30 ENVIRONMENTAL THREATS

CORE CONCEPTS

- Explain how disease is spread.
- Identify mosquito-borne diseases and how to reduce transmission.
- Recite the illnesses that can be spread by filth flies, cockroaches, fleas, ticks, chiggers, and lice and learn how to reduce a soldier's risk of contracting such illnesses.
- Identify weather-related injuries and their associated risk reduction measures.
- Recognize the different types of spiders and scorpions that pose a threat to soldiers training in the United States.
- Identify dangerous snakes that inhabit training areas and how to treat a casualty if bitten.
- List the different altitude injuries and their treatments.

INTRODUCTION

High-tech weapons systems are not the only things that can decimate an army. History is full of examples of armies that were significantly affected by disease, as well as environmental extremes (cold or heat). During the Korean War (July 1950–July 1953), for every 1,000 US Army soldiers deployed to the Korean peninsula, 30 were killed in action, 121 were wounded, and 570 were admitted to the medical treatment facilities due to disease and nonbattle injury (**DNBI**).[1] During Napoleon's 1812 Russia campaign, French forces initially totaled about 490,000; but during his retreat, they totaled at most 100,000—approximately 41,000 had been killed in combat, but the vast majority were killed by **typhus**, hunger, and cold weather injuries.[2] Even today, soldiers are impacted by disease and injury, despite improved prevention and mitigation strategies.

Due to the seriousness of DNBIs and their effects on combat strength, combat medics must teach soldiers about environmental threats and train them to use personal protective measures. This chapter provides an overview of diseases transmitted by **vectors**, threatening **arthropods**, snakes, heat and cold weather injuries, and altitude disorders.

HOW DISEASES SPREAD

Arthropods are invertebrate animals with exoskeletons, such as ticks, spiders, mites, and crustaceans (eg, shrimp and crabs). An arthropod that transports a **pathogen** from one host to another is called a vector. For example, **plague** is caused by *Yersinia pestis* (the pathogen), which is transmitted by fleas (the vector). There are several mechanisms of vector-borne disease transmission.

Mechanical Transmission

Mechanical transmission is also called passive transmission. It occurs when an arthropod carries a pathogen among hosts or contaminated surfaces. During the transfer, the pathogen remains the same and does not undergo any change in structure or number. For example, filth flies carry bacteria and other disease-causing organisms on their mouthparts and feet from infected human feces. If soldiers eat food that has been contaminated by a fly landing on it and depositing pathogens, **dysentery** or other diarrheal disease may occur. Similarly, cockroaches carry disease organisms on their appendages and mouthparts. These pathogens can cause diarrheal diseases, such as **cholera**.

Biological Transmission

Biological transmission is also called active transmission. It occurs when a pathogen changes in number or form while being carried in the body of a vector, before being transmitted to another host. There are four ways a pathogen can be passed to humans via biological transmission:

- **Inoculation** occurs when a vector injects a pathogen into the host with its saliva while it feeds on the host (eg, mosquitoes transmit **malaria** by inoculation).
- **Regurgitation** occurs when the vector vomits the pathogen into the host while it feeds on the host. (eg, fleas transmit bubonic plague by regurgitation).

Note: The bacteria that causes bubonic plague multiplies rapidly in the flea's gut and blocks it (like stopping up a drain). When the flea attempts to eat, it cannot ingest the host's blood due to the blockage. The flea ends up regurgitating the bacteria into the host.

- Fecal contamination occurs when the vector defecates into a wound on the host. The feces deposited in the wound causes irritation and itching. Scratching at the wound facilitates pathogen entry into the host body (eg, Chagas disease, also known as American trypanosomiasis, is transmitted in this way by the kissing bug).
- Crushing occurs when a vector is smashed onto the skin of a host. When the host attempts to remove the dead bug, by brushing it off with their hand, the pathogen is rubbed into the skin. (eg, epidemic typhus can be transmitted by crushing body lice and rubbing bacteria into broken skin).

Note: Many diseases transmitted by different vectors cause illnesses that are beyond the treatment capability of most combat medics. Identification of illnesses, based on signs and symptoms, necessitates a referral by the combat medic to the unit medical officer (MO) for evaluation and treatment.

Note: Many diseases (such as plague, **yellow fever**, **typhoid**, and cholera) have vaccines available that provide prophylaxis for soldiers prior to deployment to endemic areas of the world.

MOSQUITOES

Of all of the arthropods that can affect the military, mosquitoes (Figure 30-1) are the most important. They are found nearly everywhere in high numbers and are capable of transmitting many diseases, some of which impacted the outcomes of wars. During the Civil War, "fully one quarter of all illness reported in the Union Army was malarial in character,"[3] spread by mosquitoes.

Habitat

Mosquito larvae (Figure 30-2) inhabit areas with standing water, such as ponds, puddles, small containers, and ditches. Anything that can hold water provides a habitat for mosquito larvae (Figure 30-3). Adult mosquitoes may stay close to larval habitats or move for many miles, depending on the species.

Figure 30-1. An *Anopheles merus* mosquito obtaining a blood meal from a human hand. Photograph by James Gathany. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=18762

Figure 30-2. Mosquito larvae collecting at the surface of a water sample. Content provided by CDC. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=4914

Figure 30-3. A member of the Malaysian Field Epidemiology Training Program team examining a prime breeding ground (discarded tires) for mosquitoes during a dengue fever outbreak in the area. Photograph by Suhaiza Sulaiman, Malaysia. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=19726

Diseases Transmitted by Mosquitoes

Note: Only female mosquitoes feed on blood; therefore, only females transmit diseases.

Malaria

Malaria is a tremendous problem in tropical, developing countries, causing 300 to 500 million cases each year. Malaria is an ancient disease and is one of the most important preventable diseases in humans. Malaria is transmitted to humans from the bite of an infected *Anopheles* mosquito. Mosquitoes feed on the blood of an infected person and transmit the disease to a healthy person during a subsequent feeding. When a person is suspected of contracting malaria, place them under mosquito netting (also known as an insect bar) to prevent transmission of the disease to healthy individuals operating in the mosquito-infested area. The time between an infective bite and the appearance of symptoms usually ranges from 7 to 30 days, depending on the type of malaria parasite.

Malaria must always be considered in soldiers presenting with unexplained febrile illness if they are deployed to, or spent time in, a location where malaria is present. The signs and symptoms of malaria include:

- fever alternating with chills,
- headache,
- muscle aches,
- sweats, and
- abdominal pain with diarrhea.

Note: During World War II, malaria caused more casualties than combat wounds in the South Pacific. Over 60% of all American soldiers were infected at least once, and the success of the military campaign was jeopardized.[4] The soldiers who did not practice effective preventive measures contracted malaria.

Note: Blackwater fever is an acute and potentially fatal complication of malaria. It causes **hemolysis** of red blood cells, and often leads to kidney failure.

Medications for treatment of malaria are available, but management plans must be tailored for the affected individual. Factors that affect the treatment regimen include the severity of disease, the specific type of infecting parasite, parasite susceptibility to drugs, and patient factors. Supportive care is provided as well.

Dengue Fever

Aedes mosquitoes transmit the viral disease, dengue fever. A slang name for dengue fever is "breakbone fever" because of the severe joint point that infected people suffer. It is widely endemic in the tropics around the world. It is significant to the military because of its explosive nature, resulting in high numbers of casualties in a short time, coupled with a prolonged convalescent period.

Signs and symptoms of dengue fever are high fever of approximately 104 °F plus two following:

- severe headache,
- nausea and vomiting,
- pain in the muscles and joints,
- severe pain behind the eyes,
- swollen lymph nodes,
- cough, and
- sore throat.

There is no specific therapy for dengue fever; treatment is supportive. Vaccines are currently under development.

Yellow Fever

Yellow fever is a potentially fatal viral disease that is transmitted by *Aedes* mosquitoes. Yellow fever mostly occurs in urban and forest or jungle environments in Africa and Central or South America. While yellow fever affects the liver, kidney, and heart, it gets its name from the yellowing of skin (jaundice) due to the virus attacking the liver.

Signs and symptoms of yellow fever are:

- fever,
- headache,
- body aches,
- nausea and vomiting, and
- fatigue.

Soldiers are immunized with yellow fever vaccine prior to deployment in endemic areas. Booster doses are recommended every 10 years. Although uncommon among soldiers because of the effective vaccine, yellow fever can be fatal (Figure 30-4).

Place yellow fever patients under mosquito netting (or where mosquitoes cannot enter) to prevent non-infected mosquitoes from contracting and spreading the virus.

Figure 30-4. The tombstone of Henry Warren, RN, who died of yellow fever in 1855. Content provided by CDC. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=691

Encephalitis

Aedes and *Culex* mosquitoes (Figure 30-5) carry several viral **encephalitides**. They include West Nile virus (**WNV**) (Figure 30-6), St Louis encephalitis, Japanese B encephalitis, and California encephalitis.

WNV was first identified in 1937 in Africa. Epidemics have occurred in the Middle East and Europe. It was first identified in the United States in 1999, but it is not known how it arrived in New York. WNV is spread when mosquitoes bite birds and infect them with the virus. The bird becomes ill and then the virus is spread to new mosquitoes when they bite the bird. The virus may spread to other species, such as humans or horses.

Figure 30-5. This mosquito species is one of many that are West Nile virus vectors. Photograph by James Gathany. Content provided by CDC/James Gathany. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=4734

According to the Centers for Disease Control and Prevention, WNV has a range of symptoms and severity.[5] Most people who are infected with WNV do not have symptoms. Approximately 20% of people infected with WNV will develop fever, headache, and body aches. About 1 in 150 people infected will develop more severe disease. The symptoms of severe infection (West Nile encephalitis or meningitis) include high fever, neck stiffness, coma, seizures, and paralysis. Mortality is most likely to occur among elderly individuals. Treatment for WNV is supportive. A vaccine is currently under development.

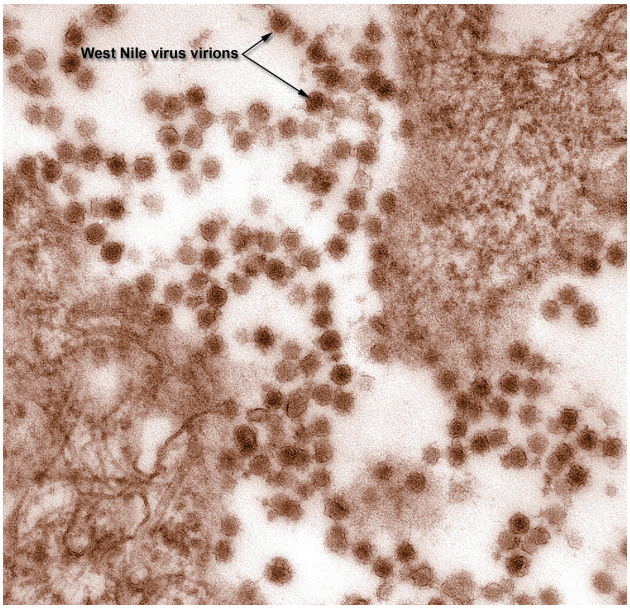

Figure 30-6. A digitally colorized transmission electron microscope image of West Nile virus in a cell culture. Photograph by Cynthia Goldsmith. Content provided by CDC/P.E. Rollin. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=10700

Prevention and Personal Protective Measures

Use mosquito control and personal protective measures for prevention of all mosquito-borne diseases. The most effective method of control is avoiding mosquito bites. Mosquito netting (insect bars) is commonly used in the military to prevent mosquitoes from biting soldiers while they sleep (Figure 30-7). Soldiers can use aerosol sprays on the inside of the net to kill any mosquitoes that may get through. Wearing long-sleeved, loose-fitting clothing is another good preventive measure. Mosquitoes can bite through clothing only when it is worn tightly against the skin.

Chemical repellents such as **DEET** (N,N-diethyl-m-toluamide) should be applied to all exposed skin surfaces and repeated every 4 to 6 hours (Figure 30-8). Use **permethrin** to impregnate fabrics (eg, uniforms, bed nets, tent screens, sleeping bags). Prevention also includes education on eliminating or destroying mosquito larval habitats (eg, standing water, runoffs, any water-holding containers near or within human habitations).

Caution: Do not apply permethrin to inner clothing or hats.

Figure 30-7. A Peruvian woman sitting next to her child who is lying in bed surrounded by mosquito netting. Photograph by Alison Paredes Torrez, Peru. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=19890

Figure 30-8. A man applying DEET (N, N-Diethyl-meta-toluamide) insect repellent. Photograph by James Gathany. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=4429

Malaria is one of the few vector-borne diseases that can be largely prevented through scrupulous use of prescribed antimalarial medications. **Chemoprophylaxis** does not provide protection against other mosquito-borne diseases. **Chloroquine** is one standard medication that prevents the parasite from surviving and causing disease in humans. In many countries, though, the malaria parasites are resistant to chloroquine, making it ineffective. In this case, other

antimalarial drugs must be used (eg, mefloquine, atovaquone-proguanil, doxycycline). Soldiers with an acute febrile illness and a history of travel to a malaria risk area must be evaluated by an MO.

Note: Due to drug resistance, malaria chemoprophylaxis may not be 100% effective.

FILTH FLIES AND COCKROACHES

The behaviors of flies (Figure 30-9) and cockroaches (Figure 30-10) make them potential vectors for disease. Cholera, dysentery, typhoid, and food-borne gastroenteritis outbreaks are associated with filth flies and cockroaches. They pick up organisms from sewage, garbage, manure, and decaying animal bodies. The organisms are then passed on to humans and animals through the feces and vomit of the fly and the "taxi ride" of the cockroach.

Figure 30-9. A dorsal view of a house fly. Content provided by CDC. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=5452

Habitat

Filth flies and cockroaches live in or near animal or human waste, garbage, decomposing plants and animals, or in mud with high organic content. A large population of flies or cockroaches is usually a good indicator of unsanitary conditions.

Diseases Spread by Filth Flies and Cockroaches

Filth flies and cockroaches are implicated in transmission of the following diseases, but they are not necessary components of the chain of infection.

Figure 30-10. A dorsal view of a cockroach, *Periplaneta americana*, which is a mechanical vector for many pathogens. Content provided by CDC. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=6319

Cholera

Cholera is a serious diarrheal disease of the small intestine, caused by *Vibrio cholerae* bacteria. If untreated, the diarrhea will result in severe dehydration and may cause death within hours. Cholera infection can occur after ingesting contaminated food or water.

Signs and symptoms of cholera are:

- severe, acute, watery diarrhea (that resembles rice water), and
- severe dehydration.

Dysentery

Dysentery is a condition in which the patient experiences severe, watery (and often bloody) diarrhea. Dysentery is most often caused by species of *Shigella* or *Entamoeba* bacteria. Contaminated food or water is usually the source of this condition. A patient with dysentery must receive aggressive rehydration.

Typhoid

Typhoid is a bacterial infection caused by food or water that is contaminated with *Salmonella typhi*. Typhoid infection presents as an acute fever. Signs and symptoms are nonspecific and difficult to distinguish from other infections that manifest as fever. They include:

- acute, long-lasting fever (differing from patient to patient in severity),
- headache,
- loss of appetite,
- gastrointestinal signs and symptoms (ranging from constipation to diarrhea), and
- nausea.

Disease management includes aggressive rehydration, antibiotic therapies when possible, and additional supportive care.

Prevention and Personal Protective Measures

Locating and removing the food sources of filth flies and cockroaches are the key to eliminating them from any environment. Field latrines and soakage pits should be constructed, used, maintained, and closed to minimize breeding grounds for flies. Sprays, fogs, and sticky traps are useful tools but are successful only when used with pest elimination measures.

SAND FLIES

Phlebotomine sand flies are small, blood-sucking gnats (Figure 30-11). Sand flies attack humans at the wrists, ankles, or any exposed part of the body.

Habitat

Phlebotomine sand flies are widely distributed throughout temperate, tropical, and subtropical areas of Europe, Africa, the Americas, and Asia. Phlebotomine sand flies thrive in areas with high humidity and temperatures above 60 °F.

Figure 30-11. This photograph depicts a *Phlebotomus papatasi* sand fly obtaining a blood meal. Photograph by James Gathany. Content provided by CDC/Frank Collins. Reproduced from Public Health Image Library. https://phil.cdc.gov/details.aspx?pid=10277

Diseases Spread by Sand Flies

Phlebotomus Fever

Sand fly bites can result in sand fly fever, which is an acute, self-limiting, sometimes recurrent viral disease. Epidemics occur among non-native persons such as US troops entering endemic areas. "During the North African campaign of World War II, large numbers of American forces were incapacitated from 7 to 14 days or longer after contracting phlebotomus fever (sand fly fever)."[6]

Signs and symptoms of sand fly fever are:

- sudden onset of fever and chills,
- headache,
- pain behind the eyes (retro-orbital),
- **photophobia**,
- **malaise**, and
- nausea and vomiting.

Leishmaniasis

Leishmaniasis is a disease found in most developing countries. Leishmaniasis is caused by the protozoan parasite *Leishmania* and is transmitted by the bite of an infected sand fly. There is no vaccine available. Leishmaniasis can present in three forms[7]:

1. Visceral leishmaniasis (kala-azar) is the most severe form of the disease. It results in death up to 95% of the time if untreated.
2. Cutaneous leishmaniasis (Figure 30-12) is the most common form of the disease. It presents with skin lesions that can scar and cause permanent disability.
3. Mucocutaneous leishmaniasis can partially or completely destroy mucous membranes of the mouth, pharynx, and nose.

Signs and symptoms of leishmaniasis include:

- irregular occurrences of fever (visceral),
- weight loss (visceral),
- **splenomegaly** (visceral),
- **hepatomegaly** (visceral),
- skin lesions (cutaneous), and
- severe lesions of the nose or mouth (mucocutaneous).

Figure 30-12. The face of a person with cutaneous leishmaniasis on his left nares. Content provided by CDC/Dr. Mae Melvin. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=15333

Prevention and Personal Protective Measures

Proper wear of the uniform and application of repellents will prevent most infections. Apply permethrin to your uniforms and DEET to your skin. Avoid dogs (and other domesticated animals), especially in areas with sand fly infestation, because dogs are considered to be the primary reservoir for leishmaniasis.

FLEAS

Adult fleas (Figure 30-13) are persistent and painful biters. They are efficient vectors of plague, typhus, and **tularemia**. Fleas become infected by feeding on rodents (eg, chipmunks, rats, and squirrels) and other mammals infected with the disease. Fleas transmit the bacteria to humans when they feed (bite). Plague and typhus have been identified as potential biowarfare agents.

Habitat

Large populations of fleas can usually be found around animal beds, burrows, and nests. Outdoors, fleas are abundant during rainy summers and in high humidity areas.

Diseases Spread by Fleas

Typhus

Typhus is a bacterial infection caused by *Rickettsia typhi* and is transmitted by infected fleas. Infected fleas defecate on a host and the host scratches or rubs the feces into a break in the skin, such as a cut or scrape.

Signs and symptoms of typhus infection usually manifest approximately 14 days after contact with an infected flea, and include:

- fever and chills,
- nausea and vomiting,
- rash (develops around the fifth day of illness), and
- body aches.

Plague

Plague has been a scourge on humanity throughout history. Since Roman times, plague has killed millions of people and greatly reshaped civilizations in its aftermath. In Europe, during the Middle Ages, flea-infested rats entered and inhabited human dwellings, which resulted in millions of people dying after they

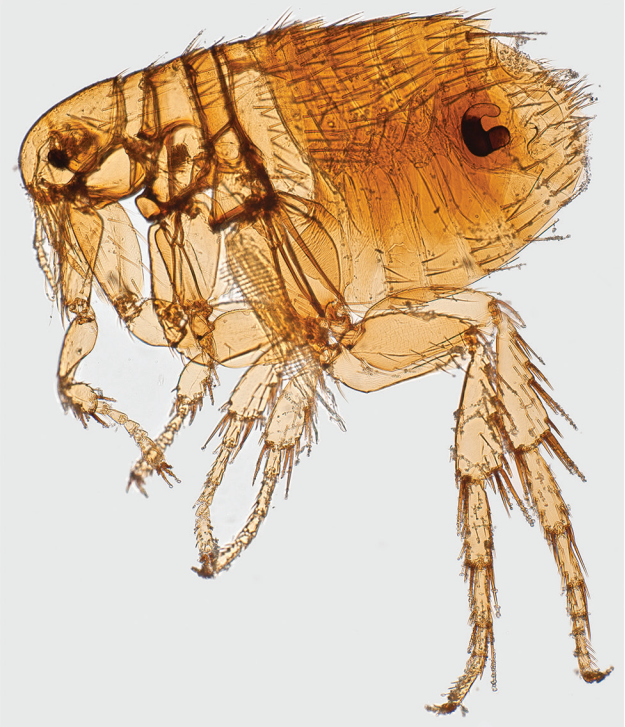

Figure 30-13. The left lateral view of a female Oriental rat flea. Photograph by James Gathany. Content provided by CDC/Ken Gage. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=22259

contracted plague from infected fleas. All mammals are susceptible to infection with the plague bacteria, and disease outbreaks still occur. Rural communities in developing countries are usually most affected by plague, but it is even found in the western United States, where people are occasionally infected.

Figure 30-14. A patient infected with bubonic plague shows symptoms that included a number of swollen inguinal lymph nodes or buboes. Bubonic plague is normally transmitted through the bite of an infected rat flea. Content provided by CDC. Reproduced from Public Health Image Library. https://phil.cdc.gov/details.aspx?pid=2047

When a flea feeds on an animal infected with *Yersinia pestis*, the plague bacteria, it ingests the bacteria along with the host's blood. After several days, the bacteria clumps together and blocks the junction where the flea's esophagus and stomach join. The blockage results in the flea no longer being able to digest the blood, so the flea begins to starve. As starvation sets in, the flea then bites hosts more frequently in an attempt to feed. However, due to the blockage, the blood backflows from the flea's esophagus into the host. This backflow carries the plague bacteria along with the blood and infects the host. Modern antibiotics are effective against plague; however, early treatment is essential.

There are three types of plague infections: bubonic, septicemic, and pneumonic. Signs and symptoms of plague infection are:

- sudden onset of fever and chills,
- headache,
- swollen lymph nodes (Figure 30-14),
- malaise,
- abdominal pain,
- bruising,
- black discoloration of tissues (especially digits or nose),
- pneumonia with difficulty breathing,
- chest pain,
- cough, and
- watery or bloody mucus (occasionally).

Isolate individuals suspected of having plague.

Prevention and Personal Protective Measures

Locating and removing the rodents are the key to eliminating the diseases they carry. Sprays, fogs, powders, poison baits, and traps are useful tools but are successful only when used with pest elimination measures.

Warning: Do not wear flea collars to repel insects. Flea collars are not labeled for human use. Contact with skin may cause severe chemical burns and absorption of toxic levels of insecticide through the skin.

TICKS

Ticks (Figure 30-15) are very efficient disease transmitters. This is because the female tick can pass the pathogen to the egg so that when the larva hatches it is already able to pass on the disease when it eats its first meal. Ticks are important disease vectors in many regions of the United States, Europe, Asia, and Australia.

Figure 30-15. Dorsal view of a tick climbing a blade of grass. Photograph by James Gathany. Content provided by CDC/ Dr. Christopher Paddock. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=10881

Habitat

Ticks and the illnesses they carry are found in all areas of the planet except the coldest regions (eg, Antarctica). Ticks inhabit wooded outdoor areas with tall grass, weeds, underbrush, and shrubs in close proximity to mammal resting places and watering holes. Although ticks are located in almost every region of the planet, they thrive in warm, humid climates.

Diseases Spread by Ticks

Lyme disease

Lyme disease is a bacterial infection that was named in 1977, when arthritis was noticed in a cluster of children in and around Lyme, Connecticut. It occurs in focal areas of North America, Asia, and Europe. Maintain a high index of suspicion when deployed in an area where Lyme disease is endemic.

Note: Lyme disease is the leading cause of vector-borne infectious disease in the United States, causing over 300,000 illnesses per year.[8]

Patients who are infected with Lyme disease often display a distinctive skin lesion in addition to experiencing **systemic** symptoms. The systemic symptoms may manifest in neurologic, orthopedic, and cardiac involvement that occur in combinations over months to years. The illness typically presents in summer and the first symptom most people notice is a red macule or papule that expands slowly in a circular manner, sometimes with a central clearing (Figure 30-16). This distinctive bull's-eye rash is called **erythema migrans**. The causative agent, *Borrelia burgdorferi,* is treated with antibiotics. If untreated, the patient may develop chronic arthritis or neurologic and cardiac problems. Signs and symptoms of Lyme disease include:

Figure 30-16. A patient suffering from Lyme disease. This patient exhibits erythema migrans, a rash that expands over a period of several days and can reach up to 12 inches across. Content provided by CDC. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=14476

- a red, slowly expanding bull's-eye rash, which starts at the bite site and gradually increases over several days up to 12 inches or more in diameter;
- tiredness;
- fever;
- headache;
- stiff neck;
- muscle and joint aches;
- facial palsy (drooping on one side of the face); and
- heart palpitations.

Rocky Mountain Spotted Fever

Figure 30-17. The characteristic spotted rash of Rocky Mountain spotted fever. Content provided by CDC. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=4476

Rocky Mountain spotted fever is one type of illness caused by rickettsial bacteria. This group of bacteria causes several spotted fever illnesses, all of which share similarities in signs and symptoms including:

- rash (a red, non-itchy rash that usually starts at the wrists or ankles and may move to the palms of the hands and the soles of the feet) (Figure 30-17),
- fever,
- headache,
- nausea and vomiting,
- abdominal pain, and
- musculoskeletal pain.

Tularemia

Tularemia is a disease caused by the bacteria *Francisella tularensis*. When there is an outbreak of tularemia in nature, large numbers of mammals such as rodents and rabbits die. Ticks and deer flies help spread this disease. Humans can contract tularemia through vectors such as ticks, by handling infected animals, or as a result of bioterrorism. Tularemia can be fatal if not treated promptly, but it does respond well to antibiotic therapy.

The signs and symptoms of tularemia depend on how the infection occurred. Ulceroglandular (Figure 30-18) or glandular infections are seen in patients

Figure 30-18. A tularemia lesion on the dorsal skin of the right hand, caused by the bacterium *Francisella tularensis*. Content provided by CDC/Dr. Brachman. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=2032

who were bitten by an infected tick or deer fly or who handled an infected animal. Ulcers appear at the site where the bacteria entered the body. Patients with glandular infections do not develop an ulcer. A conjunctival infection occurs when patients rub their eyes after touching an infected animal's body fluids. Patients who eat or drink contaminated food or water develop an oropharyngeal infection, and those who breathe dust or aerosols that contain the bacteria acquire a pneumonic infection. Pneumonic infections are the most life-threatening form of the disease and may result from a biological weapons attack that disperses the pathogen as an aerosol. Signs and symptoms of tularemia may include:

- ulcer (ulceroglandular infection),
- ocular inflammation (conjunctival or oculoglandular infection),
- swollen lymph nodes in front of the ear (ocularglandular infection),
- swollen lymph nodes in back of neck (oropharyngeal infection),
- sore throat (oropharyngeal infection),
- oral ulcers (oropharyngeal infection),
- tonsillitis (oropharyngeal infection),
- difficulty breathing (pneumonic infection),
- chest pain (pneumonic infection), and
- cough (pneumonic infection).

Tick Paralysis

Tick paralysis is a rare disorder caused by toxins in tick saliva. The signs and symptoms of this condition can be confused with other conditions such as **Guillain-Barre syndrome** and **botulism**.[9] The signs and symptoms subside about 24 hours after the tick is found and removed. Signs and symptoms of tick paralysis are:

- **ataxia,**
- difficulty standing,
- absent deep tendon reflexes,
- tachypnea,
- drooling,
- respiratory distress, and
- respiratory failure.

Prevention and Personal Protective Measures

Proper wear of the uniform and application of repellents will prevent most infections. Apply permethrin to your uniforms and DEET to your skin. Search your total body area for ticks daily. Promptly remove any that are found. With gloves on, remove attached ticks by using gentle, steady traction with forceps or tweezers applied close to the skin to avoid leaving mouthparts in the skin. Following tick removal, cleanse the skin site with soap and water. A Lyme disease vaccine is currently not available.

Note: Many diseases are transmitted to humans by tick vectors. The incidence of tick-borne diseases, especially Lyme disease, has been increasing as a result of reforestation and military deployments. Ticks can transmit viruses, bacteria, rickettsia, and parasites.

MITES

Itch Mites

Mites are tiny arthropods that are barely visible to the naked eye. Scabies, a highly contagious infestation in humans, is caused by the itch mite, *Sarcoptes scabiei* (Figure 30-19). Scabies may occur in all populations, but infestations are more common in developing countries. Scabies are most commonly found in skin folds, such as finger and toe webs, axilla, or genital areas and are easily transmitted from person to person through direct contact. They can be treated with ointments and clothes laundering.

Signs and symptoms of scabies are intense itching and a pimple-like skin rash. In rare cases, the skin may become thickly crusted.

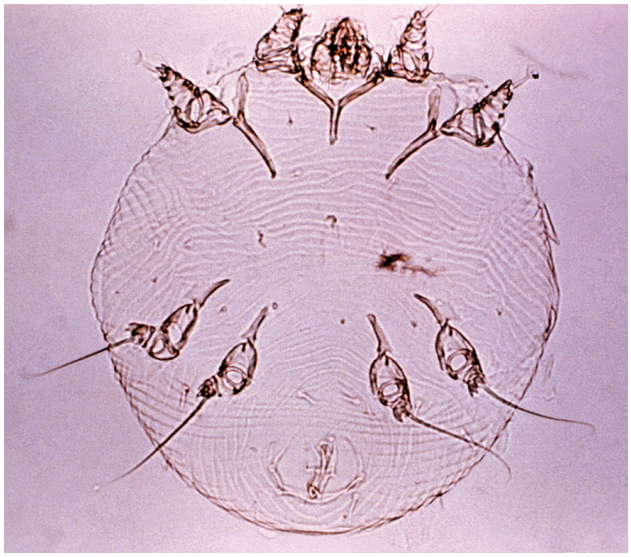

Figure 30-19. An enlarged view of a *Sarcoptes scabiei*, also known as the human itch mite. Photograph courtesy of the World Health Organization. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=6301

Chiggers

Chiggers, also known as redbugs, jiggers, or harvest mites, are the immature stages of a tiny, reddish-orange mite from the family Trombiculidae. They are found in most areas of the world and inhabit areas of tall grass associated with low, wet spots such as ponds and forest underbrush. They attach themselves to clothing and then move to an area of the body to feed. Chiggers do not embed themselves under skin; they inject saliva that helps them feed on host cell fluids (Figure 30-20).

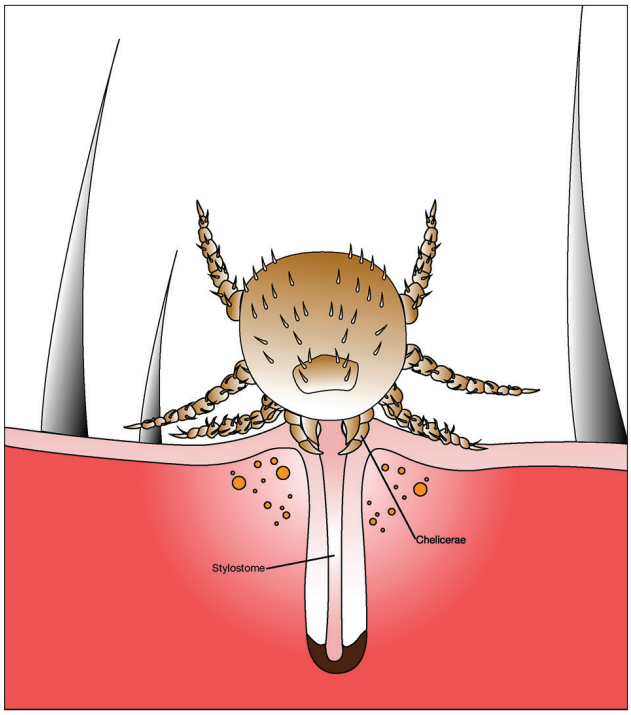

Figure 30-20. This illustration depicts how a chigger (Trombiculidae) feeds. The chigger is an extremely small, reddish-orange insect that uses digestive enzymes to break down skin cells and then feeds on the broken-down skin. Diagram by Bugboy52.40. Adapted from Wikimedia Commons. https://commons.wikimedia.org/wiki/File:File-Chigger_bite.svg

Signs and symptoms of chigger bites are intense itching with small welts over the bite area, caused by a host immune response to chigger saliva. Bites may itch for up to 2 weeks after the chigger has finished feeding and dislodged from the host.

Prevention and Personal Protective Measures

Preventive measures for scabies mites include personal cleanliness (frequent hand washing and bathing) and avoidance of potentially infested persons.

For chiggers, proper uniform wear and application of repellents will prevent most bites and subsequent infections. Apply permethrin to your uniforms and DEET to your skin.

LOUSE-BORNE ILLNESS

Head, Body, and Pubic Lice

Throughout history, louse-borne diseases have been a threat to fighting forces.[2] Soldiers during Napoleon's

Figure 30-21. A body louse, *Pediculus humanus corporis*. Content provider CDC/Joe Miller. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=5461

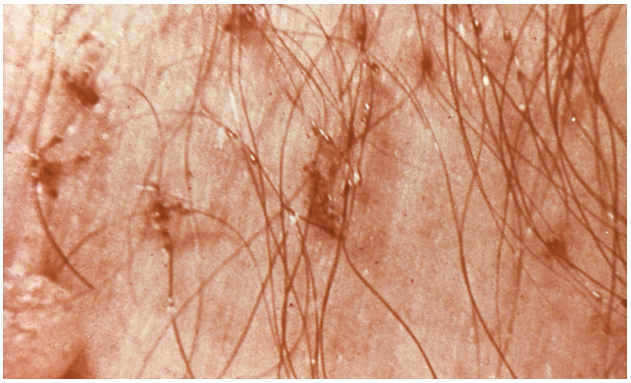

Figure 30-22. A close view of a patient's skin, infested with *Pthirus pubis* (crab lice). Content provided by CDC. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=4078

invasion of Russia were plagued so badly by body lice that it was common for them to strip and burn their uniforms just to watch the lice explode.[2] Three species of lice are of military importance: the body louse (*Pediculus humanus corporis*) (Figure 30-21), the head louse (*Pediculus humanus capitis*), and the crab louse (*Pthirus pubis*) (Figure 30-22). Anyone may become infested when exposed. Lice are easily transmitted from person to person through direct contact.

Head louse infestations are frequently found in schools and institutions. Crab lice are spread through sexual contact. Body louse infestations can be found among people living in crowded, unsanitary conditions where clothing changes and laundering are infrequent. Soldiers who do not practice good personal hygiene can become infested with lice and pass them on to other soldiers when they come in contact with their hair, clothing, sleeping bags, or linens.

Diseases Spread by Lice

Epidemic Louse-Borne Typhus

Epidemic louse-borne typhus is a bacterial disease that is transmitted from one person to another when human body lice feed on one person who is infected with typhus, and then transfer to another person. While feeding on the second person, transmission of the bacteria occurs when lice are crushed or when their feces are rubbed into the bite wound.

The signs and symptoms of epidemic louse-borne typhus are the same as for flea-borne typhus (Figure 30-23). Some people can have a relapse in disease months or years after the initial infection.

Figure 30-23. A patient exhibiting a torso rash caused by epidemic louse-borne typhus. Content provided by CDC/Dr. D.S. Martin. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=18838

Prevention and Personal Protective Measures

Prevention and personal protective measures include:

- good personal hygiene,
- regular changing of clothes,
- effective laundry procedures, and
- no sharing of clothing or bedding.

SCORPIONS AND SPIDERS

Scorpions

Scorpions are members of the class Arachnida (related to spiders, ticks, and mites). Scorpions have

Figure 30-24. The dorsal view of a highly toxic black scorpion. Content provided by CDC/World Health Organization. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=6295

Figure 30-25 A dorsal view of a brown recluse spider. Note the distinct characteristic violin-shaped mark on its dorsal cephalothorax. Content provided by CDC/Margaret Parsons. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=1125

eight legs and a small pair of claws (Figure 30-24). A scorpion's stinger is at the end of its long tail. Out of the nearly 650 species of scorpions in the world, stings of only about 25 can be fatal to humans. In the United States, only one can kill people and it is found in the Sonoran Desert. Most are relatively harmless, producing only localized sting reactions. The initial sting is very painful with little or no swelling or redness. Soldiers stung by scorpions must be evaluated by an MO to determine the risk of a potentially severe reaction to the sting. Ice application may relieve localized pain.

Brown Recluse Spiders

The brown recluse spider (Figure 30-25) is a highly venomous spider that is identified by the distinct violin-shaped area on its back. These spiders are found in midwestern and southern states of the United States, usually in woodpiles, garages, and other dark places. Brown recluse spiders have very small fangs and normally can bite only if the spider's body is pushed against a human's skin (eg, when the spider is trapped in clothing). The brown recluse spider bite may feel insignificant; however, the **venom** is hemotoxic and may cause a necrotizing ulcer (local tissue destruction) that requires medical treatment and may take over a month to heal. Pain at the site begins 1 to 4 hours after the bite and a pustule may grow and form a crater over 3 to 4 days. Healing is slow. The patient may have a low-grade fever, myalgia (muscle pain), nausea, and vomiting. Treatment is usually supportive but includes evaluation by an MO. Ice and elevation may help with localized pain. Verify tetanus vaccine status and update as needed. Provide antibiotics if a secondary infection occurs. Occasionally, surgical excision of the ulcerated area is needed.

Figure 30-26. A female black widow spider. Note the characteristic red hourglass located on the inferior abdominal surface. Content provided by CDC/James Gathany. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=20260

Black Widow Spiders

The female black widow is a highly venomous spider that is shiny black in color, with a distinct red hourglass marking on her abdomen (Figure 30-26). The bite is often unnoticed at first, but symptoms of **envenomation** occur within 10 to 60 minutes, including severe pain in the bite site and muscle spasms of the abdomen and trunk. Headache, nausea, and vom-

iting may occur. Symptoms may last 24 to 36 hours. Death is rare, but the populations at greatest risk are the very young and the very old. Treatment includes evaluation by an MO and analgesics. Evacuate to a treatment facility that can observe the casualty for 12 to 24 hours. Antivenom is rarely needed but may be ordered by an MO.

Snakes

Snake bites require special care but are usually not life threatening. Every person reacts differently, so consider all snake bites to be from a venomous snake. In the United States there are two groups of poisonous snakes—the pit vipers (including rattlesnakes, copperheads, and water moccasins) and coral snakes (Figures 30-27 to 30-30).

Signs and symptoms of a snakebite vary depending on the type of snake involved, and may include:

- noticeable bite or scratch on the skin (there may be only one fang mark);
- pain and progressive swelling in the bite area, sometimes requiring a surgical release of tissue pressure;
- rapid pulse and labored breathing;
- nausea and vomiting;
- progressive weakness to unconsciousness, and
- anaphylaxis.

Figure 30-28. A juvenile venomous copperhead snake. Photograph by James Gathany. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=22499

Figure 30-27. A timber rattlesnake, which is found throughout large portions of eastern and central North America. Photograph by Edward J. Wozniak, DVM, PhD. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=8162

Figure 30-29. A dorsal view of a water moccasin (cottonmouth). Photograph by Michael Smith. Content provided by CDC/Edward J. Wozniak DVM, PhD, Michael Smith. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=8124

Figure 30-30. A venomous coral snake. Note the color banding on the snake's body. Red on yellow banding is a distinguishing feature of a coral snake. Content provided by CDC/Edward J. Wozniak DVM, PhD. Reproduced from Public Health Image Library. https://phil.cdc.gov/Details.aspx?pid=8141

Caution: Surgical release of tissue pressure is NOT in the 68W's scope of practice.

Prevention of Snakebites

Every soldier should be aware of the venomous snakes in their area of operation and avoid their habitats when possible. When in snake habitat, always look before sitting or placing your hands on the ground, logs, rocks, or other surfaces. Always check tree branches as well, since many snakes are good climbers. Be cautious around natural bodies of water. Do not attempt to move or pick up snakes, even if they are dead or appear dead; this results in many unnecessary bites.

Field Treatment of Snakebites

The field treatment of snakebites includes the following:

- Conduct initial assessment and management of the airway, breathing, and circulation.
- Monitor for an allergic reaction or anaphylaxis.
- Provide oxygen, if available.
- Gain intravenous (IV) access in all snakebite victims (in an unaffected extremity).
- Remove watches and jewelry from the affected extremity.
- Keep the casualty as calm and inactive as possible to slow down the absorption of venom.
- Gently clean around the snakebite to remove any venom from the skin.
- Consider immobilizing and splinting the affected limb.
- Evacuate the casualty to the nearest treatment facility (tetanus prophylaxis status must be assessed).

Warning: When treating a snakebite, DO NOT delay treatment in an attempt to capture the snake. DO NOT cut into the bite site and attempt to suction the venom from the site. DO NOT place ice on the bite site. DO NOT touch the head of the dead snake, which may still contain venom and have a bite reflex. DO NOT transport a live snake with the casualty.

If possible, safely bring the dead snake to the treatment facility with the patient for identification.

Check on Learning

1. Malaria must always be considered in what group of individuals?
2. The most effective means of malaria control is avoiding mosquito bites. How is prevention implemented?
3. How is the impact of filth flies and cockroaches mitigated?
4. How is the impact of sandflies mitigated?
5. What should you do if you find a tick on yourself or a battle buddy?
6. Which arthropod could be used as a biological warfare agent?
7. What is the field treatment for a snakebite?

WEATHER-RELATED INJURIES

Risk Factors Influencing Weather-Related Injuries

Weather-related injuries are influenced by the following risk factors:

- Age—the very young and very old are more susceptible to environmental injuries.
- General health and fitness—poor health increases susceptibility.
- Fatigue—makes individuals more lax in taking proper precautions.

- Predisposing medical conditions—atherosclerosis, hypovolemia, diabetes, alcohol abuse, previous weather related injury, etc.
- Medications—peripheral vasodilator medications cause vessels to dilate and the body to lose more heat. **Diuretics** cause more fluid to be excreted, making dehydration more common. Nicotine causes peripheral vasoconstriction, which decreases circulation to the extremities. **Antihistamines** impair the body's ability to sweat and dissipate heat.
- Lack of acclimatization—individuals need about 2 weeks to become fully acclimatized to the heat. During periods of sudden temperature change, treat everyone as nonacclimatized.

Mechanisms of Heat Loss

Heat can be lost through the following mechanisms:

- Conduction—heat transfer between substances due to temperature differences.
- Convection—heat transfer through gas or liquid by circulated heat particles.
- Evaporation—heat loss at the surface from vaporization of liquid, eg, sweating (Figure 30-31).
- Radiation—energy in the form of heat radiates in waves through the air or other media (eg, water).
- Respiration—heat leaves the body through each breath.

Figure 30-31. Steam rising from Army Sergeant Jacob Cardenas after removing his body armor at the completion of a 10-mile road march. Photograph by Master Sergeant Michel Sauret. Reproduced from the Department of Defense Photo Gallery. https://media.defense.gov/2018/Apr/29/2001909901/-1/-1/0/180417-A-TI382-1069A.jpg

Environmental Factors Influencing Weather-Related Injuries

Climate, season, and weather are all factors that make you more susceptible to weather-related injuries. The cool, damp seasons of fall and winter cause more cold weather injuries than the warm seasons of spring or summer. High ambient temperature reduces your body's ability to lose heat by radiation. High relative humidity reduces your body's ability to lose heat through evaporation. Precipitation and wind chill also influence an individual's susceptibility to injury.

Atmospheric (barometric) pressure influences conditions that contribute to weather-related injuries. Atmospheric pressure is the pressure exerted by the weight of the air. The more dense the air pressure, the warmer the temperature. An increase in altitude decreases pressure, which also results in a decrease in temperature.

Mountain tops and high ridges have reduced atmospheric pressure due to their elevations and are subjected to higher wind velocities. Cooler temperatures and an increase in wind velocity results in colder weather and a possible increase in cold weather injuries. Other terrain features also affect risk of weather injuries. Valleys or depressions are lower in elevation, which results in higher atmospheric pressure and higher temperatures. There will also be less wind. Increased vegetation and higher land mass in the surrounding terrain partially obstructs wind currents. Desert areas (whether at high or low elevations) tend to have more wind and drastic temperature changes, which can result in an increase in weather-related injuries.

Heat Injury

Types of Heat Injuries

There are three types of heat injury: heat cramps, heat exhaustion, and heatstroke. Heat cramps are muscle cramps or spasms of the voluntary muscles caused by depletion in the body's water and salt (dehydration). Heat exhaustion is a systemic reaction to prolonged heat exposure and is due to excessive fluid loss and electrolyte (sodium) depletion. Figure 30-32 shows soldiers performing common activities that may increase their risk of heat injury.

Caution: DO NOT ELIMINATE HEAT EXHAUSTION AS A POSSIBLE DIAGNOSIS. Heat cramps and heat exhaustion may coexist. Heat cramps usually occur in individuals with heat exhaustion who are not acclimatized to a hot environment.

Figure 30-32. Soldiers participating in the Bataan Memorial March in Iraq in 2009. Photograph by Sergeant Eric Jungels. Reproduced from the Department of Defense Photo Gallery. https://media.defense.gov/2009/May/11/2001096023/-1/-1/0/703252-C-XRW09-636.jpg

Heatstroke is caused by failure of the temperature-regulating system in the brain. Heatstroke usually involves excessive exposure to strenuous physical activity under hot conditions; however, elderly or chronically ill patients may develop heatstroke without strenuous physical activity. An altered mental status is the defining sign of this condition.

Warning: HEATSTROKE IS A MEDICAL EMERGENCY. If treatment is delayed, mortality rates may be as high as 70%.[10]

Signs and Symptoms of Heat Injuries

Signs and symptoms of a heat injury include the following:

- Painful spasms of skeletal muscles, including muscles of the extremities (arms and legs) and the abdomen. The muscles involved are generally the larger muscle groups. The muscles feel tight and hard when palpated.
- Dehydration. The body loses too much fluid, salt, and minerals. When individuals engage in any strenuous exercises or activities, an excessive amount of fluid and salt is lost through sweat. Dehydration is as prevalent in cold regions as in hot regions.
- Skin that is moist, pale to normal, and cool indicates a less serious condition. Skin that is hot, red, and dry or moist indicates a serious condition.
- Core temperature (the body's central temperature) is normal or elevated. To measure core temperature accurately, you must obtain rectal temperature readings.
- Headache, often with weakness, fatigue, thirst, dizziness, and confusion. The casualty may feel better when lying down but may become lightheaded when attempting to stand or sit (orthostatic hypotension).
- Loss of appetite, nausea, and sometimes vomiting.
- Respirations and pulse rate may be rapid, and the pulse may feel "thready" at the radial artery. Systolic blood pressure may be normal or slightly decreased.
- Dark urine.
- Altered mental status—a sign of heatstroke.
- Seizure activity may be present.

Warning: Remember—heatstroke is a medical emergency that often results in death if treatment is delayed. Suspect heatstroke in any casualty who is warm to the touch and with an altered level of consciousness and treat immediately.

Treatment for Heat Injuries

The first step in treating a heat injury is to remove the casualty from the environment. The longer a casualty remains with an elevated temperature, the more destructive and deadly the condition becomes. Provide rapid, active cooling by removing the individual's clothing, misting the casualty with water and fanning them (to promote evaporation), applying moist wraps, and immersing the individual in cool water, if available. Apply ice packs or sheets to the neck, groin, and axilla. Gently stretch the casualty's cramped muscles.

Caution: Do not lower core temperature below 102 °F. Temperature will continue to drop after removal from water. Prompt evaporative cooling is preferred; however, be aware of potential complications such as shivering (which will increase the core temperature).

Figure 30-33. Initial Entry Training soldier Private Second Class Hannah Murray drinking water during 68W10 Field Craft Training at the Department of Combat Medic Training.

A casualty who is alert and able to swallow, has a present radial pulse, and is not nauseated may be allowed to drink fluids by mouth (Figure 30-33). Withholding fluids from combat casualties that meet the above criteria is not recommended. Even if the casualty requires surgery (including penetrating torso trauma), the factors of transport delays and preexisting dehydration present during combat operations greatly exacerbate dehydration and reduce the chance of survival. Risk of emesis and aspiration in these combat casualties is low. If you have a casualty with an altered mental status, administer a 500 mL bolus of lactated Ringer solution by IV. If IV attempts fail, do not attempt intraosseous (IO) access. Immediately evacuate the casualty to be evaluated by an MO.

Note: Salt use is discouraged because the osmotic fluid shift can cause vomiting and damage to the stomach lining.

COLD WEATHER INJURIES

Nonfreezing Injuries

Nonfreezing injuries are commonly encountered when soldiers are operating in cold, wet, and windy environments. The following are types of nonfreezing injuries that can be encountered:

- hypothermia,
- chilblains,
- immersion syndrome (paddy foot),
- snow blindness, and
- dehydration.

Hypothermia

Hypothermia is a systemic cold injury. It generally occurs from prolonged exposure to low temperatures, often above freezing, or from immersion in cold water. Wet, cold, and windy conditions represent the greatest threats. There are three degrees of hypothermia:

- mild hypothermia—core body temperature ranges between 94 and 97 °F,
- moderate hypothermia—core body temperature ranges between 86 and 93 °F, and
- severe hypothermia—core body temperature of 85 °F or lower.

Note: During assessment, obtain an accurate core temperature through rectal measurement.

The signs and symptoms vary depending on the level of hypothermia and include:

- conscious (with no altered mental status) to unconscious;
- shivering, poor muscle coordination to rigid muscles;
- weak to absent pulse; and
- pale, cold to ice-cold skin.

Note: Unresponsive, hypothermic casualties require airway protection. At a minimum, insert an oropharyngeal airway or nasopharyngeal airway. If required, initiate ventilations with a bag valve mask. Intermediate airways (eg, i-gel [Intersurgical Ltd; East Syracuse, NY]) may be considered.

Treatment begins with preventing further heat loss. Move the casualty to a warm environment and remove wet clothing. Handle the casualty gently; a cold heart is more prone to ventricular fibrillation if the patient is handled roughly. If ventricular fibrillation occurs and the tactical environment allows, initiate cardiopulmonary resuscitation with an automated external defibrillator. Assess and manage the casualty's airway, breathing, and circulation.

Rewarm the body evenly with a heat source. Begin rewarming passively, in a dry sleeping bag. If possible, give heated and humidified air with any device available. Confine active rewarming to the trunk. Give warm liquids and do not further agitate or excessively handle the casualty. If the casualty's level of consciousness is altered, anticipate hypoglycemia. Provide warm, high-calorie, or glucose fluids orally. If necessary and available, provide a 500 to 1,000 mL bolus of D5W (5% dextrose in water IV solution) warmed to 109 °F. If D5W is not available, any crystalloid solution is satisfactory. Ensure the solution does not freeze during administration. Evacuate the casualty to the nearest medical treatment facility as soon as possible. Continuously monitor the casualty's vital signs and level of consciousness while in route.

Warning: Rewarming the extremities before the core can result in acidosis and/or hyperkalemia (excessive potassium) and actually LOWER the core temperature.

Chilblains

Chilblains (Figure 30-34) are caused by repeated or prolonged exposure of bare skin in damp, nonfreezing temperatures. Chilblains are most common in cold and damp climates. The signs and symptoms may include the following:

- redness or cyanosis of affected areas;
- blue-red patches on the lower extremities, face, hands, and feet;
- hot, tender, itching skin;
- subcutaneous nodules; and
- ulcerated or bleeding lesions (with chronic repeated episodes).

Caution: Do not rub, apply direct heat (heating pads, heaters), or ice to tissue suffering from chilblain.

Treatment begins by warming and drying the injured body part. Place the injured body part in contact with a warm object, such as a rescuer's hands or the casualty's body. Instruct the casualty to cross their arms and place their hands under their armpits. Elevate the affected body part. Protect the rewarmed injury from further cold exposure or trauma. Evacuate the casualty to the nearest medical treatment facility as soon as possible.

Figure 30-34. Chilblains caused by excessive icing of the feet. Photograph by James Heilman, MD. Reproduced from Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Chilblains_from_excessively_icing_the_feet.jpg

Immersion Syndrome

Note: Trench foot occurred frequently during WWI. Soldiers stood in cold, wet, muddy trenches for extended periods of time awaiting movement orders. During the Vietnam War, soldiers were faced with similar environmental conditions. Paddy foot frequently occurred secondary to wet feet (service members walking through canals and rice paddies), even though the temperatures were higher.

Immersion syndrome (also called immersion foot, trench foot, or paddy foot) is an injury that results from prolonged exposure of the feet to cool or cold water or mud. Inactive feet in damp or wet socks and boots or in tightly laced boots that impair circulation are highly susceptible to injury (Figure 30-35).

The signs and symptoms include the following:

- Early stages (first phase). The affected area is cold, pale, numb, and tingling. Pulses are diminished or absent. This phase develops slowly over hours or days.
- Later stages (advanced phase). The casualty will complain of limbs feeling hot and burning, with shooting pains. The affected area is pale and there may be blisters, swelling, redness, and ulcerations. Anesthesia (numbness) may persist for weeks, along with hyperhidrosis (excessive sweating) and cold sensitivity. Infection and gangrene are complications of very severe cases.

Treatment for immersion syndrome is the same as the treatment for chilblains. To prevent immersion syndrome, soldiers should keep their feet warm and dry and change their socks several times each day. Ensure boots fit well and that soldiers never sleep in wet socks and boots.

Figure 30-35. A person displaying a mild case of immersion syndrome (trench foot). Photograph by Mehmet Karatay. Reproduced from Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Trench_foot.jpg

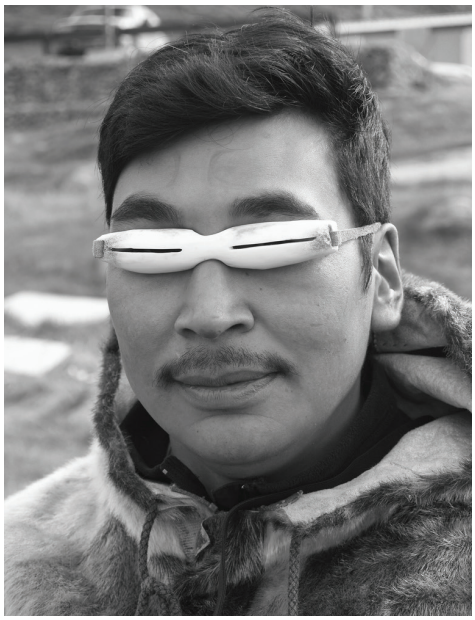

Figure 30-36. This photograph is of an Inuit (tribe of indigenous people who inhabit the arctic regions of Alaska, Canada, and Greenland) man wearing snow goggles to prevent snow blindness. Photograph by Julian Idrobo, Winnipeg, Canada. Reproduced from Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Inuit_snow_goggles.jpg

Snow Blindness

Snow blindness is a burn to the eye from ultraviolet radiation. The resulting cornea damage is similar to a welding flash burn. Snow blindness is more likely to occur in hazy or cloudy weather than in sunny weather. Signs and symptoms of developing snow blindness are:

- eye pain,
- scratchy feeling in the eyes as if irritated by sand or dirt,
- watery eyes,
- burning sensation in eyes, and
- photophobia**.**

Snow blindness can be avoided simply by wearing sunglasses or glasses with **photochromic** lenses that block 100% of ultraviolet rays. Figure 30-36 shows a type of snow goggles traditionally used by people who live in the arctic. Treatment for snow blindness includes a visual acuity test, covering the eyes with dark cloth, and evacuation. Consider the tactical environment before covering the eyes of the casualty.

Dehydration

In cold weather, it is extremely difficult to realize that dehydration is occurring. Sweat evaporates more quickly in cold environments than in warmer environments. Because evaporation is quicker, soldiers don't see a buildup of sweat on their skin or clothing and don't realize that they are becoming dehydrated.

Freezing Injuries

Frostbite

Frostbite is the freezing of body tissue, caused by exposure to very cold temperatures. Frostbite usually occurs when temperatures drop below 32 °F; however, other factors such as wind chill, duration of exposure, and inadequacy of protection can facilitate freezing even if the temperature is slightly higher than 32 °F. The body parts most easily frostbitten are the cheeks, nose, ears, chin, forehead, wrists, hands, and feet. Figures 30-37 to 30-39 show a frostbite injury over time. The signs and symptoms below are listed in the order in which they would appear with increased exposure and time:

- loss of sensation or numb feeling in any part of the body;
- sudden whitening of the skin in the affected area followed by a momentary tingling feeling;
- redness of skin in light-skinned soldiers, grayish coloring in dark-skinned soldiers;
- blisters with clear fluid (a less severe injury);
- hemorrhagic blisters (a deeper, more severe injury);
- swelling or tender areas;
- loss of previous feeling of pain in the affected area;
- pale, yellowish, waxy-looking skin; and
- frozen area feels solid or wooden to the touch.

Warning: DO NOT attempt to thaw the casualty's feet or other seriously frozen areas if the casualty will be required to walk or travel to receive further treatment. Thawing in the field increases the possibilities of infection, gangrene, or other injury. Avoid creating a "freeze-thaw-refreeze" situation.

Note: It usually takes 24 to 48 hours after warming to determine the extent of injury.

Figure 30-37. Frostbite of the toes on Mount Logan climber. Photograph by Dr S. Falz. Reproduced from Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Frost_bite.jpg

Figure 30-38. Frostbitten foot of Mount Logan climber 12 days after freezing. Photograph by Dr S. Falz. Reproduced from Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Human_toes,_12_days_post-frostbite.jpg

Figure 30-39. Frostbitten foot of Mount Logan climber 3 weeks after freezing. Photograph by Dr S. Falz. Reproduced from Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Human_toes,_3_weeks_post-frostbite.jpg

Treatment for frostbite begins with warming the area by placing an affected appendage on a battle buddy's abdomen or under arms and applying firm, steady pressure. The battle buddy's body heat will start to thaw the frostbitten appendage. For frostbite of the face, ears, and nose, cover the area with the casualty's or battle buddy's hands until sensation and color return. Cover the casualty with a blanket or other dry material. Loosen or remove tight clothing, watches, and jewelry. Evacuate the casualty. Pain medication may be required.

Warning: DO NOT—

- soak the frostbitten part in water,
- rub the affected area with snow,
- expose the affected area to any extreme heat source,
- rub or move the part in any way to increase circulation,
- allow the casualty to smoke or drink alcohol, or
- expose the frozen part to an open fire.

Prevention of Heat and Cold Injuries

The wet bulb globe temperature (**WBGT**) index is used to determine the heat condition. Use of mission oriented protective posture (**MOPP)** (Figure 30-40) or body armor (Figure 30-41) increases the WBGT by about 10 °F. In an environment where ballistic protective gear (body armor) or MOPP gear is worn, heat stress is an important consideration. Even in environments with moderate and relatively comfortable temperatures, MOPP gear can increase temperatures to the most severe and debilitating level of heat stress. It is important that soldiers operating in MOPP gear maintain adequate water consumption and follow strictly monitored work-rest cycles. These actions reduce heat injuries and help maintain personnel effectiveness. When soldiers are working, regardless of the environment, leadership must implement guidance outlined in Training and Doctrine Command Regulation 350-29 for work-rest cycles and water consumption. When to drink is as important as how much. If a soldier waits until they are thirsty to consume water, they have waited too long. Avoid alcohol consumption prior to and during hot or cold weather missions.

Drinking fluids isn't the only way your body obtains water. Food contains water too, so soldiers should eat regular meals. Usually, eating field rations or liberally salting garrison food will provide enough salt to replace what is lost through sweating. Additionally, more calories are required in cold weather to continue to generate sufficient body heat.

Figure 30-40. Army National Guard soldier Private First Class Christopher Lopez decontaminating military vehicle in MOPP 4. Photograph by Specialist Cody Kilduff. Reproduced from Defense Visual Information Distribution Service. https://www.dvidshub.net/image/4471267/chemical-decontamination-site

Figure 30-41. Soldier trying on body armor at Fort Bliss, Texas. Photograph by Sergeant First Class Gary Witte. Reproduced from Defense Visual Information Distribution Service. https://www.dvidshub.net/image/2429066/checking-fit

Increase water consumption when wearing certain or additional clothing or equipment (eg, body armor and MOPP gear). Soldiers are more likely to drink if the fluid's temperature is opposite of the environment where they are working. Provide warm fluids in cold environments and cool fluids in hot environments. Field rations, such as Meals Ready to Eat (MREs), contain electrolyte replacement solutions to supplement the flavor of water and aid with hydration.

Note: The maximum recommended daily intake of water is 12 quarts (11.4 L).

Appropriate dress can help soldiers avoid hot and cold weather injury. The mnemonic **COLD.** may be helpful when selecting clothing: **C**lean, don't **O**verdress, **L**oose and in **L**ayers, **D**ry. Military units should allow 2 weeks for soldiers to become acclimatized to hot environments. During acclimation, progressively increase the workload during the second week. During periods of sudden temperature change, treat all soldiers as acclimatized. Heat effects build up during the day and over several days; this is known as a "cumulative effect." Recovery is slow, even after temperatures have decreased. Follow the highest heat category reached for the remainder of the day. Restrict or modify strenuous physical activities during high heat-stress conditions if the combat situation permits. Have soldiers take breaks in the shade and drink water. Provide rewarming tents. Consider carbon monoxide precautions when soldiers are sleeping in tents and vehicles. Plan for the weather. In hot environments, perform heavy work earlier in the day when the temperature is cooler. In cold weather, plan to be outside when the sun is up. Use the buddy system to look out for fellow soldiers.

Altitude Injuries

Some syndromes can develop in unacclimatized persons shortly after ascent to high altitude (Figure 30-42). Altitude injuries usually begin around 10,000 feet, but may occur as low as 6,500 feet. There is no reliable way to identify soldiers who have difficulty with altitude acclimatization except by their previous experience with altitude exposure.

Types of Altitude Injuries

Acute Mountain Sickness

Acute mountain sickness is the most common altitude disorder. It is a syndrome in an unacclimatized person above 6,500 feet altitude who has a headache and one of the following:

- anorexia (decreased appetite),
- nausea and vomiting,
- lethargy,
- dizziness or lightheadedness, and
- altered mental status (the cause is unclear).

Figure 30-42. A UH-60 Black Hawk helicopter flying over the Bamyan river valley. This photograph shows the extreme altitude differences that US service members are operating in in Afghanistan. Photograph by Sergeant Ken Scar, 7th Mobile Public Affairs Detachment. Reproduced from Defense Visual Information Distribution Service. https://www.dvidshub.net/image/614493/bamyan-province-emerges-model-afghanistans-potential

Treatment for acute mountain sickness is administering oxygen by nasal cannula at 1 to 2 L per minute, descending 1,700 to 3,300 feet, and remaining at the descent altitude until symptoms resolve.

High Altitude Cerebral Edema

High altitude cerebral edema (**HACE**) is a potentially fatal condition in which a soldier experiences acute brain swelling after ascending too rapidly. Hypoxia increases vasodilation in blood vessels. This vasodilation causes an increase in blood flow to the brain. Simultaneously, there is an increase in the permeability of the cerebral capillary beds, resulting in more cerebral edema. This condition usually develops at altitudes above 8,000 feet. The signs and symptoms of HACE are:

- altered mental status for 24 hours or more,
- ataxic gait, and
- severe fatigue.

Treatment for HACE is immediate descent of 3,300 feet or more. Administer oxygen at 1 to 2 L per minute to achieve and maintain pulse oximetry readings of at least 90%.

High Altitude Pulmonary Edema

High altitude pulmonary edema (**HAPE**) is pulmonary edema (fluid in the alveoli) in an unacclimatized individual after a rapid ascent to high altitude. It can be rapidly fatal and is the most common cause of death due to altitude illness. After ascent to 10,000 to 12,000 feet (rarely as low as 8,000 feet) without proper acclimatization, the casualty's alveolar membranes become leaky and fluid starts filling the alveoli, decreasing alveolar surface area to conduct gas exchange. Signs and symptoms of HAPE are:

- dyspnea, even at rest;
- rales;
- tachypnea;
- tachycardia;
- cyanosis; and
- decreased oxygen saturation.

Treatment for HAPE is immediate evacuation and descent of 1,700 to 3,300 feet. Administer oxygen at 4 to 6 L per minute to achieve and maintain pulse oximetry readings of at least 90%.

Note: There does not seem to be any way to speed acclimatization; some soldiers acclimatize more rapidly than others, and a few soldiers may not acclimatize at all.

Management of Altitude Injuries

Prevent injury through acclimatization (the process whereby the body gradually adapts to the climate and environment). For acute mountain sickness, stop the ascent until symptoms resolve, then resume ascent following a stepped and staged plan. For HACE and HAPE, affected individuals require immediate descent with minimal casualty exertion, and evacuation. Provide oxygen, if available (high-flow oxygen therapy is not required). Refer to an MO for evaluation.

Acclimatization

Altitude disorders can be prevented by proper acclimatization. This allows soldiers to achieve the maximum physical work performance possible for the altitude at which they are employed. Once acquired, acclimatization is maintained as long as the soldier remains at that altitude but is lost upon return to lower elevations. The two types of acclimatization are staged ascent and graded ascent. The most effective acclimatization is a combination of the two.

Staged ascent requires soldiers to ascend to a moderate altitude and remain there for 3 days or more to acclimatize before ascending higher. When possible, soldiers should make several stops for staging during the ascent to allow a greater degree of acclimatization.

Graded ascent limits the daily altitude gain to allow partial acclimatization. The altitude at which soldiers sleep is the critical element. Having soldiers spend two nights at 9,000 feet and limiting the sleeping altitude to no more than 1,000 feet per day above the previous night's sleep altitude will reduce altitude illnesses.

Check on Learning

8. At what altitude should you begin assessing your fellow soldiers for altitude injuries?
9. You are in the mountains of Afghanistan on a patrol. A fellow soldier begins to show signs of an altitude injury. What should be done immediately?
10. What is the most effective type of acclimatization?

SUMMARY

As a combat medic, you will live and work in the same environment as the soldiers for whom you provide medical care. Your knowledge of how environmental factors can decimate combat effectiveness of a unit, and the actions that can preserve combat effectiveness are paramount during military operations. Many environmental threats ranging from disease vectors, venomous or nuisance arthropods and animals, heat and cold exposure, and high altitude can adversely affect an army's ability to fight and win. Prevention, mitigation, and treatment can have direct influence on victory on the battlefield.

KEY TERMS AND ACRONYMS

Antihistamines. An agent that opposes the action of histamine on H1 receptors.
Arthropod. One of a large group of invertebrate animals that includes ticks, spiders, mites, and other insects as well as crustaceans such as shrimp, lobster, and crabs.
Ataxia. Defective muscular coordination.
Botulism. A paralytic and occasionally fatal illness caused by exposure to toxins released from *Clostridium botulinum*, an anaerobic, gram-positive bacillus.
Chemoprophylaxis. The use of a drug or chemical to prevent a disease.
Chloroquine. A white, crystalline powder used to treat both malaria and amoebic dysentery.
Cholera. An acute bacterial infection, caused by *Vibrio cholera.* It involves the entire small intestine and is marked by profuse, watery, secretory diarrhea.
COLD. An acronym that helps soldiers remember how to appropriately dress in cold climates to prevent cold weather injuries. The acronym represents "clean, don't overdress, loose and in layers, dry."
DEET. N,N-diethyl-m-toluamide, a potent, broad spectrum insect repellent that is approved for use by the DOD.
Diuretics. An agent that increases urine output.
DNBI. Disease and nonbattle injury.
Dysentery. Diarrhea containing blood and mucus, resulting from inflammation of the walls of the gastrointestinal tract.
Encephalitis. An inflammation of the white and gray matter of the brain, mostly caused by a viral infection.
Encephalitides. Plural of encephalitis.
Envenomation. The poisonous effects of the bites or stings of arthropods or snakes.
Erythema migrans. A red, expanding lesion seen at the bite site of a tick infected with Lyme disease.
Guillain-Barre syndrome. A rare neurologic condition named after French neurologist Georges Guillain, which results in ascending paralysis.
HACE. High altitude cerebral edema. A potentially fatal condition in which the soldier experiences acute brain swelling due to too rapid ascent in altitude.
HAPE. High altitude pulmonary edema. Pulmonary edema (fluid in the alveoli) in an unacclimatized individual after a rapid ascent to high altitude.
Hemolysis. Destruction or disruption of red blood cells, resulting in the release of hemoglobin.
Hepatomegaly. Enlargement of the liver.
Inoculation. To spread a disease by inserting its etiologic agent.
Malaise. A feeling of discomfort, weakness, and fatigue due to an illness.
Malaria. A febrile hemolytic disease caused by protozoa of the genus *Plasmodium*.
MOPP. Mission oriented protective posture.
Pathogen. A microorganism capable of producing disease.
Permethrin. An insecticide and insect repellent.
Photochromic. Lenses that appear almost clear when indoors and darken when exposed to sunlight. Also known as light-adaptive lenses.
Photophobia. An extreme sensitivity to light.
Plague. Any widespread contagious disease associated with a high mortality rate. However, plague typically refers to the disease caused by the pathogen, *Yersinia pestis*.
Regurgitation. When the vector vomits the pathogen into the host while it feeds on the host.
Splenomegaly. Enlargement of the spleen.
Tularemia. A tick-borne infectious disease that is caused by *Francisella tularensis* bacteria.
Typhoid. Referring to typhus.
Typhus. A bacterial infection caused by *Rickettsia typhi*.
Vector. An arthropod that transports a disease-causing organism, or pathogen, from one host to another.
Venom. A toxin produced by some animals, such as scorpions, spiders, and snakes.
WBGT. Wet bulb globe temperature.
WNV. West Nile virus.
Yellow fever. A viral disease that is transmitted by mosquitoes in the genus *Aedes*.

CHECK ON LEARNING ANSWERS

1. Malaria must always be considered in what group of individuals?

   Any soldier with an unexplained febrile illness who had been recently deployed or is currently deployed in a malaria risk country.

2. The most effective means of malaria control is avoiding mosquito bites. How is prevention implemented?

   Insect bars (bed nets), properly fitted and worn clothing, chemical repellents, and eliminating mosquito larval habitats.

3. How is the impact of filth flies and cockroaches mitigated?

   Locating and removing the habitats and food sources; field latrines and soakage pits should be constructed, used, maintained, and closed to reduce fly breeding; sprays; fogs; and sticky traps.

4. How is the impact of sandflies mitigated?

   Proper wear of the uniform and application of repellents will prevent most infections. Avoid dogs and other domesticated animals.

5. What should you do if you find a tick on yourself or a battle buddy?

   With gloves on, remove any attached ticks by using gentle, steady traction with forceps or tweezers applied close to the skin to avoid leaving mouthparts in the skin. Following removal, cleanse the skin site with soap and water.

6. Which arthropods could be used as a biowarfare agent?

   Fleas.

7. What is the field treatment for a snake bite?

   Look for an allergic reaction. Provide oxygen, if available. Gain IV access in all snakebite victims (in the unaffected extremity). Remove watches and jewelry. Keep the casualty as calm and inactive as possible. Gently clean the bite site. Consider immobilization. Evacuate.

8. At what altitude should you begin assessing your fellow soldiers for altitude injuries?

   Altitude injuries usually begin around 10,000 feet, but may occur at 6,500 feet.

9. You are in the mountains of Afghanistan on a patrol. A fellow soldier begins to show signs of an altitude injury. What should be done immediately?

   Stop ascent.

10. What is the most effective type of acclimatization?

    A combination of staged ascent and graded ascent.

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