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INJURY CONTROL
PART I: UNDERSTANDING INJURIES IN THE MILITARY ENVIRONMENT

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The impact of injuries on the mission of the armed forces is dramatic. The purpose of this report is to define injuries and describe their significance in a military context; review several injury classification schemes; and provide an overview of the magnitude of the injury problem for the military. This report defines injury, reviews mechanisms of injury, and describes the major systems commonly used in injury research to classify injuries and their outcomes. The report also compares and contrasts injury coding in military and civilian hospitals. We review the types of hazards that are common causes of injury in the military, such as weapons, transportation, environmental exposures, and training and sports activities. We summarize the impact these types of hazards have on military readiness and the well-being of soldiers, both during times of war and in times of peace. Defining injuries and tools used to understand their etiology is a necessary first step in the design and implementation of effective interventions. A companion report, "Injury Control Part II: Strategies for Prevention," details specific intervention strategies for preventing and reducing the injury burden in military populations.

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EXECUTIVE SUMMARY

The impact of injuries on the mission and readiness of the U.S. armed forces is dramatic, resulting in death, disability, hospitalizations, lost duty time, and reduced military readiness. Injuries are the leading cause of death among all Americans under age 40 and are closely linked in the civilian world with a variety of risk-taking behaviors, as well as environmental factors. Members of the armed forces are predominantly young and are exposed to risks as an inherent part of their jobs. The risk of injury faced by the men and women of the U.S. military is an ever-present danger, not only in times of war, but also during peacetime. The purpose of this report is to define injuries and describe their relevance in a military context; review the major injury classification schemes; and provide an overview of the magnitude of the injury problem for the military.

The significance of the injury problem among the military cannot be trivialized. Data from the Total Army Injury and Health Outcomes Database (TAIHOD) demonstrate that acute injuries and musculoskeletal conditions account for 20% of the outpatient visits, approximately 26% of the hospitalizations, 60% of the permanent disabilities, and nearly 80% of the deaths among active-duty servicemembers each year. Injuries result in significant direct costs each year (i.e., the dollars spent on medical care and rehabilitation of the injured), but also result in tremendous indirect costs (e.g., lost productivity, decreased mission efficacy, human suffering).

This report presents a clear and precise working definition of injury, reviews various mechanisms of injury, and describes a number of classification systems commonly used in injury epidemiologic research. The report goes on to describe the manner in which the military codes injuries, and contrasts this method with the manner in which civilian hospitals code injuries under the International Classification of Disease, 9th Revision (ICD-9-CM). We also review a number of methods of categorizing injuries by their severity. We end by reviewing the types of hazards that are common in the military, such as weapons, transportation, environmental hazards, sports and athletic injuries, and summarize the impact these types of hazards have on injuries in the military, both in wartime and peace.

In order to mitigate the hazards that threaten the health and safety of our troops, to enhance and protect mission readiness, and to minimize the costs associated with injuries, it is useful to look at the injury problem from the perspective of the research epidemiologist. The exploration of the causes of injury is a necessary first step in the design and implementation of effective interventions.

A companion report, *Injury Control Part II: Strategies for Prevention*, details intervention approaches for preventing and reducing the injury burden in military populations.

INTRODUCTION

Injuries remain the most under-recognized health problem of the U.S. military. Whether we examine time lost from duty, hospitalization (27), permanent disability (7), or premature death (31), injuries and their sequelae top the list in every category. Individuals under age 40, whether in the armed forces or in the civilian sector, are at greatest risk for fatal and non-fatal injury. Injury disproportionately impacts young people because they tend to take greater risks and have higher exposure to health hazards. In addition, young people have more potential years of life to lose. An untimely death for a young person therefore results in greater loss of productive life. In fact, if diseases of the elderly are eliminated from consideration (e.g., heart disease, stroke, and cancer), injury is the leading cause of morbidity and mortality in the United States. The armed forces are comprised of young adults engaged in many hazardous occupations. The purpose of this report is to provide an overview of the impact of injuries in the U.S. military and to provide background information for categorizing and defining injuries in the military. A companion report provides a framework for developing prevention and control strategies for reducing injuries in the military (5).

Among the U.S. military, acute injury and musculoskeletal conditions account for over 20% of outpatient visits (830,000 visits) (2), approximately 26% of hospitalizations (6,200 hospitalizations) (2), almost 60% of permanent disabilities (36), and almost 80% of active-duty deaths (57). The impact of injuries is felt in many ways, including in lost productivity, decreased mission effectiveness, human suffering, and the huge economic expenses associated with the care and rehabilitation of the injured. Because of the number of surgical procedures and the relatively long hospital stays required for the management of acute and chronic injuries, hospital costs associated with the musculoskeletal system rank at the top of the scale (see Table 1). The U.S. government pays almost 1 billion dollars per month to individuals disabled as a result of service in the armed forces. Almost half of this amount is related to injury. Many of the costs associated with injury are difficult to estimate, especially those related to human suffering, lost opportunities, diminished capacity to lead a fully functional lifestyle, and the indirect costs imposed on family members who must adjust their life style or work in order to care for those who are injured or disabled.

Table 1. Worldwide Cost of Hospitalization, U.S. Army, 1995

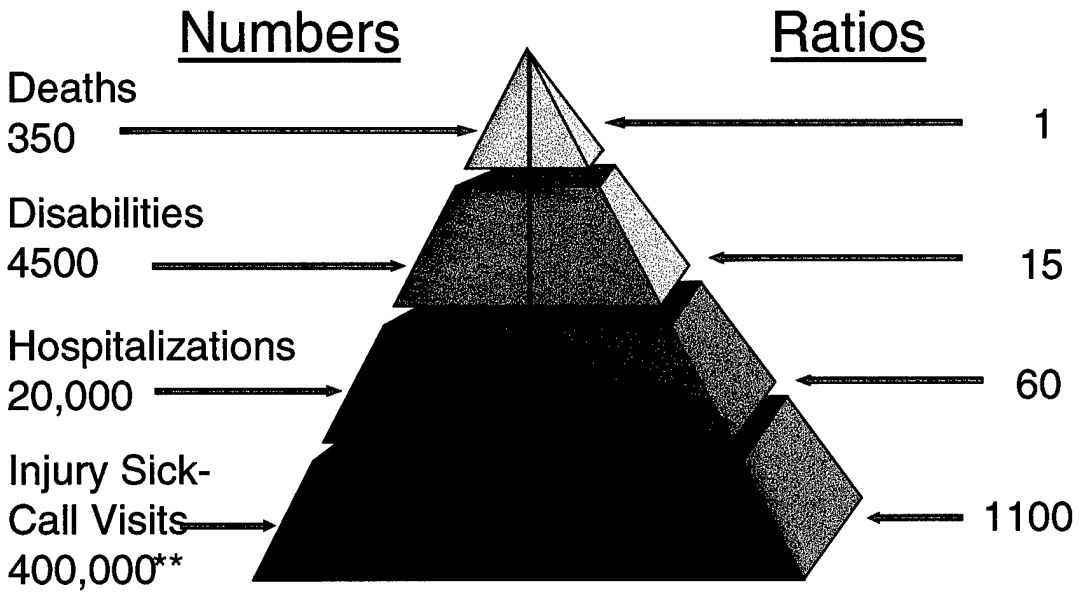
Principal Discharge Diagnosis by Major ICD-9-CM Group Code	1995 Total Cost (Millions)	Average Cost per Hospitalization
Diseases of the Musculoskeletal System and Connective Tissue (710-739)	$110.6	$9,211
Injury and Poisoning (800-999)	$68.6	$9,378
Diseases of the Digestive System (520-579)	$65.9	$7,171
Mental Disorders (290-319)	$45.9	$7,565
Diseases of the Respiratory System (460-519)	$40.2	$6,823
Complications of Pregnancy, Childbirth, and the Puerperium (630-676)	$35.7	$4,840
Diseases of the Genitourinary System (580-629)	$28.7	$7,493
Infectious and Parasitic Diseases (001-139)	$24.0	$7,527
Symptoms, Signs, and Ill-defined Conditions (780-799)	$22.1	$7,389
Diseases of the Circulatory System (390-459)	$21.8	$10,422
Supplementary Classification (V01-V82)	$20.0	$6,623
Neoplasms (140-239)	$19.6	$10,507
Diseases of the Nervous System and Sense Organs (320-389)	$17.3	$8,652
Diseases of the Skin and Subcutaneous Tissue (680-709)	$10.8	$6,784
Congenital Anomalies (740-759)	$5.0	$10,947
Endocrine, Nutritional, Metabolic Diseases, Immunity Disorders (240-279)	$4.2	$9,039
Diseases of the Blood and Blood Forming Organs (280-289)	$2.5	$11,301
Grand Total	**$542.9**	**$7,819**

* Calendar year 1995, estimated based on national HCFA DRG codes. Hospital data from the Total Army Injury and Health Outcomes Database (10, 11)

It is debatable which is the greater tragedy, the epidemic of injury throughout the armed forces, or the tacit acceptance of injuries as something random and unavoidable thereby providing the excuse for inaction. The Injury Pyramid displayed in Figure 1 (29) provides perspective on the relative importance of various measures of injury morbidity and mortality for the U.S. Army.

Perhaps one of the reasons injury prevention has not received adequate attention is the tendency to focus only on injuries resulting in death. While the need to reduce injury fatality is indeed pressing, focusing on only the tip of the iceberg diverts our attention from the hundreds of thousands of other servicemembers who suffer non-fatal, permanent, or partially disabling injuries each year.

Figure 1. The Injury Pyramid*



* Based on CY 1994 Army Population and Data
** Estimated from Research Results

Another reason that injuries may receive too little attention at the command level and too little priority as a health problem is the misleading association of injuries with the concept of accidents. The term "accident" suggests, to many people, an event that is random and unpredictable and, therefore, unpreventable. In fact, the events surrounding most injuries are scientifically understood and largely predictable. Although it is not possible to predict exactly which individual will be injured in a specific moment or specific situation, it is possible to identify high-risk groups of people and high-risk circumstances. Once these have been identified, it becomes possible to identify and rectify situations with a high likelihood of causing injury, tailor appropriate interventions, and ultimately reduce the incidence of injuries in that population.

The word "accident," moreover, is understood to have behavioral connotations that place emphasis on individual behaviors that may contribute to the incident. As a result, preventive interventions may focus on the difficult and often-unsuccessful task of trying to change behavior, and underplay or ignore the role of environmental or equipment-related interventions that could reduce the likelihood of injury regardless of individual actions or inactions. Injuries are not simply the result of random events but like other diseases, follow describable and predictable patterns (34). Most significantly, these patterns can be altered by various behavioral or environmental intervention strategies. For example, ankle injuries to parachutists have been reduced by the use of ankle braces (8) and by decreasing the porosity of parachutes (thereby reducing the speed and the impact forces upon landing) (13)—approaches that might have been ignored if the preventive intervention had focused only on improper landing technique.

For this reason many injury-control practitioners prefer a definition of injury that avoids the word "accident" entirely.

DEFINITION OF INJURY

Injuries will be defined in this report as the end result of a transfer of energy, usually sudden, above or below certain limits of human tissue, causing physical damage to tissue or death (48, 53). Table 2 lists some of the methods of energy transfer that may cause damage to human tissue, and gives examples of some specific injuries that may result, as well as the event that caused them.

Table 2. Various Methods of Energy Transfer and the Injuries that may Result from Them

Energy	Injury	Event
Mechanical	bullet wound	enemy fire
	skull fracture	Jeep rollover
	pneumothorax	land-mine explosion
	ankle fracture	basketball
Thermal	burn	air crash on flight deck
	hypothermia	man overboard
Chemical	asphyxiation	SCUD missile attack
	burns	mustard gas release
Electrical	tissue destruction	electric shock
Ionizing Radiation	cerebral edema	nuclear power plant breach
	gastroenteritis	

Mechanical energy, the energy of motion, is responsible for most common injuries (34). For example, moving objects and projectiles are common causes of injury, as are car crashes, falls, and physical assault. Thermal energy, chemical energy, electrical energy, and ionizing radiation, however, may also cause injuries. The definition given above states that injury may occur from transfers of energy above or below human tolerance. Thus, thermal energy can cause burns, and the absence of thermal energy can also cause injury—frostbite or hypothermia, for example. Chemical energy can lead to injuries such as poisonings (e.g., mustard gas). An absence of necessary biological substrates, or interference of normal energy processes like oxygen exchange, may also lead to injury (e.g., drowning and suffocation). Electrical energy can result in electrocution or electrical burns. Radiation can result in various forms of injury. For example, looking at the sun during a solar eclipse could cause retinal injury, and exposure to atomic weapons explosions can result in radiation burns or instant death.

Sometimes energy transfers result in conditions that are more commonly thought of as illnesses, rather than injuries. The etiologic agents for injury and illness may therefore be identical (30). Energy transfers that culminate in injury are generally rapid or acute. As with most rules, however, there are exceptions. For example, chronic exposure to low levels of mechanical energy may result in repetitive motion injuries, such as carpal tunnel syndrome, back pain, or other overuse injuries (58). In contrast, long exposure to low levels of radiation might result in leukemia, an illness. Thus, there is some ambiguity even in differentiating between illness and injury.

CLASSIFICATION OF INJURY

In addition to challenges in defining injuries, there may also be uncertainty in the categorization and description of specific types of injuries. There are a number of schemes for classifying injuries. Several approaches to injury classification are in widespread use, including the following:

1) body part affected (e.g., head or spinal cord injuries)
2) pathologic mechanism (e.g., fractures, burns, amputation)
3) etiologic mechanism (e.g., gun, motor vehicle)
4) intent (e.g., homicide, suicide, unintentional injury)
5) severity (e.g., Trauma Severity Score, Abbreviated Injury Scale, fatal)
6) event (e.g., car crash, earthquake)
7) location (e.g., workplace, ship, home, battlefield)
8) activity (e.g., working, fighting, sports, etc.)(25).

Individual researchers may use more than one scheme for classifying and evaluating injuries in a population.

Injury information, especially regarding inpatients, is typically collected and coded based upon nature and cause. Hospital records are universally coded using the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM)(59). The nature of injury codes (also known as N-codes) define the nature of the injury experienced (e.g., fracture) and the body part affected (e.g., femur). The range of codes from the ICD-9-CM N-codes that are commonly considered injury-related fall in the N800-N999 range (often excluding diagnoses in the N996-N999 range, since these primarily represent complications of medical treatment and surgery)(52).

External cause of injury codes, or E-codes, describe the cause of the injury and are also derived from the ICD-9-CM coding system. E-codes in the range of 800-999 (excluding E870-E879 and E930-E949) are generally used by civilian researchers to identify injuries. Historically, N-codes have been more reliable and readily available than E-codes, because accurate coding of the nature of the injury is closely tied to hospital reimbursement. Recent mandates by a large number of U.S. states have begun to improve that situation (26).

Researchers must exercise caution when interpreting published accounts of injury hospitalization rates. Data inaccuracies may arise, either through miscoding of the diagnosis by the hospital, or through limitations of the ICD-9-CM system. For example, many injury epidemiologists commonly include all ICD-9-CM N-coded cases between 800 and 999 with an injury E-code in their studies. However, ICD-9-CM N-codes for injury and poisoning (N800-999) include some conditions that might not be useful to injury researchers and may miss some potentially important injury outcomes entirely. If only this broad ICD-9-CM grouping is considered, many injuries, both acute and chronic, will be misclassified. For example, the ICD-9-CM series N800-999 includes iatrogenic "injuries," so that a patient is considered injured when admitted for pneumonia and develops a sensorineural hearing loss as a complication of therapy with gentamycin. On the other hand, if an orthopedic surgeon treats an individual as an outpatient for an anterior cruciate ligament tear and only subsequently admits that

patient for surgery, the diagnosis would be correctly coded as 717.83. This hospitalization is then grouped with musculoskeletal conditions and not injuries, and receives no E-code. Other examples of hospitalizations that are potentially injury related, but are coded outside the N800-999 series, include carpal tunnel syndrome (354.0), observation for sexual assault (V71.5), child abuse (V61.21), sunburn (692.71), some suicide attempts (300.9), stress fractures (733.14), hernia (550.9), or cellulitis secondary to blister formation (682.7).

E-codes are important in civilian hospitals for accurate surveillance of causes of injuries and identification of risk factors. However, in the past these codes have not been consistently included in hospital records. Recently there has been a concerted effort to coordinate the coding and recording of external causes of injuries. The Centers for Disease Control and Prevention (CDC) published a document in 1997 providing guidelines for the coding and presentation of injury mortality data. This framework recommends that all injury researchers adopt a two-dimensional system in which injuries are studied and described first by intent and then by mechanism (20). Uniform adoption of this system by all those who fall within the WHO jurisdiction is expected to improve injury surveillance, to allow monitoring of intervention successes and to make international comparisons possible. The military coding system, which differs from the ICD-9-CM E-code system, has been using such a two-dimensional system for several decades (6).

CODING OF MILITARY RECORDS

Military hospitals in most nations that have signed NATO Standardization Agreement (STANAG) 2050 do not use the ICD-9-CM E-codes. Instead, they use a set of codes developed to provide additional precision for military causes of injury. As an example, a 17-year summary (the period covered by the Total Army Injury and Health Outcomes Database, the TAIHOD) of these codes is provided in Table 3 for all worldwide Army hospitalizations, 1980–1996.

Table 3. Description of STANAG Codes and Frequency for U.S. Army — 17-Year Summary

Cause of Hospitalized Injury, U.S. Army — 17 year summary (1980-1996)*

STANAG Code Group	Frequency (% of total)		Total	
	Men	Women	Overall frequency	Over all %
Falls (900-999)	66,988 (30.3)	6,519 (30.0)	73,507	30.2
Land transport accidents (100-149)	42,724 (19.3)	3,441 (15.8)	46,165	19.0
Athletics (200-249)	35,657 (16.1)	2,073 (9.5)	37,730	15.5
Machinery and tools (600-699)	25,676 (11.6)	1,774 (8.2)	27,450	11.3
Poisons, fire, hot/corrosive substances (700-790)	17,009 (7.7)	3,973 (18.3)	20,982	8.6
Medical complications (250-299)	10,091 (4.6)	2,343 (10.8)	12,434	5.1
Air transport accidents (000-059)	8,373 (3.8)	342 (1.6)	8,715	3.6
Environmental injuries (800-899)	6,895 (3.1)	1,068 (4.9)	7,963	3.3
Guns, explosives (500-599)	6,537 (3.0)	174 (0.8)	6,711	2.8
Enemy instruments of war (300-479)	1,068 (0.5)	26 (0.1)	1,094	0.5
Water transport accidents (150-199)	197 (0.1)	12 (0.1)	209	0.1
Own instruments of war (480-499)	87 (0.0)	3 (0.0)	90	0.0
Grand Total	**221,302 (100)**	**21,748 (100)**	**243,050**	**100**

*Major groupings based on the NATO Standardization Agreement (STANAG) 2050 coding system. Source: Total Army Injury and Health Outcomes Database (TAIHOD)(11).

U.S. military medical surveillance databases do not use E-codes, but they do include ICD-9-CM N-codes (for type of injury and body part affected) (6, 9). Severity of injury may be determined by correlating ICD-9-CM N-codes with an Abbreviated Injury Scale (AIS) score. Other indicators of severity can be assessed using length of hospital stay, days lost from duty, or diagnostic related groups (DRGs). DRG codes are a means of classifying patients into similar groups based on their utilization of healthcare resources and length of stay. These codes capture information on a patient's diagnosis, procedures, complications, preexisting conditions, and discharge status, and are used by many institutions to evaluate quality of care and to plan for utilization of services.

INTENTIONAL VS. UNINTENTIONAL INJURIES

Determination of intent, though an integral component of both civilian and military injury cause-coding schemes, is rarely a simple matter and is handled differently in the civilian and military record-coding systems. From a research and surveillance perspective, it is not the mechanism of injury that sets intentional injury apart from unintentional injury. Rather, it is the circumstances under which these injuries occur that are different. Thus, it is necessary to distinguish between unintentional and intentional injury whenever possible, in order to develop better preventive approaches.

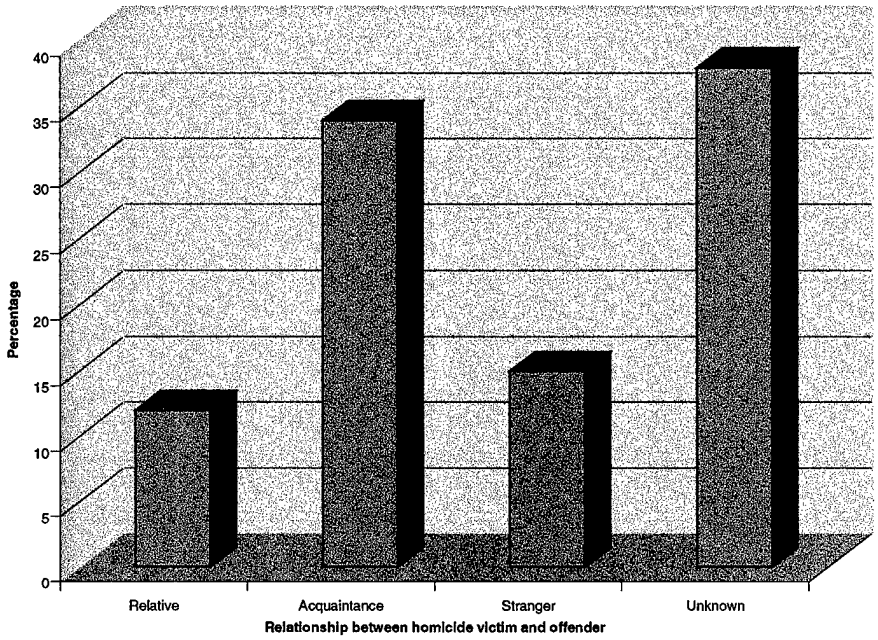
In civilian hospitals, this can be done using E-codes. For example, E965.0 is attempted homicide by handgun. Cause-of-injury coding for intentional injuries is, however, widely recognized to be inadequate, because many key pieces of information are absent from the ICD-9-CM E-coding system. Moreover, much of this information (such as motive, drug and alcohol involvement, weapon involved, relationship of victim to perpetrator, source of data, and demographics of victim and perpetrator) is not collected routinely (51). Because hospital care focuses on recovery of the patient and not primary prevention, significant changes in data collection and reporting will be needed before this problem is completely rectified.

In criminal databases and in studies of intentional injury, attempts are often made to further divide intentional injuries into categories based upon the nature of the assault and on the relationship between the victim of violence and the perpetrator. There is often a distinction made between aggravated assault, simple assault, robbery, and rape. An assault is considered aggravated if the following conditions are met: if the assailant uses a weapon, if the victim is injured seriously enough to require hospitalization for 2 or more days (whether or not a weapon is used), or if the injury is one that should receive medical treatment (e.g., broken teeth or bones, loss of consciousness). If the attacker does not use a weapon and the victim is not injured or receives only a minor injury (i.e., one requiring fewer than 2 days of hospitalization), it is labeled simple assault. Rape is "completed or attempted carnal knowledge resulting from the use of force or the threat of force (54)."

Acts of interpersonal violence are also frequently classified on the basis of the relationship between the victim and the perpetrator. While apparent random acts of violence so often portrayed in the media are frightening, most violence is perpetrated between individuals who know each other, either acquaintances or family members (Figure 2).

These data from the FBI website show that in the civilian sector nearly half the homicides in 1991 were the result of actions between friends, acquaintances, or family members. Only 15% of homicides were between strangers, though in more than a third of homicide cases, the relationships between the assailant and the victim could not be determined. Limitations of Department of Defense databases prevent the presentation of comparable historical data on homicides within the military population.

Figure 2. Relationship between Victim and Offender, U.S. Homicides, 1991



Suicide is another important and distinct form of intentional injury. Suicide rates are highest among the elderly, but suicide is also an important cause of mortality among teens and young adults. Moreover, suicide rates appear to be escalating among adolescents, particularly young men (49, 54). While rates of suicide are generally lower among active duty military than among their civilian counterparts, significant variation in suicide rates exists across the services by gender and occupation, and certain subgroups appear to be at especially high risk, such as military security and law enforcement personnel (32). Suicide prevention has been primarily the responsibility of the mental health community. However, injury control measures can be applied equally well to intentional injury and unintentional injury.

The STANAG injury coding system (6), unlike the ICD-9-CM, uses two components, or axes, to code intent and mechanism of injury. It begins with a Trauma code—a single digit code with 10 possible values distinguishing among general classes of injury (see Table 4). The information provided by the Trauma code conveys components of both intent and work activity. The Trauma code distinguishes between battle-related, non-battle related intentional, and non-battle related unintentional injuries. It also provides information about whether the injury occurred while the person was on or off duty and whether the on-duty activity was specific to certain training activities or exercises. Unfortunately, the 10 possible codes are not mutually exclusive, but are listed in order of priority such that war-related injuries are of highest priority, followed by intentional injuries and then unintentional injuries. An assault occurring on duty (e.g., a military police officer assaulted by a prisoner) can therefore only be coded as "3, assault" and not "8, on-duty," because information regarding intent takes precedence over duty status. Similarly, an injury that occurs to an individual attempting to evade

police arrest while on vacation would be coded as a "2, legal intervention," and not a "5, off-duty." (See Table 4.)

Table 4. STANAG Trauma Codes

General Trauma Class	Code	Definition
Battle wound or injury	0	Direct result of action by or against an organized enemy
	1	Other battle casualties
Intentionally inflicted non-battle injuries	2	Result of intervention of legal authority
	3	Assault, or intentionally inflicted by another person
	4	Intentionally self-inflicted
Accidental injury	5	Occurring while off-duty (includes leave, pass, AWOL, and other off-duty)
	6	Schemes and exercises
	7	All other scheduled training (including basic training), assault courses, etc.
	8	Occurring while on duty
	9	Unknown whether on or off duty

DETERMINING INJURY SEVERITY

Severity scales are often used to describe injuries and to evaluate their probable long-term sequelae and economic impact. There are a number of classification schemes in use in the United States, many of which are disease specific or patient specific. Table 5 lists some of the more common systems in use to describe general trauma.

The most commonly used anatomically based injury severity scale is the Abbreviated Injury Scale, or AIS, developed by the Association for the Advancement of Automotive Medicine (12). The AIS system rates each injury based upon the body region and consensually derived assessment of damage to that region, ranging from 1 (minor) to 6 (not treatable with current medical technology). A related scale, the Maximum AIS (MAIS) is sometimes used instead of AIS. This scale uses the single highest AIS scored injury for each individual. Another derivative of the AIS is the Injury Severity Score (ISS). This score is derived by squaring the highest AIS scores for three different body regions and then summing those squares (14). The ISS is a better predictor of overall morbidity or survivability and length of hospital stay for individuals experiencing multiple traumas (19, 45). A simplification of the ISS, the new Injury Severity Score, is an even better predictor of survival in trauma centers (50). While AIS does not provide an assessment of disability or impairment, it has proven useful in estimating injury costs (42-44, 47). There is a computer program available that links ICD-9-CM codes to an AIS score and makes the AIS system relatively easy to use, while avoiding the tedious task of reviewing each individual medical record (46).

Table 5. Severity Scales Used to Classify General Trauma

System	Common Uses
Abbreviated Injury Scale (AIS)	Anatomically based classification system that describes individual injuries and rates them based on severity. Impractical for comparing patients with multiple injuries in different regions of the body (17).
Acute Physiology and Chronic Health Evaluation (APACHE III)	Anatomically based classification system for measuring severity of illness in critically ill patients (not necessarily injured). Comprises an APACHE III score (provides initial risk stratification for severely ill patient within patient group) and an APACHE III predictive equation (provides risk estimate of hospital mortality for individual ICU patients). Scores range from 0 to 299, with ratings in 78 major medical and surgical categories. (38)
Circulation-Respiration-Motor-Speech (CRAMS) Scale	Used to prioritize which patients require services of Level I trauma center and which ones can be treated at local facilities. Simple, 10-point scale; scores less than or equal to 8 signify major trauma, requiring transport to Level I trauma facility. (23, 28)
Glasgow Coma Scale (GCS)	Assesses three measures of neurological function in victims of head trauma: eye opening, motor response, and verbal response. Scores range from 3 to 15, depending upon extent of trauma. (15)
Injury Severity Score (ISS)	Combines ratings of several injuries into a single score of severity; composite score based on the most severe AIS scores for the three most severely injured regions of the body (48).
IPCAR Score	Assesses trauma victims on the basis of five criteria: injury and pain, pulse, consciousness, appearance and bleeding, respiration and airway. Each indicator is measured on a four-point scale; total scores range from 15 for a healthy person to a low of 0 (18).
Revised Trauma Score (RTS)	Combines Glasgow Coma Scale with measures of cardiovascular and respiratory sufficiency (21).
Trauma and Injury Severity Score (TRISS)	Predicts mortality based on severity of injury, patient's age, and Revised Trauma Score (see above)(48).

INJURIES IN A MILITARY ENVIRONMENT

The military is a unique occupational environment, particularly during times of war. While the discipline of injury control, which has its roots in public health, has not been explicitly applied to the control of war-related injury, the methods used to control non-war injuries may be applied with equal effectiveness in reducing war injuries. Conflict situations yield injuries that are uncommon among any other occupational cohort and that require triage and treatment under difficult conditions. Sometimes injuries in these environments result not from enemy fire but from friendly fire, or activities related to support of the war effort but not directly related to combat. For example, a motor vehicle crash is a common cause of injury morbidity in war environments (36). Even peacetime environments may be hazardous to those on active duty in the military; maintaining an effective fighting force requires individuals to be in peak physical condition and to train continually. Soldiers, sailors, airmen, and marines must maintain a high state of preparedness, and this continuous training often necessitates the use of potentially hazardous equipment or materials. This section describes some of the common types and causes of injuries among the military during war and peacetime and highlights some of the unique aspects of military life that contribute to the injury hazard.

RECENT CONFLICTS AND WARS

It has been estimated that since 1700 AD, at least 101 million people have died because of wars. Of these, more than 90 million have been killed in the 20th century (41). Future wars will potentially subject even greater numbers of people to even more ominous weapons. While the prevention of intentional injuries remains the major focus of command during conflict situations, unintentional injuries, at least in recent history, have been far more numerous. During Operation Desert Shield/Desert Storm the majority of injuries with known causes were unintentional (60). Most non-battle fatalities were caused by transportation (motor vehicle followed by aircraft). Hospital admissions were also most commonly related to motor-vehicle crashes or falls, followed by athletic activities (36). Thus, it is now important for commanders to expand their focus to include unintentional injury prevention of motor vehicle crashes and sports injuries, if they are to achieve effective military readiness and capabilities.

SPECIAL ENVIRONMENTAL CIRCUMSTANCES AND WAR INJURIES

Weapons

Firearms, mines, grenades, missiles, biologic and chemical agents, and related equipment are used during conflicts in order to support the war effort. All of these hazards create the potential for intentional or unintentional injury. This report is not intended to serve as a tactical guide for strategies on how to avoid enemy fire, but is

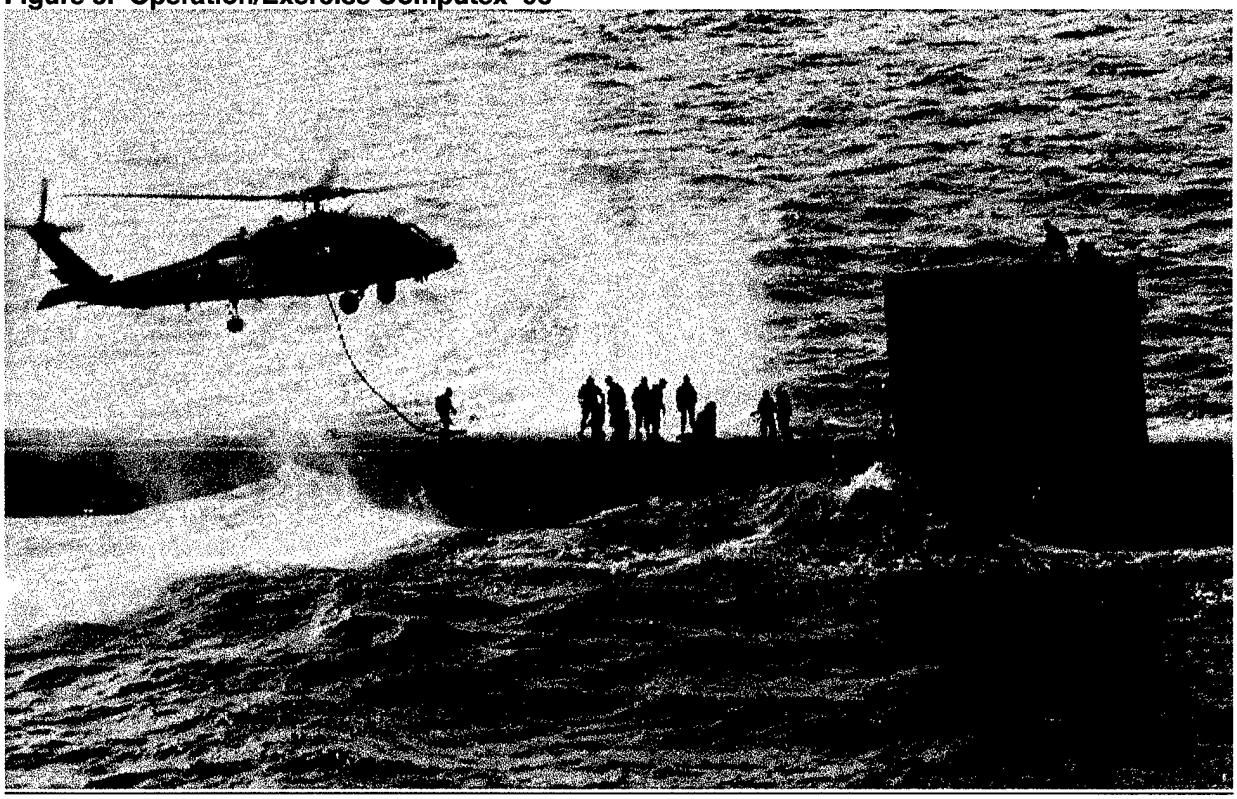
intended to serve as an overview of the types of injuries that might occur, and the factors that might influence survivability and long-term sequelae.

Weapons may cause injury when discharged unintentionally while being transported, or when a friendly soldier is mistaken for the enemy. Intentional, non-battle injury may also occur through self-inflicted wounds (about 4% of non-battle deaths during Operation Desert Shield/Desert Storm) (36). Prevention of weapons-related injuries may also lead to unintentional injury. For example, pharmacologic treatments taken for prophylaxis or as antidotes to chemical weapons attack may cause undesirable side effects or adverse reactions among servicemembers. Full chemical protective gear can limit mobility, obscure vision, or otherwise interfere with safe performance. Pesticides and insecticides, meant to provide protection, might also cause injury or illness. Transportation and use of hazardous substances, such as chemical and biologic weapons, might result in unintentional exposure among friendly forces. Grenades, missiles, and mines are also potential sources of unintentional injury among friendly forces. Long after conflicts have ended, landmines continue to pose a serious injury problem in a number of countries (3, 4).

Transportation

Transportation of troops is an essential element of any war or peacekeeping mission. During World War II, U.S. military personnel experienced more than 20,000 non-battle aviation deaths (1), presumably due to troop movement, supply transportation, and pilot training. Unfortunately, motor-vehicle crashes related to the movement of troops remain one of the leading causes of mortality in recent deployments. Hazardous travel conditions, unfamiliar terrain, sleep deprivation, stress, and illness may all contribute to the injury morbidity and mortality associated with use of motor vehicles, aircraft, and ships. Sometimes an assault or maneuver requires parachuting or landing small boats on enemy shores. The potential for enemy fire is ever present, but during recent low-intensity conflicts, the greatest risk of injury has been posed by the maneuver itself. Oftentimes troops must parachute onto unforgiving surfaces, such as a concrete airfield. The resulting impact injuries are debilitating not only for the individual servicemember who is injured, but also for the one or two other members of the unit who may end up dividing their energy between the planned mission and the rescue of their injured companions.

Figure 3. Operation/Exercise Computex '98



Navy SEALs conduct a fast-rope exercise from the cargo door of an SH-60H Seahawk assigned to Helicopter Anti-Submarine Squadron Seven (HS-7) "Dusty Dogs" onto the hull of the fast-attack submarine USS Hampton (SSN 767). This photograph provides an example of the many hazardous activities military personnel are exposed to in the conduct of their duties. (U.S. Navy photo by Photographer's Mate 2nd Class Michael W. Pendergrass).

Environmental Hazards

Environmental conditions and related factors also present hazards. Unfamiliar and dangerous flora and fauna may lead to injuries. Poisonous plants, animal bites, and insect bites and stings may cause acute injury and may serve as vectors for transmission of diseases. Exposure to cold or heat may also lead directly to injuries such as frostbite, heat stroke, or heat illness. They may also contribute indirectly to injuries by compromising a soldier's vigilance, or ability to respond to risks or make decisions. In the Persian Gulf War, oil-well fires caused poor visibility in some areas, and may have contributed to poorer health and increased susceptibility to injury (37).

Stress

The stress soldiers experience in war environments may also contribute to their injury risk. War environments require an extraordinary amount of adaptation on the part of the individuals involved. Often a soldier leaves a spouse and children behind, crosses through several time zones, enters new climatic conditions, and faces the ever-present risk of being killed or seriously injured. While the human body adapts well, coping mechanisms are better suited for short-term stress than the chronic stress of a

drawn-out conflict or even a long peacekeeping mission. During stressful situations a number of physical and mental responses occur including "arousal, alertness, vigilance, cognition, ... focused attention, ...aggression, ...(and) inhibition of pathways that subserve vegetative functions, such as feeding, (growth), and reproduction" and changes in the body's immune and inflammatory responses (22). Heart rate and respiration increases, blood pressure increases, and the body begins to produce glucose more rapidly to prepare itself for rapid response to the stressor. These mental and physiological responses to stressors associated with deployment and war conditions may influence a servicemember's ability to respond to a hazard or injury situation. Chronic stress may result in melancholic depression, poor appetite and weight loss, hypogonadism, peptic ulcers, immunosuppression, memory loss, inability to concentrate and think clearly, anxiety, "severe chronic disease, panic disorder, obsessive-compulsive disorder, chronic active alcoholism, alcohol and narcotic withdrawal, chronic excessive exercise, hyperthyroidism (or) hypothyroidism, premenstrual tension syndrome, vulnerability to addiction, Cushing's syndrome, seasonal depression (and other) atypical depression, anorexia nervosa (or) obesity, PTSD, nicotine withdrawal...(and)... vulnerability to inflammatory disease "(22). Studies of civilians experiencing war stress indicate that stress also often culminates in relationship or personality problems, including hostility and alcohol and drug misuse (56). All of these mental and physiological changes might increase susceptibility to experiencing an injury or reduced ability to recover from an injury.

Sports and Athletic Injuries

Recreation may provide a means to help relieve wartime tensions and boredom. There is, however, a tradeoff between recreation that is necessary for health and well being and prevention of injuries. During the Vietnam conflict (and virtually every other conflict) injuries related to recreation resulted in evacuation of many soldiers from the theater. We don't always retain the lessons we learn from history, however, as evidenced by the relatively high number of soldiers evacuated from the Persian Gulf for injuries incurred playing "combat football." Even for military personnel treated without evacuation, sports injuries can significantly impair a soldier's readiness for battle.

PEACETIME INJURIES AND UNIT READINESS

In recent history, peacetime injuries have been more of a threat to unit readiness than wartime injuries. Table 6 shows the number of hospitalizations for active-duty Army personnel worldwide between the years 1980 and 1996.

During this 17-year period, military conflicts were relatively uncommon: only 0.6% of injury hospitalizations were related to hostile actions. Table 6 illustrates the relative importance of the musculoskeletal condition and injury hospitalization categories, the first- and third-largest hospitalization categories, respectively. In recent years, "injury" hospitalizations have declined while hospitalizations for "musculoskeletal conditions"

have climbed. Recent evidence suggests that 75% of musculoskeletal conditions are the direct result of an injury (9).

Table 6. Worldwide Active-Duty Army Hospitalizations 1980-1996

Major Grouping	ICD-9-CM Code	Men	Women	Total
Injury	800-999	221,454	21,770	243,224
Respiratory	460-519	173,316	30,833	204,149
Musculoskeletal	710-739	174,717	25,972	200,689
Digestive System	520-579	157,350	28,708	186,058
Pregnancy Related	630-676	-	145,527	145,527
Mental Disorders	290-319	119,677	21,159	140,836
Infectious Disease	001-139	88,481	19,481	107,672
Genitourinary	580-629	45,890	45,610	91,500
Supplemental	V01-V82	63,509	25,145	88,654
Signs and Symptoms	780-799	46,902	11,444	58,346
Circulatory	390-459	44,293	3,642	47,935
Nervous system	320-389	38,818	7,869	46,687
Skin	680-709	39,173	5,627	44,800
Neoplasm	140-239	20,547	9,085	29,632
Endocrine	240-279	11,027	3,407	14,434
Congenital	740-759	7,226	1,463	8,689
Blood forming	280-289	3,799	1,120	4,919

Source: Total Army Injury and Health Outcomes Database (TAIHOD)(10, 11).

Training, Exercises, and Maneuvers

Training, while important to maintaining unit effectiveness and individual physical fitness, is also a cause of many injuries and short-, as well as long-term, disability. Each branch of the armed forces has a rigorous physical training program. While the specific types of exercises and procedures for assessing physical fitness vary from service to service, all require individuals to maintain a certain level of fitness. This is usually achieved through a variety of calisthenics (sit-ups, push-ups, etc.) and marching or running. In all branches of the armed forces, these sorts of weight-bearing activities are a major cause of temporary disability, especially through injury to the lower extremity (24, 35, 40, 55). In the U.S. Army, 50% or more of the female trainees and almost one-third of male trainees experience at least one injury requiring a medical

clinic visit during their 8-week basic-training period (16). Soldiers who are injured, whether through training or work in an operational unit, hinder mission accomplishment and create a substantial drain on resources through additional medical care utilization and lost time from work.

Figure 4. Operation/Exercise Kernel Blitz '99

During Kernel Blitz '99, a bi-annual amphibious training exercise designed to test and develop U.S. Navy and Marine Corps forces to operate in littoral areas and project combat power ashore, CH-46 helicopters fast-roped and retrieved Marine Corps Reconnaissance members during the exercise. This photograph illustrates one of the many hazardous activities military personnel are exposed to in the conduct of their duties. (U.S. Navy photo by PH3 Eric S. Logsdon).

Environmental Hazards

Other environmental hazards are as varied as the jobs that exist in each branch of the service. Aviators face risks ranging from air transport crash to hypoxia and altitude illness. Sailors face a host of risks ranging from falls down ladders or overboard to injury from handling heavy equipment (39). Even clerical workers may be at risk of occupational injury (e.g., carpal tunnel syndrome, back strain) (33). Workers may also be exposed to poisonous substances in the course of performing their duties. Many occupations require motor vehicle use, a major source of injury.

Other Hazardous Exposures and Peacetime

As in wartime environments, unintentional injury related to motor vehicle use and to athletic activities are among the most common reasons for hospitalization in peacetime. Thirty-five percent of the twelve most common injuries among hospitalized Air Force personnel during 1992 were either due to athletic and sports activities or motor vehicle crashes (36).

Intentional injuries are also a risk among active duty military. Suicides, homicides, and assaults are important injury issues to consider. For example, fighting was the tenth most common cause for hospitalization among Air Force and Army personnel in 1992 (36).

CONCLUSIONS

Injuries have an enormous impact on the military, but are a preventable public health problem. In order to mitigate the hazards that threaten the health and safety of our troops, to enhance and protect mission readiness, and to minimize the costs associated with injuries, it is useful to look at the injury problem from the perspective of the research epidemiologist. Only then will we be able to diagnose the causes of injury and design and implement effective interventions.

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