Chapter 10 – HEALTH RISKS DURING THE LIFE CYCLE OF THE DEPLOYED SOLDIER

by

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10.1 ABSTRACT

This chapter describes the timely management of occupational health risks during the entire life cycle of a soldier, from first selection as a recruit to beyond the end of his or her military career. The goal of military occupational and environmental health (OEH) programs is to contribute to the operational availability and capability of the military personnel as well as to protect their long-range health and general well-being. The monitoring of toxic hazards is especially important in OEH programs not only for potential toxic exposure itself, but because of potential interactions of such toxins with virtually every other aspect of military health. Biomonitoring established with toxic hazards in mind offers strategies for health monitoring that are likely to be useful for other health risks and outcomes as well. In a military career there are four stages: recruitment; training; operational deployment; and retirement. Health risk monitoring approaches for each of these stages are discussed.

10.2 INTRODUCTION

Occupational health standards and the management of health risks in a deployed military setting differ from most other occupations because of the deadly risks already inherent in warfighting occupations, with operational requirements not typically encountered in most other professions. The most important difference is the military operational need for short-term expedient exposures which in other occupational environments would be considered high risk, but which on an acute basis may actually be tolerable and necessary. Many of these health threats are predictable but continue to be intensively studied in military labs because of the infinite variations of these stressors that may confront service members (Figure 10-1). For example, the need to exploit hazardous environments of strategic importance may require tradeoffs between temporary exposure to potentially neurotoxic pesticides and unprotected exposure to malarial mosquitoes, or brief exposures to potentially hazardous environments, such as burning oil wells, that may be necessary during completion of a vital wartime task. There are many other special considerations in military health risk management ranging from combat materiel that may present health hazards to friendly forces (e.g. depleted uranium, low level chemical agents, laser rangefinders) to certain individual behaviors that may be more prevalent in risk takers and military environments (e.g. risky sexual behavior, physical fitness habits, smoking, alcohol abuse) that may substantially modify health risks in deployments. In addition to inadvertent or unavoidable risks in operational environments, the level of risk which may be acceptable in training environments may be determined by the need for realistic high intensity training for which there is no safer surrogate training model. Biomonitoring technologies are central to health risk management across the life cycle of the soldier (from recruitment to post-retirement) and can help to reduce the health risks by providing

better information to leaders so they can make better risk management decisions, conduct better health monitoring, establish better protective measures, and be provided better options for courses of action in risk environments.

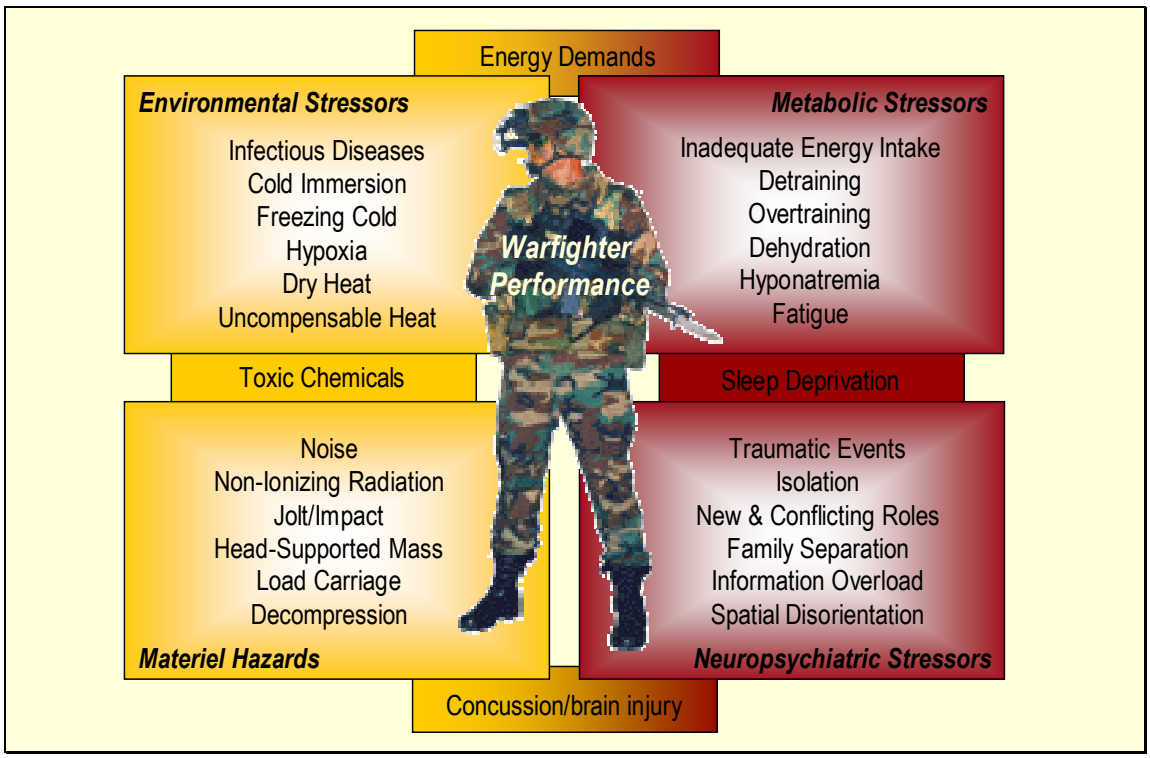

Figure 10-1: Predictable Stressors Confront Warfighters During Training and in Deployments. These have been studied individually and in combination, with continued research on predictive models, monitoring strategies and countermeasures. New variations of these stressors are often encountered.

The medical standards of fitness that determine who will enter the military and the allowable tasks to which an individual may be assigned are critical to preventing avoidable injury and illnesses. The training phase is both an opportunity for health promotion/protection and a new set of health risks. Individual resilience may be enhanced by effective training. Health risks may also be increased for some individuals in the attempt to provide a realistic high intensity training experience. Health care expertise is needed to forecast and control the occupational health risks in deployment with the goal of minimizing avoidable morbidity and mortality. In operations the soldier might be confronted with specific hazards. These hazards have to be identified as early in the planning cycle as is possible, and the associated risks have to be assessed. What is the likelihood of harmful incidents occurring and their potential injury and illness consequences? For each combination of hazard and disease an appropriate monitoring strategy including a specific health surveillance has to be established. These risks may range from those experienced only by susceptible subgroups such as pregnant soldiers or individuals with a genetic predisposition to injury (e.g. G-6-PD deficient soldiers who may not be able to take certain anti-malarial drugs); to specialized exposure groups such as submariners living in closed air environments or aircraft refuelers; or to the entire force when a new chemical prophylaxis is used during deployment or camps are established near burning garbage dumps. There is more to fitness and health than the absence of disease or injury. Occupational health interventions are required throughout the entire career of a

soldier to promote health and a healthy lifestyle, and thus to increase availability and operational capability. These same beneficial individual health behaviors may carry beyond military service in healthy veterans, thus encouraging longevity while decreasing medical expenditures. Alternatively, behaviors acquired in the military may produce a significant health care burden for the individual and the country if behaviors learned in the military degrade long-term health (e.g. cigarette smoking), if the sudden cessation of exercise and weight management habits leads to worse health consequences than for chronically sedentary overweight individuals, or if inappropriate and excessive physical training leads to an increased risk of osteoarthritis.

10.3 RECRUITMENT

Minimum baseline health and fitness standards have to be applied in order to be able to achieve the training standards. If a new recruit is not physically and psychiatrically suitable for military training, he or she will probably not complete the training, or will require much remedial training to meet standards. In either case, this has a significant adverse impact upon the training establishment, and may reduce the combat effectiveness of the force. Therefore at the time of recruitment it is important to give attention to the personal history: hereditary medical problems, habitual levels of physical activity, injuries and illnesses, mental health, psychosocial history, sexual development, history of depression and suicide, abuse, social support, risk behaviours, education, weight, nutrition, medication, dental care, chronic disease, etc. As an example, there is evidence that cigarette smoking is a predictor of general medical well-being during training [1]. A history of smoking could be regarded as a negative factor in the selection of recruits. Requiring and helping the recruits to stop smoking once they are inducted can help to achieve an improvement in their overall physical ability. There is also evidence that a higher level of physical activity or fitness before the recruitment helps to avoid training-related and time-loss injuries [2]. Therefore it is wise to require the candidates to meet well-defined minimum standards of fitness before induction.

Recruitment standards must be appropriately defined in order to minimize the likelihood of operationally-induced health hazards. Entry exams and history must both be generic enough to allow reasonably rapid accomplishment, and detailed enough to ensure that significant defects or disabilities are not missed. Follow-up tests, to include VO2, functional respiratory tests, neurological and psychological tests, etc. must be available for use in the evaluation of potential recruits whose ability to fully meet the standards is questionable. The validation against current mission requirements of these entry criteria is also important so that potentially excellent recruits are not being rejected for the wrong reasons. For example, the U.S. Army rejected many recruits from service in the past because of flat feet, a condition that was thought to be detrimental to health and performance of foot soldiers in training and on long marches. A careful study carried out by USARIEM and Nike in hundreds of basic trainees determined that flat feet were much less of a problem than the opposite, high arches [3]. As another example, up until World War 2, the U.S. Army rejected candidates who did not have two opposing (upper and lower) front teeth – upon investigation, it was determined that this requirement dated from before the Civil War, when it was necessary to have those teeth to bite open the paper cartridges then in use. Other seemingly well-established exclusion criteria such as attention deficit disorder and various forms of asthma have been periodically reconsidered. Medical standards that include body fat are intended to ensure healthy (i.e. non-morbidly obese) individuals, but these standards are also intended to ensure that new soldiers can later meet the medical standards for retention on active duty, which are more stringent. These retention standards include body fat standards that have been established to ensure individual combat readiness; lately these thresholds have been re-evaluated with pre-diabetes and other near term health and performance readiness consequences in mind [4].

In summary, the selection process should exclude those candidates with medical conditions which indicate a significant risk of them suffering ill health due to operational exposure or an inability to carry out military

functions. There should be a feedback loop from the lessons learned during operations to the medical centers responsible for recruitment, for instance when a significant ill health or disability related to a previously existing condition develops.

10.4 TRAINING CYCLES

The current and previously determined health status of the soldier should be checked by a medical staff member upon first arrival at a training center. Appropriate medical and/or administrative action should be taken to address any revelations and discoveries which might affect success in training or in operations. This may demand discharge from the service or medical care before the recruit is allowed to begin training. Gender-free training policy may provoke an increased rate of training injuries in female recruits [5]. Even at this early stage in their careers, Soldiers may be exposed to toxic hazards. A risk assessment of all potentially toxic substances used in training (cause of irritation, wounds, sensitisation, mutagenic effects, etc.) is necessary, and should be accomplished as part of the planning process for training events. Results of this assessment should be used in health awareness education during training. This education should not only cover matters such as personal cleanliness, smoking, alcohol, recreational drugs, reproductive health, sleep, diet and prevention of injuries and diseases, but also education about the prevention of thermal stress (e.g. dehydration), operational hygiene (personal protection and prevention), and methods of reducing the impact of potentially toxic substances.

It is never too early in a soldier's career for their inclusion in epidemiological surveillance systems. Data collected during routine clinical contacts and periodic health surveillance in a controlled environment can be very useful in later deployments when environmental and industrial risks cannot always be predicted and correctly evaluated. As an example, the importance of functional respiratory tests should be considered. The baseline values of FVC (Forced Vital Capacity), FEV1 (1 second Forced Expiratory Volume), and PEF (Peak Expiratory Flow) can be essential in the future evaluation of effects from exposure to airborne toxic substances such as chlorine, training gasses, phosgene, acids, fumes, and dust. Less is known about chemical agents causing bronchial hypersensitivity (e.g. acrylates, diisocyanates); normally the soldier should not be repeatedly exposed to these agents, but during operational deployments it cannot always be excluded or avoided. Sudden complaints of the respiratory function can only be objectively evaluated in comparison with a baseline value.

A similar case can be made for changes in mental functioning, with many neurotoxic chemical exposures that could be encountered in military environments affecting mood, cognition, psychomotor performance, and other neuropsychological domains. Detection of such changes requires baseline testing of soldiers upon entry into the military and periodic reassessments to adjust for ageing and other non-military exposure effects. Human studies indicate increased susceptibility to some illnesses such as the common cold in a "dose" association with semiquantitative stress burden [6]. Animal studies have shown increased toxicity of certain chemical compounds, such as malathion toxicity to tadpoles exposed to the psychological stress of predator scent in the water [7]. These are areas for further research before individual susceptibilities can be more definitely assessed and perhaps mitigated through resilience training.

Periodic health surveillance programs should try to cover all the physical, mental and psychological aspects essential for the well-being of the soldier. The rationale in the paragraphs above clearly argue in favor of extensive baseline functional studies being carried out on all soldiers as part of routine surveillance programs – significantly beyond the studies currently mandated in most NATO forces.

The U.S. Army Center for Health Promotion and Preventive Medicine (CHPPM) has established military-specific exposure guidelines that attempt to take into account both immediate incapacitating effects that will affect the warfighter and mission success, and immediate, delayed or chronic health outcomes [8]. These values must be taken into account in planning training programs.

The U.S. Army uses a standardised formal process of health hazard assessment to evaluate all new materiel from the earliest possible stages of conception through the final fielding and use [9, 10]. For many of these evaluations of new types of equipment, new methods for assessing hazards (including toxic hazards) have to be developed. For example, safety of humans operating new high-powered weapons systems such as the Multiple Launch Rocket System (MLRS) required new standards and methods of assessing risk from blast overpressure and inhalation of toxic gases associated with systems, and for carrying out survivability assessments of defeated armor [11 – 13]. The safety of new permethrin impregnated personal equipment has required the development of new assays for permethrin metabolites and protein adducts. The research role in the process of health hazard assessment and survivability analyses is shown in Figure 10-2. In those instances in which risk evaluation standards and methods have not yet been developed, the use of new systems tends to be more limited by very conservative standards until new data is available to support more realistic and practical standards. Interim advice on safety may be provided on the basis of current data in advance of completion of a fully tested and validated method or standard, with the caveat that such advice will be frequently updated as new information is derived. This use of conservative interim standards pending final evaluation of hazard is critical so that the military can employ useful equipment and tactics when the best available science supports safe use, even if the final end point of hazard analysis has not yet been reached.

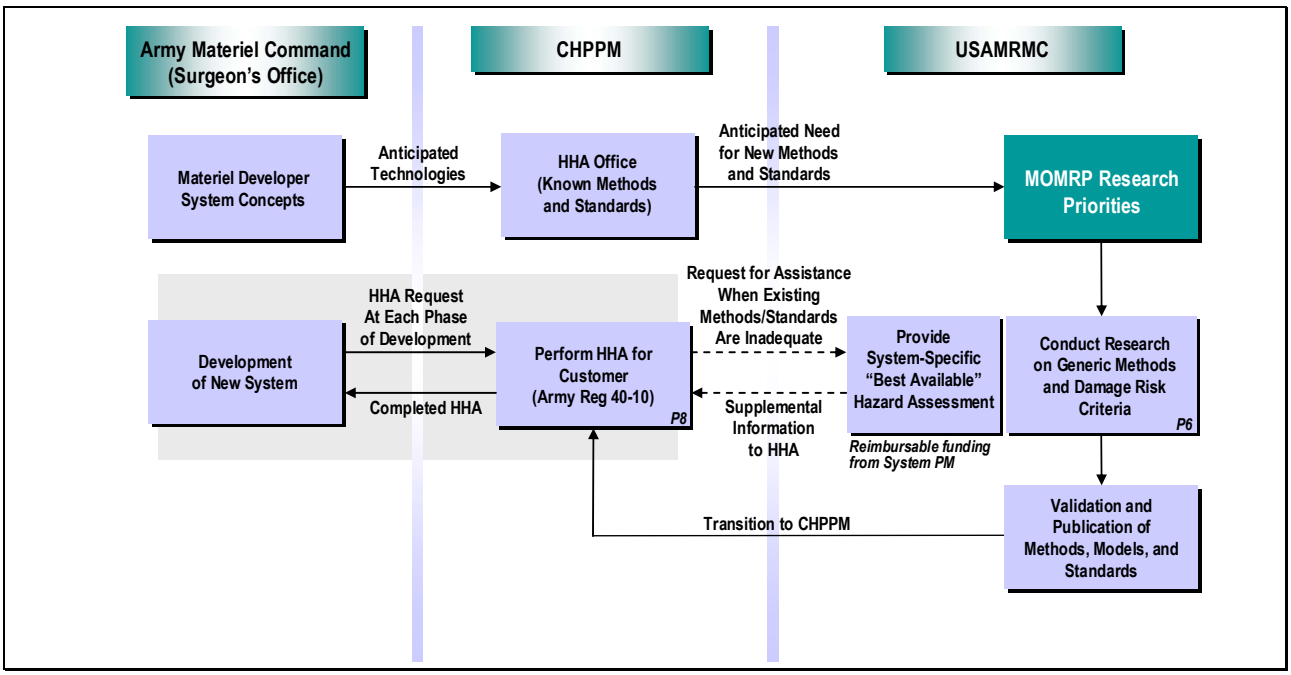

Figure 10-2: The Role of Research by the Military Operational Medicine Research Program (MOMRP) of the U.S. Army Medical Research and Materiel Command (USAMRMC) in Support of the Center for Health Promotion and Preventive Medicine (CHPPM) for the Health Hazard Assessment (HHA) Process Used by the US Army. New technologies typically present new health risks, include toxic hazards, and require conservative standards of health protection until new research establishes more realistic criteria and methods.

10.5 OPERATIONAL DEPLOYMENTS

A periodic clinical examination of the soldier is essential subsequent to initial entry examinations, even in the absence of clinical complaints or injuries. In addition to standard clinical indices, some armies also frequently assess physical fitness and body weight as part of such periodic evaluations. These measures can also provide early detection of changes in health status that suggest further evaluation. Clinical surveillance should include a set of complementary tests: hematological (RBC, WBC with differential analysis, Hemoglobin, Hematocrit); biochemical (hepatic and renal function); and health promotion screening (Blood Pressure, Serum Glucose, Cholesterol [including Total, HDL, and LDL]). These complementary tests are not only intended to evaluate the actual state of health, they should also help the soldier in aspects of health promotion and education such as in the prevention of cardiovascular diseases and diabetes. The early detection of diabetes or other cardiovascular risk factor is essential for the long-term well-being of the patient. Failure to monitor (and potentially prevent) development of such diseases might have important operational consequences, both individually and collectively.

Additional assessments and testing should be done in conjunction with deployments. Figure 10-3 highlights the variety of some of the health concerns typical of international deployments. Each deployment can bring about new and unpredictable health concerns involving psychological, infectious, toxic chemical, physical and other stressors. Assessment of standard clinical parameters is not likely to be adequate (or efficient) in pre- and post-deployment health testing for the wide variety of peculiar and unexpected new health hazards that may arise. This is to say that there is no certainty that all possible health issues will be addressed by any practical set of measures, except to ask soldiers about their health status and concerns, and then to be able to follow up on new or emerging threats through the analysis of collected environmental samples, blood samples, etc. Measurement of biochemical parameters in a stored serum sample certainly does not address all possible questions, contrary to common public perceptions (i.e. “why don’t you just measure everything in a blood sample before and after a deployment to know that soldiers are still healthy?”). Biochemical markers are still elusive for many desired applications in toxicology outcomes, and are especially problematic in the evaluation of neurological and behavioural disorders. Thus, deployment testing should be designed to detect overall changes in health status, general health indicators, sampling collections for retrospective analyses, and some assessments that are tailored to potential specific classes of threats as determined by the nature of the deployment. For example, peacekeeping missions in the midst of civil conflict may require more than typical mental health assessments [14 – 15], while deployments into areas with high industrial and agricultural toxic chemical contamination may need to focus on toxicological markers and outcomes.

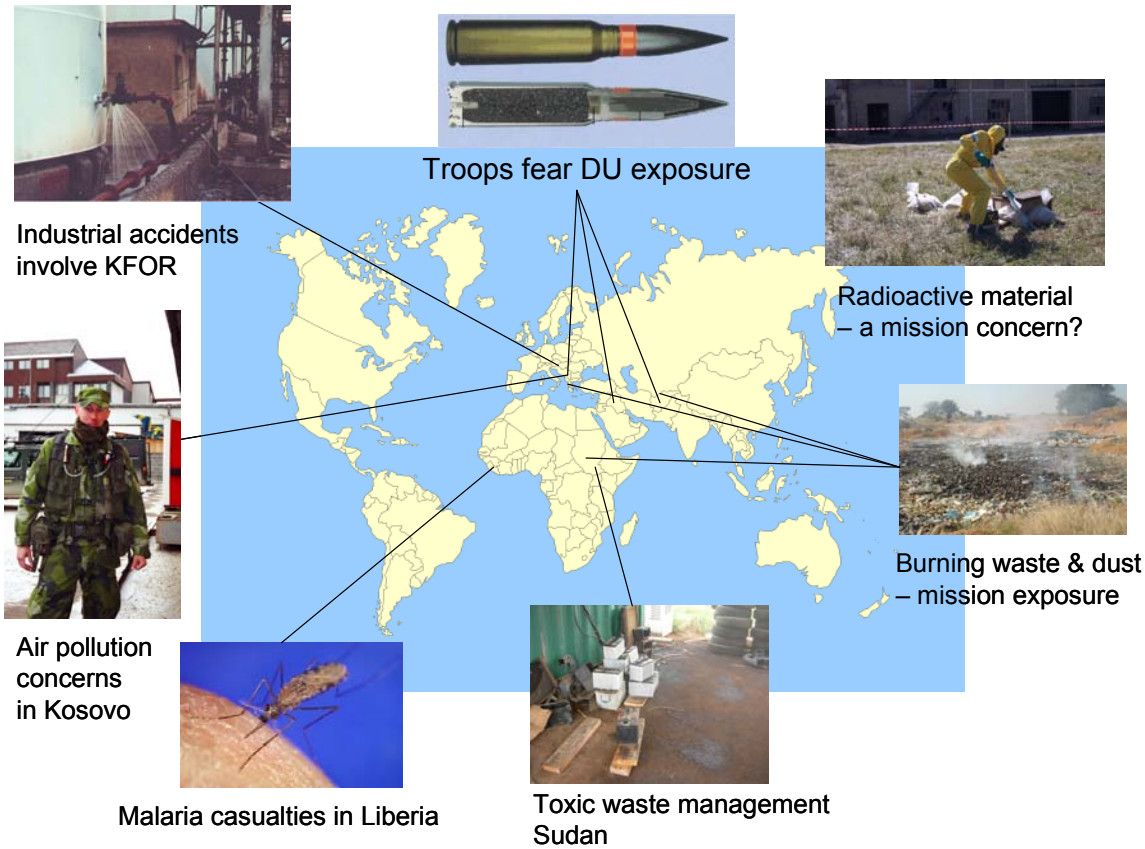

Figure 10-3: Examples of Recent Deployment Hazards Encountered by Peacekeeping Forces.

The relationship between health status and current military exposures in occupational and deployment environments is being systematically monitored in a sample of U.S. military members through the Millenium Cohort Study. This 21-year prospective study examines health outcomes of over 100,000 U.S. servicemembers starting with an initial sample enrolled in 2001 [16]. The study cohort was increased by an additional 30,000 members in 2004, and will add still more in 2007 to analyze temporal (generational) differences. Every three years, each member of the study is reassessed with an in-depth survey of recent exposures and deployment histories, as well as matching to other individual data such as inpatient and outpatient health care encounters. The participants are being followed beyond their periods of military service, and the Department of Veterans Affairs, also a participant, reviews records of all study subjects entering the VA system. A top priority for this project is to study potentially neurotoxic exposures and any associated neurological outcomes. The Millenium Cohort study has already been useful in assessing health status of service members before and after the World Trade Center bombing on Sept 11, 2001 [17].

A relatively new technology involving the combination of world surveillance databases provides a new tool for medical situational awareness and monitoring (Project Argus). A unique aspect of this database is the tracking of near-real time changes in social disruption as detected in translated news accounts and other definable events [18]. Thus, increasing reports in an area of the world of, for example, an increase in mysterious illnesses and hospitalizations, or large unexpected population movements, combined with various ground confirmation mechanisms may signify a chemical, biological, or radiological event or some natural

disaster, to include the emergence of previously unknown diseases. Further monitoring of the environment may provide additional insights from climate and other factors to predict disease outbreaks and other health threats in advance of exposure of deployed forces.

10.6 POST-MILITARY SERVICE

U.S. veterans have high rates of medical disability discharges from the Army for musculoskeletal conditions, and high-frequency sensory-neural hearing loss (HFSNHL) is endemic among military veterans. These are examples of potentially preventable problems related to some aspects of training, combat, or other military exposures. Careful studies of toxic chemical hazards such as petroleum product exposures and increased rates of noise induced hearing loss may reveal interactive effects in veterans associated with avoidable neurotoxic and noise exposures. These health outcomes are identified through epidemiological studies in combination with well-validated assessments of exposure and effect.

Behaviors supporting the maintenance of good health can be promoted in the military through various mechanisms, including exercise and weight management. One pending question is whether or not sudden cessation of these habits in new retirees precipitates rapid weight gain and loss of cardiovascular health and fitness, at rates higher than those who have remained sedentary and with less healthy eating habits for most of their life. For veterans maintaining their good health habits into retirement, there may be specific benefits to musculoskeletal and cardiovascular health later in life, including reduction of risks for osteoporosis, hypertension, sacropenia, and heart disease. Furthermore, remaining active with good habits learned during military service may prevent type 2 diabetes, neurodegenerative diseases, etc.

Military veterans are repositories of the accumulated toxic chemical and other harmful exposures over their lifetimes, and may serve as biosentinels for these effects in soldiers of the future. It may be possible to follow these veterans on a long-term basis, and to determine some effects specific to military service and militarily-unique exposures through well-designed population studies. There are several recent examples of studies that have been conducted post-hoc to determine effects of uncontrolled exposures. These include the effects of Agent Orange herbicide on U.S. veterans of the Vietnam war [19, 20]. A study of Japanese-Americans many of whom served in WWII includes assessment of brain pathology and chemical residues in dying ageing men [21]. A study of neurodegenerative diseases in military veterans compared to their peer groups indicated a higher rate of ALS but no difference in overall PD rate [22]. A comparison of groups from the 1970s that were used in experimental exposures to chemical agents versus soldiers used only in equipment tests, revealed no differences in health outcomes, although the test groups were not well matched because of non-random selection criteria in the initial studies [23]. Epidemiological studies of the causes of serious illness and death in specialized groups such as submariners may reveal something about inhalation risks associated with closed air environments on different types of submarines, although the appropriate control group for comparison of such a specialized group of largely self-selected individuals is a problem.

10.7 CONCLUSIONS

Figure 10-4 summarizes current monitoring and record keeping objectives that will help to quickly detect, identify, and prevent or reduce health risks in future deployments. Monitoring methods for toxic hazards are needed at every step. A proposed schema for standardisation of the identification of hazards through the implementation of control measures is shown in Figure 10-5.

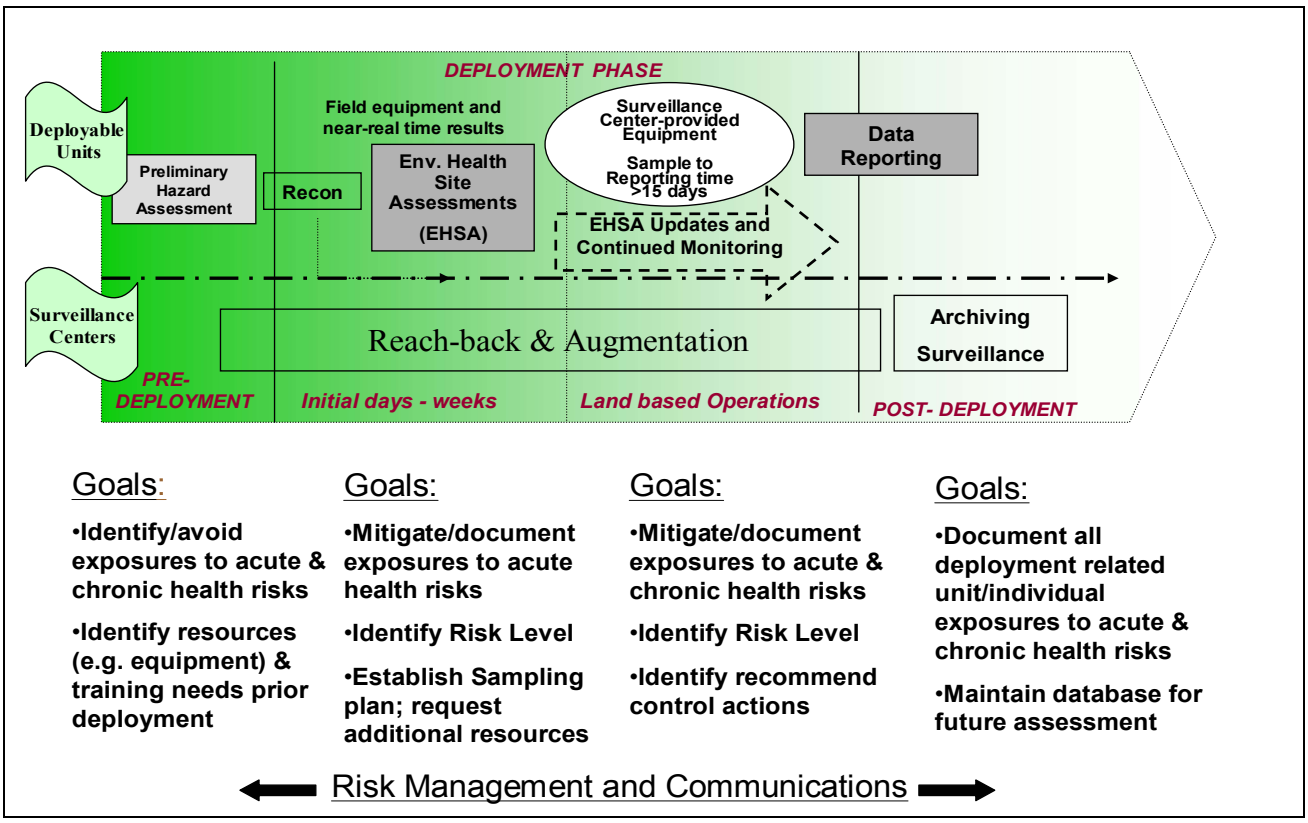

Figure 10-4: Overview of the U.S. DoD OEH Surveillance Process Including Steps During Pre-Deployment, Initial Deployment, Longer-Term Land-Based Operations, and Post-Deployment Phases (chart from presentation by COL Deniece Van Hook, presented at HFM-057/RTG-009 Gent meeting, 2006).

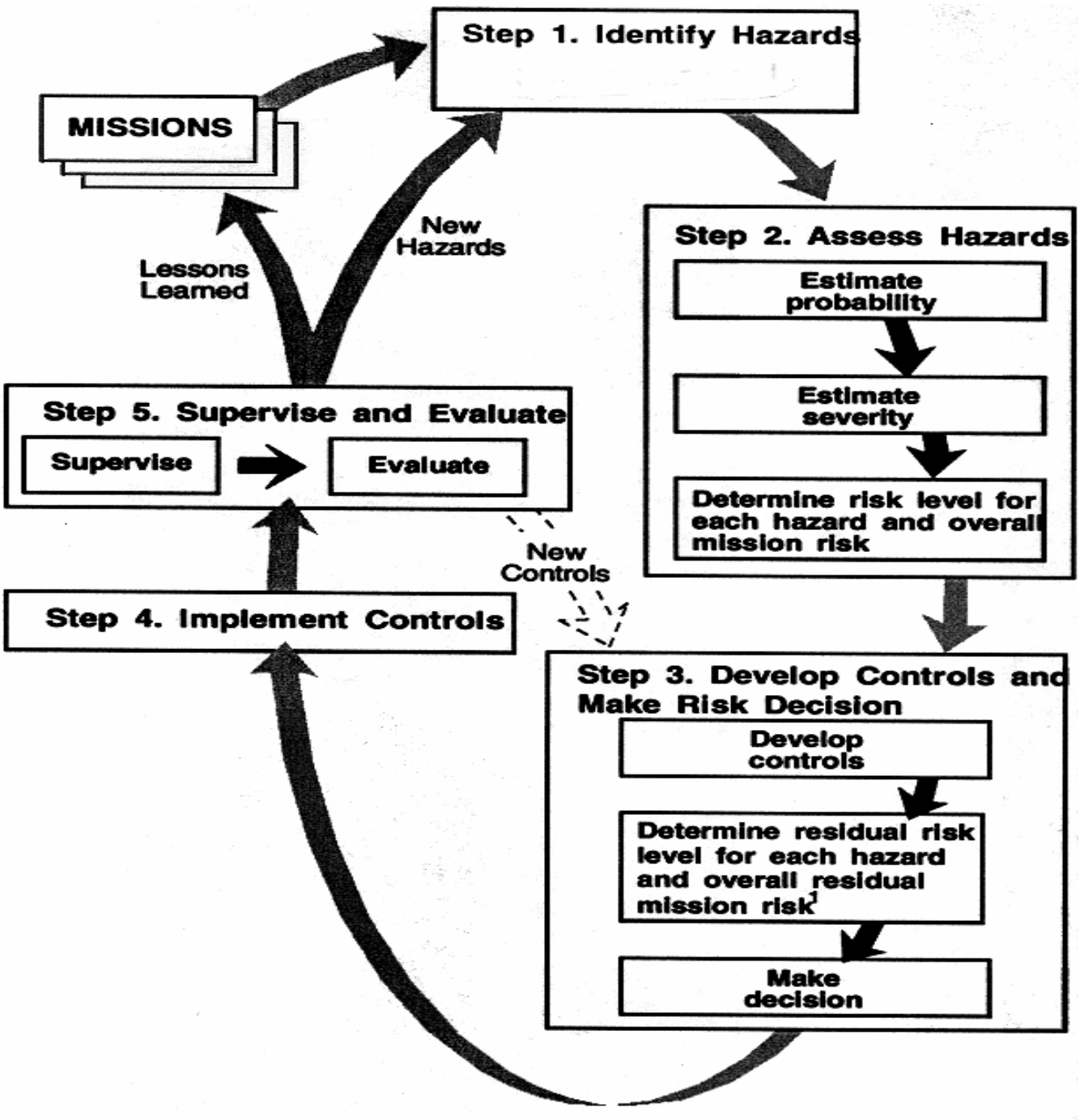

Figure 10-5: Health Risk Management Scheme Proposed for NATO. Steps 2 and 5 are key opportunities for the application of biomonitoring technologies [24].

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