects such as precipitation, humidity, and dust accumulation. Trap placement (such as spacing, distance from area requiring control) and maintenance (emptying contents and treating outer surface daily vs weekly) to create and maintain an effective barrier should also be addressed. During this study, we found that using only ½ of the manufacturer's recommend strength of Terminator Fly Attractant coupled with changing traps weekly instead of daily, provided sufficient kill under resource-limited contingency settings, and resulted in greatly increased fly kill over full strength attractant-baited traps that were changed daily per manufacturer's recommendations. Future studies could include biological assays to evaluate attractant activity of different lures and currently marketed baits.

One of the goals of the Navy Entomology Center of Excellence and the Deployed War Fighter Protection Program is to develop and evaluate user friendly and economically feasible traps capable of selectively sampling filth-breeding flies. Field conditions for personnel deployed during contingency operations are often less favorable than garrison conditions, thus smaller, lighter, low maintenance traps are preferred, such as, for example, the Florida Fly-Baiter[12-16] which combines visual attraction and cords treated with Maxforce Fly Spot Bait (10% imidacloprid insecticide, with attractants 0.1% muscalure ((Z)-9-tricosene) and 89.9% sugar). Additional research and testing should attempt to identify and adapt available or novel chemical attractants to augment trap efficacy and selectivity. Because few, if any, studies of this type have been conducted to date, this study should provide additional insight into the feasibility of attract and kill filth fly systems for use in integrated fly management programs, and can be used as a stepping stone for similar studies leading to the development of better fly management systems in the future.

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Field Evaluation of Commercial Off-the-Shelf Spatial Repellents Against the Asian Tiger Mosquito, *Aedes albopictus* (Skuse), and the Potential for Use During Deployment

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ABSTRACT

The Testing and Evaluation Department of the US Navy Entomology Center of Excellence (NECE), Naval Air Station, Jacksonville, Florida, is dedicated to the evaluation of novel equipment and vector control techniques to provide guidance on effective protection measures against human pathogens transmitted by blood-feeding arthropods. Personal protective measures (PPM), to include repellents, are part of a series of techniques that contribute toward reducing human-vector contact for globally and domestically deployed military forces. However, improper PPM use and limited availability has created vulnerabilities, causing troops to purchase spatial repellent products that are not approved by the Department of Defense. In order to ensure the most effective products are available, NECE has evaluated the spatial repellency response of *Aedes albopictus* (Skuse) to 4 commercial off-the-shelf (COTS) spatial repellents to provide technical guidance on proper use and effectiveness. The COTS products evaluated ThermaCELL, OFF! Clip On, Lentek Bite Shield, and Bug Button Mosquito Eliminator. A Biogents Sentinel (BGS) trap was placed in 5 locations with a spatial repellent device suspended at the level of the BGS trap opening over 4 of them (the fifth was control). Each trap catch was collected every 12 hours, at which time the spatial repellent device was rotated to the next position. Using this method, each spatial repellent device and control was rotated across each of the 5 locations a total of 6 times. Spatial repellent efficiency was evaluated by comparing the total number of mosquitoes collected in the BGS traps during a 12-hour period. The number of adult mosquitoes repelled by the ThermaCell spatial repellent was significantly more than other spatial repellents with the exception of OFF!. These data indicate that COTS products using repellent insecticide rather than botanicals are more effective at deterring *Ae. albopictus* from biting a host.

Humans have used repellents to protect themselves from pestiferous blood-feeding insects since prehistoric times. The most probable primitive repellent is the use of smoke to mask kairomones (odors from humans who are attractive to host-seeking mosquitoes) and provide relief from insect biting pressure. A personal protective measures (PPM) system that includes the use of repellents is vital to efforts in reducing transmission of vector-borne diseases (VBDs) to military personnel. Prior to World War I when synthetic repellents were introduced, natural plant oils were the principal means of protection against pestiferous insects.[1] Today, the most commonly used repellents are topically applied products, or topical repellents. Topical repellents constitute a wide array of chemicals ranging from natural botanicals such as citronella to synthetically derived N,N-Diethyl-3-methyl benzamide (deet). However, the use of topical repellents is often complicated by an unpleasant smell, oily residue, and dermal irritation. Furthermore, studies to improve the longevity of topically applied repellents have shown a loss in efficiency due to transdermal absorption.[2] To improve user acceptance, additional repellent application methods should be evaluated for efficacy.

The spatial action of repellents is not a novel concept,[3] but their use among the military has been sporadic at best. Although field evaluations of ThermaCELL (The Schawbel Corp, Bedford, MA) have shown the capability to repel biting insects up to 90% for 6 hours,[4] no spatial repellents have been issued a National Stock Number or approved for use by the Department of Defense (DoD).[5] Currently recommended PPM for military members is effective when used properly but has largely been unsuccessful in theater due to limited availability, improper use, and troop concerns with dermal exposure.

The Navy Entomology Center of Excellence (NECE), Naval Air Station, Jacksonville, Florida, evaluates and tests novel techniques or equipment used for preventing VBDs. Commercial off-the-shelf (COTS) spatial repellents are being purchased and used by troops, raising product awareness and popularity. The increase in product use among troops has initiated spatial repellent testing at NECE to provide technical guidance for proper use and product effectiveness. In this article, results from the spatial repellent evaluations and their potential role for use by the military are discussed.

MILITARY PERSONAL PROTECTIVE MEASURES

As Peterson states, "War and disease truly are deadly comrades."[6] It is common knowledge that insect-vectored diseases have devastated military campaigns throughout history. The Napoleonic campaigns alone were crippled by plague, typhus, and yellow fever, literally rewriting military history. Military campaigns create a situation of immunologically naive populations in a concentrated area, exposure to foreign pathogens, and societal stress promoting the perfect storm for a disease epidemic among troops. Due to post-World War II advancements in medical entomology and military medicine, insect-vectored pathogens have had a smaller impact on war. However, deployed troops still face VBD threats that have been both deadly and debilitating to the mission. In 2003, 80 of 225 Marines deployed to Liberia for 10 days fell ill to malaria.[7] Korzeniewski and Olszanski[8] reported a 1% leishmaniasis infection rate among US service members during operation Iraqi Freedom. In 2009, the US Navy deployed multiple teams to Key West, Florida, to provide operational assistance against dengue outbreaks. The continued occurrence of illness caused by VBDs threatens operational readiness of the military and exposes a gap in protection for US troops. However, this gap in protection is not from a lack of instruction or understanding of how to protect troops against vectors and diseases, but rather an apparent reluctance, or outright refusal, of some individual personnel to fully comply with the PPM guidelines.

Currently, the DoD promotes an insect repellent system that outlines 3 protection strategies: (*a*) deet application to exposed skin, (*b*) treatment of uniforms with permethrin, and (*c*) proper wear of uniforms to maximize coverage. This insect repellent system is required by the DoD when exposure to VBDs is likely. In addition, the DoD requires use of additional PPM such as permethrin treated bed nets.[5] This system will provide maximum protection only when components are used properly.

User acceptability of PPM is a constant challenge to its effectiveness. Sanders et al[9] reported that responders in a 2004 study of personnel returning from Iraq and Afghanistan indicated that a majority (51.2%) never used deet, even though most (68.5%) knew that deet was readily available. Of those that did use deet, only 14.6% reported using it more than occasionally. Many fail to follow the DoD PPM guidelines for several reasons:

Manufacturer provided specifications and information for some current commercially available spatial repellent products.

Product	Type	Cost per Unit	Area Covered	Batteries	Butane	Length of Use	Mosquito	Biting Flies	Tick	Comments
ThermaCELL*	Allethrin	$29.99	225 sq ft	No	Yes	4 hours	Yes	Yes	No	Length of use is per insecticide pad. Butane cartridge lasts 12 hours.
ThermaCELL Lamp	Allethrin	$31.99	225 sq ft	No	Yes	4 hours	Yes	Yes	No	Length of use is per insecticide pad. Butane cartridge lasts 12 hours.
OFF! Clip On*	Metafluthrin	$10.00	Personal space	Yes	No	12 hours	Yes	No	No	Odorless
OFF! Lamp	Allethrin	$15.00	225 sq ft	No	No	4 hours	Yes	No	No	Candle used as heat source.
Bite Shield Clip On*	30% Geraniol	$29.99	15 ft radius, 2000 sq ft indoors	Yes	No	120 hours	Yes	Yes	Yes	Also repels lice, fleas, and fire ants.
Bite Shield wrist bands	20% Geraniol	$5.99	Personal space	No	No	120 hours	Yes	Yes	Yes	Also repels lice, fleas, and fire ants.
Bug Button*	Natural oils†	$1.00	Personal space	No	No	220 hours	Yes	Yes	Yes	Also repels lice and many stinging insects.
Flowtron FD-15	Citronella oil fragrance	$24.95	See comment	Yes	No	30 days	Yes	Yes	No	Manufacturer does not specify area covered

*Product evaluated in this study.
†Citronella oil, Phillipine geranium oil, Indonesian lemongrass oil

underestimating the risk of vectors and the diseases they transmit; improper use of insecticide treated bed nets and uniforms; and lack of trust in military issued deet. The lack of knowledge among personnel regarding regional vector threats and proper use of PPM can be addressed with additional training from their commands. However, command emphasis on proper use of insecticide treated bed nets, permethrin treated uniforms, and personal repellents is sometimes ineffective.[10] In addition, even when command emphasis is excellent, personnel are concerned with the short and long-term exposure of some PPM components. Kitchen[11] reported that personnel expressed concerns for their safety when using deet largely because of dermal sensitivities, unpleasant odors, and plasticizing effects. The required daily PPM use is an additional hurdle that further complicates the situation.[12]

Additional tools should be added to the vector control toolbox to improve PPM strategies. Ideally, there should be a vector control component that is easily deployed, tactical, and requires minimal user participation. Product development, however, can take years of research and millions of dollars before something reaches the end user. Therefore, products that are currently available to the general public should be tested and evaluated for military use. Due to the popularity among outdoorsmen in the civilian market, commercially available spatial repellents have drawn the attention of DoD personnel for use against biting arthropods. The NECE initiated spatial repellent device testing and evaluation studies in Jacksonville, Florida, after careful evaluation of commercially available products and trends of use by DoD personnel.

Figure 1. Marketing imagery of COTS spatial repellent devices tested in this study:
A - ThermaCELL Mosquito Repellent (http://www.hermacell.com)
B - OFF! Clip On (http://www.off.com)
C - Lentek BIte Shield (http://www.koolatron.com)
D - Bug Button Mosquito Eliminator (http://www.bugbutton.com)

SPATIAL REPELLENT DEVICE TESTING AND EVALUATION

Nolen et al[13] defined a spatial repellent as a compound, dispensed into the atmosphere of a 3 dimensional space, which inhibits the ability of host-seeking insects to locate a target. A repellent that is dispersed to protect a defined space can be distributed in several ways, including plastic or paper strips,[15-17] coils,[18] candles,[19] fan emanators,[20,21] and heat generating devices.[4,22] In addition, commercially available spatial products currently on the market using repellent insecticides* or natural oils have shown effectiveness. Overall, reports have shown that repellent insecticides provide the most protection, but natural oils have also shown spatial repellency that warrants proper testing and evaluation.[14,23,24] The Table presents a sample of the many spatial repellent products available to the end user, underscoring the difficulty involved in choosing an effective spatial repellent device for protection. Military end users are personnel who deploy both domestically and globally. It is our mission to provide guidance on safe and effective VBD prevention.

To find the best available spatial repellent devices and determine if any are suitable for military use, NECE evaluated 4 spatial repellent devices currently available on the market. The objective of this study was to determine the efficacy of COTS spatial repellents against *Aedes albopictus* (Skuse) (Asian Tiger Mosquito) and evaluate their durability for potential military use. Originally from Southeast Asia, the *Ae. albopictus* (Skuse) is established in 20 countries and has been reported in more than 50 worldwide.[25,26] This container-breeding species is a daytime biter and competent vector of many pathogens including dengue and chikungunya viruses.

The COTS devices evaluated (Figure 1) were: ThermaCELL; OFF! Clip On (S.C. Johnson & Son, Inc, Racine WI); Lentek Bite Shield (Koolatron, Brantford, Ontario, Canada); and Bug Button Mosquito Eliminator (Evergreen Research, Inc, Golden, CO). Biogents Sentinel traps (BGS traps) (Biogents AG, Regensburg, Germany) (Figure 2) were used to provide maximum artificial host attraction to container-breeding mosquitoes that are considered as primary vectors of dengue and chikungunya viruses.[27-30]

In a suburban neighborhood in Clay County, Florida, a single BGS trap was placed in each of 5 separate locations 20 m apart with a spatial repellent device suspended

*An insecticide with aromatic properties that repel insects from reaching their intended target. The insecticide repellents used in this study incorporate an inert absorbent pad impregnated with an insecticide with evaporative emissions repulsive to *Ae. albopictus*, discouraging them from approaching the protected individual.

Figure 2. One of the Biogents Sentinel traps placed at each of the 5 positions during the spatial repellent device study. The trap acted as an artificial host for the *Ae. albopictus* mosquito, using attractant and a 12 volt battery powered system to mimic convection currents created by a human body (green arrows). The mosquitoes enter the trap through the center opening (red arrow) and are trapped for collection.

from a shepherd's hook holder 0.30 m above the trap opening of each of 4 of them (Figure 3). The fifth BGS trap was control, without a suspended repellent device. The BGS traps were started between 6:30 AM and 7:00 AM with continual operation until 7:00 PM to 7:30 PM to obtain a 12 hour diel collection period. Each trap catch was collected every 12 hours, at which time the spatial repellent device was rotated to the next position. Using this method, each spatial repellent device (and control) was rotated across each of the 5 locations a total of 6 times. To ensure consistent operation among the devices, repellents were changed according to manufacture recommendations and power sources (butane, batteries) were changed daily. An analysis of variance was performed on the female mosquitoes collected in the BGS traps during this study with the null hypothesis of no significant difference between any of the treatments. The means were compared using a *t* test at 95% confidence interval. Operational notes were recorded throughout the study to document reliability of the devices during field use.

There were 867 female *Ae. albopictus* collected during this study. As shown in Figure 4, The number of adult mosquitoes repelled by the ThermaCELL spatial repellent was significantly greater than other spatial repellents with the exception of OFF! Clip On ($P>.001$). When compared to the control trap, ThermaCELL reduced trap capture by 76% and the OFF! Clip On reduced trap capture by 64%. The spatial repellent device using natural oils, Bug Button, did not significantly reduce trap capture when compared to the control trap. However, statistically the Lenteck Bite Shield performed as well as the OFF! Clip On and reduced trap capture by 43%. These data indicate that COTS devices using repellent insecticide rather than botanicals are more effective at deterring *Ae. albopictus* from biting a host.

SPATIAL REPELLENT DEVICE RELIABILITY

The ThermaCELL spatial repellent device operated without failure throughout this study. There are no batteries needed to power the device, but due to an internal heat generator, the device gets hot. In addition, this device requires timely user monitoring to change the insecticide pad every 4 hours and the butane cartridge every 12 hours for continuous operation. Furthermore, the manufacturer recommends that the device remain horizontal (not attached to the user) making it difficult for mobility. Use of this device by military members could cause logistical issues with resupply of insecticide pads and butane. A potential heat signature from the device is also a tactical concern.

The OFF! Clip On was less sturdy. During this study, one device failed due to the fan contacting the housing of the unit. This device can be carried directly on the user, facilitating mobility. It uses batteries as the power source and the insecticide pad lasts 12 hours, reducing the amount of attention needed when operating. The housing is a bright blue color, reducing the ability to blend in with the uniform, and the fan is audible during operation. Use of this device by military members could cause logistical issues with resupply of insecticide pads and batteries. The sounds produced by the fan and the color of the housing are also a potential tactical concern.

The Lentek Bite Shield device is sturdy but it was the least reliable of all the devices tested. Two devices failed requiring replacement during this study. This device uses batteries as the power source, its repellent cartridge lasts 120 hours, and it can be carried directly on the user, facilitating mobility. However, the batteries seem to drain quickly, causing the fan to slow and reducing the amount of repellent being dispersed. The housing is white, reducing the ability to blend in with the uniform, and the fan is audible during operation. Use of this device by military members could cause logistical challenges with resupply of batteries, and the sounds

Figure 3. Photos of each of the 4 test items suspended over the BGS Sentinel trap using rope and shepherd hooks:
A - ThermaCELL Mosquito Repellent
B - OFF! Clip On
C - Lentek BIte Shield
D - Bug Button Mosquito Eliminator

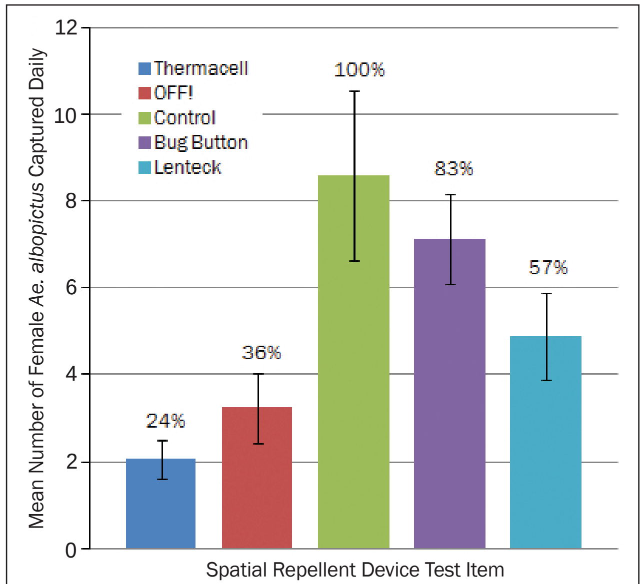

Figure 4. Mean number of female *Ae. albopictus* mosquities captured daily by traps protected by each spatial repellent device over entire study period. The control trap capture is considered to be the 100% baseline. The percentages shown for each device are calculated against the control trap capture total.

produced by the fan along with the color of the housing are potentially a tactical concern.

The Bug Button Mosquito Eliminator is a sturdy, solid disk providing easy set up and maintenance for the user. The manufacturer claims 220 hours of protection and the device can be carried directly on the user, maximizing mobility. There are no logistical concerns with this device making it easily deployable in theater. However, the bright yellow color of the disk does not allow the device to blend in with military uniforms.

SUMMARY

The DoD insect repellent system outlines all necessary measures to provide maximum personal protection against vector-borne diseases. However, lack of consistent participation by military personnel highlight a disconnect between PPM availability and what personnel will use. Even though deet was developed shortly after World War II, it continues to be the "gold standard" of topical repellents. Other personal repellents listed in government supply systems and those available to civilians present some of the same drawbacks mentioned earlier (dermal irritation, unpleasant odors, oily residue) that cause DoD personnel to avoid using deet. There is a need for an additional PPM that is simple to use and does not require dermal application. In theory, spatial repellents should be able to meet these requirements, but the logistical and reliability issues of currently available devices complicate their utility in a deployed environment, and would likely result in reduced use by personnel.

In NECE's spatial repellent study described in this article, it was determined that spatial repellent devices using repellent insecticides are the most efficient at protecting against *Ae. albopictus*, an important vector of dengue and chikungunya viruses.[31] Overall, the ThermaCELL spatial repellent device was the most effective device and is suitable for field use. Results from this study show that this device could potentially reduce biting pressure by 76%, providing a level of protection that will reduce VBD risk among personnel. This device works well for stationary situations where supplies are easily obtained and tactical issues are not a priority. However, this device is not ideal for use during deployments, highlighting a need for the development of a military grade spatial repellent device. Logistical and tactical concerns outlined in this article should be addressed. Future studies should be conducted to develop a military-specific spatial repellent device. The ideal device should be versatile (indoor/outdoor), portable, tactical, easily deployable, and contain repellent insecticides that vaporize at ambient temperatures.

The Navy Entomology Center of Excellence continues to test and evaluate spatial repellents and has partnered with the Walter Reed Army Institute of Research to expand the idea of using spatial repellents to protect deployed forces. Additional PPMs should be made available to military personnel to expand the tools for VBD protection. With resolution of supportability and reliability challenges, these devices can provide protection to our military members, especially in stationary deployment situations.

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The Asian Tiger Mosquito,
Aedes Albopictus (Skuse)

A Long-term Survey of Indian Meal Moths in A Dry Goods Warehouse Using Monitoring Traps With Pheromone Lures

Choe Hyon Chong, PhD

Stored product pest infestation is a worldwide problem. Economic losses of stored products due to stored product pests can amount to 9% in developed countries and to more than 20% in developing countries.[1] Damage by stored product pests include not only the economic loss, but also the inefficient availability of products; potential health issues such as respiratory and skin allergic reactions due to insect hairs, molts, or waste; and excessive use of chemical pesticides that often presents health and environmental concerns. Further, loss of the facility's reputation and customers' trust can result.

The Indian meal moth, *Plodia interpunctella (*Hübner), is widely considered to be one of the most economically important stored dry food pests.[2] This species is tolerant to a wide range of temperature. Indian meal moths live everywhere in the world, except in the Arctic and Antarctic regions. In temperate regions, it can easily survive over years in food manufacturing plants or warehouses, especially when there are no efficient pest management plans. Larvae or eggs stay dormant during cold months (below 13°C) and begin development when the temperature rises.[3,4] Female moths lay eggs when the temperature is between 13°C and 35°C.[5] In Korea, it was determined that Indian meal moths can produce 5 to 6 generations per year in dry vegetable storage areas.[6] Also, the species uses an extremely wide range of dry products as the food source. Larvae eat almost every type of stored products of both animal and plant origins, with a preference for oil seeds and pet foods.[7] Female moths prefer oil products for their oviposition sites, so the newly hatched larvae can easily find food sources.[8] They are also facultative scavengers as they feed on dead cadavers of their species and other small terrestrial arthropods.[5] Indian meal moths often disperse to the outside and stay on lawns around the buildings, although the food source outside facilities is unknown.[9] Furthermore, they have developed resistance to common pesticides.[7]

Changes in the numbers of Indian meal moths were monitored using glue-board traps with pheromone lures in a US military commissary distribution center in the Republic of Korea (ROK), from July 2007 to February 2010. The survey was conducted to discover the pattern of spatial and seasonal aggregations of Indian meal moths in the warehouse and to evaluate pest controls and warehouse management.

MATERIAL AND METHODS

The Warehouse, Cleaning Practice, and Pest Control

The warehouse is a central distribution center, located in the US Army Garrison Yongsan, ROK. As the facility receives, stores, and distributes food and other products into many US military installations in the ROK, successful pest management is critical to prevent the spread of infested commodities to other commissaries, retail outlets, and warehouses. The warehouse encloses 79,897 m^2, and the interior height is 6.1 m. Half of the building was constructed in 1962, and the other half added in 1988. The warehouse receives an average of 25 containers per week.

The cleaning schedule in 2007 was monthly floor mopping and weekly sweeping. It increased to weekly floor mopping and daily sweeping in 2008 and 2009, as numerous moths were captured on pheromone traps in 2007. Phosphate pesticides were applied as an immediate remedy when active growths of Indian meal moths were detected in August 2007 (space fogging), June 30, 2008 (residual spraying), and June 13, 2009 (residual spraying). Pest control dates were determined by trapping data, and types of pesticides and treatment methods were advised by the garrison Department of Public Works.

Trapping

The glue-board type of pheromone trap with attractant for Indian meal moths, 4 related moths (almond moth (*Cadra cautella* (Walker)), raisin moth (*C. figulilella (*Gregson)), Mediterranean flour moth (*Ephestia kuehniella* Zeller), tobacco moth (*E. elutella (*Hübner))), and the cigarette beetle (*Lasioderma serricorne (*Fabricius)) was used (IMM+4 and CB lures, STORGARD Traps; Trécé Inc, Adair, Oklahoma). Pheromone lures were replaced every 60 days in accordance with the manufacturer's specifications.

Traps were placed on the floor underneath pallet rack frames, as stored product pests tend to move close to surfaces such as floors, walls, or ceilings to find resting areas.[10,11] The traps were placed in storage areas for vulnerable food products such as raisins, corn meal, grain, snacks, cereals, and pet food.[12]

The trapping period began on July 25, 2007, and ended on February 2, 2010. The number of traps and intervals of monitoring varied as the program progressed. Seventeen traps were installed in July 2007, and 13 traps were added near cereal and pet food storage areas in August 2007 (Figure 1). These traps were replaced with 19 traps on August 14, 2007 (after a pest control treatment in the warehouse) (Figure 2). The monitoring interval was as short as 2 days in the beginning (July to September 2007), and extended to 5 to 10 days from October to December 2007. Twenty traps were used from April 23 to December 8, 2008 (Figure 3). For the final phase, 14 traps were placed on April 28, 2009 and removed on February 2, 2010 (Figure 4). Monitoring intervals were extended in 2008 and 2009, as the numbers of collected samples were smaller than in 2007. They were checked every 7 to 10 days during warmer months (April to October) and every 20 to 30 days during cold months (November to February).

Data Analysis

Raw data of the numbers of Indian meal moths collected on each date cannot represent the changes of pest population sizes, as they were measured with different numbers of traps and monitoring intervals. Therefore, trap captures were converted to monthly and daily average trap captures. Monthly average trap capture or the number of Indian meal moths collected per trap during a month was calculated using the following formula:

$$\frac{\text{total Indian meal moths collected during a month}}{\text{number of traps}}$$

Daily average trap capture or the numbers of Indian meal moths collected per day per trap was calculated using the formula:

$$\frac{\text{total Indian meal moths collected between 2 monitoring dates}}{\text{number of traps}}$$

The data in the following discussion are stated as mean$\pm$standard error.

In order to detect aggregations of moths, total number of samples collected on each trap were calculated. Also, the data was tested with one-way analysis of variance (ANOVA) using Excel version 2007 (Microsoft Inc, Redmond, WA). The null hypothesis: the trappings were random without being influenced by trap locations. The alternate hypothesis: the trappings were influenced by trap locations.

The traps collected Indian meal moths as well as cigarette beetles and other crawling pests.* Data for cigarette beetles and other arthropods are excluded in this study as they were collected much less frequently.

RESULTS AND COMMENT

Occurrence and Abundance

Indian meal moths were detected in the warehouse from April to November during each year's survey periods, with a tendency of increase toward summer and decrease toward winter (Figures 5, 6, 7). This result is consistent with previous studies for the Indian meal moth life cycle in the ROK.[4,13]

As shown in the Table, monthly average trap captures reached their peaks from June to September. In 2009, a peak was detected at the end of October, when numerous individuals were collected for a short period after replacement of pheromone attractants. As illustrated in Figure 7, the number of collected specimens dropped abruptly afterwards.

Daily average trap captures peaked during August and September 2007 (Figure 5), September 2008 (Figure 6), June and November 2009 (Figure 7). After September, the collections decreased, possibly due to reduced temperature, daylight, and humidity.[7]

The results allowed the prediction of efficient pest control periods in the warehouse. Pesticide applications should be performed from May to June, immediately after active growths are detected in the warehouse. Control by chemicals in July or August should be carefully planned, as they are not likely to kill many larvae that are probably growing inside stored products. Pest control after September is unnecessary and a waste of resources, because the population naturally decreases.

Vulnerable Sites in the Warehouse

As shown in Figures 8, 9, and 10, numbers of trapped specimens were more aggregated in storage areas for pet foods, cereals, crackers, candy bars, and rice. Such items are typically preferred by Indian meal moths as food and oviposition sites.[7,8] Storage for cereals and pet foods are located by the partition wall, which provides shelter to Indian meal moths.[11]

*Most common: centipedes (Chilipoda spp) and roll bugs (Armadillididae spp). However, at most one or 2 crawling pests per trap were captured in a year. In total, less than 15 crawling pests captured in all the warehouse traps in any year of the survey.

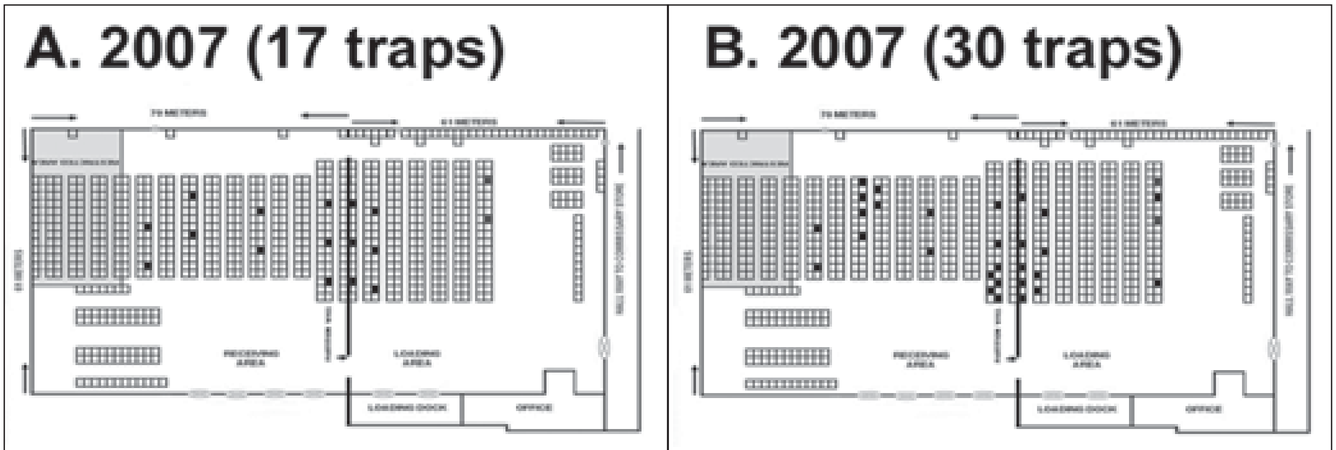

Figure 1. Locations of attractant baited traps placed in the warehouse in July 2007 (A), and early August 2007 (B).

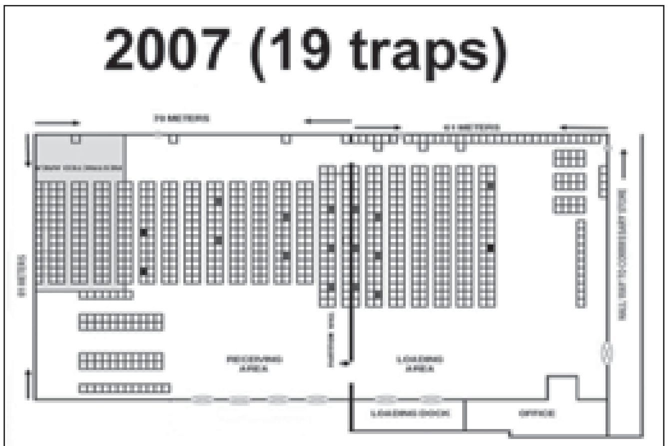

Figure 2. Locations of attractant baited traps placed in the warehouse on August 14, 2007, following a pest control treatment.

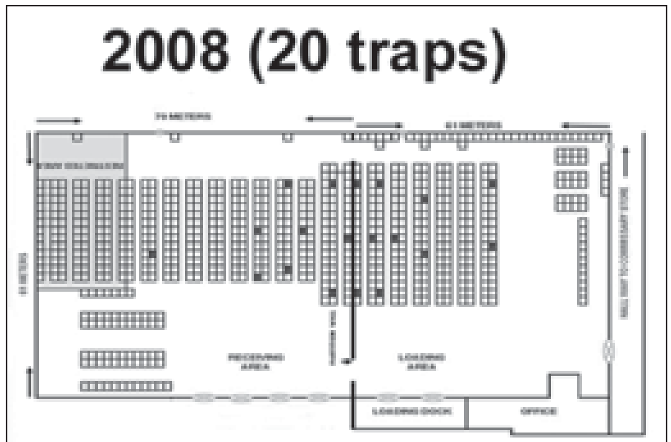

Figure 3. Locations of attractant baited traps which were in place in the warehouse from April 23 to December 8, 2008.

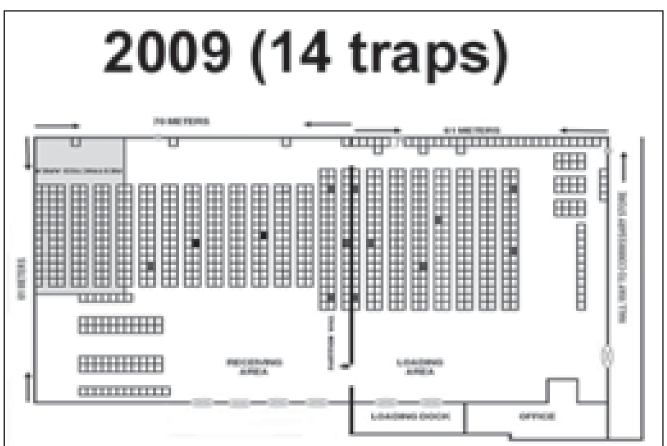

Figure 4. Locations of attractant baited traps placed in the warehouse from April 28, 2009 to February 2, 2010.

Based on one-way ANOVA test, aggregations were significant in 2007 and 2008, at 95% confidence interval: F=4.32, df=15, P=1.73E-07 for 2007; F=2.94, df=19, P=3.1E-05 for 2008. However, it was insignificant in 2009: F=1.68, df=12, P=.08.

Evaluation of Pest Control Treatments

Changes of trapped Indian meal moths before and after a pest control application were negligible in 2007 (Figure 5), however, they were evident in 2008 and 2009 (Figures 6 and 7). In 2007, daily mean captures continued to increase until September, despite a space fogging with residual pesticide that was applied in August. In 2008, population growths diminished immediately after the pest control treatment in June, but were sporadically active from July through November. In 2009, populations were retarded after the control in June, and there were only a few low peaks afterwards.

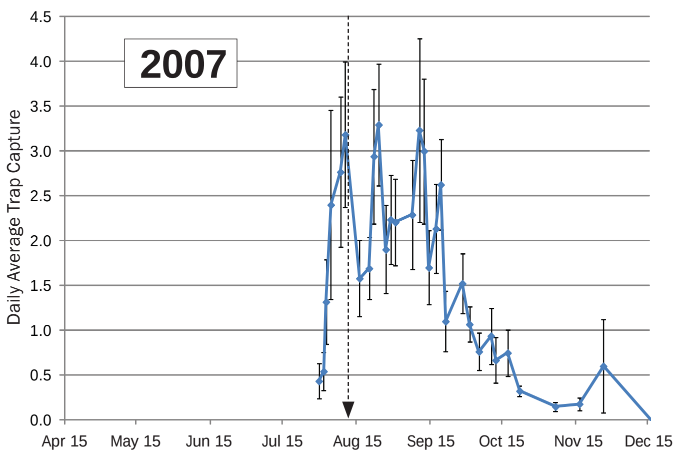

Figure 5. Average (mean±SE) daily trap captures of Indian meal moths during 2007. Note: ▼ indicates pest control treatment in the warehouse.

The findings discussed above suggest that pest control probably cannot be effective when population growths are vigorous. In 2007, when the daily average trap capture was over 4, the number of moths collected by traps stayed at same level (Figure 5). However, pest controls at the early stage of pest development resulted in reduced pest populations. In 2008 and 2009, when pest control treatments were planned, daily trap capture was approximately 1.50 (consistent with the threshold indicated in *Armed Forces Pest Management Board Technical Guide 27*[14]), detected moth numbers decreased after pest control treatments (Figures 6, 7).

Reduction of Pest Populations

In general, detected numbers of Indian meal moths fell over the years of the survey. The average number of Indian meal moths collected per day per trap during the total surveyed period was highest in 2007 (1.64±0.11). They were reduced by nearly one-half in 2008 (0.71±0.05) and in 2009 (0.72±0.09) as shown in the Table. Daily average trap captures often exceeded 4.0 in 2007, but barely reached 2.0 in 2008 and 2009 (Figures 5, 6, 7). The glue board traps used to monitor female moths also actively attracted males. As a result, males collected were not available as mates.

Data on the trapped Indian meal moths were an effective educational tool. Presentation of the data resulted in improvements in warehouse management while the survey was underway. The warehouse cleaning schedule was enhanced in 2008. The loading docks, which are often open during operating hours, were equipped with screens as physical barriers to prevent entrance of pests from the outside. Fans were operated near the vulnerable commodities during summer months, which possibly lowered temperature, distracted movements of the moths, and dispersed commodity odors.[10]

CONCLUSION

The following benefits of long-term monitoring were realized:

- More efficient pest control was available with reduced amounts of use, as trappings demonstrated aggregated sites and seasons.
- Monitoring traps raised awareness among employees, which resulted in positive changes in warehouse management.
- Trapping combined with enhanced warehouse management and efficient pest control reduced the risk of Indian meal moths in the warehouse.

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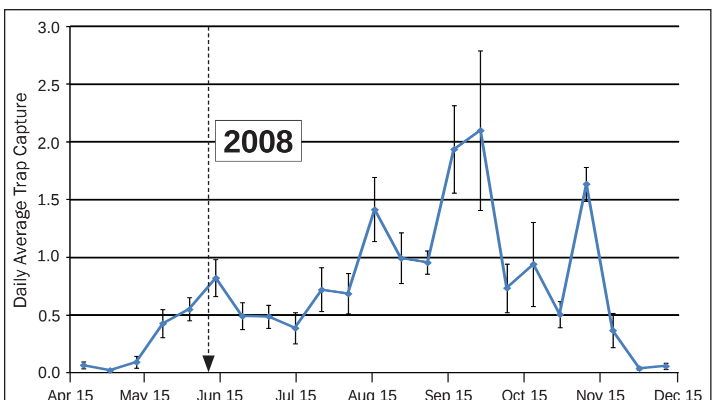

Figure 6. Average (mean±SE) daily trap captures of Indian meal moths during 2008. Note: ▼ indicates pest control treatment in the warehouse.

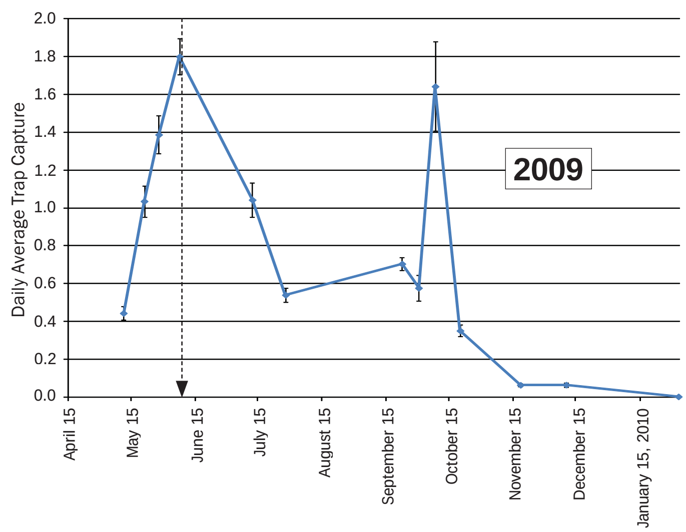

Figure 7. Average (mean±SE) daily trap captures of Indian meal moths during 2009. Note: ▼ indicates pest control treatment in the warehouse.

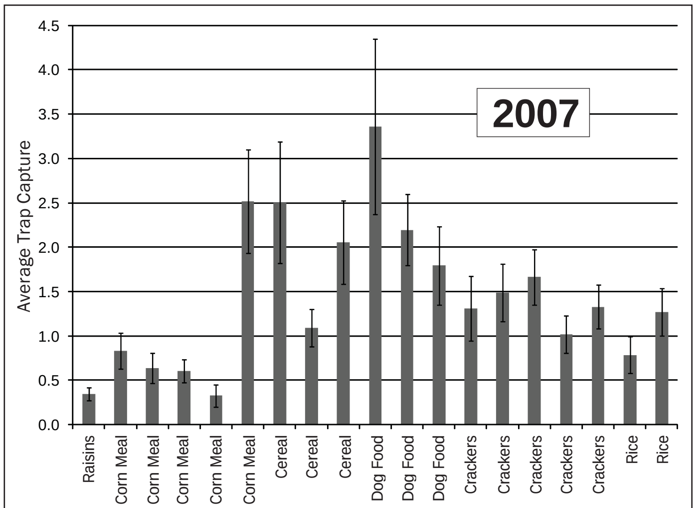

Figure 8. Average (mean±SE) trap capture of Indian meal moths for each trap location during 2007.

Number of Indian meal moths captured by month. Occurrences that disturbed the collection process are explained in footnotes.

Year (No. Traps)	Month	Surveyed Days: Period	Total Trap Capture (Average Collection Per Trap Per Day, Mean±SE)
2007	Jul	15[a]: 25 Jul-10 Aug	817
	Aug	15[b]: 14-31 Aug	652
	Sep	28[a]: 5-28 Sep	1,003
	Oct	22: 1-22 Oct	353
	Nov	34: 23 Oct-26 Nov	98
	Dec	22[a]: 5-27 Dec	0
	Total	136	2,923 (1.64±0.11)
2008	Apr	10[a]: 20-30 Apr	7
	May	28: 1-28 May	218
	Jun	26[b]: 29 May-24 Jun	293
	Jul	25: 5-30 Jul	534
	Aug	27: 1-27 Aug	521
	Sep	30: 28 Aug-26 Sep	896
	Oct	14[a,d]: 27 Sep-10 Oct	194
	Nov	35: 22 Oct-27 Nov	896
	Dec	9[a]: 1-9 Dec	14
	Total	204	3,573 (0.71±0.05)
2009	May	30[a]: 28 Apr-28 May	368
	Jun	9[b]: 29 May-17 Jun	252
	Jul	20: 8 Jul-28 Jul	267
	Aug, Sep	56[c]: 29 Jul-30 Sep	573
	Oct	20[d]: 9-20 Oct	243
	Nov	40[c]: 21 Oct-10 Dec	20
	Dec, Jan, Feb	53[c]: 11 Dec-2 Feb	2
	Total	228	1,393 (0.72±0.09)

Notes:
a. Placement and/or replacement of traps
b. Pest control treatment
c. Lack of manpower
d. Shortage of traps

as they conducted monitoring, maintained traps, and communicated with warehouse managers.

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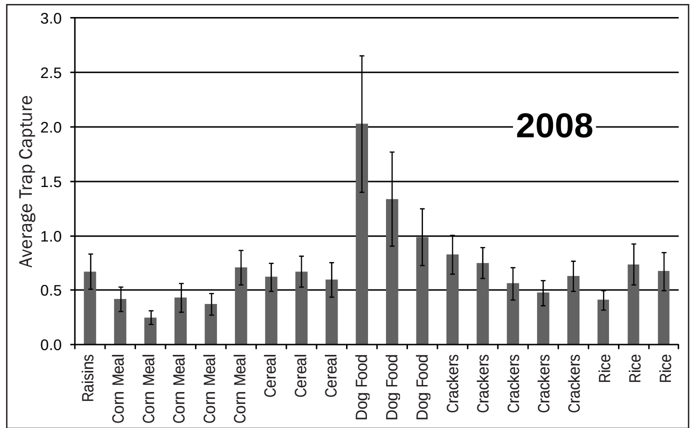

Figure 9. Average (mean±SE) trap capture of Indian meal moths for each trap location during 2008.

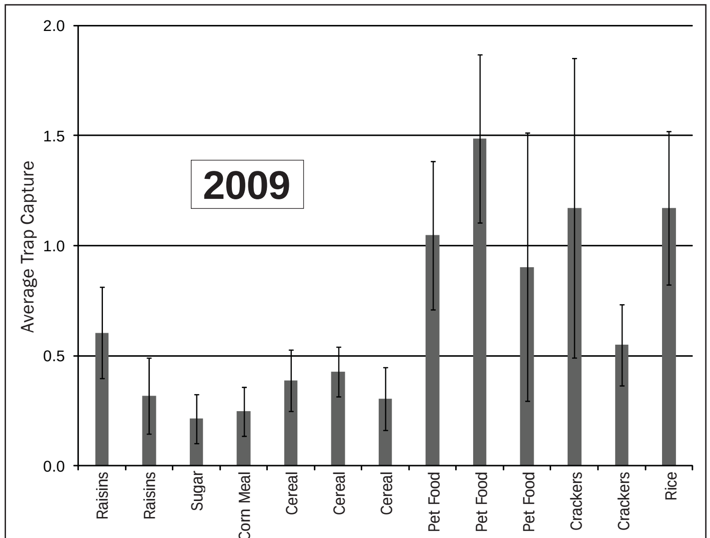

Figure 10. Average (mean±SE) trap capture of Indian meal moths for each trap location during 2009.

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Complications of Male Circumcision Treated at a Military Hospital in Afghanistan

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ABSTRACT

Circumcision of male infants and children is a common ritual in Afghanistan. As in many other developing countries, there are few safeguards relating to the procedure, particularly in rural areas. Performance of ritual circumcision may result in complications requiring treatment beyond the capabilities of the practitioner performing the initial procedure. It is not uncommon for local nationals to seek care at deployed military medical facilities for a wide variety of problems, and complications related to attempted circumcision are no exception. We describe 2 such cases recently presented to a US Army combat support hospital in rural Afghanistan for surgical treatment of the unintended consequences of male circumcision. We offer a review of the most common complications associated with circumcision and treatment options for each. It is valuable for the surgeon operating at the military medical hospital in remote areas of the world to be familiar with the management of the most common complications of circumcision.

Circumcision is a common surgical procedure, performed on approximately 30% of males worldwide.[1] The prevalence of circumcision throughout different regions of the world is variable. The World Health Organization estimates a near universal prevalence rate in predominantly Muslim areas of southwest Asia.[1] A wide variety of practitioners with unverified capability or skills may perform this procedure, particularly in rural areas. Complications of the procedure occur and are more common when practitioners lack adequate training and supplies.[2] The management of these complications may be beyond the capabilities of the practitioner performing the initial procedure, often leading patients to seek help at other nearby medical facilities. The inset "Circumcision in Afghanistan" on page 97 describes the common practice in that country today. We describe 2 patients who recently presented to a US Army combat support hospital in rural Afghanistan and review the management of the complications encountered following attempted circumcision.

CASE 1

A child, aged approximately 4 years, was presented by his father for the complaint of persistent bleeding from the site of circumcision, reportedly performed by a local practitioner approximately 10 days prior. The child's father reported that bleeding at the surgical site had persisted, despite ash being applied to the wound. No fever, nausea, or vomiting were reported and the child was reportedly eating and voiding normally. Examination confirmed the patient to be afebrile. His only wound involved the distal penis, which when cleansed revealed an excessive removal of foreskin, exposing approximately 1.5 cm of the penile shaft circumferentially (Figure 1). Evidence of recent bleeding and clot formation was apparent. The patient's father was counseled regarding the proposed plan of care, which included admission, placement of a urethral catheter, and surgical debridement in the operating room to fully examine the wound.

The child was taken directly to the operating room for debridement of the wound while under general anesthesia and after administration of a deep dorsal penile block and circumferential ring block. The wound was cleansed, hemostasis obtained, and the wound was dressed with gauze dressings soaked in 5% solution of mafenide acetate (Sulfamyalon). He was provided pain control and returned to the ward with the Foley catheter in place. The next day, the patient's father was counseled regarding the plan to close the wound primarily, if possible. Coverage with split thickness skin graft was also discussed by the surgical team in the event that penile skin was inadequate to close the wound without tension.

The operation was performed by first placing simple stay sutures to assist with retraction of the skin and avoiding unnecessary use of forceps. The skin proximal to the


Figure 1 Excessive removal of foreskin

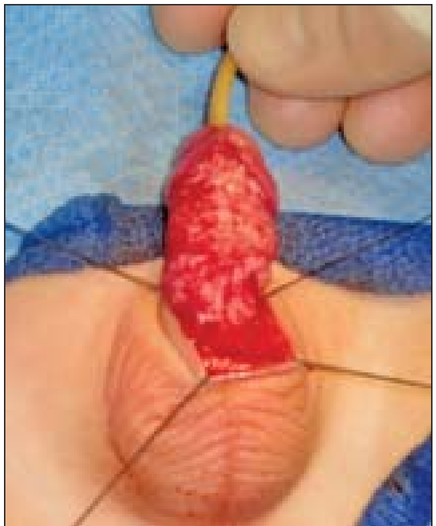
Figure 2. Retraction and undermining of residual skin


Figure 3. Reapproximation of skin to corona

wound was undermined with curved scissors until approximately 4 cm of skin was freed circumferentially (Figure 2). Hemostasis was easily maintained with the use of dilute epinephrine irrigation fluid and needle-tip Bovie electrocautery. Great care was exercised to remain in the plane between the skin and the underlying Buck's fascia to avoid any additional injury to the tissue.

Once free of the subcutaneous attachments, the proximal skin edge was reapproximated to the subcoronal penile skin adjacent to the glans. A series of 4-0 chromic sutures were used in interrupted fashion to reapproximate the skin and close the circumferential defect (Figure 3). The previously placed Foley catheter served as a penile scaffold to allow hands-free manipulation of the phallus during the repair. Once the repair was completed, the wound and glans were dressed with Bacitracin ointment and sterile dressing of Kerlix. The patient recovered quickly from the procedures and demonstrated little pain overall.

The patient's Foley catheter remained in place for 3 days. He was able to void spontaneously soon after removal. On postoperative day 5, the wound was healing well and the patient was discharged home with his father.

CASE 2

A male infant was presented to our hospital by his father who reported bleeding and swelling at the site of circumcision performed on his son several days prior. No other symptoms were reported except that there was no evidence that that infant had voided recently. The child was generally calm, except during the focused examination. Exam revealed the patient to be afebrile and healthy overall except at the site of the penile wound. There was a dark coagulum surrounding the circumcision site and the urethral meatus was not visible (Figure 4). To ensure a proper examination, the patient's father was counseled about the need to move to the operating room to debride the wound and perform a surgical repair, if possible. Once the patient was under the effects of anesthesia and


Figure 4. Coagulum with ash over partially amputated glans


Figure 5. Partially amputated glans and transected urethra


Figure 6. Repair of glans and residual hypospadias

after a penile block was administered, the wound was cleansed and gently debrided, revealing the glans had been partially amputated in an oblique manner as part of the attempted circumcision (Figure 5). The urinary meatus was barely visible at ventral surface near the base of the amputated glans. A 6 Fr urinary catheter was placed through the residual urethra without difficulty revealing ample clear urine. The glans was gently debrided and the transected surface appeared healthy, allowing for reapproximation of the glans tissue to resemble a normal glans structure, albeit with residual hypospadiac meatus (Figure 6). The repair was performed with 4-0 chromic suture. The wound was dressed with Bacitracin ointment while leaving the Foley catheter in place.

Whether or not the patient had distal hypospadias prior to the circumcision is unknown, but such a preexisting condition would partially explain the findings at presentation. The patient tolerated the procedure and remained on the ward with Foley catheter in place for 6 days to allow the transected distal urethra to heal. The urinary catheter was removed and patient voided spontaneously without difficulty. He was discharged home on postoperative day 7.

COMMENT

Commonly used circumcision techniques include the use of the Gomco clamp, Plastibell, Mogan clamp, and a variety of freehand methods. Regardless of the technique used, a wide range of complications can be seen following the procedure, usually divided into acute and late complications. As with any complications of circumcision, the prevalence is difficult to estimate when performed in a nonmedical setting. Acute complications include bleeding, infection, urinary retention, excessive skin removal, and partial amputation. Late complications include inadequate removal of skin, skin bridges, chordee, epidermal inclusion cyst, urethrocutaneous fistula, and meatal stenosis.[3-6]

Bleeding is most commonly encountered at the time of surgery or in the immediate postoperative period. Usually, such bleeding can be easily controlled with direct pressure. Bleeding that is still not controlled can be treated with topical hemostatic adjuncts including dilute lidocaine with epinephrine, thrombin, fibrin glue, and bipolar cautery. Infection is the next most common complication and usually responds well to local wound care and antibiotics, although the clinician should be aware that serious necrotizing infections have been reported. When urinary retention occurs following circumcision, the clinician should be aware that this has been associated with the initiation of a systemic infection and sepsis.

Separation of the remaining penile skin from the excision margin due to excessive skin removal may occur acutely. These wounds should be treated with local wound care and be allowed to heal by secondary intention without a need for skin grafting. After initial skin removal, the proximal edge often retracts and the resultant appearance is that excessive skin has been removed. Reapproximate the skin ends should be attempted, even if this is not possible circumferentially. This often facilitates healing by secondary intent and provides partial skin coverage. The clinician must reevaluate the remaining distal foreskin of these patients closely to avoid scar formation that could result in phimosis or penile chordee.

By far, the most dramatic and serious of the acute complications seen is partial or complete amputation of the glans. Best results are obtained through primary repair of these injuries if possible. A Foley catheter should be inserted into the urethra to identify the urethra and to serve as a handle for intraoperative manipulation. The primary goal is to promote long term nonobstructed voiding which is achieved by focusing on the meatus. This may require a ventral incision and spatulation of a neomeatus to allow for voiding and decrease the risk of meatal stenosis. This will result in a functional hypospadic patient, however, reconstructive options can be entertained. The Foley catheter should remain in place for 1 to 2 weeks to stent the repair and prevent meatal stenosis.

Several complications related to circumcision may present in delayed fashion. Inadequate removal of skin may result in phimosis. Depending on the degree of scarring and amount of remaining excess skin, this may result in a medical threat to the child or simply a cosmetic consideration. Revision circumcision may be performed after careful consultation with the parents of the risks and benefits. Glanular adhesions are another commonly seen complication. These result from a minor injury to the glans during the procedure with resulting scar forming between the glans and the cut edge of the foreskin. These skin adhesions may tether the penis and result in pain or curvature with erection. They may be treated by simple surgical division. Another occasionally seen complication is an epidermal inclusion cyst. This occurs when a portion of epidermis rolls under skin that is primarily closed. Treatment is surgical excision if they become large or infected.

Finally, late complications can be seen related to urethral injury. It is important to remember the superficial location of the penile urethra. Surrounded by a minimal amount of corpus spongiosum, the penile urethra is at increased risk for injury during penile procedures, including creation of a urethrocutaneous fistula. Treatment involves formal delayed repair of the urethra and possible coverage by other tissue such as tunica vaginalis or dartos.

Meatal stenosis can be caused by direct irritation of the meatus that is no longer protected by the prepuce, or by surgical injury that results in tissue ischemia and scarring. Irritation may be secondary to mechanical trauma or from contact with ammonia in a urine soaked diaper which leads to meatitis and meatal ulcers. Treatment with meatotomy may be indicated if significant obstruction to urine flow occurs.

The above examples illustrate complications of circumcision currently being seen at military hospitals in Afghanistan. The deployed military surgeon may be called upon to assist with many similar problems. It is valuable for the surgeon operating at the military hospital to be familiar with the management of the common complications related to circumcision and other procedures performed in developing countries. A list of experience-based considerations and recommendations for management of circumcision-related complications is provided below.

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KEY POINTS TO CONSIDER

- Given the ages of the patients and the nature of the lesions, all examinations and procedures should be done in the operating room.
- Placement of an age appropriate small caliber urethral catheter is prudent as it helps localize the urethra and may serve as an adjunct for manipulation of the penis during the procedure
- Use of stay sutures minimizes unnecessary tissue handling during reapproximation. A small stay suture through the glans can also be used for penile manipulation.
- Use of a deep dorsal penile block with circumferential ring block allows for decreased narcotic use in postoperative pain relief. If available, a caudal anesthetic block is optimal for pain.
- Using a weight-based infiltration of Marcaine at the base of the glans, injected down to the fascia followed by a subcutaneous ring of local anesthesia. Local anesthetic with epinephrine should not be used for this purpose due to risk of vasoconstriction induced ischemia.
- Bipolar cautery is helpful in preventing injury to fragile tissues.
- The primary goal is to ensure unobstructed voiding from a patent meatus.
- Reattachment of a transected glans should be attempted only if there is adequate postoperative support and trained personnel to deal with potential ischemia and sloughing.
- A postoperative urethral catheter can easily be managed using a double diaper technique (cut a small hole in the inner diaper and place the catheter through the hole to drain in the outside diaper, thus separating urine from stool).
- Post skin excision appearance is often deceiving and patients often do well without any sequelae if the cut skin edges are reapproximated after proximal skin mobilization.
- A 5 French pediatric feeding tube can be used when an appropriate size Foley catheter is not available; it can be secured to the glans with suture as required.

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CIRCUMCISION IN AFGHANISTAN

Male circumcision is one of the oldest surgical procedures known, most often performed due to cultural or religious beliefs. Since the 19th century, the procedure has generally been justified for medical reasons. Most commonly, circumcision involves complete removal of the foreskin (prepuce) thereby exposing the entire glans of a flaccid penis.[7] Muslims comprise the largest religious group in Afghanistan and circumcision is regarded as a tradition originating from the Prophet, and therefore beneficial. It is believed that more than 80% of the males in Afghanistan are circumcised.[7]

Although not regarded as absolutely necessary, most parents bring their preschool aged boy to either the local "barber", or, if available, to a "doctor" at a local clinic to perform his circumcision. In the southern provinces of Afghanistan, it is estimated that the village barber provides the service of circumcision for 70% to 85% of the boys. Traditionally this man has 4 tasks in the village: to cut hair, perform circumcisions, and to be the drummer and alternately guitarist at village gatherings. When the boys are aged between 3 and 7 years, the father will make arrangements to meet with the barber. The barber's kit includes 2 essential items: a sharp knife and a bag of ash. He performs his task in the middle of the village. The child is placed on the lap of the father, the penis is exposed, the glans is pushed inward as the foreskin is pulled away and then it is quickly cut with the sharp knife. A poultice of ash is then placed on the bleeding edge of the foreskin to achieve hemostasis. The barber is paid in trade by the family with harvested crops, small livestock, or other bartered services.

The other 10% to 15% of boys not serviced by the barber are taken to the local doctor, who is typically a well-educated male who owns and operates the village drugstore, often considered the village clinic. This practitioner performs the circumcision rite in the clinic. The child is generally provided a mild sedative and anesthetic, likely a narcotic, and the doctor then pushes down on the glans while pulling up on the foreskin and amputates the excess foreskin with a sharp scissors. The exposed edges of the foreskin are stitched to the coronal ring of the glans and the child is sent home with follow-up appointment scheduled for one week later. According to Mr Shafiq Mubarak, Afghan cultural advisor, the procedure performed at the "clinic" generally costs the family about 700 Pakistani Rupees, the equivalent of US $8, a large sum of money for much of the populace.

Erratum

In the January-March 2013 issue of the *AMEDD Journal*, the article "Heatstroke in a Military Working Dog," contains the following incorrect sentence on page 35, left column, first paragraph:

> There was no evidence of bloat on abdominal radiographs, and thoracic radiographs showed diffuse pulmonary disease (acute respiratory distress syndrome/acute lung injury, pneumonia, noncardiogenic pulmonary edema were ruled out).

The correct sentence is:

> There was no evidence of bloat on abdominal radiographs, and thoracic radiographs showed diffuse pulmonary disease, which could have been caused by acute respiratory distress syndrome/acute lung injury, pneumonia, or noncardiogenic pulmonary edema, none of which could be ruled out.

Quarantine and Isolation: A Primer for Military Leaders

MAJ Joseph B. Topinka, JAG, USA

The Centers for Disease Control and Prevention (CDC) Office of Public Health Preparedness and Response (PHPR) website contains a section that addresses the issue of a zombie apocalypse (http://www.cdc.gov/phpr/zombies.htm). The CDC's Zombie Preparedness campaign "began as a tongue-in-cheek campaign to engage new audiences" with emergency preparedness messages. As Dr Ali Kahn, the PHPR Director, notes: "If you are generally well equipped to deal with a zombie apocalypse you will be prepared for a hurricane, pandemic, earthquake, or terrorist attack." The campaign, and indeed the very idea of a zombie invasion, certainly translates well into a discussion about quarantine and isolation. One only has to watch Hollywood zombie movies such as *Night of the Living Dead*, *28 Days Later*, or the critically acclaimed American Movie Channel series *The Walking Dead* to realize the importance of quarantine and isolation rules and the hazards of not following those rules (such as turning into a zombie). While I do not foresee a world-wide zombie pandemic like that described in Brook's *World War Z*[1] coming to a military installation near you, epidemics and pandemics of equal impact are a reality in today's highly mobile society. This article provides an overview of governing quarantine and isolation authorities that both military and federal civilian leaders should understand. Such understanding is important to ensure the military mission is maintained in the face of a medical emergency that could quickly spread installation-wide or further.

FEDERAL VS STATE AUTHORITY

Historically, there has been tension between state and local governments and the federal government regarding the exercise of public health power. In 1824, that tension was demonstrated in the case of *Gibbons v Ogden* (22 US 1 [1824]) dealing with a water navigation rights dispute between New York State and the Federal government. The US Supreme Court voided the New York State law since the Commerce Clause of the US Constitution specifically granted Congress the power "to regulate Commerce with foreign nations, and among the several States…."[2] Chief Justice Marshall specifically stated that "quarantine and health laws…are considered as flowing from the acknowledged power of a State to provide for the health of its citizens."[3] In 1902, in the case of *Jacobson v Massachusetts* (197 US 11 [1905]), an immigrant failed to comply with a town's vaccination order in the face of a smallpox outbreak in Cambridge, Massachusetts. Justice Harlan, delivering the opinion of the court in support of the order, agreed that the Constitution guarantees individual liberties but he looked to the principles of the social compact laid down "for the common good, for the protection, safety, prosperity and happiness of the people, and not for the profit, honor or private interests of anyone man, family or class or men."[4]

The cases support the general police powers of the states under the 10th Amendment of the US Constitution. This power gives the states the authority to declare and enforce isolation and quarantine areas within their borders. Although there is variation among states' approaches to compelled isolation and quarantine, generally, the governor is the person authorized to declare a public health emergency that may trigger the isolation/quarantine restrictions. Most states have enacted isolation and quarantine statutes based on the Model State Emergency Health Powers Act.[5] This model act is designed to be legislatively passed in part or in its entirety by the states. The model act attempts to provide a comprehensive framework for state emergency health powers including isolation and quarantine. An understanding of the model and how a state has applied it, or not, is critical for leaders in command or on military installations within the geographical boundaries of a particular state.

Gibbons v Ogden and *Jacobson v Massachusetts* are two of the most important cases in public health law supporting state's rights, but they do not undercut the federal government's authority to quarantine under certain circumstances. In fact, at the federal level, the United States Surgeon General, with the approval of the Secretary of Health and Human Services (HHS), is authorized by 42 USC §264 (2010) to make and enforce quarantine regulations "necessary to prevent the introduction, transmission, or spread of communicable diseases" including "apprehension, detention, or conditional release of individuals." These powers are implemented through 42 CFR §§70.2, 70.5, and 70.6 (2002) which allow the Director of the CDC to take reasonably necessary measures to prevent the spread of diseases between states if local efforts are "insufficient." They further codify the authority of the Secretary of HHS to require permits for interstate travel by certain infected persons, and to order their detention.

Camp E. A. Perry, Georgia, yellow fever detention (isolation) compound (1888). Photo courtesy of the National Library of Medicine.

MILITARY AUTHORITY

Like state and local leaders, a commander is responsible for maintaining the health and safety of the military installation, facility, or organization under his or her command. This is particularly key to a military commander who, by virtue of his or her position possesses authority to maintain health and safety, may isolate and quarantine personnel and property on a military installation when a threat is imminent, and take action that is reasonably likely to limit the threat. Actions taken by commanders in response to a public health crisis are based on the nature of the outbreak and applicable laws, regulations, and policies. In addition, since a military installation may be under exclusive federal control,* the military commander has broad authority to wield public health powers to protect lives and property under his or her command. It should be noted that determining which military commander has the appropriate authority can be a challenge that requires early coordination and agreement. A proper understanding of the definition of military commander as described in *Department of Defense Instruction* (DoDI) *5200.08*[6] may help in making that determination.

Military commanders have many tools for containing contagious diseases, use of which should be considered before initiating involuntary isolation or quarantine. These tools carry few legal consequences and minimize the cost and inconvenience associated with more drastic measures. Such tools include voluntarily isolation or quarantine, closing facilities such as schools or child care centers, cancelling large public gatherings, encouraging telecommuting, promoting health measures such as frequent hand washing, and distributing surgical masks and hand sanitizers. Should involuntary isolation or quarantine on a military installation become necessary, DoD guidance does apply.[7] However, the decision process to implement said guidance should consider similar actions taken by neighboring local and state authorities to ensure continuity with the greater community.

DoDI 6200.03[7] provides guidance for involuntary quarantine. It permits a military commander, in consultation with the command's public health emergency officer, to declare a public health emergency within the scope of his or her authority. Upon doing so, the commander may then implement relevant emergency powers to achieve the greatest public health benefit while maintaining operational effectiveness. These emergency powers are broad and include authority to isolate or quarantine military and civilian personnel on the installation if it is understood that isolation or quarantine might prevent the spread of a communicable disease. Executive Orders 13295[8] and 13375[9] list qualifying communicable diseases and the list includes: cholera, diphtheria, infectious tuberculosis, plague, severe acute respiratory syndrome, smallpox, yellow fever, and viral hemorrhagic fevers. Interestingly, influenza (flu) is on the list; albeit it is influenza caused by novel or reemergent influenza viruses that are causing, or have the potential to cause, a pandemic.

The military commanders' emergency powers include authority to limit or terminate access to the installation or facility. Commanders can order military personnel to submit to testing and physical examination. They can require nonmilitary personnel to submit to a physical examination and/or testing as necessary for diagnosis. Commanders can require vaccination or treatment to prevent the transmission of a communicable disease. Military members who violate a commander's directive may be subject to disciplinary action in accordance with the Uniform Code of Military Justice.† Nonmilitary personnel are subject to federal statutes including 18 USC

*Not all military installations are exclusively federal jurisdictions. Where jurisdiction is concurrent, coordination with state and local governments is not only critical, but legally required.

†The Uniform Code of Military Justice (UCMJ), a federal law (64 Stat. 109, 10 USC, chap 47) is the judicial code which pertains to members of the United States military. Under the UCMJ, military personnel can be charged, tried, and convicted of a range of crimes, including both common-law crimes (eg, arson) and military-specific crimes (eg, desertion).

§1382 (Entering military, naval, or Coast Guard Property) and 50 USC §797 (Penalty for violation of security regulations and orders). Various administrative sanctions are also available to commanders.

ISOLATION AND QUARANTINE DEFINED

It is important to define the terms quarantine and isolation. People frequently confuse the terms, and their confusion could lead to improper implementation of preventive safety measures on an installation. *DoDI 6200.03*[7] defines both terms:

Quarantine

> The separation of an individual or group that has been exposed to a communicable disease, but is not yet ill, from others who have not been so exposed, in such a manner and place to prevent the possible spread of the communicable disease.[7(p41)]

Isolation

> The separation of an individual or group infected and/or suspected to be infected with a communicable disease from those who are healthy in such a place and manner to prevent the spread of a communicable disease.[7(p40)]

Similar definitions have recently been added to the Federal Quarantine, Inspection, Licensing regulation of 42 CFR 70 et sec.* They are similar to those in the previously mentioned Model State Emergency Health Powers Act.[5] Unfortunately, not all states have the same quarantine and isolation definitions, resulting in confusion, especially for the military installation geographically located in a jurisdiction with a definition that is different from that found in *DoDI 6200.03*.[7]

When teaching, to clarify the difference between the 2 terms to military public health officials, I use the CDC's Zombie Preparedness Campaign and use zombie analogies. Using the Hollywood genre, if a zombie bites a person, the bitten person should be quarantined as the person has been exposed to a communicable disease, but is not yet ill. However, if the person presents with pain and discoloration of the infected bite area, fever, chills, slight dementia, vomiting, acute pain in the joints, heart stoppage, zero brain activity, and then reanimation (as envisioned by Brooks[10]), it is time to isolate the person. My students never forget the difference between the definitions.

DoD QUARANTINE AND ISOLATION PROCEDURES

According to *DoDI 6200.03*,[7] quarantine and isolation shall be accomplished through the least restrictive means available and shall be terminated when no longer necessary to protect the public health. Places of quarantine must be maintained in a safe and hygienic manner, and the installation commander is required to provide adequate food, clothing, medical care, and other necessities to those in isolation or quarantine. Obviously, there is a significant logistical aspect to support these procedures. In addition, there are specific due process rights afforded to individuals which are similar but not exactly the same as those rights afforded in the Model Act.[5] Specifically, the public health emergency officer is required to furnish written notice of the reason for the quarantine and plan of examination, testing, and/or treatment. For anyone subject to quarantine who contests the reason for quarantine, the public health emergency officer must provide an opportunity for that person to present information supporting an exemption or release from quarantine. The commander or designee† shall review the information for determination of the case. The reviewing official shall exercise independent judgment and promptly render a written decision on the need for quarantine of the person. A personal anecdote: during several emergency preparedness exercises, I drafted such notices without example or reference. I normally use formats similar to those used by the state and local jurisdictions surrounding the military installation. They can usually be modified for DoD purposes with little effort while still looking similar to the state and local formats. These similarities help reduce confusion among the military and civilian populations who are living in the area surrounding an installation.

Emergency isolation hospital at Camp Funston, Fort Riley, Kansas, in 1918 for Soldier victims of the influenza pandemic that killed millions of people worldwide between 1918 and 1920. Courtesy of the National Museum of Health and Medicine, Armed Forces Institute of Pathology, Washington, DC. (NCP1603)

*77 *Federal Register* 30729 (Dec 26, 2012): 75880-75884.

†The commander may designate a senior officer or employee of the command who was not previously involved in any factual determination concerning the person being considered for quarantine/isolation.

ISOLATION AND QUARANTINE OUTSIDE OF A MILITARY INSTALLATION

In general, military personnel cannot enforce isolation or quarantine orders imposed by either the US Surgeon General or by state or local governments. Doing so would involve the application of police powers, which is proscribed by the Posse Comitatus Act (18 USC §1385 (1878)). This statute prohibits the use of Army personnel for law enforcement purposes. Enforcement of an isolation or quarantine order issued by someone other than an installation commander is the responsibility of federal law and/or local law enforcement officials.

There are several exceptions to the Posse Comitatus Act. For example, Congress enacted a statutory exception in the Insurrection Act (10 USC §§331-335 (1807)). The Insurrection Act authorizes the president to use federal military forces to suppress domestic violence that hinders execution of state or federal law, or otherwise deprives citizens of their constitutional rights. Federal courts have created 2 common law exceptions to the Posse Comitatus Act, which are commonly referred to as the "military purpose doctrine" and the "indirect assistance doctrine." The first exception, military purpose doctrine, allows the use of military personnel in a law enforcement capacity when the operation has a specific military purpose. As a result, military personnel may be used in a law enforcement capacity on a military installation or to protect military personnel or property. The second exception, indirect assistance doctrine, allows for the use of federal military personnel in a passive role that only indirectly aids law enforcement, such as the use of military facilities or equipment by civilian law enforcement personnel. Since the Posse Comitatus Act only prohibits the use of federal military personnel in a law enforcement activity, the statute's prohibitions do not apply to members of the National Guard when in Title 32 status (primarily state active duty).* However, Posse Comitatus does apply to National Guard personnel in Title 10, Federal status (full-time duty in the active military service of the United States).* Thus, National Guard members serving in a nonfederal status can be used to enforce a quarantine order that is issued outside of a military installation.

Finally, it is important to understand that pursuant to *DoD Directive* (DoDD) *3025.18*,[11] a commander at any level, especially an installation commander, can provide immediate assistance to save lives, prevent human suffering, or mitigate great property damage under imminently serious conditions. "Immediate response authority" is based in the belief that local and state authorities may not be able to immediately respond in sufficient numbers to an emergency incident that requires saving lives, preventing human suffering, and mitigating great property damage. This authority is used only under unique conditions, when guidance cannot be obtained from higher headquarters on a timely basis, due to an attack on the United States or other emergency circumstances. Under these circumstances, DoD component personnel may apply DoD resources during Defense Support of Civil Authorities operations[11] in the following order of priority only:

1. To save human life.
2. To mitigate human suffering.
3. To protect essential US governmental capabilities, such as continuity of the US government.
4. Protecting US governmental officials.
5. Prevention of loss or destruction of federal property, and restoration of essential federal functions.
6. To preserve or restore services of state and local government.

This authority should be exercised sensibly and with prudence. Beyond the situations listed, nonlaw enforcement assistance should only be provided in compliance with the Robert T. Stafford Emergency Disaster and Assistance Act (42 USC §§5121-5206), implemented by *DoDD 3025.18*.[11] The Stafford Act authorizes the President to declare a major disaster or emergency if an event is beyond the combined response capabilities of the affected state, territorial, and local governments. Following a declaration, the President may direct any federal agency to use its resources in support of state and local assistance efforts. If an emergency involves an area or facility for which the federal government exercises exclusive or primary responsibility and authority, the President may unilaterally direct the provision of emergency assistance.

The guidance and information contained in this article should ensure that military commanders and federal civilian leaders are legally well-prepared for a zombie apocalypse (or lesser medical catastrophe) in terms of quarantine and isolation authorities. The task of synchronizing federal responsibilities and authorities with state and local authorities, and with military commanders' responsibilities under *DoDI 6200.03*,[7] can be confusing and daunting. Considering the potential magnitude of an epidemic or other medical crisis, the value

*http://www.arng.army.mil/SiteCollectionDocuments/Publications/News%20Media%20Factsheets/ARNG_Factsheet_May_06%20ARNG%20fact%20Sheet.pdf of understanding the laws, regulations, and guidance in this article cannot be overstated.

ACKNOWLEDGEMENT

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American Soldiers in communicable disease quarantine confinement, 8th Evacuation Hospital, Casablanca, North Africa (1943). Photo courtesy of the National Library of Medicine.

The Battle of Yellow Jack: A Comparative Look at Preventive Medicine During the American Civil War

COL Barry F. Graham, USA

The US Army is an organization built upon what is often described as "tribal lore." Tribal lore is a concept whereby the elders of the tribe imbue the lessons learned from past trials, tribulations, and experiences to the younger members of the tribe. In tribal societies, this feat is accomplished through storytelling, observation and emulation. In short, tribal lore at its most basic foundation is the application of best practices and lessons learned. The modern US Army employs the same techniques, albeit in a codified and structured, methodological manner, through the after action review process and ultimately the creation of doctrine and Army regulations.

The current *Army Regulation 40-5* [1] specifies:

> The overall objectives of field preventive medicine are to provide commanders with healthy and fit deployable forces; to sustain the health and fitness in any military operation; and to prevent casualties from DNBI [disease and nonbattle injuries] and stress reactions.[1(p4)]

But what did the Army do before the implementation of Army-wide policies and regulations concerning preventive medicine? History is replete with examples of what the Army did or, more often than not, failed to do. One need only look a mere 150 years in the past to find prime examples.

During the American Civil War, the most costly of all American conflicts, it is estimated that over twice as many Union Soldiers died of diseases (250,152) than were killed in action (110,070).[2] Clearly, preventive medicine, or the lack thereof, played a key role in the composition and disposition of the Union Forces during the American Civil War. An example of that fact is the story of how two Union commanders, during two different years in two separate theaters of war, approached the same task of executing preventive medicine programs to thwart yellow fever, resulting in two completely different outcomes.

MG Benjamin Butler, a politically appointed general with no formal military training, arrived to take control of the fallen Confederate city of New Orleans, Louisiana, on May 1, 1862. Occupying and controlling the rebellious, former Confederate shipping hub would be a daunting task for Butler and his Union forces requiring the full range of public administration tasks, not the least of which was dealing with annual scourge of yellow fever.[3(pp36,37)] Yellow fever was colloquially known as "Yellow Jack," a name derived from the age-old nautical tradition requiring arriving ships with known health problems to fly the all-yellow international maritime signal flag for the letter "Q" to signify that a contagious disease was present on the ship. That ship and its crew were then under quarantine until cleared by the port authority medical staff.[4]

Yellow fever was the most mysterious and terrifying of all southern diseases. It is typified by fever, jaundice, headaches, bleeding from the nose and mouth and in its final stages, vomiting of a dark, coffee ground-like material which was actually half digested blood. Fatality rates for those afflicted with this malady ranged up to 50%. Those who did survive a yellow fever outbreak were rewarded with life time immunity to the disease. The fever appeared annually throughout the coastal regions of the south during the late summer months and had the potential kill hundreds, or even thousands, especially the unacclimatized. For this reason, yellow fever was often known locally as "the strangers' disease." The fear of this disease had major psychological impacts upon the northern Soldiers of Butler's command who marched into the streets of New Orleans in 1862.[3(pp3,15)] It appears that many in Butler's command were more afraid of yellow fever than they were of any Confederate Soldier.

The cause of yellow fever was still unknown in 1862. Not until the groundbreaking work of Army physician MAJ Walter Reed in the early 20th century would the medical community understand that yellow fever was actually spread through the bites of the *Aedes aegypti* mosquito.[5] The conventional medical wisdom of the mid 19th century medical community held that yellow fever was spread through unsanitary conditions and the unhealthy, bad air created by those conditions. In fact, this theory is partially true. Unsanitary conditions created havens for the mosquitoes, and thereby perpetuated the spread of the deadly disease. Based upon the perceived impact yellow fever would have on his command and the need to do something about it, Butler devised a plan to establish a proactive campaign to battle the conditions of Yellow Jack. He believed that if he eradicated the conditions required for Yellow Jack, meaning the bad air, he could then control the disease. Butler's plan was simple and straightforward. First, he consulted not only with his assigned Union Army medical staff, but more importantly with the local doctors. By virtue of location, the local physicians had experience in dealing with the annual yellow fever outbreaks, although many of were initially reluctant to assist.[3(p38)]

Butler implemented a 2-pronged, simultaneous attack on yellow fever in New Orleans. His strategy included a strict quarantine of any vessels arriving in New Orleans and a comprehensive field sanitation program to rid the city of bad, unhealthy air. A ship quarantine station was established some 70 miles south of the city, manned by Union troops and local physicians with orders to detain and quarantine for 40 days any vessel thought to be infected with yellow fever. In a rather Draconian step, Butler threatened the local physicians with execution in the event that any infected ship was allowed though the blockade. Simultaneously, Butler employed a literal army of local workers and Soldiers to work around the clock executing a wide range of field sanitation efforts to remove standing, stagnant water, trash, and human and animal waste products throughout the city. The northern press praised Butler's initiatives, with Harper's Weekly stating that "he will probably demonstrate before the year is out that yellow fever, which has been the scourge of New Orleans, has been merely the fruit of native dirt and that a little Northern cleanliness is an effectual guarantee against it."[3(p38)] In 1863, Harper's Weekly published a cartoon of a scrub brush and soap wielding Butler standing in front of an approving Abraham Lincoln. Butler's efforts ultimately had the results that he sought; only 2 cases of yellow fever death resulted in New Orleans in all of 1862 and, more importantly, the paralyzing fear of yellow fever which once strangled the northern troops as they entered New Orleans was mitigated under Butler's Union control.[3(p38)] Butler's efforts had controlled the disease as well as the fear that it created. Butler's actions had a long-term impact of the Crescent City, with only 11 yellow fever deaths occurring in New Orleans between 1862 and 1865. However, after civil authority was returned to the civilians of New Orleans in 1866, 185 people died of yellow fever. That number soared to 3,107 deaths in 1867. Over 4,000 died of yellow fever in New Orleans during the sweeping epidemic of 1878, including noted Confederate General John Bell Hood, his wife, and one of his 11 children.[6]

Butler's fundamental but effective preventive medicine program had proved successful in New Orleans. However, the scene 2 years later and 965 miles away in New Bern, North Carolina, was a different story altogether. The eastern North Carolina community of New Bern is a low lying town, surrounded by swamps and marshy land. The summer of 1864 had been characteristically wet and humid, bringing with it swarms of the ubiquitous southern mosquitoes. Since its occupation by Union forces in 1862, New Bern had become a military hub, crowded with troops and the trappings of an army of occupation. MG Butler himself, as he approached the town in 1864, described New Bern as having "an awful stench" and further observed that the sanitation ditches in the Union camps were never filled in or covered, and the camps were moved when the smell of human excrement made the location of the camp unbearable.[7] Unlike Butler's command in New Orleans 2 years earlier, BG Innis Palmer's command had taken virtually no preventive medicine steps that did anything to thwart a yellow fever outbreak. In fact, the lack of Union camp sanitation plans and poor Union camp discipline, combined with a long, hot, wet summer, obviously had the opposite effect, actually setting the stage for a yellow fever epidemic.

When yellow fever did strike New Bern in 1864, it began very quietly and without much fanfare. History reports that SGT Mason Rogers of the Fifteenth Connecticut was the first yellow fever casualty of 1864, succumbing to the ravages of the disease on September 9, 1864. Union surgeon Dr Hubert V. C. Holcombe, who had spent time in Vera Cruz, Mexico, before the war and was well acquainted with the symptoms of yellow fever, reported the death and his suspicion about a yellow fever outbreak up the Union chain of command. None of the other Union physicians had ever personally observed a yellow fever outbreak. That was about to change. Medical Director for the Department of North Carolina, Dr D. W. Hand, initially denied the existence of yellow fever within the command and is even reported to have scolded Holcombe for trying to create a stir. When presented with overwhelming medical evidence of the disease, Dr Hand finally relented and acknowledged the existence of yellow fever and reported the findings to his superior, BG Innis Palmer. Dr Hand received treatment in kind from BG Palmer and was subjected to scorn and ridicule, while being accused of ignorance of southern diseases.[3(p106)]

Finally, in the face of increasing sickness within the command, both Palmer and Hand were forced to accept that yellow fever had indeed struck New Bern. However, the District of North Carolina chain of command kept the outbreak from the press for fear of creating a panic amongst both the Union troops and the North Carolina population. Palmer and Hand's efforts proved fruitless, since history records that Union sailors as far south as Beaufort, South Carolina, knew of the outbreak of symptoms of yellow fever even before Sergeant Rogers' death.[3(p106)] Because of cover-up and initial inaction, the District of North Carolina and the Union garrison at New Bern were forced into a reactive rather than proactive scenario with regard to dealing with the yellow fever outbreak.

When finally spurred to action, Union forces in New Bern executed with a vengeance in an attempt to thwart the spread of yellow fever. Union officials enacted a strict quarantine system and burned pine branches and barrels of tar in the streets to "purify the air." Buildings thought to be infected with yellow fever were burned to the ground, and as many healthy Soldiers as possible were given furlough or transferred to "healthy" locations inland to prevent their infection, although some units remained in place to maintain law and order, implement sanitation measures and care for the sick.[3(p107)] By October 1864, the plague had hit its peak and Union forces were so decimated by the disease that Union officials ordered the newly formed and untrained First North Carolina Colored Heavy Artillery to move rapidly to New Bern to assist with sanitation operations. It was believed that that the locally raised black troops would be immune to yellow fever and thus fare better in New Bern. The First North Carolina reportedly spread 200 loads of lime around the dwellings of New Bern making the city appear to be blanketed in snow. Likewise, the First North Carolina cut down and burned over 500 cords of woods as well as 200 barrels of turpentine.[7(p24)] However, contrary to the conventional medical thought of the day, the locally raised Soldiers of the First North Carolina were not completely immune to yellow fever; 58 Soldiers fell sick with the disease, and 15 of them died. The first frost of November 1864 brought an end to the epidemic. However, the total cost to Union forces was 763 Soldiers sickened by yellow fever and 303 died. Additionally, 16 medical personnel were sickened by the disease, 8 of whom died.[3(p107)] In 1864, yellow fever caused more casualties to the Department of North Carolina than the Confederate Army. In addition, historians estimate that the civilian death toll from the outbreak in and around New Bern numbered well over 1,000.[7(p26)]

The net result of the yellow fever outbreak in New Bern was that the Union Army's Department of the Southeast finally published strict standing orders, based largely upon the horrors of the New Bern epidemic. These orders required district level commanders to maintain sterling camp sanitation standards (including the very liberal use of lime), the quarantine of all Confederate deserters and refugees, and to keep the results of New Bern quiet to avoid a panic amongst the Soldiers, the civilian population and the press.[3(p107)]

Based upon the historical facts concerning these separate preventive medicine operations, what lessons can be learned that apply for commanders in the 21st century? How did actions, or inactions, by each command ultimately impact the operational capability of the commands, and what were the long-term implications?

Dr Lion Poles of the Kaplan Medical Center (Rehovot, Israel) provides an excellent, simple, 12-step model for biological event consequent management consisting of the following logical steps[8]:

1. Preparation
2. Detection
3. Diagnosis/event confirmation
4. Containment
5. Management of the population at risk
6. Triage
7. Management of the sick
8. Handling of the deceased
9. Dealing with high risk zones
10. Investigative actions
11. Political aspects
12. Determining the end of the event

When overlaid upon the Poles 21st century biological contingency model described above, we can easily see that Butler's preventive medicine campaign closely followed that model, beginning with step one. Butler's concerns regarding the future impact of yellow fever on his command drove him to prepare his Soldiers, his command, and the city of New Orleans for an epidemic. First and foremost, Butler did an excellent job of assessing the situation and devising a strategy. He relied upon and was greatly assisted by local expertise, which formed the foundation of his plan to suppress the outbreak of yellow fever in 1862. Next he implemented his 2-pronged preventive medicine strategy designed to detect the sources for the disease—incoming ships and unsanitary conditions. Butler's strategy of containment kept infected ships out of New Orleans via his quarantine stations, while his sanitation teams rid the city of the conditions that perpetuated the disease, effectively containing the conditions that supported its spread. These proactive actions allowed Butler to manage the population at risk, and to keep New Orleans free of a yellow fever epidemic in 1862. Butler's actions negated the need to apply the other steps in the Poles' model because the proactive actions of his command effectively stopped the disease through 1865. Butler's actions maintained the health of the command and the city in general while, perhaps more importantly, eradicating the paralyzing fear of yellow fever that gripped the Union Soldiers and the residents of New Orleans. As a commander, he kept his forces healthy and preserved combat strength for other operational requirements.

MG Butler's success in New Orleans in 1862 provided the Union Army with an effective model and means for dealing with the ravages of yellow fever in southern climates. The details of Butler's actions in New Orleans were well known in the northern press and broadcast throughout the Union. However, Civil War Army planners and commanders alike failed to recognize the utility of the preventive medicine successes that Butler's command had achieved in New Orleans and failed to standardize any proven preventive medicine tactics, techniques, and procedures across the Union Army. The 1864 debacle in New Bern provides proof and illustrates the consequences of this failure.

Because the Department of North Carolina failed to prepare for a yellow fever epidemic and were slow to detect, diagnosis, or acknowledge the outbreak, the Union command found itself thrust rapidly into the throes of a growing epidemic and was forced to execute all the steps of the Poles model at an expedited, feverish rate. The debacle of New Bern in 1864 probably could have been avoided; well over 1,000 lives, both military and civilian, saved; and combat power sustained had Union military commanders recognized, acknowledged, and publicized the lessons MG Butler had learned and applied in New Orleans only 2 years earlier. Unfortunately, the US Army of the 1860s had yet to develop the self-critical after action review and lessons learned culture that is institutionalized today.

When examining preventive medicine requirements and best practices, today's commanders have the benefit of a codified and time-tested preventive medicine biological strategy as presented in *Army Regulation 40-5*.[1] The regulation gives straightforward, clear guidance for any commander in regard to his or her role in protecting the health and safety of the Soldiers and civilians residing on the installation:

> Installation commanders are responsible for resourcing and implementing the preventive medicine components of installation infrastructure and services in coordination with the director of health services and the chief of preventive medicine services. Installation commanders provide the safe and healthy living and work environments and services such as drinking water, food, safe worksites, and recreational activities. Preventive medicine personnel provide the medical oversight and monitoring of installation infrastructure and services that may pose health threats. They provide the technical advice and assistance to installation commanders to minimize risks from such threats.[1(p17)]

Commanders today have the benefit of both historical hindsight and fully developed, time-tested biological contingency management models, as well as the expertise of preventive medicine professionals at the installation. However, commanders at all levels must still exercise their responsibility to fully and regularly engage and empower those preventive medicine personnel in order to be fully prepared for any biological contingency.

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A New Volume in the Borden Institute Textbooks of Military Medicine Series

Military Quantitative Physiology: Problems and Concepts in Military Operational Medicine

Karl E Friedl, PhD, and William R. Santee, PhD, Editors

COL (Ret) Brian Lukey, USA

For as long as there has been a US Army, it has been challenged with maintaining performance effectiveness—fueling (feeding) and maintaining hydration of individuals and large groups in challenging environments, and dealing with stressors such as fatigue and uncompensable heat. Modern problems introduced by technology such as lasers and improvised explosive devices also make the military the go-to place for research and information that relate to civilian issues, such as commercial laser eye safety standards or blast risks from automobile airbags.

The US Army Medical Research and Materiel Command and the Borden Institute have produced the first summary of Army physiological research in a new volume of the Textbooks of Military Medicine series. *Military Quantitative Physiology: Problems and Concepts in Military Operational Medicine* is edited by COL (Ret) Karl Friedl and Dr William Santee, who together have more than 60 years of accumulated experience in solving problems in military physiology. Recruiting world-renowned experts, they assembled a wide-ranging compilation of the most military-pertinent operational medicine research efforts, with potentially far-reaching implications for civilian medicine as well.

The book effectively captures the state of knowledge resulting from more than a century of organized research efforts in areas vitally important to Soldier health and performance. The efforts extend from the Civil War, when teams of researchers were sent to Union Army camps to gather information from thousands of Soldiers on anthropometry, lifting strength, pulmonary function, and other physiological factors. While reminding us of the rich history of military physiological research, the book also helps determine the directions of future study.

A logical question from both those providing funds and leaders over the years has been "are we there yet?" If this research has been going on for more than a century, shouldn't we have all the answers we need? How much more can we learn about how we rest, feed, exercise, and train Soldiers? The book makes clear the continuous process of evolving better information and interventions, as science and technology advancements provide new opportunities to optimize health and performance of our Soldiers, in addition to how much more needs to be done.

Only in the past decade have we had the computing power and information technology to convert this information into useful predictive models for medical planners, commanders, and Soldiers. Unfortunately, the book could not capture the rapidly advancing work in computational biology that is now harnessing years of research findings in the form of decision support tools. The sophistication of those tools is rapidly increasing; they will soon support applications on every smartphone.

The book contains 12 chapters written in an easy-to-read format by 28 world-renowned subject matter experts presenting practical information directly applicable to helping the Soldier. Many scientists have dedicated their lives to mitigating the deleterious effects of common stressors for military personnel, and humankind in general, to improve quality of life and human performance. The book is the first to highlight the Army's pivotal research from devoted biomedical scientists, clinicians, and modelers who developed useful computational physiology models. Addressing important life science problems related to training, eating, resting, and protection, these cutting-edge models have resulted in enhanced systems to augment decision-making in new and complex situations.

The book addresses numerous areas of interest, including prediction of human limits; modeling the physiological and medical effects of exposure to environmental extremes; measurement and prediction of sleep and performance in the operational environment; performance-maintaining and performance-enhancing drugs and food components; psychosocial factors in harsh and remote environments; nutrition and military performance; water requirements and Soldier hydration; evaluation of the thermal environment; protection of the skin; blast injury; load carriage; and injury control.

Each chapter is a well-written, comprehensive summary of quality research on a pertinent stressor and contains numerous references to more detailed studies. The research has immediate and long-term, dual-use (military and civilian) applications. For example, the US Army Research Institute of Environmental Medicine hydration tables are used worldwide in efforts to prevent heat injuries caused by inadequate water intake. Future refinements with personalized monitors that signal individual water needs, perhaps through a wearable system, should provide further protection of health and optimize performance.

Individual chapters capture an entire body of literature and experience in interesting and specific military problems. For example, Chapter 5, "In Vivo Diagnostics and Metrics in the Assessment of Laser-Induced Retinal Injury," represents the culmination of 40 years of research on laser eye safety by Bruce Stuck and colleagues. The Army initiated this program when lasers were a new technology, realizing the importance that an understanding by Soldiers of the medical effects (especially on the retina) would play in the safe and effective employment of these emerging systems. With the termination of this research program and retirement of the key experts, it is especially important to have this summary of the issues that drove this research for national security purposes, from aviation safety concerns to health hazards of new tactical lasers. This research has been foundational in national standards for laser safety and contributed to current international treaties on blinding lasers.

Other chapters contain similar summaries by the Army's established experts: COL (Ret) Wayne Askew discusses the area of field nutrition research which provided the scientific basis for modern field feeding concepts and rations, such as the First Strike Ration; Dr Jim Stuhmiller presents blast model research that helps acquisition managers evaluate safety concerns for current and future high-powered weapons systems; MAJ (Ret) Joe Knapik describes load carriage research that has led to the current designs of load handling systems including rucksacks that accommodate gender differences in anthropometry and strength; and Dr Bill Santee discusses thermal strain modeling that provides modern tools to prevent heat injury and maximize Soldier effectiveness in the heat.

I highly recommend this book to every clinician and medical researcher involved in helping our Soldiers mitigate the effects of military operational stressors. Active duty military medical personnel may obtain one complimentary book directly from the Borden Institute using an online order form (http://www.cs.amedd.army.mil/borden/BordenOrder.aspx). The book may be purchased either through the Borden Institute (202-512-1800) or the Government Printing Office (http://bookstore.gpo.gov/).

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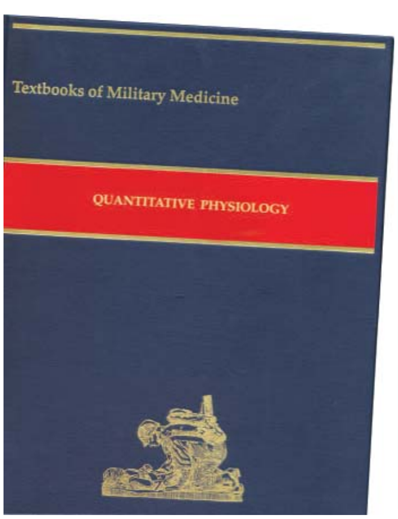

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The *United States Army Medical Department Journal* is published quarterly to expand knowledge of domestic and international military medical issues and technological advances; promote collaborative partnerships among the Services, components, Corps, and specialties; convey clinical and health service support information; and provide a professional, high quality, peer reviewed print medium to encourage dialogue concerning health care issues and initiatives.

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