# Chapter 29

# DISCUSSION SUMMARY: EXPOSURE CHARACTERIZATION—QUESTIONNAIRES AND OTHER TOOLS

JOEL C. GAYDOS, MD, MPH*; AND KATHLEEN KREISS, MD†



*Colonel (Retired), Medical Corps, US Army; Science Advisor, Armed Forces Health Surveillance Center, 11800 Tech Road, Suite 220, Silver Spring, Maryland 20904
†Field Studies Branch Chief, Division of Respiratory Disease Studies, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Mailstop H-2800, 1095 Willowdale Road, Morgantown, West Virginia 26505

## INTRODUCTION

Members of the US uniformed services are occupationally exposed to a very large number of potentially hazardous agents.[1] These agents may be associated with the use and maintenance of their own equipment, the result of other human activity, or naturally occurring.[1,2] These military exposures have occurred for thousands of years.[1] However, in the last 40 years in the US military, exposures to defoliants (Agent Orange) and oil well fires have caused considerable concern.[3–5] In the recent wars in Afghanistan and Iraq, US military personnel have been diagnosed with unusual conditions, such as eosinophilic pneumonia and constrictive bronchiolitis.[6,7] The possibility looms that unidentified exposures may have contributed to these conditions and that these exposures persist. Concern about occupational exposures and potential chronic adverse effects in the recent wars has also been fueled by reports of large numbers of troops living and working for long periods near open burn pits covering many acres, exposures to severe sandstorms, and US military members fighting a sulfur plant fire that burned continuously for almost a month.[8–12] Recently, two medical journals devoted entire volumes to potentially hazardous exposures of military personnel.[13,14]

Recognizing and mitigating potentially hazardous exposures, identifying those possibly exposed in Afghanistan and Iraq, characterizing their exposures (consisting of primarily airborne hazards), and developing and implementing long-term programs to deal with the consequences of the exposures continue to be challenging.[15] To assess the current situation and develop plans for the future, the US Department of Veterans Affairs (VA) and the US Department of Defense (DoD) partnered to conduct a symposium during August 21–23, 2012 in Crystal City, VA. Major objectives of the Joint VA/DoD Airborne Hazards Symposium were to develop an overview of potential health effects (short-term and long-term) related to airborne hazards for Operation Enduring Freedom (Afghanistan, October 2001–present), Operation Iraqi Freedom (March 2003–August 2010), and Operation New Dawn (Iraq, September 2010–present) and to summarize current epidemiological evidence on the deployment health effects of interest. Another objective was to foster discussion of potential actions for the DoD and VA to improve surveillance, standardize evaluations, and increase communication and collaboration.[1] The symposium consisted of didactic presentations, discussions, and focused work groups. This chapter summarizes the discussion and findings of Work Group B. Members of this group were tasked with identifying and assessing the available tools for exposure characterization (placing emphasis on the use of questionnaires), and with providing recommendations to improve exposure characterization in the future.

## IMPORTANCE OF EXPOSURE CHARACTERIZATION

In referring to exposures of military members, some have used the term *exposure characterization*. Ideally, characterization of an actual or potential exposure would include the following:

- potentially harmful agent or agents,
- reliable and meaningful measurements of the agents' concentrations in time and space,
- identifying information on the people who may have been exposed and their duration and manner of exposure (exposure pathways),
- absorbed doses,
- target organs and disease states that may result, and
- available tests to document the absorbed dose and to detect pathological changes resulting from the exposure.

Others have used the term *exposure assessment*. Exposure assessment has been defined as the quantitative or qualitative evaluation of human contact with a potential toxicant that includes the intensity, frequency, and duration of contact, and may include evaluations of the following:

- rates at which the chemical crosses an internal or external boundary of the human body (chemical intake or uptake rates),
- route by which it crosses the boundary (dermal, oral, or respiratory exposure route),
- amount of the chemical that actually crosses the boundary (a dose), and
- amount absorbed (internal dose).[16]

Whether speaking of exposure characterization or exposure assessment, the ability to identify and measure exposures of military forces, to identify those potentially exposed, and to generate reliable estimates of risk for acute or chronic health effects are of great importance for several reasons:

- to minimize or reduce acute health effects that may result in decrements in job performance, thereby placing the success of the military mission at risk;
- to reduce the loss of trained military personnel who may decide to leave military service because of persistent symptoms associated with their deployment;

- to acknowledge the military's and the nation's duty to prevent injury and illness in uniformed members to the greatest extent possible and to care for those who become ill or injured as a result of their service; and
- to develop research questions and support research related to acute and chronic health effects associated with military exposures to prevent morbidity and mortality in the future.[17]

## TOOLS FOR EXPOSURE CHARACTERIZATION

Environmental monitors are used to identify and quantitate agents of concern over time. These devices may be placed on an individual (eg, in the breathing zone area [personal sampling devices]) or situated at critical points in the environment in an attempt to identify the agents present and to provide some indication of concentrations over time in a defined area. Because continuous monitoring for specific individuals over time is unlikely to occur, available sampling data may be entered into models with other related data (eg, wind and additional meteorological data) and estimated exposure values generated for individual service members or entire military units.

Although environmental sampling data are usually incomplete, biomonitoring may be utilized when suitable tests are available. Biomonitoring involves the collection of body fluids or tissues at appropriate times relative to the possible exposure and testing of these for the agent of concern or metabolites that correlate with exposure. Another tool that is commonly used to compensate for inadequate exposure data is the questionnaire. Questionnaires may be general in nature and broadly applied or specifically designed for selected occupational or exposure groups. These usually attempt to obtain self-reported information on exposures and state of health. If the agent or agents of a potential exposure are known—and the target organs and pathological effects are defined—and a reliable test is available to identify those exposed or those who are experiencing a pathological effect, initial medical screening and later periodic medical follow-up may be initiated for the occupational groups of concern.

In a general manner, adverse health effects, including those from hazardous exposures, are monitored through public health surveillance programs that some refer to as medical surveillance programs.[18] All of the uniformed services engage in various types of public health surveillance. "Public health surveillance is the ongoing, systematic collection, analysis, and interpretation of health data, essential to the planning, implementation, and evaluation of public health practice, closely integrated with the dissemination of these data to those who need to know and linked to prevention and control."[19(p1)] For example, respiratory diseases may be monitored closely in groups with known or suspected exposure to respiratory toxicants. In selected situations, the occurrence of respiratory morbidity and mortality in the groups of interest is compared with the occurrence in other similar groups without known or suspected exposure. The value of public health surveillance can be greatly increased if the population of interest is well defined and the exposure of concern is well characterized. The public health practitioner who can reasonably define the population at risk, the adverse outcome of interest, and the probable latency period has a good chance of identifying a problem if a problem does indeed exist.

### Environmental Monitoring

The issues related to environmental monitoring during military deployments have been extensively reviewed elsewhere and are only briefly mentioned here.[15,20–22] Environmental monitoring is usually the responsibility of military preventive medicine (PVNTMED) personnel. In recent conflicts, these PVNTMED specialists have been assigned broad areas of responsibility, which has caused them to focus on collecting area samples rather than individual or personal samples.[23] An area sample represents only the situation at the sampling site during the defined period of operation of the sampler. Because meteorological and working conditions may vary considerably over time, extrapolation of these results is often not recommended. Additionally, routine sampling is usually conducted only for particulate matter, metals associated with particulate matter, and sometimes volatile organic compounds.[23] Sampling to detect and identify other compounds of possible concern (eg, semivolatile organics, dioxins, and novel or unknown toxicants) is uncommon.[23]

Getting state-of-the-art sampling equipment and trained operators for this equipment into the areas where monitoring is needed has been challenging. Administrative requirements of the military purchasing and training systems have been an impediment. Transportation to distant areas has also been challenging because warriors, guns, and bullets receive priority on aircraft and other vehicles. Over the last two decades, sampling devices have been greatly improved to include significant reductions in size and weight. However, military commanders have many critical priorities, and the importance of monitoring potential exposures must be explained and emphasized by qualified PVNTMED and other medical personnel. These challenges continue to be frequently encountered.[15] Persistent efforts are needed to:

- improve the US military's ability to monitor the deployment environment,

- identify and characterize actual or potential exposures quickly,
- mitigate their impact on health and performance, and
- facilitate any follow-up actions needed.

## Modeling

Modeling by military medical personnel to prevent disease and nonbattle injuries is frequently done prior to a military mission as part of an effort to identify and analyze medical threats and predict disease and exposure risks in different geographic regions at various times of the year.[24] This type of modeling is routinely supported by the National Center for Medical Intelligence (Fort Detrick, MD), the Armed Forces Health Surveillance Center (Silver Spring, MD), and public health organizations in the uniformed services. Results from this work are used to assist military commanders and medical personnel in identifying and responding to the disease and exposure risks, to include implementing specific preventive measures (eg, immunizations and prophylactic drugs) when these are available.

Defining troop exposures through modeling after a potential exposure has occurred is a much more difficult task. A noteworthy example is the modeling of exposures to products of combustion from the demolition of oil wells in Kuwait by Iraqi troops in Operation Desert Storm in early 1991.[5] A major obstacle in completing this project was determining troop locations in time and space. Administrative actions have been initiated to improve the capability of medical personnel to identify individual military members in time and space, relative to a potentially hazardous exposure; but the detail needed for meaningful modeling may not be attainable. Reliable exposure modeling requires adequate amounts of pertinent data; highly trained, experienced people; sophisticated computer hardware and software; and time.

Modeling prior to a military mission and after a potential exposure has occurred can be expected to be used in the future. Therefore, the US military should maintain and improve its expertise in this area. However, it is unlikely that modeling to define possible past exposures would be used effectively on a regular basis.

## Biomonitoring

In situations where exposed individuals can be identified and a reliable test exists for the agent of concern, biomonitoring may be implemented. An example is the ongoing evaluation of veterans who were wounded by depleted uranium fragments.[25] However, an attempt to prospectively conduct biomonitoring on members of a defined military unit possibly exposed to the burning oil wells of Operation Desert Storm encountered problems with interpretation of laboratory tests and lost data and information.[26] A large explosion and fire destroyed study logs. In the absence of environmental monitoring results and information on other exposures (eg, food consumed, such as grilled meat), interpreting results for tests such as DNA-polycyclic aromatic hydrocarbon adducts was problematic. In general, attempts to do biomonitoring may not be feasible because the agent is unknown, an appropriate laboratory test may not be readily available or extremely expensive, and the effort may have to be implemented as a research project. It is unlikely that biomonitoring will be used frequently in the military in the immediate future. However, research in this area should be encouraged because this tool could be valuable in selected situations and could possibly have widespread use in the more distant future.

## Questionnaires

In an extensive review of the challenges to exposure assessment in Gulf War veterans published in 2006, Glass and Sim[17] concluded that, "Due to the poor quality and accessibility of objective military exposure records, self-assessed exposure questionnaires are likely to remain the main instrument for assessing the exposure for a large number of veterans."[17(p627)]

In the US military, the word "deployment" refers to the relocation of forces and material to desired operational areas. The desired operational areas are generally places where hostile action is occurring or could be expected to occur. The US military currently uses three deployment-related, self-administered questionnaires:

1. the Pre-Deployment Health Assessment (DD Form 2795, September 2012),
2. the Post-Deployment Health Assessment (PDHA; DD Form 2796, September 2012), and
3. the Post-Deployment Health Re-Assessment (DD Form 2900, September 2012).

These questionnaires are 7 to 10 pages long and request information about the service member's state of health, alcohol use, and deployment experiences that include exposures and concerns related to deployment. Some potential exposures are specifically addressed, such as exposures to blasts and explosions, depleted uranium, and animals. Deployment questionnaires contain many items relating to mental health.[27]

The Pre-Deployment Health Assessment questionnaire is administered within 60 days prior to the expected deployment. Completion of the PDHA occurs when an individual is administratively being released from the deployment area or within 30 days after returning to a home base. The

Post-Deployment Health Re-Assessment questionnaire was initiated in 2005 because field research indicated that health concerns, particularly those relating to mental health, occurred more frequently several months after a deployment. It is completed 90 to 180 days after returning to home station. [27]

All three deployment questionnaires were developed as tools to identify and address health issues and concerns, and potentially harmful exposures and concerns. Completion of these questionnaires requires follow-up with a face-to-face encounter with a trained healthcare provider to review and address responses to the questionnaire, as well as related issues and concerns. The DoD deployment questionnaires were developed for implementation as clinical tools. Significant shortcomings with the deployment questionnaires have been identified. In the first case, soldiers in Iraq who may have experienced a potentially harmful exposure to hexavalent chromium were told about their exposure and instructed to report the event in their postdeployment forms (PDHAs).[28,29] Of 227 soldiers with completed PDHA forms filed and available for review, only 55 (24.2%) accurately reported chromium exposure.[29] Only 96 (42.3%) soldiers, including the 55 identified previously, mentioned chemical exposure of any kind.[29]

A second case came to light following the first death of a US service member from rabies after an overseas dog exposure since 1974.[24,30,31] The service member who died was reported to have mentioned being bitten by a dog in Afghanistan on his PDHA form, but the medical officer who reviewed his form took no action.[31] An extensive effort was initiated by the US Army Public Health Command (Aberdeen Proving Ground, MD) to identify other uniformed service members who had contact with wild animals and may be at risk of rabies and in need of treatment.[31] Efforts to identify soldiers at risk for rabies included review of health assessment forms completed following deployment and other medical data bases.[31] Review of health assessment forms and other medical records resulted in well over 100 soldiers receiving rabies postexposure prophylaxis.[31] The outreach effort also identified about 300 soldiers who had never reported the dog bite they received.[31] Approximately 50 of these 300 soldiers were given postexposure prophylaxis.[31]

Investigators have pointed out that data and information from the PDHA must be carefully assessed and used with caution, with consideration that true exposure risks will probably be underestimated.[29] The need for continuous evaluations of the Deployment Health Assessment questionnaires has been identified.[29] Even though the deployment-related questionnaires were developed as tools to facilitate recall and discussion during individual patient encounters and have documented shortcomings, investigators continue to use the responses in these forms to develop population-based data.[32–34] Others have argued that policies and priorities should not be determined solely on the basis of PDHA studies.[29]

## WORK GROUP B DISCUSSION

Work Group B members supported positions developed by others and published regarding monitoring for hazardous exposures, such as the following:

- military commanders must be informed about the reasons for monitoring and must provide command support and leadership;
- monitoring must be done with clearly defined objectives and a meaningful plan; and
- efforts must continue to improve military procurement and training systems to facilitate having state-of-the-art equipment and trained operators available when needed.[15,24,35]

Work Group B members did not see postexposure modeling or biomonitoring to be tools that would be readily available and widely used in the near future. However, the need to continue to develop expertise and to do research with these tools was acknowledged.

Members of the group noted that full protection of deployed forces from hazardous exposures cannot be accomplished by monitoring devices and questionnaires. Military leaders must be informed about known and likely exposures, and be alert to the possibility of unanticipated exposures; they must assume their responsibility and take action to avoid or minimize exposures.[15,24] Examples of ongoing exposures in which early interventions could have reduced the possibility of exposure and later concerns about the exposure were identified by: (*a*) the use of large, open burn pits in the recent Iraq war for years; and (*b*) civilian contractors and military units working on a site contaminated with carcinogenic hexavalent chromium, an exposure that persisted through several rotations of military units.[28,29] Prompt recognition of a hazard, followed by a quick response of trained and equipped PVNTMED personnel, should increase the possibility that appropriate monitoring, appropriate use of questionnaires tailored to the situation, and perhaps the use of other tools previously discussed—all specifically designed for the situation at hand—would lead to the best possible exposure characterization. Rapid, reliable exposure characterization would contribute greatly to preventing morbidity and mortality, and would facilitate follow-up of those who may need it.

Considerable time was devoted to the discussion of questionnaires. Work Group B members agreed that questionnaires have value in assisting with patient recall and

providing information to providers during clinical encounters. Additionally, the group agreed that questionnaire data could identify the need for new research or support research projects currently underway. However, there was little or no support for the idea that one or a few large questionnaires could cover all possible exposure situations.

One suggestion was to develop a *questionnaire bank*. The bank would contain questions that had been developed and evaluated for various categories of exposures. Responders to situations during deployments, such as clinicians and researchers, could use the bank to find questions pertinent to their work and develop specialized questionnaires for their particular needs. There was strong support for the idea that responding to an incident required a questionnaire tailored to the situation.

The use of large questionnaires that cover a broad range of topics in the US military was discussed. Most thought these questionnaires were too often viewed by service members as simply another requirement that had to be completed. Therefore, the reliability of the responses was unpredictable and depended on the service member's state of mind. Overcoming this situation would require questionnaires that were clear and concise. Additionally, service members and healthcare providers had to be convinced about the importance of the questionnaire and had to feel comfortable that they knew the intent of the questionnaire and the possible outcomes. With regard to possible outcomes, the importance of trained providers evaluating all answers and appropriate follow-up being implemented in a timely fashion was stressed.

## SUMMARY

All questionnaires developed should be clear and concise and have:

- the reasons for the questionnaire and the expected outcomes clearly stated;
- the manner in which the questionnaire would be presented to uniformed members described;
- the method, place, and time for administering the questionnaire identified;
- the manner of follow-up of responses by trained personnel stated; and
- the intended use of the data obtained described.

Glass and Sim[17] believed that the practical choice for exposure assessment in military populations is the use of piloted and validated questionnaires that are completed during or soon after exposure. However, they point out the need for built-in checks of reliability, retesting to assess repeatability, and other safeguards.[17] The cautions and checks that they have identified for questionnaires must be considered for implementation by those who develop and administer questionnaires to US military members.[17] Work group B participants recommended the following:

- continue efforts to inform military leaders about hazardous exposures and their leadership responsibility to identify and respond to these;[15,24]
- continue efforts to procure and field state-of-the-art monitoring equipment in a timely fashion and personnel trained to operate the equipment;[15]
- maintain and improve expertise in the modeling of exposures and biomonitoring and support research in the areas that may be of value to the military;
- consider developing a questionnaire bank that would contain questionnaires and questions on various types of exposures and exposure outcomes (DoD and VA clinicians, public health specialists, and environmental scientists should have access to the repository)—the questionnaire bank would facilitate rapid development of questionnaires tailored to specific exposure scenarios; and
- develop checks of reliability and other safeguards for the deployment-related questionnaires currently being used.[17]

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