

Chapter 27

DEPLOYMENT SURVEILLANCE

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INTRODUCTION

The Persian Gulf military campaigns of the early 1990s, Operations Desert Storm and Desert Shield, shined a spotlight onto the Department of Defense (DoD) public health programs dedicated to addressing deployment exposures and associated health outcomes of deployed service members and veterans. Media reports and personal testimonies of syndromic illnesses

and disease conditions rose throughout the decade. However, the impacts of deployment exposures and related illnesses were not unique to the Persian Gulf War. Ongoing health effects, physical and nonphysical, are a poignant legacy of any military campaign. In this regard, the public health toll of military conflict is not truly known at the time each deployment ends.

CONSEQUENCES OF THE PERSIAN GULF WAR

Historically, the DoD placed general public health and preventive medicine emphasis on food and water safety, arthropod-borne diseases, endemic infections, and other communicable diseases with the potential to negatively impact deployed forces. Emphasis included providing and managing resources and capabilities needed to support base and expeditionary forces. For example, deployment preventive medicine personnel assessed and provided recommendations for exposures to heat and cold. If such recommendations were not taken, heat injuries (eg, heat stroke or heat exhaustion) or cold injuries (eg, frostbite or chilblains) may predictably have occurred. As another example, water evaluation and treatment in deployed settings mostly focused on chlorine disinfection. Without such preventive measures, diarrheal and infectious diseases such as dysentery and salmonella caused significant disease outbreaks. In the past, soldiers were trained to conduct industrial operations so that hazards were minimized and appropriate personal protective equipment was worn. However, after the Persian Gulf War, with its many potential environmental exposures, such as oil well fire smoke, pesticides, chemical warfare agents, and particulate matter, as well as reports of veterans experiencing various health issues, the DoD increased its focus on capturing environmental exposure data for service members both during and after deployments.¹

Health symptoms are commonly reported following armed conflicts. Symptoms have included fatigue, shortness of breath, headache, sleep disturbances, forgetfulness, and impaired concentration,^{2,3} and the etiologies of these problems have remained largely undefined. Concerns over potential wartime exposures have risen as well. The US military deployed Agent Orange, a blend of tactical herbicides sprayed in the jungles of Vietnam in the 1960s, to remove trees, mangroves, and dense tropical foliage that provided enemy cover.⁴ In subsequent years and in the decades that followed the Vietnam conflict, veterans suffered cancerous diseases and other health problems.⁵ It wasn't until 1991 that the US Department of Veterans Affairs (VA) began linking certain illnesses to Agent Orange.⁴

The National Academy of Sciences conducted a review of the scientific and medical literature concerning Agent Orange and other herbicides exposure and possible health effects as required by Public Law (PL) 102-4, the Agent Orange Act of 1991.^{3,6} The academy sought to demonstrate a statistical association between health outcomes and herbicide exposure, identify the risk of developing adverse health outcomes following herbicide exposure, and identify mechanisms of action or evidence of a causal relationship between health outcomes and herbicide exposures. The National Academy of Sciences committee faced great difficulty in their epidemiological review, given the scarcity of quantifiable exposure information. Hence, cohort reconstruction, dose estimation, and the ability to address causality were not fully achieved from substantiated data.³

Today, the VA maintains a presumptive policy that postulates an association between specific symptoms and conditions with exposure to Agent Orange if the veteran meets legitimizing criteria.⁶ Yet, even considering the costs and problems associated with Agent Orange exposure in Vietnam, it was not until after the Persian Gulf War that the DoD heightened efforts to identify potential environmental exposures to service members and the adverse health outcomes they may cause.

By June 13, 1991, the ground war was considered a victory and the last US service members who supported the Persian Gulf War returned home.⁷ Disease and injury rates were very low in comparison with other conflicts, and the low rates were attributed to successful preventive medicine efforts. Nonetheless, over 60,000 service members, veterans, and their families eventually sought medical evaluation as part of medical registry programs developed after the Persian Gulf War.⁸⁻¹⁰

In December 1991, PL 102-190, the National Defense Authorization Act for Fiscal Year 1992, as amended, served as the first of many congressional forays into the area of assessing deployment-related exposures and their potential health consequences. PL 102-190,

section 734, required the secretary of defense to establish and maintain a registry of service members who were exposed to the fumes of burning oil in Operation Desert Storm.¹¹

In response to PL 102-190, the US Army Environmental Hygiene Agency developed a database and public website where Persian Gulf War veterans could request or look up potential exposures to and health risks from oil well fire emissions. This was the first time a service member could estimate his or her individual exposure based on environmental sample data and modeled exposure data.¹

In November 1992, Congress recognized that other potential hazards and environmental factors may have led to the medical problems of some Persian Gulf War participants. In response, PL 102-585, section 704, directed the DoD Persian Gulf Registry to expand and include any other member who served in Operation Desert Storm.¹¹ The Office of the Secretary of Defense, Office of the Special Assistant for Gulf War Illnesses, stood up GulfLINK, established in August 1995, to provide online access to Persian Gulf War medical, operational, and intelligence documents from 1990–1991. Its purpose was to provide service members, veterans, and interested persons with information regarding health effects of those who served in the Persian Gulf War.¹²

In the years following the Persian Gulf War, multiple expert boards and committees studied veterans of the war and the health consequences of their service.^{8,10,11,13–17} The Institute of Medicine and the Presidential Advisory Committee on Gulf War Veterans' Illnesses noted that the formalized registries established by the DoD and the VA served an important purpose but were not designed to answer epidemiological questions.^{9,10,13,14} The Presidential Advisory Committee noted that the current scientific evidence did not support a causal link between the symptoms and illnesses reported by Persian Gulf War veterans and known environmental exposures.⁹ It was noted that very little personalized exposure information was available. Defining relevant control groups and obtaining data for them were very difficult, and the lack of exposure data limited even the most expert and well-funded investigations to identify health outcomes linked to specific environmental exposures or risk factors.⁹ The Government Accounting Office noted that without accurate exposure information, further epidemiological research on the risk factors or potential causes for veterans' illnesses may result in little return.¹⁵ Even now, in the many years following Operation Desert Shield and Operation Desert Storm, uncertainty remains regarding the link between potential exposures, health risks, and adverse outcomes in the 697,000 deployed US troops.

DEPLOYMENT SURVEILLANCE TODAY

Documenting Exposures

A major limitation of all epidemiological studies to date has been the lack of detailed exposure data. Every committee reviewing the Persian Gulf War has recommended that broad-based exposure and outcome data be collected on all future deployments. Health surveillance is the ongoing, systematic collection, analysis, and interpretation of data derived from instances of medical care or medical evaluation, and the reporting of population-based information for characterizing and countering threats to a population's health, well-being, and performance.¹⁶ Deployment encompasses all activities from origin or home station through destination, specifically including the continental United States, inter-theater, and intra-theater movement legs, staging, and holding areas.¹⁷ The Institute of Medicine recommended "a single, uniform, continuous and retrievable electronic medical record for each service person. The uniform record should include each relevant health item (including baseline personal risk factors, every inpatient and outpatient medical contact and all health-related interventions)."¹⁴ Although this system does not yet exist, progress has been made to move this vision forward.

The history of compensating veterans for health issues emanating from military occupational exposures is extensive. Obtaining and understanding individual exposures through objective sampling and analysis during operational conditions such as contingency and expeditionary missions has been logistically difficult for the military. Making the association between a deployment exposure and a health outcome is not straightforward. This was certainly true in the case of personnel who served in the Persian Gulf War. The absence of data for Persian Gulf War exposures believed to have resulted in veterans' health problems prompted the DoD, following the Persian Gulf War, to expand its efforts to collect and document battlefield exposures, track operational movement, and periodically survey service members' health status. A first attempt was implemented in Bosnia during Operations Joint Endeavor and Joint Forge. Efforts matured in the wake of policies and investments in equipment, training, software, and skilled personnel.

In the years following Operations Joint Endeavor and Joint Forge, occupational and environmental health deployment exposure data were documented in various reports and stored in multiple databases, many

of which were restricted or included limited content. Exposure data was summarized in various documents by deployment location and through proprietary formats depending on the DoD service collecting the exposure data and preparing the reports. Further, some of the limited exposure reports were used for inclusion into the service member's medical record using an overlay of Standard Form 600, Chronological Record of Medical Care. However, there was no standardization among these documents when considering format, content, analysis, and conclusions. Eventually, the Army and Navy determined that inclusion of exposure documents in individual medical records was inappropriate because the information only broadly estimated population-based exposures and potentially associated health risks. The deputy assistant secretary of defense (force health protection and readiness), the proponent for DoD Instruction 6490.03, *Deployment Health* (2006),¹⁸ directed the development of a multiservice exposure monitoring summary as a solution to these problems.

The Periodic Occupational and Environmental Monitoring Summary

The Periodic Occupational and Environmental Monitoring Summary (POEMS) became the multiservice document to implement DoD's interpretation of occupational and environmental health exposure information for deployment sites. Deployment sites include, but are not limited to, regions of combat operations, peacekeeping, deterrence operations, disaster relief, and humanitarian assistance. The POEMS describes conditions at base camps, airports or airbases, seaports, forward operating vicinities, forward operating bases, and so on. The POEMS yields a broad assessment of potential short-term (acute) and long-term health effects that may be experienced by personnel at a particular deployment site, based on the hazards known to exist at that site.¹

The POEMS addressed the requirements within DoD Instruction 6490.3, *Implementation and Application of Joint Medical Surveillance for Deployments* (1997); DoD Instruction 6055.05, *Occupational and Environmental Health* (2008); and Joint Chiefs of Staff Memorandum

MCM 0028-07, *Procedures for Deployment Health Surveillance* (2007).¹⁷⁻¹⁹ The DoD Joint Environmental Surveillance Work Group developed a standard template for the POEMS. The work group included representation from the offices of the deputy under secretary of defense, the deputy assistant secretary of defense, the Joint Staff, the US Central Command, and the service surgeons' offices.

The POEMS is the responsibility of the combatant commander but is authored and edited by technical specialists from the service-specific surveillance centers (specialized deployable teams and units, the Army Public Health Center, the Navy and Marine Corps Public Health Center, the US Air Force School of Aerospace Medicine) who assess data and attribute the potential health risks. These analysts comb through information from field observations, reports, sampling results, and known geographic and endemic conditions. The information within the report is typically unclassified.

Service members, veterans, and the doctors who care for them are the primary audience of the POEMS. The environmental surveillance data and the summaries of associated health risks contained in the POEMS are population-based assessments. Occupational and environmental health surveillance data do not reflect individual exposures, and the resultant risk assessments are not predictive of any future health outcomes for an individual within the population at the site. Rather, the POEMS is a tool to assist clinicians in addressing patient concerns and in developing differential diagnoses or identifying diagnostic procedures for observed health outcomes that they believe may be related to prior or current environmental exposures.

Service members also have access to the POEMS to help them understand any health risks from potential occupational and environmental exposures. The exposures may be listed on their predeployment and postdeployment screening questionnaires. The POEMS may also be used to address various congressional inquiries. The POEMS are posted on a publicly accessible (login and password required) DoD database, the Deployment Occupational and Environmental Health Surveillance (DOEHS) data portal.²⁰

DATA REPOSITORIES

While the POEMS captures population-based assessments of deployment sites, it does not provide individual-level data. Data are collected at every step of the deployment process, from the first predeployment medical examinations through each movement and medical encounter in theater, until after the final

postdeployment medical assessments are completed. While these encounters are not primarily designed for medical surveillance, the data that they generate can be used to provide a more complete picture of an individual's exposures and outcomes. These data are collected in the repositories described below.

The Defense Occupational and Environmental Health Readiness System

The Defense Occupational and Environmental Health Readiness System–Industrial Hygiene (DOEHRS-IH) is a comprehensive, automated information system that provides a single point for assembling, comparing, using, evaluating, and storing occupational personal exposure information, workplace environmental monitoring data, personal protective equipment usage data, observation of work practices data, and employee health hazard educational data. DOEHRS-IH provides a definition, collection, and analysis platform to generate and maintain a service member's Individual Longitudinal Exposure Record, a joint DoD/VA initiative to create a complete record of service members' exposures over the course of their careers. DOEHRS-IH describes the exposure assessment, identifies similar exposure groups, establishes a longitudinal exposure record baseline to facilitate postdeployment follow-up, and provides information to enable exposure-based medical surveillance and risk reduction. Stakeholders include the following:

- the Navy, Air Force, Army, and Marine Corps;
- the Military Health System;
- line components;
- DoD functional community working groups, the DoD Industrial Hygiene Work Group, and the Joint Environmental Surveillance Work Group;
- service chief information officers and functional representatives;
- the Defense Logistics Agency;
- the US Army Veterinary Command; and
- the National Nuclear Security Agency.

The DoD recognizes the importance of linking environmental hazard data with unit locations and works closely with the VA to provide exposure data to adjudicate disability claims as required. Since 1991 the DoD has implemented programs and policies to better address the health protection of deployed service members for both acute and latent or chronic health conditions that may result from environmental health hazard exposures. Occupational and environmental health assessments are conducted at base camps soon after they are established to document baseline monitoring of the air, water, and soil for hazardous agents. In addition, annual (or periodic) occupational and environmental monitoring summaries are completed at major deployment locations to identify any changes in occupational and environmental health exposure risks and associated health implications. Exposures of concern are promptly

investigated, and if there is a likelihood of latent or chronic health effects, special medical surveillance programs are established, such as in response to the chromium exposures at the Qarmat Ali Industrial Water Treatment Plant in Iraq. When appropriate, exposure registries are created for a specific event, as conducted in response to the Operation Tomodachi, Fukushima Nuclear Power Station, Japan, accident in spring 2011.

The Individual Longitudinal Exposure Record will create exposure registries based on location, date, time, and exposure agent, supporting contemporary benefits claims as well as retrospective studies. This concept will assist service members and veterans in verifying whether their disabilities were caused by their military service. Exposure alone does not always lead to illness or injury; the VA relies on scientific evidence to determine when there is a link between exposure to environmental hazards and specific illnesses or injuries that would make service members or veterans eligible for VA disability benefits.

Department of Defense Serum Repository

The DoD Serum Repository was established in 1989 to store serum that remained following mandatory HIV testing in the Army, Navy, and Marine Corps. Air Force samples were added in 1996. In 1997, the DoD began mandating an HIV test and the associated collection of a serum sample both within 1 year before deployment, and within 30 days after redeployment. These paired sera samples can be queried for seroconversions to infectious diseases encountered during deployment, as well as biomarkers and signs of environmental exposures. In addition, the serum samples are tied to relevant demographic, occupational, operational, and medical information, which are useful for epidemiologic analysis.

Defense Medical Surveillance System

The Defense Medical Surveillance System, operated by the Armed Forces Health Surveillance Branch, is a relational database including data on service members throughout their careers in the military since 1990. The system receives and integrates standardized data from multiple service and DoD sources worldwide, including medical events such as hospitalizations, outpatient visits, reportable diseases, HIV results, and health risk appraisals; personal demographic characteristics; and military and operational experiences of all Army, Navy, Air Force, and Marine personnel over their military careers. There are now more than 200 million rows of data regarding more than 6.5 million service members in the online database.

PASSIVE DEPLOYMENT MEDICAL SURVEILLANCE: MEDICAL SITUATIONAL AWARENESS IN THE THEATER

Surveillance of any type, including medical surveillance, can be defined as either active or passive. Active surveillance involves asking someone to provide specific information, such as filling out reportable disease reports or special surveys. Active surveillance is time and labor intensive because it requires someone to do something they would not otherwise do in the course of their regular duties. Passive surveillance is much more common. It is less time and labor intensive than active surveillance because it is simply the gathering of data that were collected for other purposes. The tradeoff is that because the data were not collected specifically for surveillance, it is more likely to be incomplete or not able to fully answer all of the questions that need to be answered.

Medical Situational Awareness in the Theater (MSAT) is an example of passive surveillance. It is a web-based application available through the DoD Secret Internet Protocol Router Network (SIPRnet), which in 2010 replaced a legacy product, the Joint Medical Workstation. MSAT provides medical decision support and a common operating picture by combining information from multiple sources, such as the electronic health record, personnel movement and location records, medical logistics, and biosurveillance systems. While none of these systems were set up for the specific purpose of providing overall medical situation awareness to Joint Task Force commanders' medical staff, their integration provides a more complete picture in a more timely and less labor intensive manner than requiring individuals at each location to provide separate medical situation reports.

ACTIVE DEPLOYMENT MEDICAL SURVEILLANCE

Disease Reporting System-internet

After the H1N1 influenza pandemic, the disease epidemiology program of the then-US Army Public Health Command determined that the Reportable Medical Events System, in use at the time, lacked the flexibility, completeness, and timeliness to effectively monitor and report disease information. Therefore, the web-based **Disease Reporting System-internet (DRSi)** was designed to be web-based, be more cost-effective, and employ joint-service technology solutions. All preventive medicine assets within fixed medical treatment facilities transitioned to DRSi by the beginning of fiscal year 2011. By policy, all medical treatment facilities must enter all armed forces reportable medical events into DRSi within 24 hours. Armed forces reportable medical events, selected and defined by the consensus of a tri-service panel, are those determined to represent an inherent and significant threat to public health and military operations. Although most armed forces reportable medical events are infectious diseases and match those required by the Centers for Disease Control and Prevention and the Council of State and Territorial Epidemiologists for reporting at state and national levels, there are a few, such as cold and heat injuries, that are more specific for military populations.²¹

Postdeployment Health Surveys

In fiscal year 2000, the Armed Forces Health Surveillance Branch assumed the DoD mission of receiving, tabulating, and archiving all completed predeployment

and postdeployment survey forms. The Pre-Deployment Health Assessment is primarily a medical screening tool ensuring that the deploying service member is medically fit for that particular deployment and has been prescribed all needed medications and vaccinations. The Post-Deployment Health Assessment is completed by redeploying service members within the first week of redeployment. The Post-Deployment Health Reassessment is completed between 90 and 180 days following redeployment. Both of these post-deployment surveys include general questions about symptoms and exposures that may have been encountered during deployment. They are primarily tools to be used to connect redeploying service members to medical services. Unfortunately, they are unsuitable as passive surveillance tools because their design was determined to be inadequate for supporting epidemiological research; data has demonstrated that recall bias and misclassification occur frequently.²²

Theater Medical Information Program

The **Theater Medical Information Program** was included in PL 105-85, the National Defense Authorization Act for Fiscal Year 1998, which identified the requirement for a system that assesses the medical condition of active, reserve, and Guard members of the armed forces during deployment outside the United States. The requirements included accurate records of service members' medical conditions before deployment, as well as any changes in their medical condition during deployment. The Theater Medical Information

Program is also designed to address many functional areas, including medical logistics, blood management, and medical threat and intelligence.

Deployment Environmental Surveillance Program

In July 1996, the then-US Army Center for Health Promotion and Preventive Medicine established the Deployment Environmental Surveillance Program to serve as a single point of contact for deployed occupational and environmental health surveillance. The goal of the program is to meet continuing requirements and recommendations regarding exposure information during deployment, a necessity following the concerns about unknown exposures during the Persian Gulf War.^{7,9,13,14,23,24} Its mission is to develop a system capable of providing pertinent information needed by commanders and other decision-makers to detect, assess, and counter environmental and occupational hazards. Today, the Deployment Environmental Surveillance Program is staffed by environmental scientists, engineers, health risk assessors, and geographers, and it is provided additional support from occupational medicine physicians, industrial hygienists, entomologists, health physicists, chemists, and epidemiologists assigned to the technical programs throughout the current Army Public Health Center (Provisional).

The current primary functions of the Deployment Environmental Surveillance Program are analyzing deployment occupational and environmental health surveillance data and producing information on ways of detecting, assessing, and countering environmental health risks during deployments. The program provides consultative assistance, laboratory analyses, and on-site environmental surveillance to deployed

preventive medicine assets to identify, prevent, and reduce potential environmental health risks. Program staff also perform spatial and temporal analysis of potential environmental and occupational exposures and health risks using geographic information systems. This information is integrated with health outcome data to identify necessary changes in medical threat assessment and countermeasures. Finally, archives of environmental and occupational hazard data collected by deployed units allow investigations of any future adverse health outcomes following a deployment.

Modeling

The National Center for Medical Intelligence and the Armed Forces Health Surveillance Branch use sophisticated modeling software and predictive algorithms to identify and analyze disease threats and exposure-related health risks, accounting for geographic region, climate, seasonality, and vector presence. This type of modeling is supported by service-specific public health organizations to plan strategies, for example, clinical predeployment prophylaxis measures for preventing and mitigating expeditionary and deployment-related communicable and endemic diseases. Results from these analyses are used to assist military public health officers, military commanders, and medical personnel to plan deployment medical packages. Additionally, the results enable these personnel to focus on interim deployment medical surveillance for syndromic illnesses and conditions that are not captured through straightforward reportable medical event reports. Reliable exposure modeling requires adequate and pertinent data; highly trained and experienced people; sophisticated computer hardware and software; and time.²⁵

DEPLOYMENT SURVEILLANCE DURING A UNIQUE MISSION: THE EBOLA OUTBREAK

The Ebola virus disease (EVD) outbreak in western Africa between 2013 and 2016 was one of the most expansive and deadliest epidemics in the modern era. As of June 2016, the epidemic resulted in 28,616 confirmed, probable, and suspected EVD cases.²⁶ An EVD case was characterized by fever and malaise and included nonspecific symptoms such as myalgia, headache, vomiting, and diarrhea. Of those with EVD, 30% to 50% developed the hemorrhagic form resulting in multiorgan failure and subsequent shock or death.²⁷ EVD was widespread, impacting large parts of Guinea, Liberia, and Sierra Leone, among other countries. It resulted in unprecedented modern social disruption, humanitarian needs, and death. As of June 10, 2016, there were 11,300 fatalities.²⁶

The DoD, in support of the US Agency for International Development, made critical contributions against EVD, including the deployment of uniformed personnel to Monrovia and Liberia as part of Operation United Assistance (OUA).²⁸ The DoD joined a global initiative including local and regional ministries of health, the World Health Organization, the Centers for Disease Control and Prevention, and others collaborating to conduct investigations, coordinate contact tracings, implement controls, administer and manage treatment, and promote prevention measures. In addition to those deployed as part of OUA, the DoD successfully trained 1,539 healthcare workers and support staff, formed 30-member medical support teams for short-term assistance to medical

professionals, erected 10 DoD EVD treatment units, stood up a 25-bed Monrovia medical unit, operated 7 mobile laboratories, and contracted the procurement of 1.4 million sets of personal protective equipment.²⁸ As of 2016, OUA cost \$402.8 million, including direct support, research and development (eg, vaccine development), and cooperative threat reduction (eg, biosurveillance and biosecurity).²⁸ Nearly 3,000 personnel were deployed to western Africa at the peak of the epidemic.²⁹

The DoD established predeployment training requirements for personnel in OUA. The predeployment training, an example of occupational health primary prevention, was developed as a tiered approach based on exposure risk assessments of the probable conditions to be encountered by personnel supporting OUA.³⁰ Tier I consisted of universal training required for all deployers and included education on the basic EVD process, transmission, symptomology, avoidance awareness, donning and removal of personal protective equipment, and daily symptom and temperature screening. Tier II outlined requirements for personnel expected to interact with the local populace. Tier III was for personnel assigned to medical units or expected to handle remains. Lastly, Tier IV training was required for personnel supporting laboratory testing.³⁰

On the ground, commanders, leaders, and troops were required to conduct daily surveillance for specific symptoms experienced by their personnel over the interim 24-hour period and refer those with symptoms to sick call.³¹ Further, onsite clinical operational personnel conducted routine drills for the management and aeroevacuation of EVD casualties. Ground personnel were responsible for performing logistical activities in accordance with published guidance on protocols to prevent transmission of infectious disease during the decontamination of equipment, decontamination of personnel transport vehicles, and execution of site waste management.³²⁻³⁴

DoD clinical and aeromedical support to OUA included contingency operation plans for EVD exposure casualties, with guidance for the screening, management, and evacuation of individuals presenting at or having been transferred to their facilities or vehicles following travel to a country with widespread Ebola virus transmission. Further, the guidance included procedures for environmental cleaning, waste management, and updated infection control protocols. For example, the US Military Hospital–Kuwait developed an occupational health screening program that was risk stratified according to Centers for Disease Control and Prevention definitions of EVD exposure risk. The surveillance program included twice daily temperature checks, as well as symptom screening over 21 days following the last day of potential exposure. Positive screens warranted removing personnel from the hospital's direct patient care and communal work environment, isolation for further evaluation, and as needed, clinical management. Furthermore, the hospital updated infectious control policies for percutaneous or mucocutaneous exposure to blood or body fluids.

Active surveillance for confirmed, probable, and suspected EVD cases was conducted through the DRSi, by telephone to the US Army Public Health Command, and through procedures stipulated by local public health departments. Clinical Ebola specimen submission and testing on patients was coordinated with the medical treatment facility laboratory, the preventive medicine department, and the appropriate state or local public health departments. Surveillance for changes to soldier health continued even after the mission concluded in western Africa. In the 30 days before or after returning to the United States (the re-deployment period), troops were required to complete the Post-Deployment Health Assessment and undergo debriefings and training for the recognition and reporting of clinical symptoms. Troops were also required to complete the Post-Deployment Health Reassessment 90 to 180 days after return to their home duty station.

CHALLENGES IN DEPLOYMENT SURVEILLANCE

Deployment surveillance efforts continue to mature and provide better information regarding deployment exposures and outcomes. This data-driven approach is broadening the concept of operational health support from the recognition and treatment of injury and disease as it occurs to analyses that take place after samples have been collected, analyzed, archived, and evaluated for association with measured outcomes. Ideally, the results of samples and measurements taken on deployments are available in a timely fashion so that preventive measures to reduce

exposure can be taken when warranted; however, this is not always possible.

The ability to measure exposures and ultimately evaluate them with respect to delayed health effects raises questions, such as what should be sampled, how frequently, and to what limit of detection. Many of these questions can be reasonably resolved utilizing a combination of intelligence, professional judgment, and common sense, but there are still numerous unknowns in terms of exposures, outcomes, and dose and temporal responses.

Complicating matters in military populations, it is necessary to account for competing exposure risks and mission requirements. What is considered an acceptable exposure may be debated and is sometimes adjusted based on the requirements and details of each mission. For the commander on the ground, environmental exposures add complexity to the process of managing competing risks. Army commanders are currently trained to manage risk in accordance with Field Manual 100-14, *Risk Management*, which applies a probability and severity of health outcome matrix to specific hazards.^{35,36} Obvious catastrophic events such as a release of highly toxic materials have severe health risks, although the probability of such a release may be estimated as very low. The commander can mitigate risk by selecting troop locations with regard to proximity and plume direction from industrial facilities. However, exposure to low ambient levels of chemicals may cause delayed health effects or produce little obvious and measurable impact on the immediate mission, although the probability of occurrence is likely higher. Even with immediate monitoring information, uncertainties relating to actual health impact make decision-making difficult.³⁷

For some hazards, guidance for acceptable levels of occupational exposure exist but may not be applicable for extended work shifts or the continuous exposures possible in deployed settings. Screening levels derived for application in risk assessment to represent “no adverse effect levels” for the general population are not suitable because they are meant to protect sensitive members of the population for lifetime exposures and utilize very conservative assumptions at each step of the derivation. These screening levels may be suitable as a basis for determining whether or not a remedial action should be considered, but do not serve as a useful threshold to predict the frequency or magnitude of a health effect. There may be no health effects, or they might be subtle and not discernable without specific, tailored, outcome-based medical surveillance. Without such surveillance, specific outcomes might be identified only after weeks, months, or years. A time lag between measurement and available results has affected the usefulness of monitoring on recent deployments. Because of the time lag, monitoring data may not be utilized in a preventive sense to reduce exposure but may still raise questions with respect to significance and prognostic interpretation for those exposed once the reports are written. This raises questions regarding the value of such information for any purpose other than after-the-fact epidemiological analysis.^{2,10,23,38}

In 1997, the Government Accounting Office reviewed Gulf War illness analytic efforts and emphasized the need for accurate, dose-specific information beyond simply measuring the presence or absence of exposure

when low-level or intermittent exposure is possible.¹⁵ With current technology, this would require continuous monitoring of a broad range of low-level hazards during deployments, as well as a large enough population with frequent enough outcomes to identify a trend in dose-response. Further, adequate information on confounding variables would need to be collected. Identifying such confounding variables prior to deployment may be difficult without knowledge of which exposures or outcomes will be a concern and subject to analysis. Specific information would also be required at the individual level. Adequate predeployment baselines on conditions or symptoms would be necessary to establish the critical chronological relationship. Current predeployment questionnaires are too simple to capture these data, although the proposed seamless medical record may alleviate this problem.

In May 2015 the US Government Accountability Office published a report following the examination of

- (1) the extent to which the military Services centrally store occupational and environmental health surveillance (OEHS) data and verify its reliability; (2) how, if at all, the DOD identifies potential occupational and environmental health risks for sites in Iraq and Afghanistan, and to what extent these risks are mitigated; and (3) the extent to which DOD and VA use occupational and environmental health surveillance data to address post-deployment health conditions.³⁵

For the report, the Government Accountability Office reviewed and analyzed DoD and military service policies and interviewed DoD, military service, and VA officials, as well as groups representing service members and veterans. The Government Accountability Office found inconsistencies between the DoD and service-specific policies regarding occupational and environmental health surveillance data storage. This conclusion is supported by the fragmentation and duplication of exposure data held within the DOEHS and the military exposure surveillance library. Further, DoD’s policy did not address quality assurance of occupational and environmental health data. The assessments stored in the DOEHS and the military exposure surveillance library include recommended countermeasures; however, the extent to which they are being implemented is unclear because combatant commands do not require forward-deployed base commanders to document their decisions and actions on implementing them. Another limitation underpinning the limited usefulness of the occupational and environmental health surveillance data is the inability to capture deployment exposure data at the individual level. This has rendered it difficult to establish a causal link among deployment exposures and health outcomes.³⁹

SUMMARY

The Institute of Medicine has determined that military deployments, especially in Vietnam and the Persian Gulf, demonstrate that health consequences of participation in military action arise and continue long after the deployment ends. Evaluating these concerns and providing healthcare to those who have been affected is challenging to both epidemiologists and medical caregivers. Although the DoD and the military services have developed policies resulting in occupational and environmental health surveillance data capturing and reporting systems, much work needs to be done to improve data quality and usability. However, no system can be expected to address every unanticipated research issue. Even in the face of these challenges, the DoD takes seriously the recommendations of objective panels and reviews, and accepts the challenge of implementing them. The

military proactively assesses potential deployment-related exposure threats to the health and safety of its service members. This is done amid a broadening spectrum of occupational and environmental health concerns, ranging from acute injury as a result of combat operations to possible influences of low-level chemical and physical exposures on chronic diseases that might manifest years later, perhaps long after cessation of military service. This is especially true as forces are increasingly used for worldwide operations other than war, including humanitarian assistance and nation-building missions. While debate is ongoing regarding the scope and appropriate level of concern for deployment exposures as a basis for decision-making, current monitoring affords US troops more varied and sensitive sampling of their environment than any working population in the world.

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