Chapter 23

DEPLOYMENT INJURIES

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INTRODUCTION

Injuries are a major cause of morbidity and mortality during deployments.[1–3] They adversely affect personal and unit readiness and can affect the success of a mission by consuming both limited manpower and available medical resources. During the Persian Gulf War, nearly 5,000 US Army soldiers were admitted to medical treatment facilities in Southwest Asia for injury-related conditions from 1 August 1990 through 31 July 1991.[3]

An injury is the result of an energy transfer from one medium to another—a human being.[4] For an injury to occur, the amount of energy transferred must exceed the individual's ability to absorb it.[4,5] Injury control is the science of preventing the energy transfer, reducing the amount transmitted to safer levels, and repairing the damage inflicted.

Health care providers, to a large extent, become involved in injury control only after the injury occurs. The focus of physicians and others has been to limit damage through treatment and rehabilitation of the injured patient. During deployment, however, such factors as mission success, access to medical care, and availability of replacements require that injury prevention be a primary focus of those responsible for medical readiness. On deployment, injury prevention is a force multiplier. Physicians and other providers must be involved in primary, secondary, and tertiary injury prevention (Table 23-1). A key part of that involvement is the management of comprehensive injury surveillance systems that permit the evaluation of medical care in the field for combat[6] and noncombat casualties. Reducing the number and severity of injuries is, however, a multidisciplinary undertaking (Exhibit 23-1). It involves safety professionals, equipment designers, commanders, small unit leaders, and medical personnel. Interactive and effective communication between the myriad players is essential.

A comprehensive discussion of injury prevention techniques and strategies is beyond the scope of this chapter. Injuries are a broad and diverse diagnostic category with many causes. Even when the focus is narrowed to unintentional blunt and penetrating trauma, which is what this chapter will concentrate on (eliminating battle injuries, homicide, and suicide from the discussion), there are a multitude of injury types, causes, and preventive strategies. This chapter will provide a framework of historical and epidemiologic information that demonstrates the impact of injuries on deployments, followed by an overview of available methods for identifying, managing, and eliminating high-risk situations.

MAGNITUDE OF THE PROBLEM

Historical Perspective

Traumatic unintentional injuries can have a significant effect on operations during deployment. Relative to other nonbattle casualties, unintentional nonbattle injuries have been increasing in importance since the early 20th century.

TABLE 23-1

INJURY PREVENTION SYSTEMS AND THEIR PURPOSES

System Level	Purpose
Prevention System (Primary Prevention)	Prevent occurrence Reduce incidence Be a force multiplier
Acute Care System (Secondary Prevention)	Recognize injuries early Treat injuries early Minimize severity
Rehabilitation System (Tertiary Prevention)	Optimize patient's function Minimize disability

Through the first World War, illnesses were the greatest threat to a US soldier's health.[7] In the second World War, as the US Army became increasingly mechanized and as advances in the sanitary and medical control of infectious diseases were made, nonbattle injuries became the leading cause of death in US soldiers.[8] In the US Navy and Marine Corps, injuries were the fourth leading type of casualty, fatal and nonfatal, in World War I.[1] They were the third leading cause during World War II and the Korean War. In the Vietnam War, they had become the leading type of casualty. During Navy and Marine Corps deployments in the 20th century, injury casualty rates (both battle and nonbattle) have remained constant while disease casualties have declined dramatically.[1]

Several studies have examined the epidemiology of injuries, mainly musculoskeletal injuries, in soldiers at basic training facilities and in garrison.[9–11] But good published deployment injury data are few, and most are available only years or even decades

EXHIBIT 23-1

INJURY PREVENTION PARTNERS DURING DEPLOYMENTS

- Safety Center/Safety Command/Safety Officers
- Commanders, noncommissioned officers, and supervisors
- Service members
- Military schools
- Preventive and occupational medicine care providers
- Other medical care providers
- Technology and equipment developers
- Engineers
- Data system managers

after the deployment. Comprehensive Army statistics on injuries in World War II and the Korean War were not published until the 1970s.[8,12] Reports of disease and nonbattle injuries (DNBIs) in the Vietnam War were not available until the 1980s and 1990s.[13,14] Other reports have not separated diseases and nonbattle injuries from all casualties.[15]

Deaths During Recent Deployments

During the Persian Gulf War, 183 of 225 (81.3%) unintentional nonbattle deaths among all deployed US military personnel were due to injuries, as opposed to 30 (13.3%) deaths due to illnesses. Suicides accounted for 10 (4.4%) deaths and homicides for 1 (0.4%) death; one death was reported as cause unknown.[2] In contrast, among the nondeployed force, unintentional injuries accounted for 56.1% of the total deaths. This difference clearly illustrates the relative importance of unintentional injuries during deployments.

Among the deployed, motor vehicle accidents were the leading mechanism of death (62 deaths, 33.9%), followed by aircraft accidents (47 deaths, 25.7%). Motor vehicles accidents were also the leading cause of death in the nondeployed forces: 439 of 784 deaths (56.0%). Death by explosion was rare in nondeployed forces (1 death, 0.05/100,000 person-years) but was a significant cause of death in Southwest Asia (18 deaths, 6.8/100,000 person-years). Table 23-2 compares the causes of unintentional trauma death for service members who deployed to the Persian Gulf War and those who did not.

Hospital Admissions During Recent Deployments

Admissions of soldiers to US Army hospitals during the Persian Gulf War, August 1990 through July

TABLE 23-2

NUMBER, RATE, AND RATE RATIO OF UNINTENTIONAL TRAUMA DEATHS IN US MILITARY PERSONNEL DEPLOYED TO THE PERSIAN GULF REGION AND NONDEPLOYED FORCES, 1 AUGUST 1990 THROUGH 31 JULY 1991

	Nondeployed		Deployed		
Cause of Death	No.	Rate*	No.	Rate*	Rate Ratio
All DNBI†	1,397	73.38	225	84.95	1.16
Unintentional trauma	784	41.18	183	69.09	1.68
Motor vehicle	439	23.06	62	23.41	1.02
Aircraft	104	5.46	47	17.74	3.25
Explosions	1	0.05	18	6.80	136.00
Other	175	9.19	56	21.14	2.30

*per 100,000 person-years
†DNBI: disease and nonbattle injury
Data source: Writer JV, DeFraites RF, Brundage JF. Comparative mortality among US military personnel in the Persian Gulf region and worldwide during Operations Desert Shield and Desert Storm. *JAMA*. 1996;275:118–121.

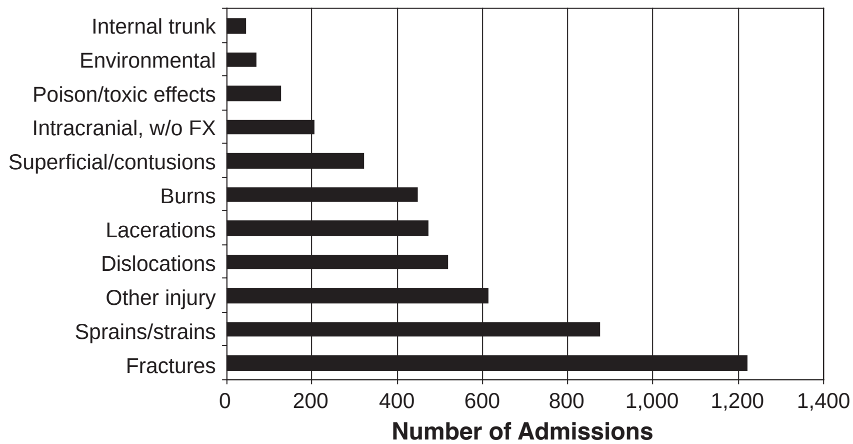

Fig. 23-1. Primary Discharge Diagnosis for US Army Soldiers Hospitalized in Southwest Asia, 1 August 1990 to 31 July 1991

1991, have been analyzed.[3] During the deployment, 19,926 US soldiers were admitted to hospitals in Southwest Asia. Acute nonbattle injuries (4,940, 24.8%) were the primary reason for admission during the conflict. Figure 23-1 summarizes the leading types of injuries reported. The highest number and rate of nonbattle injury admissions were reported during the ground and air war and in the month following cessation of hostilities (Figure 23-2).

Of the available computerized admissions records of nonbattle injury, only 2,632 (53.3%) were coded to indicate the cause of injury. Among these, motor vehicles accidents were the leading cause of admission during the deployment (494, 18.8%). Falls (491, 18.7%) were second, followed by sports and athletics injuries (450, 17.1%). The mechanisms of injury are summarized in Figure 23-3. Sports injuries are a significant contributor to nonbattle injuries.

Outpatient Visits During Recent Deployments

A concerted tri-service effort to collect and report outpatient surveillance data is a recent development. During the Persian Gulf War, the US Army had no theater-wide surveillance program. In 1993, the Joint Staff mandated medical surveillance with weekly reporting of DNBI on all joint deployments. A uniform, theater-wide program for collecting outpatient data was in place during deployments to

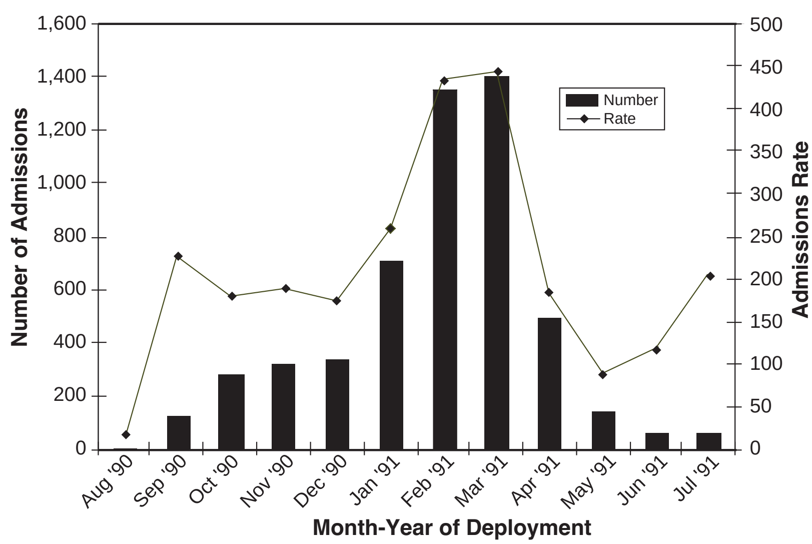

Fig. 23-2. Rate and Number of US Army Soldiers Hospitalized in Southwest Asia, 1 August 1990 to 31 July 1991, by Month

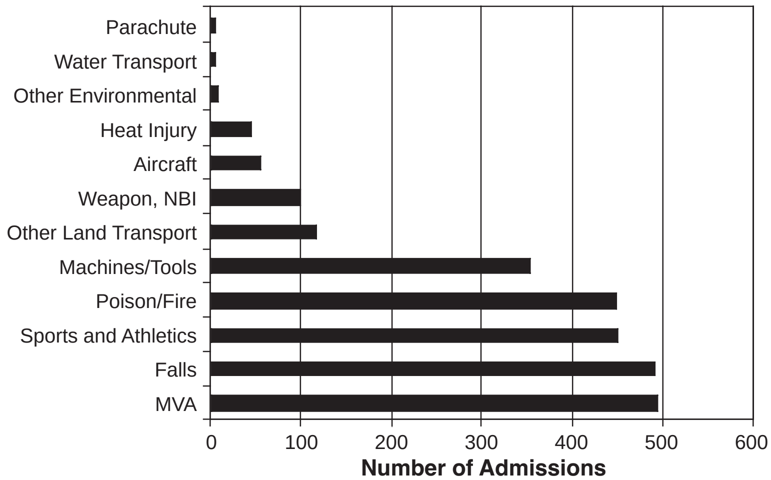

Fig. 23-3. Reported Mechanisms of Injury for US Army Soldiers Hospitalized in Southwest Asia, 1 August 1990 to 31 July 1991

Somalia and Haiti and the 1994 Bright Star training exercise in Egypt.[16] Yet information from these deployments still has been incomplete or nonspecific. For example, the Somalia data listed injuries and orthopedic conditions as a single category and did not describe what the injury or condition was. Improvements and refinements were implemented in the mid-1990s during deployments to Haiti and Bosnia.

During Operation Restore Hope in Somalia, 32 outpatient facilities reported injury surveillance data. Each week, 2.5% to 3.5% of the force was seen for an injury or orthopedic problem. However, no more specific information about the encounter was reported. Similar rates were seen during Operation Uphold Democracy in Haiti.[16] In the 1994 Bright Star exercise in Egypt, 146 (25%) of outpatient visits were injury related during the 19-day deployment. Sprains and strains were the leading cause of injury and resulted in restricted duty in 70% of cases.[16]

Who Is at Risk

Military populations are by their nature (mostly young, healthy men) at high risk for injuries, whether deployed or at their home installations. Studies in civilian populations show that young men are more likely to be hospitalized or die as a result of an unintentional traumatic injury than any other US population subgroup.[17,18] Young men are more likely to be risk takers and may have jobs that place them at risk.

The hospital admissions data from the Persian Gulf War have been analyzed to create a profile of who is at risk of being admitted for an injury.[3] US Army men were 30% more likely to be admitted for an injury than Army women. Being younger than 25 years of age conferred an 18% to 21% higher risk than being in the older age groups. Rank is also associated with higher risk: enlisted soldiers were 70% more likely than officers to be admitted for an injury. Reserve component soldiers were at a 20% higher risk of admission than the active duty Army troops.

While the above data were not analyzed by occupation, risk should also vary by military occupation. For example, truck drivers are likely to be at a higher risk of injury in motor vehicle accidents, dock workers of being crushed, and helicopter pilots of being involved in an aircraft crash than other military personnel.

EVALUATING THE PROBLEM

Surveillance and Reporting

Physicians and other health care providers are an important part of the injury prevention and control process. Through medical surveillance and clinical impressions, they can gather important information and report it to risk managers. Such information could significantly alter the level of danger believed to be present in an operation. Good, solid surveillance data combined with accurate and timely reporting have been effective in identifying dangerous products and activities.

GROUND SAFETY DATA SHEET

Name: (last, first, m.i.)   Injury date: (mm/dd/yy)   Time:

SSAN: / /   Sex: Age:

Organization: Grade/rank: Job series/AFSC:

Injured on duty: ☐ yes ☐ no ☐ unknown

Illness: *report to Public Health*

1. Injury (*check all that apply*)
- ☐ needle stick
- ☐ contusion/bruise
- ☐ laceration/cut
- ☐ puncture
- ☐ abrasion/scrape
- ☐ fracture
- ☐ sprain/strain
- ☐ inhalation/ingestion
- ☐ burn/blisters
- ☐ environmental (heat, cold, altitude, depth)*
- ☐ electrical shock/electrocution
- ☐ rupture/avulsion
- ☐ amputation
- ☐ foreign body
- ☐ overexertion
- ☐ other:

2. Part of body (*check all that apply*)
- ☐ eye
- ☐ head
- ☐ neck
- ☐ arm
- ☐ hand
- ☐ chest/shoulder
- ☐ spine/back
- ☐ abdomen
- ☐ pelvis
- ☐ knee
- ☐ ankle
- ☐ foot
- ☐ eg (other part)
- ☐ other:

3. Event type (*check 1*)
- ☐ military aircraft (form)
- ☐ parachute – *go to a*
- ☐ motor vehicle – *go to b*
- ☐ other transport – *go to c*
- ☐ march/drill –*go to d*
- ☐ sport/recreation – *go to e*
- ☐ other fall/jump – *go to f*
- ☐ slip/trip/stumble – *go to g*
- ☐ lift/push/pull – *go to h*
- ☐ immersion/diving – *go to i*
- ☐ struck by – *go to j*
- ☐ thermal - *go to k*
- ☐ poisoning – *go to l*
- ☐ electromag/radiation – *go to m*
- ☐ machinery – *go to n*
- ☐ electricity/lightning – *go to o*
- ☐ fighting – *go to p*
- ☐ gun/explosion – *go to q*
- ☐ other:

4. Intent (*check 1*)
- ☐ unintentional
- ☐ in battle
- ☐ non-battle assault (intentional)
- ☐ self-inflicted
- ☐ unknown

5. Place (*check 1*)
- ☐ on maneuvers
- ☐ military property (non-maneuverable)
- ☐ private residence
- ☐ sports area
- ☐ street/highway
- ☐ commercial area
- ☐ industrial/construction area
- ☐ farm
- ☐ other specified:
- ☐ unspecified

6. Disposition
- ☐ return to regular duty
- ☐ return to limited duty: days
- ☐ sent home for rest of shift (military: quarters, no duty)
- ☐ sent home for days (military: quarters, no duty: <u>X</u> days)
- ☐ admitted to hospital
- ☐ died before admission
- ☐ died after admission
- ☐ other:

Returned to duty

Date: (mm/dd/yy)

Time:

*Additional injury information:

Describe circumstances:

(**Fig. 23-4** *continues*)

a. Parachute
- ☐ impact with aircraft
- ☐ chute failure
- ☐ opening shock
- ☐ ground impact
- ☐ dragged by chute
- ☐ other:

b. Motor Vehicle

(1) Vehicle:
- ☐ military
- ☐ personally owned vehicle
- ☐ unknown

(2) Person:
- ☐ driver
- ☐ passenger
- ☐ pedestrian
- ☐ other/unknown

(3) Seatbelt/Helmet:
- ☐ yes
- ☐ no
- ☐ unknown

(4) Vehicle type:
- ☐ car
- ☐ truck
- ☐ sport utility
- ☐ tracked vehicle
- ☐ private aircraft
- ☐ commercial aircraft
- ☐ other:

c. Other transport
- ☐ watercraft
- ☐ motorcycle
- ☐ bicycle
- ☐ pedestrian
- ☐ other:

d. March/drill
- ☐ ceremony-related
- ☐ long-distance march
- ☐ training

e. Sports/recreation
- ☐ baseball/softball
- ☐ basketball
- ☐ boxing
- ☐ football
- ☐ golf
- ☐ gymnastics
- ☐ hockey
- ☐ horsemanship
- ☐ racquet sport
- ☐ running/track
- ☐ hunting/shooting
- ☐ skiing
- ☐ soccer
- ☐ swimming
- ☐ volleyball
- ☐ weight training
- ☐ wrestling
- ☐ other:

f. Fall/jump *(not parachute)*
- ☐ on same level
- ☐ on/from steps
- ☐ from ladder/scaffold
- ☐ from building
- ☐ from tree/cliff
- ☐ other:

g. Slip/trip/stumble
- ☐ due to obstacle
- ☐ on slippery surface
- ☐ while lifting
- ☐ other:

h. Lift/push/pull/twist without falling
- ☐ cargo handling
- ☐ flightline activity
- ☐ warehousing
- ☐ medical/patient
- ☐ outdoor maintenance
- ☐ other exertion:

i. Immersion/diving
- ☐ immersion
- ☐ diving
- ☐ other:

j. Struck by…
- ☐ falling object
- ☐ projected object

k. Thermal effect
- ☐ scald/steam
- ☐ hot object
- ☐ fire/flame
- ☐ heat, unspecified
- ☐ cold
- ☐ other:

l. Poisoning
- ☐ therapeutic drug
- ☐ illegal drug
- ☐ vehicle exhaust
- ☐ other ingestion
- ☐ other inhalation
- ☐ unknown, other:

m. Electromagnetic/radiation
- ☐ ultraviolet light
- ☐ laser
- ☐ microwave
- ☐ ionizing radiation (radioactive)

n. Machinery
- ☐ vehicle (non-road)
- ☐ fixed
- ☐ for lifting
- ☐ hand tool
- ☐ other:

o. Electricity/lightning
- ☐ electric appliance
- ☐ other 110/220
- ☐ high tension wire
- ☐ lightning strike
- ☐ other:

p. Fighting
- ☐ fists/teeth/feet, etc
- ☐ other weapon:

q. Gun/explosion
- ☐ military rifle or shotgun
- ☐ military sidearm
- ☐ mounted machine gun
- ☐ mine, bomb
- ☐ exploding gas
- ☐ personal rifle/shotgun
- ☐ personal handgun
- ☐ other:

Fig. 23-4. A sample Injury Surveillance Form

Because deployed service members are at a greater risk of suffering a serious injury (eg, death, hospital admission) than those not deployed, reasonably accurate predictions of the number of losses and type of injuries expected on a mission need to be made to determine required troop strengths and medical assets. Ultimately this information can be used to develop injury prevention measures.

To make accurate and useful predictions, medical surveillance during deployments needs to be an essential part of the field preventive medicine program. This need has been recognized, and programs have been developed for the missions in Haiti and Bosnia. Accurate and timely data delivered to medical and line commanders in the field can lead to appropriate responses to higher-than-anticipated injury rates or unusual injury types. Figure 23-4 shows a prototype injury surveillance form, developed under the auspices of the Armed Forces Epidemiological Board, that could be adapted for use during deployments.

The medical surveillance system should work in concert with the existing accident reporting systems managed by the safety professionals. In the Army, that system requires the reporting of any accident that causes a lost workday.[19]

Medical surveillance identifies an injury only after it has occurred, and many systems have recorded only the medical diagnosis in general terms. Often missing from the data are the pre-injury, during-injury, and post-injury events that contribute to the occurrence and severity of the injury. An injury surveillance system that captures and reports the type, the mechanism, and, if possible, the circumstances surrounding the injury event is needed to allow risk managers and others, such as commanders, to fully understand the evolution of an unintentional trauma casualty.[4]

The effectiveness of surveillance is demonstrated by a civilian example: the National Electronic Injury Surveillance System (NEISS), operated by the Consumer Product Safety Commission.[20] This surveillance system uses a probability sample of emergency rooms throughout the United States to collect injury incidence data and is a model of how reports from the field (in this case, the general US population) can be used to reveal dangerous consumer products and lead to the implementation of control measures. For the Consumer Product Safety Commission, these could include better hazard labeling, product recall, or product reengineering. The same principles can and should be applied during deployments of military personnel.

Tracking of specific types of injuries by researchers and clinicians has led, in one example, to better automotive design.[21,22] Using crash tests and reports from emergency rooms and other settings, automotive developers have been able to pinpoint specific problem areas in the design of automobile passenger compartments. Reengineering based on these reports has made automobiles safer and reduced the severity of injuries following a crash. The Army has used this type of reporting in its MANPRINT[23] and Health Hazard Assessment programs[24] to assess the health risks and human performance issues of military equipment at any stage in its life cycle. An ankle brace developed in the late 1980s and early 1990s for service members in airborne units to reduce the risk of jump injuries is an example of how medical surveillance, safety professionals, product developers, and line units can work together to produce an intervention that reduces injury risk and aids the mission.[25] Postmarketing surveillance of the brace continues to evaluate its safety, effectiveness, and efficacy.

Risk Assessment

Injury prevention is a five-step process (Exhibit 23-2). The Army Safety Center defines the process in a similar way.[26] Although risk of injury is inherent in all military operations, risk managers must find ways to reduce or eliminate unnecessary risks (Figure 23-5). In the military, successfully implementing this process allows a commander to accomplish the mission. The scope of the safety program, its general direction, and the responsibilities of all involved are made clear by regulation (eg, AR 385-15[26]) and, in the Army, the commanding general of US Army Forces Command establishes safety policy,

EXHIBIT 23-2

THE FIVE-STEP PUBLIC HEALTH APPROACH TO INJURY PREVENTION

1. Identify the problem and its magnitude
2. Determine the causes of the problem
3. Know what works to prevent the problem and develop a plan
4. Implement the plan
5. Evaluate the results

		Hazard Probability				
Effect		Frequent A	Likely B	Occasionally C	Seldom D	Unlikely E
Catastrophic	I	Extremely high	Extremely high	High	High	Medium
Critical	II	Extremely high	High	High	Medium	Low
Moderate	III	High	Medium	Medium	Low	Low
Negligible	IV	Medium	Low	Low	Low	Low

Fig. 23-5. This matrix shows how risk managers classify the level of danger inherent in an operation. The resultant score, the risk assessment code, is based on a hazard's likelihood of occurring and its potential for doing damage. It is used to prioritize the need for and timing of interventions.

standards, and guidelines during operations, exercises, and maneuvers.

A civilian model that may be useful in conducting a risk assessment is shown in Figure 23-6.[27] The operational, political, epidemiologic, and managerial elements of identifying and controlling an injury problem are given equal weight in an unbroken circle. This is a good visual analogy of how risk assessment can be approached. The assessor can enter the circle at any point and travel in any direction but often must address each of the elements to identify and control risk successfully.

PREVENTION AND CONTROL STRATEGIES

Injuries do not just happen; in injury control science, there are no such things as accidents. Leading up to every injurious event are a series of actions or inactions and conditions that combine to produce the injury.[4] Making sense of these complex interactions is key to anticipating and countering them. Simply providing education and training materials and issuing recommendations will not effectively prevent injuries.[25,28]

Injury Event Modeling

There are two important models that evaluate causes and effects of unintentional injuries: the classic epidemiologic model of agent–host–environment interaction and the Haddon matrix. The epidemiologic model is applicable to injury prevention,[29] and Haddon incorporated it into his matrix because the three points of this triangular model represent the elements that must interact to produce an injury.

The agent in unintentional trauma is usually mechanical or kinetic energy transferred from an object to a human being. The mechanical impact or impulse could be from the sudden and unexpected deceleration of one motor vehicle striking another, a falling crate, or a human body hitting another during a football game. Other energy transfers, such

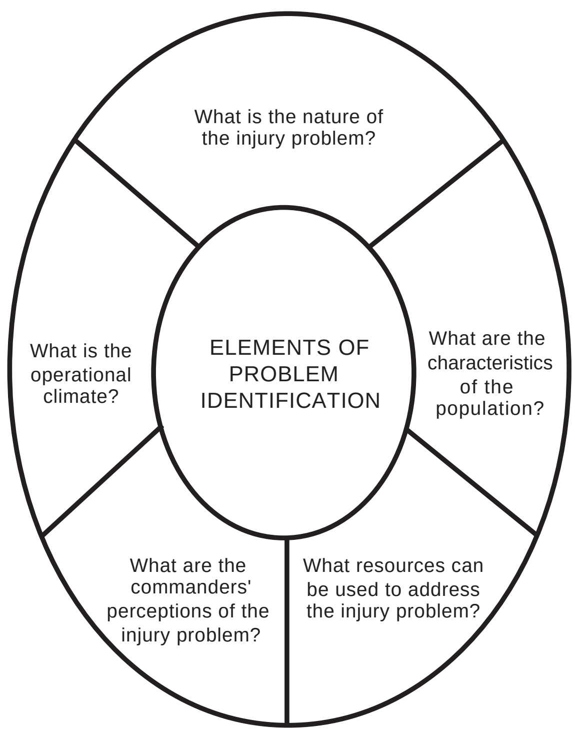

Fig. 23-6. Risk Assessment Model. Source: The National Committee for Injury Prevention and Control. Injury prevention: Meeting the challenge. *Am J Prev Med.* 1989;5(3 suppl):23. Adapted by permission of Oxford University Press.

as thermal, chemical, and radiological, also play a role. The environment can facilitate or reduce an energy transfer (eg, driving conditions, guardrails, other barriers), the amount of energy transferred (eg, shock absorbing material, availability of safety equipment), and ultimately the damage done by an injury (eg, emergency medical response, available medical care). The host is the individual receiving the transferred energy. Factors related to hosts include their chance of exposing themselves to danger (eg, fatigue, other impairment), their ability to tolerate the amount of energy transferred (eg, muscle mass, bone density), their behaviors (eg, using seat belts, wearing a helmet), and their ability to heal (eg, age, physical condition).

In the 1960s, Haddon developed a matrix that includes the three points of the epidemiologic triangle and adds the preevent, during-event, and post-event phases of an injurious event.[30,31] The matrix has been used most often for motor vehicle injuries but can be applied to almost any potentially hazardous situation. The resulting 3 x 3 matrix (Figure 23-7) is a comprehensive model that serves as a framework for developing and evaluating control programs. But it is not, as Haddon himself warned, a formula or guide that needs to be strictly followed.

The matrix does not focus as much on the causes of injuries as on the means available to reduce morbidity and mortality by helping the user identify where interventions may be effective.[32]

The figure shows a Haddon matrix that could be applied in a deployment situation. As the prevention officer moves through the model, he or she can identify possible places for intervention. In reality, many of the elements are beyond the control of medical and safety personnel, but by thinking through the possible cause of injuries, thinking of interventions to counteract them, and either applying or lobbying for the doable interventions, the burden of injuries can be reduced.

Developing an Injury Prevention Program

Haddon later proposed a 10-point system for reducing the risk of injury.[32] It addresses preevent, during-event, and postevent interactions. These include eliminating, reducing, or modifying the amount and type of energy available for transfer; reducing an individual's absorbed dose; increasing the individual's threshold for injury; and countering and repairing the damage when an injury does occur (Exhibit 23-3). These 10 points clearly illus

	Human	Vehicle	Environment
Preevent	Fatigue Alcohol/drugs Anxiety	Speed Cargo (eg, explosives) Vehicle condition	Road conditions Time of day Speed limit Blackout conditions Operational tempo
During event	Bone density Muscle mass Helmet or seat belt use	Speed Site of impact Severity of impact Explosion Vehicle design (eg, occupant protection)	Road design (eg, barriers, breakaway light poles)
Postevent	Preexisting medical condition Age Severity of initial injury	Dissipation of energy Postcrash fire	First aid Emergency medical response Time to medical care Level of care available Temperature

Fig. 23-7. A Haddon Matrix for a Military Convoy

trate the complexity of designing effective preventive programs. Like Haddon's matrix, they provide a way to systematize the process of defining countermeasures to a potentially dangerous situation. They also reinforce the fact that successful injury control strategies require input, support, and cooperation from many diverse professionals.

Baker has developed a four-point outline for interventions to reduce injuries.[33] The general guidelines suggest modifying the environment (including the social environment), providing training and education, strengthening the individual, and providing an emergency medical response capability.

A simpler way to approach development of preventive strategies may evolve from the model used by occupational health professionals called the hierarchy of controls.[34] It separates preventable on-the-job illness and injury into three broad areas of interventions in descending order of effectiveness: engineering changes, personal protective equipment, and administrative controls. This triad can be discussed in the context of reducing the hazards associated with motor vehicles through safer roads and more crashworthy motor vehicles (engineering changes), providing seat belts (personal protective equipment), and establishing and enforcing speed limits (administrative controls). In the field, these controls can translate into building safety into equipment and processes; using seat belts, flak jackets, and helmets when required; and following established safety procedures and orders. It should be noted that safety guidelines and education are most effective when there is the threat of legal punishment if they are not followed.[27]

Unlike civilian injury prevention strategies, military approaches must take into account the potential limits placed on any intervention by operational requirements. These requirements may also create hazards. In a very simplistic example, the dangers of driving at night without headlights are well known; in fact, it is illegal to do so in the United States. Mission success may, however, require night driving under

EXHIBIT 23-3

HADDON'S TEN-STEP INJURY PREVENTION SYSTEM

1. Prevent the creation of the hazard in the first place (eg, ban certain sports activities, such as tackle football).
2. Reduce the amount of hazard brought into being (eg, transport explosives in smaller quantities).
3. Prevent the release of a hazard that already exists (eg, enforce no-smoking rules around fuel dumps).
4. Modify the rate of release or spatial distribution of a hazard (eg, build military vehicles to better absorb energy during a crash, thus reducing the amount of energy transferred to the occupants; require the use of seat belts even in tactical vehicles, when possible).
5. Separate in time or space the hazard and that which is to be protected (eg, store fuel and ammunition away from living quarters).
6. Separate the hazard and that which is to be protected by imposition of a barrier (eg, require the use of appropriate personal protective equipment such as helmets and cut-resistant gloves).
7. Modify basic, relevant qualities of the hazard (eg, make explosives more stable).
8. Make what is to be protected more resistant to the hazard (eg, encourage "safe" physical training activities).
9. Begin to counter the damage already done by the environmental hazard (eg, train all personnel in emergency first aid, establish an emergency medical response capability).
10. Stabilize, repair, and rehabilitate the object of the damage (eg, deploy the right mix of medical specialists and equipment to provide effective acute and rehabilitative care).

Source: Haddon W Jr. Advances in the epidemiology of injuries as a basis for public policy. *Public Health Rep.* 1980;95:411–421.

blackout conditions. Accepting this as a necessary hazard means looking for other ways to reduce the hazards created by this operational requirement. Options to consider (though they still may not be possible given the operational tempo) could include ensuring drivers are well rested, spacing vehicles at a greater distance than normal, requiring the use of seat belts and helmets, providing sufficient traffic controls, and providing an increased level of emergency medical support. Ultimately, however, it will be the commanders who will decide what necessary risks must be assumed to ensure the success of a mission.[26]

Often, simple solutions to serious problems work well. During the Allied buildup in England for the Normandy invasion in World War II, football was banned in US camps to reduce the risk of injury and loss of soldiers from the invasion force.[35] Soldiers were provided with bats and balls instead.

Haddon's matrix and 10-point system and other models allow the injury-control professional, whether medical or safety, to see and evaluate the full spectrum of contributors to an injurious event. Selecting what interventions are possible and where to attempt them becomes easier using this somewhat structured approach.

EFFECTING CHANGE

On deployment, safety and injury prevention is the responsibility of the commander and everyone else down through the chain of command to the individual service member.[36] Prevention and control of injuries is a partnership among many people. The responsibility of the medical community is to understand the process of injury causation and prevention, track the kinds and severity of injuries, inform the commanders of the magnitude and nature of the injury problem, and work closely with commanders and safety professionals to reduce the risk.

The primary injury control function of preventive medicine is the collection, analysis, and reporting of complete and accurate surveillance data. Solid and detailed injury epidemiology is essential for identifying hazards, determining their potential impact on the mission, influencing commanders and the deployed community, and evaluating control measures. But while surveillance and epidemiology may be the primary contribution to injury control, physicians and other health care providers must use their medical, epidemiologic, political, and managerial skills to define and effect the changes needed to reduce hazards within the context of the military mission. Commanders and others must be kept informed of the injury burden in their units and what steps can and should be taken to maintain readiness. Prevention and control are an ongoing process. Interventions must be continuously reviewed and evaluated, and surveillance is the key to determining effectiveness.

SUMMARY

Safety in working, playing, and living should not be the first casualty of a deployment. Given the limits on personnel and medical resources and the increase in potential hazards during a military operation, injury prevention becomes a mission-essential responsibility for everyone. Health care personnel, and especially those in preventive medicine, are key players in reducing the burden of unintentional trauma casualties.

Medical personnel need to be strong advocates for primary, secondary, and tertiary injury prevention during deployments. This is accomplished first through routine, detailed, and accurate surveillance to define the magnitude of the problem, persons at risk, and type and mechanisms of injury. This is followed by timely reporting of this essential information. Medical personnel need to communicate and work with the prevention partners identified above, at times forcing injury prevention onto commanders' and others' agendas, to define problems and seek out solutions based on the strategies discussed in this chapter. Next, appropriate solutions should be implemented and evaluated continually to determine the effectiveness of the intervention. The proposed solution may need to be adjusted or discarded and other solutions tried. The models and methods presented here are guidelines to developing successful injury prevention programs, because injury prevention is both a science and an art.

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