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Risks to Deployed Forces

War by its nature is a tremendously hazardous endeavor. Clearly, it entails risks to life and limb from weapons and battle. At least up through World War I, however, non-battle-related disease and injury have taken an even greater toll upon the health of deployed forces than have battle injuries (Garfield and Neugut, 1997).

The non-combat-related risks to deployed forces include an array of different threats to health. Infectious diseases, non-battle-related injuries, injuries from heat and cold exposures, and psychological stress have been large contributors to casualties in war after war. Chemical and biological weapons are increasingly seen as threats to deployed forces, as are environmental contaminants and toxic industrial chemicals.

The military has responded to these threats with military medical research programs and the subsequent implementation of doctrine and protective measures that have reduced the impacts of disease and non-battle injury (DNBI) to the very low levels observed in Operations Desert Shield and Desert Storm (the Gulf War) and in Bosnia. Many infectious disease threats have largely been eliminated by use of vaccines, prophylactic drugs, vector control, insect repellents, and protected food and water supplies. Improved clothing, footwear, and military doctrine have greatly reduced the impacts of injuries from heat and cold exposures. The strategies now in place for countering the traditional acute diseases and injury threats to military operations are fundamentally sound. This report has addressed these traditional concerns of military medicine in a very limited fashion and focused on improved medical surveillance to better assess and respond to traditional and emerging threats, record keeping to permit appropriate care and retrospective analysis, and the complex issue of medically unexplained symptoms in returning service members.

INFECTIOUS DISEASES

Throughout history infectious diseases have been the single greatest threat to the health of those involved in military operations. Epidemics of contagious diseases such as influenza, food- and waterborne illnesses such as hepatitis, typhoid fever, and shigellosis, and vector-borne diseases such as typhus, yellow fever, malaria, and dengue have caused entire armies to become militarily ineffective (Zinsser, 1935). Tropical and subtropical regions have been especially hazardous because of vector-borne diseases. As recently as the Vietnam War, infectious diseases took a heavy toll on the U.S. military population. Disease was listed as the cause of 56 to 74 percent of active-duty Army patient admissions to hospitals in Vietnam from 1965 to 1970 (Ognibene, 1982). Until 1967, the total number of lost days of duty by active-duty Army personnel initially admitted for medical care from DNBI outpaced those from battle injury. From 1968 to 1970, DNBI contributed nearly half of the lost days of duty (Ognibene, 1982).

Because infectious disease has long been recognized as a serious threat, the military has, through painful lessons, developed effective strategies to address these threats. At least in the most recent declared war, the Gulf War, the strategies used to reduce risks from infectious disease and severe climate proved successful. In contrast to previous experiences, infectious diseases were not a major cause of lost personnel, even though many infectious diseases that pose serious health threats are endemic to the region of deployment (Hyams et al., 1995).

Although diarrheal disease was common during the rapid buildup of Gulf War troops from August to September 1990, the majority of troops experienced mild traveler's-type diarrhea that resolved spontaneously (Hyams et al., 1995). Gastroenteritis rates also dropped dramatically when fresh produce was eliminated from troops' diets (Hyams et al., 1995). No cases of sandfly fever were observed in Gulf War troops, and only seven cases of malaria were reported, and these were among troops who had crossed into southern Iraq. Twelve cases of visceral leishmaniasis and 20 cases of cutaneous leishmaniasis were diagnosed. In general, careful control of the water and food supplies, inspection of food preparation facilities, and use of insecticides and medical prophylaxes through immunizations seem to have been good defenses against infectious disease. This protection was facilitated by the isolation of the troops and the fact that most troops were deployed during the cold winter months, when sandfly and other arthropod activity is limited.

Infectious diseases remain among the serious threats to deployed military forces. Although the military has exerted tremendous effort in countering these threats and understands them well, the ever-changing and evolving nature of infectious diseases will require continued vigilance and development of preventive methods. Multidrug-resistant malaria, increasingly widespread dengue epidemics, hantavirus infections, and other hemorrhagic fevers are among the current diseases that may be encountered during future deployments, for which vaccines are not available, and against which complete protection may be difficult or impossible to achieve by current methods.

NON-BATTLE INJURIES

Non-battle injuries (injuries sustained in non-combat aspects of a deployment, such as in motor vehicles accidents and during training) have historically been a significant hazard for deployed troops. In past conflicts, rates of such injuries have frequently rivaled those from battle injuries and wounds (Table 2-1) (F. D. Jones, 1995b). In the Gulf War, 55 of the 65 non-battle-related deaths resulted from accidental injuries, including two helicopter crashes and an accident involving a light armored vehicle (Helmkamp, 1994).

Although total DNBI rates have fluctuated slightly between 5 and 10 per 100 soldiers per week during the major deployments in the last decade (Table 2-2), injury has been among the top contributors in all of these deployments. In the Gulf War, 18.4 percent of all DNBI were injuries, whereas in the Somalia and Bosnia deployments, 25.2 and 27 percent of DNBI were injuries (McKee et al, 1998; U.S. Army Center for Health Promotion and Preventive Medicine, 1998). In Southwest Asia since 1996, orthopedic injuries, both sports-related and other, have contributed 23.1 percent of DNBI cases (Thompson, 1999).

TABLE 2-1. Battle Injury and Wound Rates per 1,000 Troops per Year During Various U.S. Wars

War	Year	No. of Non-Battle-Related Injuries	No. of Battle-Related Injuries and Wounds
U.S. Civil War	1861–1865	—	97
World War I	1917–1918	—	238
World War II			
Pacific	1942–1945	122	39
Europe	1942–1945	101	108
Mediterranean	1942–1945	131	80
Korea	1950	242	460
	1951	151	170
	1952	102	57
Vietnam	1965	67	62
	1966	76	75
	1967	69	84
	1968	70	120
	1969	63	87

SOURCE: F. D. Jones, 1995b.

TABLE 2-2. Average Disease and Non-Battle Injury (DNBI) Rates for Recent Deployments

Deployment	Service	Person-weeks	Rate (%/week)
Operation Desert Shield/ Storm (Gulf War)[a]	Army	1,242,300	5.8
Operation Desert Shield/ Storm (Gulf War)[a]	Marine Corps	787,310	6.5
Somalia[a]	Tri-Service	163,093	10.6
Operation Joint Endeavor (1995–1996)[a]	Tri-Service	495,528	7.1
Operation Joint Guard (1997)[a]	Tri-Service	453,002	8.1
Southwest Asia Operations (1996–)[b]	Tri-Service	1,576,738	5.2
Operation Allied Force (1999)[b]	Air Force	63,483	8.1

SOURCES: [a]McKee et al., 1998; U.S. Army Center for Health Promotion and Preventive Medicine, 1998; McKee, 1999. [b]Thompson, 1999. Data are as of May, 1999.

Military rates of hospitalization for injuries, independent of deployments, are quite high and well above the goal specified in *Healthy People 2000* (Bray et al., 1999; Public Health Service, 1991). The high rates have recently prompted interest from the Injury Prevention and Control Work Group of the Armed Forces Epidemiologic Board. The group identified sports-related injuries, motor vehicle-related injuries, and falls or jumps as major causes of hospitalization for injury among military personnel and recommended research focused upon prevention (Injury Prevention and Control Work Group, 1996).

Heat and Cold Injuries

Injuries from exposure to heat, cold, and other environmental factors can constitute important components of non-battle injuries. Injuries that occur as a result of exposure to excessive heat include heat rash, sunburn, heat cramps, heat exhaustion, and heat stroke. They made up less than 1 percent of DNBI during the Gulf War deployment, 2.3 percent during the Somalia deployment, and less than 1 percent during the Bosnia operations (U.S. Army Center for Health Promotion and Preventive Medicine, 1998; McKee et al., 1998). In Southwest Asia Operations, they have contributed roughly 1 percent of overall DNBI cases since 1996 (Thompson, 1999). Commanders have the most critical role in prevention of heat injuries through enforcement of physical fitness requirements, heat acclimation procedures, work and rest schedules, the appropriate use of clothing and equipment, and adherence to proper nutrition (U.S. Army

Research Institute of Environmental Medicine and Walter Reed Army Institute of Research, 1994; Withers et al., 1994).

Among the many cold exposure-related injuries of military significance, trenchfoot, frostbite, and hypothermia are the most common in the military. Although injuries due to cold exposures were not recorded in detail until World War I, historically, many U.S. Army personnel who were exposed to cold environments during a deployment experienced cold-related injuries. For example, 10 percent of the U.S. wounded Army personnel in both World War II and Korea suffered from cold-related injuries (Hamlet, 1987). Commanding officers of every Army unit were responsible for making sure that the soldiers wore dry socks, changed their shoes or boots regularly, rubbed their feet with animal fat at least once a day, and exercised their feet to provide proper circulation (Whayne and DeBakey, 1958). As with heat-related injuries, aggressive leadership will continue to be required for prevention of cold-related injuries in cold climates.

PSYCHOLOGICAL STRESS

Psychological stress is an important potential source of military casualties both during combat and in the years that follow. Especially since the Vietnam War it has been recognized that the stress accompanying combat can have both acute and chronic effects. Acute or short-term stress reactions have gone by many names, as noted below. Posttraumatic stress disorder (PTSD) is the name formalized in 1980 for long-term reactions to war-zone exposure (American Psychiatric Association, 1980).

Acute psychiatric casualties were first recognized as a significant source of personnel loss in battle in World War I. Most neuropsychiatric casualties in World War I were given the popular label "shell shock." By 1917, one-seventh of all discharges for disability from the British Army had been due to mental conditions. Of 200,000 soldiers on the pension list of England, one-fifth suffered from war neurosis (Salmon, 1929). Soon, physicians discovered the importance of forward and rapid treatment, that is, that patients with war neuroses improved more readily when they were treated near the front and were more likely to improve if they were treated quickly (Salmon, 1929). Eventually, three principles became the critical elements of combat psychiatric casualty treatment: proximity, immediacy, and expectancy. The most effective procedure was found to be the treatment of the combat psychiatric casualty in a safe place as close to the battle scene as possible (*proximity*), as soon as possible (*immediacy*), and with explicit understanding that he was not ill and would soon be rejoining his comrades (*expectancy*) (Artiss, 1963). The treatment was to be simple, such as rest, food, and maybe a warm shower.

Once it became clear that shell shock was not caused by the concussion of shelling, "war neurosis" was used as the diagnosis for the acute psychiatric casualty in World War I. Eventually, medical personnel were told to identify such casualties as "N.Y.D. (nervous)," for "not yet diagnosed (nervous)," which did not

suggest that it should be incapacitating or require hospital treatment. In World War II, the term "combat fatigue" came to be preferred (F. D. Jones, 1995a).

In World War II, planners operated on the belief that preinduction screening could minimize potential psychiatric casualties (Glass, 1966a). Draft registrants with any significant history of psychiatric disturbance, especially those with anxiety symptoms, were not selected for service. Soldiers who showed symptoms after induction were discharged. Manifestation of psychiatric symptoms provided an honorable way of avoiding induction, producing a massive loss of potential personnel (F. D. Jones, 1995a). Yet, even though the disqualification rate of registrants was about 7.6 times as high as that in World War I (1.6 million registrants were classified as unfit because of mental disease or educational deficiency in World War II), separation rates for psychiatric disorders were 2.4 times as high (Glass, 1966b).

In addition to proving to be ineffective in preventing breakdown, the liberal separation policy for those with neurotic symptoms led to major personnel losses. Glass (1966b) noted that in September 1943, more soldiers were being eliminated from the U.S. Army than were being brought in and most of those separated were for psychoneuroses (35.6/1,000/year). Military psychiatrists concluded that reliance on psychiatric screening was ineffective, with studies indicating more similarities than differences between acute psychiatric casualties and their fellow soldiers (Glass, 1973; F. D. Jones, 1995a).

Epidemiologic studies of World War II combat stress casualties indicated that they had a direct relationship to the intensity of combat and were modified by physical and morale factors (Beebe and DeBakey, 1952). A notable study by Beebe and Appel (1958) indicated a breaking point for the average rifleman in the Mediterranean Theater of Operation of 88 days of company combat—days in which the company sustained at least one casualty. Noy's review of that work found that psychiatric casualties had remained in combat duties longer than medical and disciplinary cases and that their breakdowns were related to exposure to battle trauma more than medical and disciplinary cases were (Noy, 1987).

The importance of group cohesion in possibly preventing and treating psychiatric breakdown was another lesson of World War II. In his summary of lessons learned in neuropsychiatry in World War II, Glass writes,

> Perhaps the most significant contribution of World War II military psychiatry was recognition of the sustaining influence of the small combat group or particular members thereof, variously termed "group identification," "group cohesiveness," "the buddy system," and "leadership." This was also operative in noncombat situations. Repeated observations indicated that the absence or inadequacy of such sustaining influences or their disruption during combat was mainly responsible for psychiatric breakdown in battle. These group or relationship phenomena explained marked differences in the psychiatric casualty rates of various units who were exposed to a similar intensity of battle stress. The frequency of psychiatric disorders seems to be more related to the characteristics of the group than to the character traits of the involved individuals. Thus, WWII clearly showed that interpersonal relationships and other social

> and situational circumstances were at least as important as personality configuration or individual assets and liabilities in the effectiveness of coping behavior. (Glass, 1973, p. 995)

The overall incidence of combat stress casualties in modern warfare has ranged from 10 to 25 percent of all combat casualties (Mareth and Brooker, 1985), but the incidence has been much higher in certain instances. In the 1973 Yom Kippur War, Israel suffered acute combat stress casualties at rates estimated to be from 30 to 50 percent (F. D. Jones, 1995a). The rate of combat stress casualties was highest among support personnel, probably responding to the trauma of seeing dead and mutilated comrades. In the 1982 Lebanon War, the rate of casualties from acute stress was estimated at 23 percent (F. D. Jones, 1995b).

The experiences of Vietnam veterans brought the first widespread recognition of delayed or chronic PTSD in deployed forces. People diagnosed with PTSD are characterized by symptoms of increased arousal, sudden reliving of a traumatic event through recurrent and intrusive recollections or dreams, and avoidance of stimuli associated with the trauma (American Psychiatric Association, 1994).

The National Vietnam Veterans Readjustment Study (NVVRS) was a comprehensive national study of the postwar psychological problems of Vietnam veterans, mandated by the U.S. Congress in P.L. 98-160 (Kulka et al., 1990). The study indicated that 15.2 percent of all male Vietnam theater veterans and 8.5 percent of female Vietnam theater veterans had current cases of PTSD. Among men and women with high levels of war-zone exposure, current PTSD was higher: 35.8 percent among men and 17.5 percent among women. An additional 11.1 percent of male and 7.8 percent of female veterans suffered from "partial PTSD"—symptoms that are of insufficient intensity or breadth to qualify as PTSD but that may still warrant professional attention. NVVRS analyses of the lifetime prevalence of PTSD indicated that almost one-third of male and more than one-fourth of women Vietnam theater veterans had PTSD at some time during their lives (Kulka et al., 1990).

Deployed populations in earlier wars also experienced the chronic effects of combat stress. Futterman and Pumpian-Mindlin (1951) reported a 10 percent prevalence of "war neurosis" in a series of 200 psychiatric patients seen in 1950. Another study observed "gross stress syndrome" in World War II veterans up to 20 years after combat (Archibald and Tuddenham, 1965). After PTSD was recognized in the 1980s, additional studies were carried out to assess PTSD in World War II and Korean War veterans. Although the prevalence of PTSD in older veterans is unknown, World War II veterans were similar to Vietnam veterans in their reactivity to stimuli reminiscent of their war trauma (Orr et al., 1993). An additional study indicated current PTSD prevalences of 37 percent among World War II veterans and 80 percent among Korean War veterans among those who had previously sought psychiatric treatment (Blake et al., 1990; Friedman et al., 1994). In a sample of 1,210 veterans of World War II and the Korean War, the prevalence of PTSD ranged from 0 to 12.4 percent depending on the PTSD measure (Spiro et al., 1994).

During the Gulf War, acute psychiatric casualties were rare. Only 6.5 percent of all medical evacuations from Southwest Asia during the Gulf War were classified as being for psychiatric reasons (Stretch et al., 1996). Since the Gulf War, many different studies have been carried out to estimate the prevalence of PTSD in various groups of Gulf War veterans, with a range of PTSD prevalence reported from 4 to 36 percent (Sutker et al., 1993; Wolfe et al., 1993) (several studies have been critiqued and summarized by Haley [1997]). A telephone survey of a large population-based sample of Gulf War veterans found that 1.9 percent reported symptoms of PTSD, whereas 0.8 percent of the military population deployed elsewhere during the same time reported symptoms of PTSD (Iowa Persian Gulf Study Group, 1997).

Military personnel on peacekeeping as well as combat deployments are at risk of long-term effects from psychological stress. A survey of a large cohort of military personnel deployed to Somalia for peacekeeping duty found that 8 percent met the diagnostic criteria for PTSD roughly 5 months after their return (Litz et al., 1997).

Even when deployment stress does not result in PTSD, it appears to result in increased levels of general psychological distress among deployed forces. Psychological symptom measures for samples of soldiers during deployments to operations in the Persian Gulf, Somalia, and Bosnia indicated that they had significantly elevated levels of psychological distress compared with those for nondeployed soldiers (Stuart and Halverson, 1997).

The deployment missions (combat, peacekeeping) themselves are not the only sources of stress for deployed military personnel. In a recent health survey of Department of Defense (DoD) personnel, the most frequently cited source of stress for both men and women was being away from family (reported by 19.5 percent of both men and women) (Bray et al., 1999). Chapter 7 discusses further some of the varied sources of stresses relating to deployment and separation from family as well as reintegration into the home environment.

Strategies for protecting forces from combat and deployment stress in future deployments must take into account the range of missions and environments that they will likely encounter. Clearly, these stresses cannot be eliminated, but some of their effects may be mitigated. High-intensity warfare, low-intensity warfare, peacekeeping, and humanitarian deployments each pose different challenges and mixes of psychological stressors (F. D. Jones, 1995c), so the preventive response requires flexibility, adaptability, and improvisation (Belenky and Martin, 1996a). As with other risks to the health of deployed troops, commanders must be aware of them and must be prepared to address and prevent them to the extent possible.

TOXIC INDUSTRIAL CHEMICALS

Historically, preventive measures for deployed forces have focused on the prevention of acute risks to health that will affect the mission. Growing awareness of the potential long-term risks posed by environmental and occupational exposures in the United States has been accompanied by recognition that such hazards may be

present during military deployments as well. The burning of oil wells in Kuwait during the retreat of the Iraqi Army during the Gulf War made clear that local industrial sources can create hazards for deployed forces. Troops may be exposed to hazardous chemicals through inadequate environmental protection in the area of operations, industrial accidents, sabotage, or the intentional or unintentional actions of other forces (Life Systems Inc. and GeoCenters Inc. for U.S. Army Center for Environmental Health Research, 1997). Since military attention to these exposures is recent, their toll on deployed forces from previous wars is unknown. Improved environmental surveillance and exposure assessment are planned to provide a better understanding of the risks for deployed forces (National Research Council, 1999b). At the same time, improvements in medical surveillance and record keeping after deployments (discussed in Chapters 4 and 5) will be needed to note any long-term effects from environmental exposures.

CHEMICAL WEAPONS

The proliferation of chemical warfare capability among potential adversaries in recent years and the potential effects of chemical warfare agents on U.S. military forces are causes of serious concern. During future deployments, U.S. military forces are increasingly likely to confront opponents with chemical weapons capability. Other sections of this study (National Research Council, 1999a,b,c) address the overall threat and risk assessment and the capability of the military to detect the agents used in chemical weapons and to protect military personnel using avoidance, protective masks, and clothing. Potential exposure to chemical weapons will have medical consequences that must be recognized and managed even if protective measures are used appropriately and minimal or no acute casualties result. The combined effects of low-level exposures, whether suspected or confirmed, and the stress of dealing with a chemical attack will create a need for risk communication, intensive long-term surveillance, careful analysis of medical outcomes, and skillful medical management of the affected personnel.

BIOLOGICAL WEAPONS

Like chemical weapons, biological weapons are an increasing concern because of their intensive development by the former Soviet Union and Iraq and their proliferation to other potential adversaries. The list of potential agents includes bacteria such as those that cause anthrax, plague, and tularemia; viruses, such as smallpox and neurotropic alphaviruses; rickettsiae; and biologic toxins. Although protection against aerosols is afforded by current equipment (masks), the difficulty of detecting and identifying biologic agents in aerosols has limited the effectiveness of detection equipment (National Research Council, 1999b). For the foreseeable future DoD must rely heavily on prophylactic vaccines and drugs and must be prepared to deal with the long- and short-term medical effects

experienced by casualties exposed to biological weapons. Immunization of all military personnel with the currently licensed anthrax vaccine has greatly reduced the threat of anthrax which has widely been regarded as the most effective and imminent biologic threat.

PROTECTIVE MEDICATIONS

Some of the potential risks to deployed forces include the protective medications themselves. Although protective medications are selected because they can help protect service members in dangerous environments, they can have risks of their own. In many cases, the benefits have been thoughtfully and thoroughly weighed against these risks. The use of DEET (diethyl *m*-toluamide) as a mosquito repellent is an example. DEET carries a slight risk of neurotoxicity when used at high doses and has been associated with rare deaths in susceptible people. It is considered safe enough for over-the-counter sale to civilians, however, and is far less hazardous to service members than mosquito bites in areas where malaria is endemic. One of the studies carried out concurrently with this study further addresses a framework for assessing risks to deployed forces (National Research Council, 1999a).

INTERACTIONS

In addition to the separate risks posed by each of the exposures described above, the potential for additive or synergistic effects of such exposures has become a source of concern. During deployments, military personnel are exposed to combinations of drugs, biologics, and chemicals to which civilians are not exposed. As in civilian settings, the health effects of exposures to these mixtures are poorly characterized, but the diversity and number of agents preclude testing of all possible combinations or the development of reliable predictors of all possible interactions that could result in increased toxicity (Institute of Medicine, 1996b). The Institute of Medicine Committee to Study the Interactions of Drugs, Biologics, and Chemicals in U.S. Military Forces included in its recommendations enhanced surveillance systems, a battery of experimental studies, and careful epidemiologic studies (Institute of Medicine, 1996b).

The risks described in this chapter are ones that have been recognized to various degrees by the military leadership and preventive medicine community. The next chapter discusses another aspect of health risks to deployed forces that is a particular focus of this study because it has not yet been addressed by the military with a prevention or mitigation strategy.