Medical Concerns of the Desert Soldier: Establishing a Model for Comprehensive Medical Care in a War Zone

Maj Ken Hoffman, MC*

The author provides a review of causes for morbidity and mortality during Desert Shield/Desert Storm using available medical information sources. Some information is most relevant for troops under command control, other information is applicable to troops who will be interacting with local populations. Describing the medical problems for each scenario, he demonstrates the need for a cohesive framework within which to present all relevant information and illustrates the use of one model. He concludes that an accurate medical outpatient surveillance system needs to be developed through which a comprehensive matrix of prevention and treatment strategies could be planned.

Desert Shield and Desert Storm have been incredibly successful in achieving all military objectives with a minimal loss of allied lives. Significant also was the incredibly low rate of casualties from both battle and nonbattle causes. Throughout, medical preparations for casualties looked excellent in some areas and troublesome in others. This was partially due to the difficulty in accurately assessing probable medical needs over time. There may be an accurate assessment for given points and situations, but assessing needs over a continuum should be done routinely at a strategic planning stage.

When troops were deployed to Saudi Arabia, the first medical concerns appropriately focused on the environment. To avoid heat casualties, water discipline was established. Heat casualties have been very light. Diarrhea in any new environment generally happens and is temporarily disabling. Protected or inspected food and water supplies have been used successfully to minimize the extent of diarrhea. Most areas of the world have endemic hepatitis A and malaria. Deployed troops have their vaccinations updated as relevant for the region to which they will be deployed. They are given immunoglobulin to prevent hepatitis and chemoprophylaxis as appropriate to prevent malaria. Psychological problems greatly concern the commanders. During this deployment, careful attention has been paid to family issues, troop deployment in groups, anticipatory anxiety, and boredom. A major change in environment is the prohibition of alcohol out of respect for the host nation. Psychological casualties appear lower than expected.

Medical planning had been approached from three perspectives. The most obvious perspective is from the reports received by the Surgeon General from hospitals and clinics treating deployed troops and from military medical experts. However, the troops live within a new environment within which they will find time to intermingle with the people and adapt to their lifestyle. At this level, behavior has a critical role in the prevention of both illness and accidents. A second perspective looks at data already developed for tourists visiting the countries mentioned. Also relevant from this perspective are the published articles from medical authorities within these countries who may give insight into relevant problems from their personal interest. The last perspective has been a look outside the data sources to establish what is necessary. Consideration must be given to data needed to establish a better surveillance and medical intelligence system applicable for planning purposes.

The Military Medical Perspective

The Walter Reed Army Institute of Research has outlined the key injury and disease risks to troops deployed to Saudi Arabia.[1,2] The military is concerned about both individual morbidity and the impact of that morbidity on the military task. The sensitivity to injury and illness is correspondingly higher when compared to that of the civilian sector where a day off from work is not generally considered critical. The military must have within its plans a mobile infrastructure to support the disabled at a time when priority is placed on full deployability. From this context, the list of potential disease and injury problems is long and is described below. Table I outlines the short and long term infectious disease risk by country.[3] (Although the order changes, the named diseases are quite similar between countries.)

Heat injuries: Heat injuries are clearly the greatest risk for an unacclimated command and troops. Awareness appears to be the key to prevention; Command supports and enforces routine water intake irrespective of perceived thirst. There have been relatively few casualties from this.

Diarrheal diseases: Travelers' diarrhea is common. Between July 14, 87 and Aug 22, 87, 4500 American troops were monitored during a joint military exercise in Cairo, Egypt. Of all troops 4% were seen by medical personnel for an acute diarrheal episode. Etiologic agents were identified in 49%. A survey of 163 troops who did not seek medical treatment reflected that up to 40% may have had diarrhea during this time period.[4] There have been significant local outbreaks of viral and bacterial diarrheas during this deployment. These seem to be functions of adequate sanitation and

*Uniformed Services University of the Health Sciences, Department of Preventive Medicine/Biometrics, 4301 Jones Bridge Road, Bethesda, MD 20814-4799.

food sources at a time of rapid troop buildup.

Musculo-Skeletal injury: Although not a disease, it is a leading cause of morbidity, along with diarrhea. It has been the leading cause of evacuation.

Mental stress: Combat Stress classically results in one casualty per three or four physically wounded. Post-Traumatic Stress is well described among war veterans; some of whom may be part of the current deployment. More subtle but more prevalent is the potential stress of boredom leading to a variety of psychological and physiological symptoms. Commanders play a key role in prevention and reported rates have varied from inconsequential to a leading cause of evacuation.

Oral health: Acute necrotizing ulcerative gingivitis, acute pericoronitis of the third molar, and periodontal abscesses will worsen under deployment conditions. If not cared for preventively, this can be an unexpected cause for man-days lost while debilitating pain is treated. Poor oral hygiene combined with skin cracking may be an indication of nutritional problems.

Dust-related reactions: Asthma is one of the most frequently reported conditions. The sand is incredibly fine and gets blown everywhere. Dust may carry a variety of allergenic spores and particles.

Respiratory diseases: Adenoviruses, rhinoviruses, influenza, parainfluenza, and *Mycoplasma pneumoniae* are potential problems under crowded conditions.

Sandfly fever: The most common insect-borne disease in the region presenting with debilitating flu-like symptoms. These insects are most active from dusk to dawn. There have been some suspected cases in Saudi Arabia.

Hepatitis A: A classic military problem when camps become unsanitary. Natural childhood infection is common in many countries. Hepatitis E (enteric) has not been reported.

Malaria: Chloroquine sensitive throughout most of the region, *P. falciparum* is reported throughout western Saudi Arabia, along the Red Sea, and the Arabian Sea. Malaria from *P. vivax* is the key risk in the steppes of Iraq. Iraqi troops could introduce malaria into Kuwait.

Leishmaniasis: The mideast is the classic area for finding cases of cutaneous leishmaniasis. Visceral leishmaniasis is relatively rare. Sandflies are the vector for these diseases.

Other dermatological conditions: In 1944 to 1945, skin diseases accounted for 75% of all sick call complaints, 20% of hospital admissions, and 15% of evacuations to the US from North Africa. In Vietnam, skin conditions was the third leading cause of hospital admissions and became more important than malaria as a leading loss of manpower. A hot and sometimes humid climate is expected to create problems with miliaria (heat rash), intertrigo, acne, eczema, and contact dermatitis.

Other arboviral fevers: Dengue (mosquito transmission), West Nile fever (mosquito transmission), crimean-Congo hemorrhagic fever (CCHF) (tick transmission), and sindbis (mosquito transmission) are reported in the region. CCHF occurs in western Saudi Arabia and Iraq. Use of IV ribavirin for those infected and prophylactic ribavirin for contacts can be lifesaving.

Schistosomiasis: *S. mansoni* and *S. haematobium* lurk in much of the untreated fresh water bodies in the mideast.

Q fever: Mostly in Eastern Saudi Arabia, much of the local population has been naturally infected from dairy products and dust from infected livestock. This could be a major source of problems for non-immune troops.

Helminthic diseases: These include ascariasis, ancyclostomiasis, enterobiasis, echinococcosis, trichuriasis, strongyloidiasis, taeniasis, and dracunculiasis. Of the local population, 60% to 75% may have one or more of these infections.

Table I. *AFMIC Disease Risk by Country.*

	S. A.	Kuwait	Iraq	Bahrain	Qatar	UAE	Oman	Yemen	Syria	Jordan	Turkey	Iran	Israel
ACUTE	Diarrhea	Diarrhea	Diarrhea	Diarrhea	Diarrhea	Diarrhea	Diarrhea	Diarrhea	Diarrhea	Diarrhea	Diarrhea	Diarrhea	Diarrhea
	Malaria	ARD	ARD	ARD	ARD	ARD	Malaria	Malaria	ARD	ARD	ARD	Malaria	ARD
	ARD	Ent Prot	Ent Prot	Ent Prot	Ent Prot	Ent Prot	ARD	ARD	Ent Prot	Ent Prot	Malaria	ARD	Meningit
	Ent Prot	Typhoid	Malaria	Typhoid	Typhoid	Typhoid	Ent Prot	Ent Prot	Typhoid	Meningit	Typhoid	Arb vir	STD
	Typhoid	Meningit	Typhoid	Meningit	Meningit	Meningit	Typhoid	Typhoid	Meningit	Typhoid	Ent Prot	Ent Prot	Ent Prot
	Meningit	STD	Meningit	STD	STD	STD	Meningit	Meningit	STD	STD	STD	Typhoid	Typhoid
	STD	Arb vir	STD	Cholera	Cholera	Cholera	STD	STD	Malaria	Arb vir	Meningit	Meningit	Spot Fev
	Cholera	Malaria	Arb vir	Malaria	Malaria	Malaria	Cholera	Cholera	Arb vir	Cholera	Arb vir	STD	Arb vir
	Arb vir		Cholera	Arb vir		Arb vir	Arb vir	Arb vir	Cholera	Malaria	Cholera	Cholera	Cholera
													Malaria
LONG	Hepatit	Hepatit		Hepatit	Hepatit	Hepatit	Hepatit	Hepatit	Hepatit	Hepatit	Hepatit	Hepatit	Hepatit
	Leish	Leish					Leish	Schisto	Leish	Leish	Leish	Leish	Leish
	Schisto	Schisto					Schisto	Leish	Schisto	Schisto	Schisto	Schisto	Schisto

Spirochaetal diseases: Leptospirosis is a known world-wide problem but occurs infrequently in the mideast. However, tickborne and louseborne relapsing fevers are both known to be present in the area.

Sexually transmitted diseases: Syphilis, gonorrhea, chancroid, hepatitis B, and HIV are all present. Hepatitis delta is frequent among hepatitis B carriers. The local blood supply may not be adequately screened for HIV.

Meningococcal disease: Type A outbreaks have occurred among pilgrims to Saudi Arabia. All US troops recruited within the past five years have been vaccinated.

Typhus: Murine (flea) and epidemic (louse) typhus are reported. Rodent populations contribute greatly to the spread of epidemic typhus.

Plague: *Yersinia pestis* is transmitted by infected fleas usually living on rodents and may create an endemic problem in southern Saudi Arabia.

Rabies: A persistent problem throughout the middle-east due to the large dog population. Disease occurrences are relatively infrequent.

Brucellosis: Iraq may be undergoing an epidemic of this cattle disease. Beware of contact with unpasteurized dairy products and raw meat, tissues, and other animal fluids. Transmission can be airborne as well.

Toxoplasmosis: As much as 33% of the Saudi Arabian population may be infected. It is usually asymptomatic but could be a problem for pregnant women.

Trachoma: This chronic chlamydial infection of the conjunctiva can lead to blindness and is aggravated by the dry, dusty conditions of the countries.

Anthrax: Natural outbreaks occur and are cutaneous in its first manifestations. A respiratory case should trigger concern about a beginning of biological warfare.

Drug abuse: This region is a corridor for the opium and hashish trade. Alcohol abuse has not been a problem.

Organophosphates:[5] The key concern about chemical warfare lies with the threat of GA (tabun), GB (sarin), GD (soman), and VX use. These all block acetylcholinesterase and result in nicotinic (skeletal muscle and preganglionic fibers) and muscarinic (gland and smooth muscle) overactivity. A well-fitting full face gas-mask, protective clothing, pretreatment with pyridostigmine, and immediate postexposure treatment with atropine, pralidoximine, and diazepam may be lifesaving.

Although the disease threat list is extensive and comprehensive, strategic planning for primary prevention is relatively simple and straightforward. Environmental controls, protective clothing, command policy, individual health habits, and vaccinations can minimize the rates of almost all illnesses and injuries. Implementation of the plan under tactical conditions can be a significant problem. Should the plan be ineffective in key risk areas, there will be a significant loss of manpower.

Environmental controls are preferable to almost all other methods. When possible, flies, ticks, lice, and fleas should be eradicated. Air conditioning helps to reduce heat casualties and improve morale. The presence of rodents should flag a potentially dangerous disease situation and efforts should be made to improve the sanitation. Potable water would be separated from waste water.

When a protective environment is impossible, proper clothing is essential to prevent heat injury, sunstroke, insect bites, and schistosomiasis. Sunglasses will prevent sand blindness. Proper boots and pads will prevent blisters. Frequent changes of socks will prevent skin infections.

Command policy establishes mission priorities and discipline. Water and food sources are established and sanitation assured through enforcement of established policy. Relaxing standards can lead to increased morbidity. Proper concern for troops' well-being, fairness, and a demonstration of competence will reduce the numbers of psychiatric casualties (and associated physical syndromes with an underlying psychiatric etiology).

Individual health habits are ultimately the responsibility of the soldier and require the soldier to take an active interest in maintaining personal health. The application of insecticide, using mosquito netting, eating approved foods, handwashing, not swimming in unapproved fresh or salt water are examples of individual responsibility.

There are extensive vaccination requirements for all deployed soldiers. All must have updated tetanus, diphtheria, mumps, measles, rubella, polio, meningitis, and influenza vaccinations. Other vaccinations such as yellow fever, hepatitis B, plague, typhoid, and rabies may be required as mission and occupation dictate. Passive immunoglobulin for hepatitis A is recommended for all without prior documented hepatitis A infection for most overseas deployments. Troops will need periodic revaccination every six months. Other passive immunoglobulins may be required in the event of acute exposures. Prophylactic medications (such as chloroquine and primaquine for potential malaria exposure and ribavirin for CCHF exposure) may be required as needed.

The Military and 'Tourist' Perspective

The military perspective tends to focus on the soldier in a variety of environments, the specifics of each is relatively unimportant. Soldiers are assumed to be under extensive command control and in a potentially dangerous environment. This conceptually is different from what a civilian would face even within the same country to which the soldier is deployed. However, logistically, it is impossible to be totally isolated from the community environment. As war threat and actions continue, refugees will flow back through the lines of advancing troops and usual community sanitation standards will collapse. For this reason, it makes sense to explore the advice given to travelers going to the Middle East.[6] A short country description of Saudi Arabia and Iraq will serve to illustrate this point. However, Table II gives a more comprehensive overview of the potential risks of a country.

Table II.

Disease/State	S.A.	Iraq	Kuwa	Bahr	Qatar	UAE	Oman	Yeme	Syri	Jord	Iran	Turk	Isra
Insect Borne													
Malaria			A										
P. falciparum	S						S	S					
P. vivax		S				S			S		R	S	
CC Hem Fever		1									1		
Leishmaniasis													
cutaneous	1	1	1	1	1	1	1	1	1	1	3	1	1
visceral	1	1	1	1	1	1	1	1	1	1	3	1	1
Relapse fever	1	1	1	1	1	1	1	1	1	1	2	1	1
Typhus	1	1	1	1	1	1	1	1	1	1	2	1	1
Food/Water													
Brucellosis	3	4	3	3	3	3	3	3	3	3	2	3	1
Cholera	1	1	1	1	1	1	1	1	1	1	2	1	1
Dracunculiasis	1	1	1			1	1	1	1	1		1	1
Echinococcosis	1	1	1	1	1	1	1	1	1	1	2	1	1
Giardiasis											2		
Guinea worm				1	1								
Hepatitis	2	2	2	2	2	2	2	2	2	2	2	2	2
Poliomyelitis	3	3	3	3	3	3	3	3	3	3	3	3	1
Schistosomiasis	1	1	1	1	1	1		1	1	1	2		
Taeniasis	1	1	1	1	1	1	1	1	1	1	2	1	1
Typhoid fever	2	1	2	2	2	2	2	2	2	2	2	2	2
Other													
AIDS	1	1			1	1	1	1	1	1	1	1	1
Air Polution												2	2
Dust reactions	2		2	2			2		2	2			2
Human related	B								C				
Rabies	1	1	1	1	1	1	1	1	1	1	1	1	1
Snakes/Scorpion	1												1
Sea/Coral Sting				D									
Trachoma	1	1	1	1	1	1	1	1	1	1	2	1	1

KEY: 1 = occurs 2 = common 3 = prevalent 4 = epidemic

NOTES: A: Although malaria is not normally present, foreign troops have come from areas known to be infected and may carry malaria into the country.

B: Meningitis has been reported primarily amoung pilgrims coming for the Haj. Meningococcal vaccinations are required.

C: Syrian drivers are known for their aggressiveness in poorly maintained vehicles on hazardous roads. Watch out.

D: The Bahrain coast is known for its beauty but be beware of coral danger close in and sea snakes, sharks, and rays farther out.

Saudi Arabia

Saudi Arabia is the largest country in the region, about the size of the Eastern United States. Within its boundaries are two of the holiest cities in Islam, Mecca and Medina. It is bounded by the Straits of Aqaba, the Red Sea, Yemen, Oman, United Arab Emirates, Qatar, Bahrain, the Persian Gulf, Kuwait, and Iraq. Summer temperatures (March through September) can reach 130F during the day with a rapid drop to the 70s at night. Winter temperatures are usually in the 70s during the day with a drop into the 40s at night. Freezing temperatures have been reported in the winter. Coastal areas have more moderate temperatures, but humidity averages 85% to 100%. The inland desert has very low humidity, and very fine sand. Rainfall is rare.

Data gathering is problematic. Little out-patient and general population data is available except as reported through the World Health Organization (WHO). WHO's primary focus is on infant and adult mortality rates. However, looking at diseases that affect the younger population of any developing country in which the older population has been exposed to many diseases will give insight into potential problems our troops may face. Most of this information will be gathered from hospitalized patients whose treatment providers are oriented towards publishing their difficulties. An excellent general background on child health in Saudi Arabia described the problems faced by newborn Saudis.[7] Respiratory tract infections, gastroenteritis, and anemia were the leading causes of admission to two hospitals. Of preschool children, 35% may have a parasitic disease, most frequently implicated are *A. lumricoides*, *H. nana*, and *G. lamblia*. *G. lamblia* may affect 10% to 50% of the general population depending on local sanitation and hygiene conditions. Kala-azar (leishmaniasis), hydatid disease (echinococcosis), and bejel (endemic nonvenereal syphilis) may be common. Schistosomiasis rates have dropped significantly from 11% to 2% between 1983 and 1987. The rates were higher in foreign nationals than in native Saudis.[8] Trachoma rates in rural areas may exceed 90%. Hepatitis A antibodies are present in over 90% of adults and range from 23% to 80% in children under ten years old. Hepatitis B surface antigen rates are high, ranging from 6% to 20%. The rate from 2700 samples collected throughout all provinces reflected a rate of 16.7% with no difference in sexes, but a regional difference ranging from 9% in the east to 25% in the southwest. Anti-HBs and anti-HBc were found in 30% to 67%, indicating a high carrier rate.[9] Tuberculosis is the primary infectious disease in adults. Poliomyelitis rates had been high in the 1970s and 100 cases were reported in the last year. Hemoglobin disorders are very prevalent but usually mild. However, these individuals may need periodic blood transfusions. Thalassemic individuals are reported to have Hepatitis B infection rates of 80% to 98%, Hepatitis B carrier rates of 15% to 32%, and delta infection rate of 7% to 21%. HIV+ was reported in 2.2%.[10] Toxoplasmosis prevalence in screened pregnant women ranges from 25% to 36%.[11]

Meningitis among pilgrims during Haj has been a continuous concern. A single group A *Neisseria meningitidis* III-1 may have been solely responsible for recent epidemics in Nepal, Chad, and Saudi Arabia.[12] Immunizations are required of all pilgrims.

Dust allergies may be common. Allergic disorders are reported in 9.3% of a study population.[13] Heavy exposure to sand particles over long periods may lead to a "desert lung" syndrome caused by the deposition of sand silica.[14]

Iraq

Except for an area around Kuwait, Iraq is landlocked; bordered by Iran, Turkey, Syria, Jordan, Saudi Arabia, and Kuwait. The Turkish border is mountainous, with oil fields at the steppes of these mountains. This land is also fertile and the homeland of the Kurds. The rest of the country is generally flat and stony with some stretches of sand. Marshes can be found in the area around Kuwait. Temperatures can reach 130F in the summer. A dry constant summer wind enhances a very dry climate. Winters are generally mild except for the mountainous areas which can go down to freezing. Iraq also has spring and fall winds that can create dusty gusts up to 50 miles per hour.

Brucellosis is reported as epidemic. Brucella arthritis is frequently seen.[15,16] Children hospitalized for diarrhea between the ages of four weeks and seven years have been found to be affected mostly by *Salmonella spp.* (*S. typhimurium* and *worthington* predominate).[17] Sewage sludge cakes are routinely used as fertilizer. Although attempts are made to rid the sewage of *Listeria monocytogenes*, it still persists and may be found in the soil. It may infect animals eating vegetation grown on this fertilizer.[18] Six hundred water samples were taken from the Tigris River in Mosul. Human and some animal fecal streptococci were found throughout.[19] Twenty stray dogs were studied in Bagdad for the presence of helminths — 60% had *Taenia spp.*, 50% had *Dipylidium caninum*, 40% had *Toxocara canis*, 35% had *Ancylostoma caninum*, 20% had *Echinococcus granulosus*, and <15% had *Spirocerca lupi*, *Dirofilaria immitis*, *Mesocestoides lineatus*, or *Strongyloides stercoralis*.[20] Throughout Iraq, echinococcosis infections in dogs range from 67% to 100%, with 41% heavily infected.[21] Rats have been found that are positive for *Fasciola hepatica*.[22] Within the Basrah slaughterhouses, *Fasciola gigantica* was found in 4.8% of buffaloes, 3.3% of cattle, 0.72% of sheep, and 0.13% of goats.[23] This could cause problems in humans.

Relatively unique among the Middle-East countries, concern about pesticide residues appear in the literature. Environmental pollution resulted in a high number of mercury poisoning in 1971 to 1972 from contaminated flour.[24] Iraqi Kurds have been found in Turkey

to be suffering from organophosphate poisoning.[25] Analysis of bomb fragments, soil, and wool suggest poison gas has been used against Kurds.[26] Pretreatment with diphenhydramine HC1 > 20mg/kg have been protected against the onset of toxicosis and death from organophosporus insecticides in mice.[27] Although the use of chemical and sound epidemiologic methods must be used to confirm the use of chemicals.[28] An erroneous conclusion concerning chemical use should have a disastrous impact.

General Health Promotion Guidance

Whereas the military plans ahead to prevent potential losses of manpower, the tourist needs to prepare for probable disease threats that may be present during a current visit to the country. Conceptually, both the tourist and the soldier may be separated from large segments of the local population but the soldier may have a more tightly controlled source of food and water. Within a garrison setting, the military should be able to environmentally control the insect population and sanitation standards. The tourist will need to rely upon personal protective measures (but possibly under more pleasant conditions). As military personnel remain in the country for extended periods of time, the likelihood increases that any individual will come in contact with local culture, population, prisoners of war, and refugees.

In all countries, insect-borne diseases have been reported. Cutaneous leishmaniasis occurs with some regularity and visceral leishmaniasis has sporadically occurred. Tick-borne relapsing fever, epidemic typhus, and murine typhus are also known to occur. However, tourists should not find any of these to be a great hazard to them personally with the possible exception of tourists going to Iran.

AIDS and HIV infection are reported in all countries except Kuwait, Bahrain, and the United Arab Emirate (UAE). There are increasing demands for HIV testing prior to entering the country or prior to being granted an extended stay visa. The chief concern for tourists should be the potential need for local medical care. Needles may be reused and blood for transfusion may be inadequately screened.

The other risks occurring in all countries include trachoma and rabies. Trachoma is a leading cause of blindness but can be easily treated. Unless a gritty unpleasant feeling in the eyes becomes accepted, trachoma should pose little threat to a tourist. Rabies is a more serious problem for those who anticipate contact with dogs and other animal populations. Rabies vaccination would be the appropriate prophylaxis.

Foodborne and waterborne diseases are potentially greater problems. Brucellosis is prevalent in all countries except Israel where it is known to occur. News reports indicate that it is epidemic in Iraq. Raw milk, uncooked meat, and close contact with domestic animals should be avoided. Poliomyelitis is prevalent in all countries except Israel (where it is reported also). This is a vaccine preventable illness. Hepatitis A and typoid fever are common throughout the area. Cholera, echinococcosis, and taeniasis are reported in every country. Most countries report dracunculiasis and schistosomiasis. Giardiasis is reported common in Iran and Guinea worm is reported in Bahrain and Qatar. Advise to prevent occurrence of these diseases follow a universal caveat to beware of the water used to drink or bath. Raw meat, salads, or vegetables are not to be eaten. Only fruit that can be peeled or cooked should be consumed.

Medical Surveillance Needs and Data Collection

It should be obvious by now that determining medical "truth" is a difficult task. Much of our epidemiologic knowledge about the problems troops face has been gathered through inpatient hospital records, focused epidemiologic field investigations, and anecdotal reports. Reviews of the literature generally reflect the areas productive investigators find interesting. At present, the reporting requirements are most complete when they pertain to hospital admissions. Reports in the literature tend to focus on hospitalized patients as well. Outpatients are generally reported as total numbers seen/time irrespective of diagnosis or treatment. Research science seems to occur in hospitals and government funding seems focused to this area.

Medical and command concerns appear to have been well placed but lacking a strong conceptual framework for future planning. This paper will describe a framework within which a comprehensive assessment can take place, taking into account primary, secondary, and tertiary prevention needs. The author advocates one conceptual framework that would help comprehensively address health needs in future conflicts.

Integrating the Classic Infectious Disease and Injury Model

The infectious disease model in epidemiology generally addresses a triangle looking at host, agent, and environment. The Haddon matrix for describing potential intervention strategies to prevent injuries also defines a host (human), agent (vehicle), and environment. On the other axis of the matrix is stressor related to time: pre-event, event, and post-event. Add to this matrix the concept that all interventions can be classified as either active or passive from the perspective of the host. This concept is illustrated in Figure 1. The numbering convention will be utilized in the discussion that follows.

	Prevention	Host	Agent	Environment
Pre-War	Passive	IA1	IB1	IC1
	Active	IA2	IB2	IC2
War	Passive	IIA1	IIB1	IIC1
	Active	IIA2	IIB2	IIC2
Post-War	Passive	IIIA1	IIIB1	IIIC1
	Active	IIIA2	IIIB2	IIIC2

Figure 1. The Haddon matrix.

In the case of Desert Storm, prevention can be viewed from three perspectives; the human "host" or individual potentially affected, the agent carrying the potential illness or injury cause, and the environment which modulates the interaction between human and agent. Individual human traits consist of genetic composition, and environmental impact on learned behavior and physical conditioning (eg, melanocyte-rich skin protects against UV radiation, manic-depressives may get syphilis during a period of highly promiscuous sexual activity). The agent or vector can carry the causal factor of illness to the human host (eg, a mosquito carrying malaria or a bullet carrying destructive energy). The environment can promote or prevent illness and injury (eg, swamps that allow more mosquitos to breed, air conditioning to prevent heat injury). Individual, group, and societal decisions have impact on all three perspectives.

There are three discrete time periods that must be considered when planning for war. War itself, by definition, is life threatening and medical planning must be tangent to and circumscribe the event. Not all groups or individuals threatened by war will be exposed to it and time of exposure will vary significantly between individuals and groups. During the exposure, individuals and groups will operate in isolation, depending on their own wits, training, and conditioning for survival. Planning for this period must focus on endurance and basic life-saving skills. Planning addressing time before this period will impact greatly on the probability that those who fight will not be injured. Planning done for after this period will increase the probability that those injured will survive.

Implicit in the development of the third dimension is interaction between group or societal efforts to prevent morbidity and individual efforts to remain healthy. A group can be defined as an entity which is perceived as interactive with other groups and consisting of necessary individuals defined by their role. Examples of groups would be a work group (squad, platoon, company), command group (hierarchal chain of command), and medical group (American Medical Association, Medical Research and Development Command). A society consists of a multitude of interactive groups which in total defines a larger entity (eg, the United States of America). Societal priorities may facilitate the implementation of a group plan. Organized medicine and individual medical practitioners are only a component in health promotion strategies. However, medical input can be critical to the success of an otherwise viable program.

For a society to effectively implement a comprehensive health promotion program takes a tremendous amount of decision-making energy and organizational motion as opposed to simply saying that the individual carries the responsibility for keeping healthy. The need for active participation at the individual level implies passivity at the group or societal level. An individual who can passively remain healthy only results from an active group plan and implementation of a health promoting program. It takes a great deal of dedicated effort for an individual to voluntarily modify behaviors designated as unhealthy as opposed to being placed in a situation where the modified behavior is relatively involuntary or supported by group expectation.

Using this model, let us revisit the impressive array of problems outlined at the beginning of this article and fit them into the matrix. Recommendations of the American Public Health Association are used as the primary preventive guide for infectious diseases.[29] Since we are now in the post-war period, less time will be given to discussion of successful strategies; they've yet to be evaluated.

Heat Injuries: Intervention focuses on many cells in the matrix and the number of injuries is minimal. Active command attention resulted in active and passive strategies being adapted. "Passive" strategies predominate. IA1, IIA1; water discipline was enforced and troops. were forced to drink water. IB1; Sun exposure was avoided. IB2; people rested when off duty. IIB2; troops remained covered and motionless during the day, moving at night. IC1; diplomacy does not avert war threat and troops are moved into the desert environment. IIC1; diplomacy allows timetable for war to be set and operation was planned for the winter months.

Musculo-Skeletal Injury: IA2; contact sports are played, but soldiers are educated how to avoid injury. This has been the source of many injuries. IIA1; helmets and vests are designed to protect against impact. IIA2; soldiers are trained for combat and learn how to take prisoners. IIB1; enemy equipment is destroyed. IIB2; troops are trained to fire Patriot missiles. IIC1; people live in bomb shelters. IIC2; mine fields are cleared.

Diarrheal Diseases: Travelers' diarrhea is common. IB1, IIB1; pre-packaged food and water are provided, potentially for the duration of the deployment. Foodborne outbreaks have generally occurred when local food was eaten. IA1; typhoid vaccine sometimes used. IB2, IIB2; soldiers are told how to sterilize water and food.

Mental Stress: Boredom has been the key pre-war problem. IA1; letters from home, planned preparation, planned interesting rest and relaxation help prevent it. IA2; the individual can plan for use of free time, learning Arabic, reading, engaging in sports, maintaining physical fitness. The agent may be harder to identify, but would revolve around idle time; the "wait" from "hurry up and wait." IB1; decrease waiting time through mission essential or recreational activities. IB2; develop and pursue self-driven interests. IC1; bring in movies and a PX. IC2; take advantage of the opportunity of living in Saudi Arabia. IIA1; incorporate a reasonable rotation of duty to share boring tasks. IIA2; adapt a duty performance pattern or

routine and mental 'exercises.' Combat Stress becomes the main agent of the war setting. IB1; demonstrate good leadership by good training, competence, fairness, and caring. IB2; prepare by learning stress-reduction techniques. IIB1; plan for an appropriate sleep-rest cycle, ensuring that 'decision-makers' are especially well rested. IIB2; be alert to stress within oneself and in buddies. IIC1; it is avoided by being in a peaceful environment where exposure to extraordinary stressors are minimal. Many troops considered to be within a war zone may actually live in an area more peaceful than their home of record. Post-Traumatic Stress Disorder (PTSD) results from the aftermath of exposure to extraordinary stress and within a war zone, is treated like combat stress. Within the pre-war period, it is important to realize that some war veterans may manifest signs and symptoms of PTSD from a previous war.

Alcohol and Drug Abuse: IA1; antabuse in the body when an alcoholic thinks about drinking. IA2; decision is made to stop smoking or drinking, attending AA meetings. IB1; low-tar cigarettes are marketed, no alcohol is allowed in country. IC1; the military and the Arabian environment condemn alcohol and drug use, making it harder to obtain, but allow tobacco use (cigarettes are used, but there is little alcohol use).

Oral health: IA2, IIA2; Soldiers brush and floss their teeth with fluoridated toothpaste while avoiding simple carbohydrates and tobacco products.

Dust-related reactions: IA1; desensitization therapy may be used but is unpredictable. IA2, IIA2; antihistamines, decongestants, and anti-inflammatory drugs can be taken as needed. IB1, IIB1; sealed surroundings can be built to protect against the dust. IB2, IIB2; the individual can wear a protective mask and avoid dust. IC1, IIC1; especially dusty conditions can be avoided but this is unlikely, however, planning operations for wetter times of year may be helpful.

Infectious Diseases: These can be generally categorized as food-borne (botulism, hepatitis, diarrheal diseases), waterborne (typhoid, cholera, schistosomiasis), vector-borne (malaria, leishmaniasis, arboviral diseases, typhus, Q fever, plaque, sandfly fever), animal-human (brucellosis, rabies, toxoplasmosis), and person-person (helminthic diseases, hepatitis, meningococcal and other respiratory diseases, sexually transmitted diseases). IA1; vaccine is given for meningococcal disease and typhoid fever. IA2; troops are educated about the signs of disease and are asked to wear protective clothing, to keep away from domestic animals and stray dogs, use insect repellant, drink from only approved water sources, eat only inspected foods. Sexual relationships are prohibited. IB1, IIB1; vectors are eliminated through cleaning up and protecting the water and food supply. Pesticides are used freely to keep the rodent and insect population down. IB2, IIB2; troops are trained to use insect repellents freely and how to safely remove ticks. IC1, IIC1; camps are set up and war occurs only in locations where there is minimal prevalence of disease. Although this may not be anticipated in advance, if there is no disease organism in the proximal area, no one gets sick. However, troops from distant, disease ridden areas may serve as a vector, bringing new disease into the local environment. Prior to war, the environment may be cleaned up to be free of mosquitoes and other disease vectors. There is no known sexual contact between the troops and local population.

Potential Biological and Chemical Warfare Agents: Anthrax and Organophosphates: IA1; Vaccine can be given for anthrax. IIA2; personal protective gear is worn. IC1; equipment is made unavailable to manufacture agent. IIA2; personal protective gear is worn, injector antidotes available. IIC1; organophosphate producing factories are targeted for destruction.

Post-war categories (IIIA1-IIIC2): These are similar to the pre-war categories except that personal and group vigilance is less. Troops prepared for war, physically and emotionally, now prepare to go home. Their thoughts are not on the local environment, and the perception of less threat can translate to a lackadaisical concern about the environmental, disease, and injury threat. Because of the environmental destruction of supplies and sanitation, foodborne and waterborne outbreaks of disease are more likely. Starting with the threat of destruction, civilian refugees will begin coming through both enemy and ally camps; both of which will be exposed to the refugee health problems and incur the burden of assistance to those in need. Possible problems in the pre-war phase are highly likely to be medical problems in the post-war phase. Following any disaster, luck and innovation have a large role in mitigating both morbidity and mortality, however, careful planning and attention to detail in the pre-war phase will enhance the post-war effort of restoring a normal state of health. Hospitals set up to support the war always function in the IIIC1 category. Prior to war, they are part of the IC1 category, providing a safe environment to enhance recovery from pre-war injuries. This has been the traditional role of medicine; to focus on the diseased or injured individual and provide treatment. Provision of tertiary prevention programs has been the responsibility of the medical community.

CONCLUSIONS

As we review the cause of morbidity thus far, we realize that the greatest problems were not from the infectious diseases, but from the unavoidable consequences of war and behavioral factors which were left unchecked by preventive measures. The wealthier Arabic countries have actively worked to decrease infectious disease risk within their own borders and exposure of our troops to potential infectious disease risk was minimal. Perhaps the greatest infectious disease risk was through water and

food sources. To protect troops from this threat, they were kept isolated, given water from controlled sources, and prepackaged meals (MREs) from the United States. Departures from this policy resulted in sporadic foodborne outbreaks of diarrhea. With surrender and a large number of both refugees and prisoners-of-war, a greater potential exists for the person-to-person spread of indigenous diseases, even those which had been rare in a pre-war environment. As troops get ready to depart, concern about diarrhea may be superseded by the boredom of eating MREs. This may lead to a greater exposure to local food and water resulting in more cases of foodborne and waterborne disease.

Within the context of boredom, troops engaged in 'healthy' competitive sports which resulted in the majority of our nonbattle injuries. The primary war risk resulted from environmental alterations. Minefields are intended to maim and kill. Breaching these fields exposed our soldiers to risk but behaviorally, they have done so with a high level of vigilance. Injuries, as a result, were minimal. Perhaps the greater risk is after the war, when vigilance is relaxed and the boundaries of the minefield are inadvertently breached.

The medical focus has been within the spectrum of infectious disease and battlefield injuries. However, hospital personnel have had to care for many non-battle injuries and relatively few infectious diseases. With command support, medical advocacy for primary prevention of heat injury has been particularly effective. With light casualties, tertiary care facilities have been relatively free to practice a peacetime civilian standard of care. A post-war environment with refugees and prisoners-of-war may task the facilities to a far greater extent than had occurred during the war.

The Arabian social environment resulted in a ban on alcohol use. This has been declared the significant event in minimizing physical injuries and motor vehicle accidents. Weapon distribution, training, and use is carefully monitored in the military environment. Firearm related injuries were also minimal. Paradoxically, for many, the United States may provide a less safe environment; both alcohol and firearm use are freely allowed with minimal controls. Clearly, social control of the environment within which the individual exists is crucial when establishing an effective primary prevention program.

A review of the injury/disease prevention matrix would reflect that targeting the environment is particularly effective for prevention. There is no problem if the risk does not exist geographically. Given the fact that we cannot avoid all risks, the next most effective method is in 'passive' prevention methods where groups and society take an active role in either decreasing risk from the agent or modifying the individual's susceptibility to risk. However, if the cost for developing a 'passive' prevention program is too great, either emotionally or financially, then the individual may be 'educated' to take an active role in risk avoidance. Individually active prevention programs alone are not expected to be as effective as one where the group and society also are involved. The most efficient and realistic program appears to happen when environmental risks have been minimized and a balance reached where the group sets the norms of expected behavior to which the individual actively conforms. It is this integrated approach to prevention which involved the military command, Arabic norms, and individual commitment towards the well-being of the group that allowed for a remarkably low incidence of both disease and injury during the Desert Shield and Desert Storm operations.

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