Medical Surveillance of Injuries in the U.S. Military

Descriptive Epidemiology and Recommendations for Improvement

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Introduction: Injury surveillance is the first and most critical step of the injury prevention process. Without it, successful injury prevention could not be sustained. The purpose of this paper is to describe advances in military medical surveillance, compare the incidence of injuries with other illnesses, define the size and causes of the injury problem for the military, and make recommendations for improved surveillance and injury prevention.

Methods: Medical and personnel data for nondeployed active duty personnel were obtained from the Armed Forces Health Surveillance Center for 2000–2006. Rates of nonfatal injuries and injury-related musculoskeletal conditions, frequencies of injury types, and causes of injury hospitalizations are described.

Results: Injuries were the leading cause of medical encounters among military personnel. The rate of hospitalization for injuries was approximately 1000 per 100,000 person-years and, for injuries treated in outpatient clinics, 999 per 1000 person-years. The leading injury type resulting in hospitalization was fractures (40%) and the leading injury type resulting in outpatient visits was sprains and strains (49%). Leading causes of hospitalization were falls/near falls (17.5%), motor vehicle mishaps (15.4%), and sports (13.1%).

Conclusions: Injuries are the biggest health problem of the military services. Military medical surveillance data are useful for determining the magnitude and causes of the injury problem, identifying possible prevention targets, and monitoring of trends among military personnel.
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Introduction

Surveillance is the first and most important step of the public health process.[1–4] As stated by William Foege in his foreword for the second edition of *Principles of Public Health Surveillance*,

> . . . epidemiology and analysis cannot be superior to the surveillance system used for collecting the facts analyzed. The analysis of those facts, the interpretation of their health implications, the interventions designed, and the programs launched are all based on the quality of the surveillance system used. Surveillance systems are therefore basic to everything that follows in public health.[5]

Injury surveillance is critical to sustained injury prevention for a number of reasons[1,6,7] including:

- Identification of the biggest, most severe injury problems
- Detection of emerging injury problems
- Setting objective, evidence-based priorities
- Evaluation of newly implemented policies and programs
- Monitoring continuing success of policies and programs

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Table 1. Population for active duty DoD and services by year, 2000–2006[a]

Year	DoD	Army	Navy	Air Force	Marines
2000	1,352,932	467,222	364,086	350,803	170,821
2001	1,334,640	464,229	358,233	341,362	170,817
2002	1,305,995	455,415	349,181	334,757	166,641
2003	1,164,209	347,316	339,719	332,336	144,838
2004	1,197,679	353,693	347,399	349,349	147,237
2005	1,135,551	327,222	333,846	327,969	146,514
2006	1,145,289	358,524	318,805	318,312	149,647

[a]Source: Defense Medical Surveillance System, 2007, with adjustment for deployments
DoD, Department of Defense

Where injury prevention is concerned, it is important to keep in mind that if you cannot measure the health outcome, you cannot prevent it with any certainty.[7,8]

In the past, public health surveillance of injuries has focused primarily on fatalities,[9] but that is not adequate as the vast majority of injuries are nonfatal. In Western European countries and the U.S., for every one death there are approximately 30 hospitalizations and 300 emergency department visits.[9] The military is no exception to this observation. Data from the U.S. military show that for each unintentional injury death, there are 33 injury hospitalizations and almost 4000 outpatient visits (includes emergency department visits plus other outpatient clinic visits).[10] For this reason, it is strongly recommended that injury surveillance systems capture both morbidity and mortality. At a minimum, injury deaths and hospitalizations should be monitored.[11–14]

The Department of Defense (DoD) Injury Surveillance and Prevention Working Group[15] and the Armed Forces Epidemiological Board (AFEB) Working Group[2] strongly recommended medical surveillance of nonfatal injuries. Only hospitalization data were readily available for use in surveillance at the time of those recommendations in the late 1990s. Now the military services maintain rapidly accessible hospitalization and outpatient data.

The purpose of this paper is to illustrate the potential value of military medical surveillance data for injury epidemiology and prevention. The paper will: (1) compare the occurrence of injuries to other health problems among U.S. military personnel; (2) show the magnitude and causes of the problem of injuries for U.S. military services using routinely available medical data; (3) discuss capabilities and limitations of military medical surveillance for injuries; and (4) make recommendations to improve military medical surveillance systems and the injury prevention process.

Methods

The population for the analyses in this paper encompassed all nondeployed active duty military personnel for the Army, Air Force, Navy, and Marines from January 1, 2000, to December 31, 2006. Most of this paper will focus on data for the most recent year of complete data, 2006. On average, the active duty population was 85% men and 15% women. In addition, 83% of the men and 77% of the women were aged ≤35 years. Table 1 shows the populations for each of the four military services in person-years, corrected for time spent deployed to Operations Iraqi Freedom (OIF) and Enduring Freedom (OEF). This was done because the medical surveillance data presented do not include injuries or other health conditions treated in deployed settings.

The definition of injury adapted for this report was derived from one employed by the DoD Military Injury Metrics Working Group[16] that states: injuries are traumatic wounds or other conditions of the body caused by external force or exposure (i.e., transfer of kinetic energy, heat, or cold), and microtraumatic physiologic harm resulting in loss of capacity due to a continued or repeated neuromuscular stress or strain. The definition includes both generally accepted ICD-9-CM codes from the 800–999 code series for acute injuries but also selected diagnoses from the musculoskeletal disorders in the 716–739 code series (e.g., stress fractures, tendonitis, bursitis) that are commonly accepted as injuries in the sports medicine literature[17–21] and the Armed Forces Health Surveillance Center (AFHSC) Installation Injury Reports.[22] Only those visits for which injury was the primary diagnosis were included. In order to capture incident cases, diagnoses for the same condition for the same person were excluded if the same injury diagnosis occurred in the record more than once in a 60-day period of time.

To determine importance of injuries as a public health problem compared to other health conditions, a request was made to the AFHSC for hospital and ambulatory/outpatient care data on all active duty military personnel from the Defense Medical Surveillance System (DMSS), broken down by the seventeen standard Principal Diagnosis Groups (PDGs) from the ICD-9-CM code book. The data for this part of the request were for the calendar year 2006 (January 1, 2006, to December 31, 2006) for each of the Services and for the DoD, including (1) all medical encounters for each PDG, (2) the number of individuals with one or more of a particular diagnosis for each of the seventeen PDGs (i.e., visits for duplicate diagnoses excluded),

and (3) the number of bed days in the hospital for a specific diagnosis in each of the seventeen PDGs.

To document the general rates and trends of injury since 2000, overall injury encounter frequencies, Service populations, and rates were requested from the AFHSC for overall injuries (acute and chronic or overuse) and for lower-extremity overuse injuries. Lower-extremity overuse injuries were examined because weight-bearing physical training, such as running and marching, is unavoidable in the military, and these activities are a major cause of injuries primarily to the lower extremities.

In order to determine the types of injuries for which military personnel received medical care in the most recent complete year, 2006, a data request was made for both hospital and outpatient data broken out by diagnosis and location in the form of the Barell Matrix.[23,24] It should be noted that medical data for these and other injury outcomes are from land-based medical treatment systems and third-party civilian medical care providers receiving reimbursement from the services for care of active duty personnel. These categories of hospitalization and outpatient data are virtually 100% complete.

To quantify injury-related musculoskeletal conditions, data on conditions in the ICD-9-CM code series 716 to 739 were requested in the form of a matrix modeled after the Barell Matrix[24] for hospitalized and ambulatory (outpatient) conditions treated in 2006. The 60-day exclusion rule (described above) was applied to reduce duplicate entries due to follow-up. The method for creating the injury-related musculoskeletal injury category is more fully described in a later paper in this supplement to the *American Journal of Preventive Medicine*.

A request was also made to the AFHSC for DMSS hospitalization data by cause of injury for the most recent complete year (2006). This was done to determine what circumstances and events are associated with different types of acute injuries (ICD-9-CM codes 800–999). North Atlantic Treaty Organization (NATO) Standardization Agreement (STANAG) 2050 cause codes[25] were employed for coding of hospitalization information on military personnel rather than ICD-9-CM E-codes as STANAG CODES are the only routinely captured injury cause code data available for the Services. Injury causes of hospitalization also received codes for intent (intentional versus unintentional) as well as three digits that provided specific cause information. General cause code categories included air transport, land transport, athletics, falls, machinery/tools, environmental factors, and instrumentalities of war. Military outpatient data were not cause coded at the time of this report.

Rates of injury were calculated using person-years in the denominator, based on personnel data for each Service. Rates of hospitalization were calculated per 100,000 person-years, while rates of outpatient visits were calculated per 1000 person-years. Denominators were corrected for the number of person-years deployed to OIF or OEF during the year in question (Table 1). Statistical tests comparing rates of injury are not performed because: (1) differences in clinical treatment locations and therefore record aggregation among the Services preclude valid statistical comparisons (e.g., shipboard medical records are maintained separately from treatment in land-based Navy clinics); (2) numbers of cases and denominators for this "census" data are so large that very small differences in rates will be significant. Frequencies and rates of injury for women, age and racial groups are not reported because many subgroups would be too small to have reliable case numbers or rates.

Results

Relative Magnitude of the Injury Problem

Figure 1 shows the relative importance of injuries versus other health conditions. In this figure, both acute and traumatic injuries and injury-related musculoskeletal conditions are combined to form the "injury" category. The graph clearly indicates that injuries were the leading cause of medical encounters, with over 1.95 million in 2006. This is more than 2.5 times the next leading category, mental disorders, at just over 755,000 encounters. Almost a million individual service members were affected by injuries. This is more than 2.5 times the number of personnel affected by the next leading PDG, Sense Organ Disorders. The number of hospital bed days for injuries, 68,000 days in 2006, was surpassed only by mental disorders, at almost 98,000 for the year. It should be noted in regard to bed days that most injuries, even those as serious as fractures, were treated on an outpatient basis.

Injury Rates and Trends for the DoD and the Services

Figure 2 shows overall rates and trends for all injury-related medical encounters (hospitalizations and outpatient visits combined) in 2006—the overall DoD and the individual Services' injury rate. The DoD rate was over 1600 injury visits per 1000 service members per year. The army showed the highest rates of medical encounters, almost 2200 per 1000 person-years. Rates for the Services were fairly flat from 2000 to 2006.

Figure 3 displays rates for the most common general type of injury: lower-extremity overuse injuries (e.g., conditions such as stress fractures, Achilles tendonitis, plantar fasciitis, bursitis) for the DoD and the Services. The rate of DoD lower-extremity overuse injury visits was almost 900 per 1000 person-years. The lower-extremity overuse injury rates were highest for the army and lowest for the navy. Rates of lower-extremity overuse injuries appear to be decreasing for the army and going up for the air force and the marines. It should be kept in mind that on average half of the navy is at sea at any given time, and shipboard outpatient injuries are not captured in the

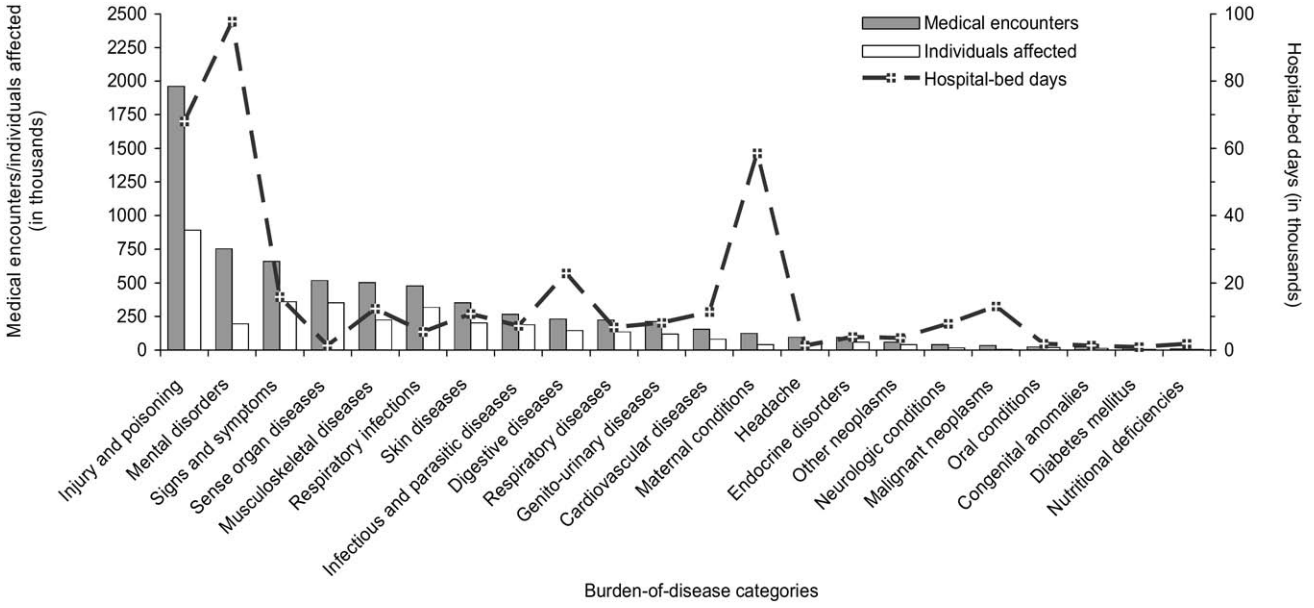

Figure 1. Burden of injury versus disease, active duty military, 2006
Injury category includes injury-related musculoskeletal conditions from ICD-9-CM code series 716-739. Chart excludes conditions arising during the perinatal period (medical encounters=1322).
Source: Defense Medical Surveillance System, 2007

automated medical records system. As with Figure 1, these figures (2 and 3) give a sense of the burden injuries place on the military medical treatment system.

Table 2 displays the number of service members with one or more hospitalizations by PDG for DoD and the Services in 2006. Injuries (n=11,591) were the leading cause of adverse health event hospitalizations for the DoD (note: pregnancies are not considered adverse health events). The same was true for Army and Marine Corps; however, injuries were only the second leading cause of adverse health event hospitalization for the Air Force and the Navy where the number of injuries was exceeded by the number of mental conditions. The rate of hospitalization for service members with one or more injuries, for the DoD in 2006, was 1012 injury hospitalizations per 100,000 personnel.

Table 3 shows the number of service members with one or more injuries treated in outpatient clinics by PDG for the DoD and the Services. Over 1,000,000 injuries to service members were treated in outpatient

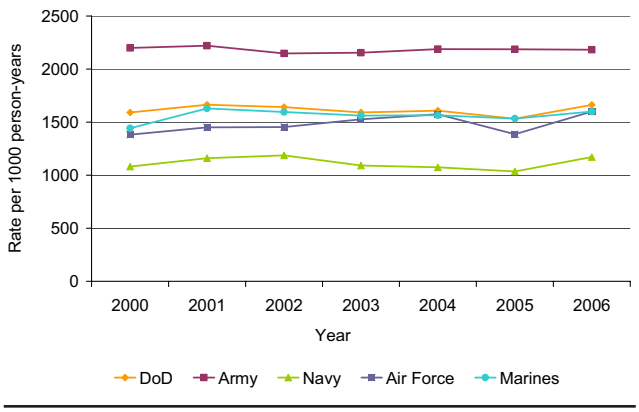

Figure 2. Overall rates of injury, active duty DoD and services, 2000–2006
All inpatient and outpatient visits; includes primary and nonprimary diagnoses.
Source: Defense Medical Surveillance System, 2007

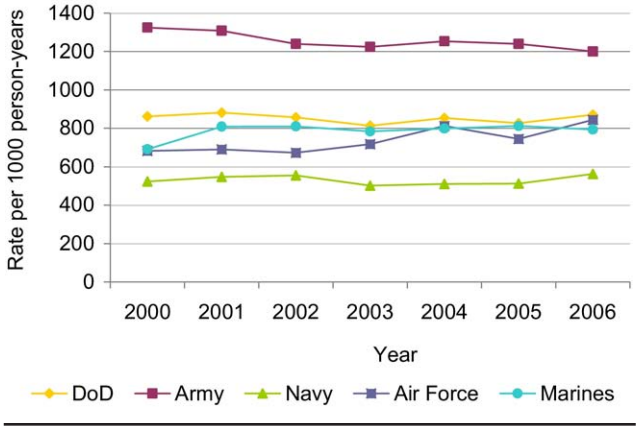

Figure 3. Lower-extremity overuse–injury rates, active duty DoD and services, 2000–2006
All inpatient and outpatient visits; includes primary and nonprimary diagnoses.
Source: Defense Medical Surveillance System, 2007

Table 2. Hospitalizations by Principal Diagnosis Group for active duty DoD and services, 2006[a,b]

Category	ICD-9-CM codes	DoD			Army			Navy			Air Force			Marines		
		Injury[c]	Not injury	*n*	Injury[c]	Not injury	*n*	Injury[c]	Not injury	n	Injury[c]	Not injury	*n*	Injury[c]	Not injury	*n*
Infectious/parasitic	001–139	0	1,197	1,197	0	602	602	0	223	223	0	243	243	0	129	129
Neoplasm	140–239	0	1,858	1,858	0	803	803	0	477	477	0	467	467	0	111	111
Endocrine	240–279	0	867	867	0	356	356	0	207	207	0	230	230	0	74	74
Blood	280–289	0	468	468	0	169	169	0	107	107	0	142	142	0	50	50
Mental	290–319	0	10,503	10,503	0	5,434	5,434	0	2,046	2,046	0	1,862	1,862	0	1,161	1,161
Nervous	320–389	45	1,036	1,081	25	464	489	8	202	210	6	237	243	6	133	139
Circulatory	390–459	0	2,494	2,494	0	1,091	1,091	0	527	527	0	678	678	0	198	198
Respiratory	460–519	0	2,668	2,668	0	1,424	1,424	0	370	370	0	461	461	0	413	413
Gastrointestinal	520–579	4	6,361	6,365	4	2,812	2,816	0	1,317	1,317	0	1,587	1,587	0	645	645
Genitourinary	580–629	0	2,543	2,543	0	1,154	1,154	0	497	497	0	726	726	0	166	166
Pregnancy	630–677	0	15,157	15,157	0	5,004	5,004	0	4,207	4,207	0	4,908	4,908	0	1,038	1,038
Skin	680–709	0	2,005	2,005	0	941	941	0	378	378	0	278	278	0	408	408
Musculoskeletal	710–739	3,532	2,718	6,250	1,854	1,420	3,274	528	478	1,006	709	528	1,237	441	292	733
Congenital anomalies	740–759	0	312	312	0	122	122	0	70	70	0	84	84	0	36	36
Perinatal	760–779	0	5	5	0	3	3	0	1	1	0	1	1	0	0	0
Symptoms ill-defined	780–799	0	4,275	4,275	0	2,106	2,106	0	846	846	0	1,004	1,004	0	319	319
Injury/poison	800–999	8,010	2,429	10,439	4,387	1,174	5,561	1,183	454	1,637	969	467	1,436	1,471	334	1,805
Total		11,591	56,896	68,487	6,270	25,079	31,349	1,719	12,407	14,126	1,684	13,903	15,587	1,918	5,507	7,425

[a]Source: Defense Medical Surveillance System, 2007
[b]Incident rule: visit is >60 days from preceding visit for the same diagnosis (identified using 3-digit ICD-9-CM code)
[c]As defined by Armed Forces Health Surveillance Center's (AFHSC) Installation Injury Reports, primary diagnosis only, to exclude follow-up visits
DoD, Department of Defense

clinics. This was more than twice as many as for the next leading cause, respiratory diseases. The same is true for each of the military Services. For the DoD overall, the rate of injury clinic visits for service members with one or more injury of a particular type in 2006 was 999 outpatient (ambulatory) injuries per 1000.

Diagnoses and Locations of Acute Traumatic Injuries

Table 4 displays types of injuries (e.g., fractures, sprains, strains) resulting in hospitalization by body location (Barell Matrix format) for the DoD. These acute, mostly traumatic, injuries caused almost 7000 hospitalizations in 2006. The most common type of acute injury hospitalized in 2006 was fractures, accounting for 40% of the total. The next most common, after fractures, were internal injuries (12%), open wounds (9%), and sprains and strains (8%). The leading location of hospitalized injuries was the lower extremities, with a combined total of 28% of injuries. The second leading location of hospitalized injuries was the upper extremities at 19%. Just over 9% of injury hospitalizations were due to traumatic brain injuries (TBI).

Table 5 presents data on the types of acute injuries by body location (Barell Matrix format) for ambulatory/outpatient injuries—a total of over 540,000 injuries. The leading types of injuries were sprains and strains, accounting for 49% of total outpatient injuries. Contusions followed at 16%, then fractures (10%), and open wounds (8%). There were over 7000 TBIs treated in outpatient settings (1.3% of outpatient injuries).

Diagnoses and Locations of Overuse and Chronic Injuries

Table 6 identifies the general types of injury-related musculoskeletal conditions that result in hospitalization. This table is arranged in the same manner as the Barell Matrix, with injury types on the horizontal axis and body location on the vertical axis.[24] These types of injuries resulted in just over 3300 hospitalizations of active duty service members in 2006. The most common conditions were categorized as "other derangements of joints," accounting for 47% of hospitalizations. The second leading category of injury-related musculoskeletal conditions was "pain and inflammation," which includes conditions commonly seen in civilian orthopedic and sports medicine clinics, such as Achilles tendonitis, plantar fasciitis, bursitis, and patello–femoral syndrome. These painful, sometimes disabling overuse inflammatory conditions account for 25% of all hospitalizations. The most common region of the body suffering this type of injury was the back and spine. Back complaints and injuries constituted 43% of the total injury-related musculoskeletal conditions that required hospitalization.

Table 7 shows the types of injury-related musculoskeletal conditions by body location (Barell Matrix–like format) that resulted in treatment in outpatient clinics. Over 535,000 injury-related musculoskeletal conditions to active duty service members were treated in outpatient clinics in 2006. "Pain and inflammation" was the most common type of injury, at 84% of the total. The most commonly injured body region was the lower extremity, accounting for 49% of the total.

Causes of Injury-Related Hospitalizations

Table 8 shows the frequencies, rates, and percentage distribution of the leading causes of injuries resulting in hospitalizations of DoD military personnel for the total DoD and for each of the military services. The "Falls and miscellaneous" category accounted for 34% of all hospitalizations in the DoD in 2006. Within this category, falls/jumps and near-falls (slips and trips) accounted for the largest portion, 18% of all injury hospitalizations. The second leading cause was "Accidents of land transport," which resulted in 19% of all injury hospitalizations. Nonmilitary, privately owned–motor-vehicle mishaps were the leading type of vehicle associated with injury hospitalizations, accounting for 15% of all injuries. Athletic and sports injuries constituted the third leading category of hospitalization for injury, 13.1% of all hospitalized injuries. Intentional, nonbattle injuries (e.g., fight- and assault-related injuries) were the fifth leading cause of hospitalized injuries, resulting in 8.0% of the total for the DoD. Parachute jump–related injuries accounted for 4.7% of all hospitalizations in the DoD. However, the vast majority of parachute injuries occurred among army personnel.

Discussion

Summary of Current Military Medical Surveillance Data on Injuries

In 2006, a total of 764 military service members died from nonbattle injuries.[26] However, this number was small compared to the roughly 1,000,000 service members who suffered nonfatal, nonbattle injuries as reported in this article. When looking at hospitalizations, injuries accounted for 17% (n=11,591) of all hospitalizations. The next most common reason for hospitalization was mental disorders at 15%, followed by gastrointestinal diseases at 9%. Looking at conditions treated in outpatient clinics showed that injuries were the leading health problem requiring outpatient medical care, at 27% of all such visits (n=1,143,846). The next leading cause of outpa-

Table 3. Ambulatory visits by Principal Diagnosis Group for active duty DoD and services, 2006[a,b]

Category	ICD-9-CM codes	DoD			Army		
		Injury[c]	Not injury	*n*	Injury[c]	Not injury	*n*
Infectious/parasitic	001–139	0	193,385	193,385	0	68,973	68,973
Neoplasm	140–239	0	55,346	55,346	0	17,807	17,807
Endocrine	240–279	0	87,137	87,137	0	30,655	30,655
Blood	280–289	0	10,816	10,816	0	3,502	3,502
Mental	290–319	0	245,095	245,095	0	116,542	116,542
Nervous	320–389	13,344	492,853	506,197	4,338	177,962	182,300
Circulatory	390–459	0	102,929	102,929	0	36,761	36,761
Respiratory	460–519	0	508,782	508,782	0	186,057	186,057
Gastrointestinal	520–579	19	193,621	193,640	8	74,330	74,338
Genitourinary	580–629	0	167,720	167,720	0	63,504	63,504
Pregnancy	630–677	0	64,596	64,596	0	22,347	22,347
Skin	680–709	1,284	245,189	246,473	530	88,902	89,432
Musculoskeletal	710–739	589,828	276,789	866,617	259,004	115,834	374,838
Congenital anomalies	740–759	0	17,650	17,650	0	7,050	7,050
Perinatal	760–779	0	850	850	0	378	378
Symptoms ill-defined	780–799	0	483,273	483,273	0	190,682	190,682
Injury/poison	800–999	539,371	33,998	573,369	222,032	14,527	236,559
Total		1,143,846	3,180,029	4,323,875	485,912	1,215,813	1,701,725

[a]Source: Defense Medical Surveillance System, 2007
[b]Incident rule: visit is >60 days from preceding visit for the same diagnosis (identified using 3-digit ICD-9-CM code)
[c]As defined by Armed Forces Health Surveillance Center's (AFHSC) Installation Injury Reports, primary diagnosis only, to exclude follow-up visits
DoD, Department of Defense

tient visits was respiratory illness at 12% (n=508,782) and the third was neurologic conditions at 11% (n=492,853). These findings are consistent with previous military data.

For every traumatic injury death in 2006, there were 11 hospitalizations and 715 injuries treated in outpatient settings (Figure 4). When ratios for all injuries—acute and overuse/chronic in nature—were calculated, there were 16 hospitalizations and over 1500 outpatient visits for every death (Figure 4). It is clear from these data that nonfatal injuries are by far the biggest health problem of the military. More attention must be focused on these nonfatal injuries to reduce the impact of injuries on the health and readiness of U.S. military personnel.

As seen in Table 4, the most common type of acute traumatic injuries requiring hospitalization are fractures, accounting for almost 40% of all hospitalized injuries. From the perspective of hospitalizations, prevention of fractures must be a top priority. TBIs, which tally about 9% of hospitalized injuries, are of concern because of their potential long-term disabling effects.

Examination of injuries occurring in outpatient settings reveals a different order of priorities. Sprains and strains caused 49% of outpatient visits, with more than 265,000 injuries treated (Table 5). Based on these numbers, sprains and strains should be another top priority for prevention. Fractures were the third leading category of outpatient injuries, at 10%. This is impressive, as there were over 53,000 fractures treated on an outpatient basis across the military services, indicating how serious outpatient injuries can be. Although TBIs accounted for less than 1.5% of outpatient injuries, they numbered more than 7000, an obvious cause for concern.

When looking at injury-related musculoskeletal conditions (Table 6), joint derangements, such as meniscal tears, articular cartilage derangements, and loose bodies, accounted for 47% of all overuse/chronic injury hospitalizations. The biggest overuse/chronic injury problems seen in ambulatory care (Table 7) are conditions that cause pain and inflammation, including Achilles tendonitis, plantar fasciitis, bursitis, and patello–femoral syndrome.

Table 3. Ambulatory visits by Principal Diagnosis Group for active duty DoD and services, 2006[a,b] (*continued*)

Navy			Air Force			Marines		
Injury[c]	Not injury	*n*	Injury[c]	Not injury	*n*	Injury[c]	Not injury	*n*
0	52,341	52,341	0	48,633	48,633	0	23,438	23,438
0	13,777	13,777	0	19,417	19,417	0	4,345	4,345
0	24,571	24,571	0	25,710	25,710	0	6,201	6,201
0	3,301	3,301	0	3,166	3,166	0	847	847
0	50,822	50,822	0	54,715	54,715	0	23,016	23,016
3,795	118,212	122,007	4,135	142,140	146,275	1,076	54,539	55,615
0	25,924	25,924	0	33,178	33,178	0	7,066	7,066
0	104,984	104,984	0	160,329	160,329	0	57,412	57,412
3	43,649	43,652	3	58,040	58,043	5	17,602	17,607
0	37,877	37,877	0	53,669	53,669	0	12,670	12,670
0	17,819	17,819	0	20,545	20,545	0	3,885	3,885
283	56,827	57,110	244	70,849	71,093	227	28,611	28,838
104,394	54,913	159,307	168,022	78,003	246,025	58,408	28,039	86,447
0	4,089	4,089	0	4,584	4,584	0	1,927	1,927
0	205	205	0	203	203	0	64	64
0	105,803	105,803	0	147,584	147,584	0	39,204	39,204
114,054	7,228	121,282	125,087	8,217	133,304	78,198	4,026	82,224
222,529	722,342	944,871	297,491	928,982	1,226,473	137,914	312,892	450,806

Cause-of-injury data presented in this paper showed that the leading causes of acute traumatic injury hospitalizations for military personnel are falls, motor vehicle mishaps, and athletics/sports (Table 8). For the military, these causes of injuries should be given top priority (1) for prevention, where evidence of effective interventions exist; and (2) for research, where evidence of preventability is lacking.

For each level of severity (hospitalization or ambulatory/outpatient care) and each category of injury (acute or overuse/chronic), a different set of injury prevention priorities could be derived. Ruscio et al.[10] approached this issue by estimating numbers of limited duty days for each type of injury seen in the Barell Matrix and injury-related musculoskeletal matrices. Across the entire DoD, it was estimated that acute and overuse/chronic injuries together resulted in over 25,000,000 days of limited duty in 2005.[10] The leading cause of acute traumatic injuries was fractures of the upper and lower extremities, which led to more than 5,000,000 days of limited duty. That was followed by lower-extremity sprains and strains, at more than 1,800,000 days of limited duty. Among the injury-related musculoskeletal conditions, overuse injuries (pain and inflammation) of a lower extremity resulted in an estimated 3,800,000 million days of limited duty. Based on the amount of morbidity in terms of limited duty days, priority for prevention (by injury type) was given to fractures of the extremities, lower-extremity overuse injuries, and lower-extremity sprains and strains. Among cause coded injuries, the leading causes of the top five injury diagnosis groups resulting in limited duty days were found to be falls, sports and physical training, handling of guns and explosives, private vehicle mishaps, and slips, trips, and twists.[10] These data also suggest that the sheer numbers of nonfatal injuries should shift some emphasis from fatal injuries to nonfatal injuries.

Comparisons of U.S. and Military Rates

To get a relative sense of how big the problem of injuries is for the military and how well the services are doing to prevent injuries, one can compare the rates of injuries among military service members with other populations. The most convenient comparisons can be made with U.S. and various state data. Military hospitalization rates for

Table 4. Frequency of injury hospitalizations by major ICD-9-CM injury code and body location (Barell Matrix), 2006[a,b]

Injury location	Fracture	Dislocation	Sprains/ strains	Internal	Open wound	Amputations	Blood vessel	Contusion/ superficial	Crush	Burns	Nerves	Unspecified	Systemwide and late effects	*n*	% total
HEAD AND NECK															
Traumatic brain injury															
Type-1	117	0	0	246	0	0	0	0	0	0	0	0	0	**363**	**5.2**
Type-2	49	0	0	212	0	0	0	0	0	0	0	0	0	**261**	**3.8**
Type-3	11	0	0	0	0	0	0	0	0	0	0	0	0	**11**	**0.2**
Other head, face, neck															
Other head	0	0	0	0	46	0	0	0	0	0	0	69	0	**115**	**1.7**
Face	357	1	0	0	61	0	0	0	0	11	0	0	0	**430**	**6.2**
Eye	0	0	0	0	36	0	0	27	0	2	0	0	0	**65**	**0.9**
Neck	2	0	0	0	8	0	0	0	1	4	1	0	0	**16**	**0.2**
Head, face, neck unspecified	0	0	0	0	0	0	5	48	1	27	0	8	0	**89**	**1.3**
SPINE AND BACK															
Spinal cord															
Cervical	18	0	0	18	0	0	0	0	0	0	0	0	0	**36**	**0.5**
Thoracic/dorsal	21	0	0	3	0	0	0	0	0	0	0	0	0	**24**	**0.3**
Lumbar	7	0	0	1	0	0	0	0	0	0	0	0	0	**8**	**0.1**
Sacrum coccyx	0	0	0	3	0	0	0	0	0	0	0	0	0	**3**	**0.0**
Spine, back, unspecified	0	0	0	15	0	0	0	0	0	0	0	0	0	**15**	**0.2**
Vertebral column															
Cervical	50	8	22	0	0	0	0	0	0	0	0	0	0	**80**	**1.2**
Thoracic/dorsal	52	0	3	0	0	0	0	0	0	0	0	0	0	**55**	**0.8**
Lumbar	89	4	13	0	0	0	0	0	0	0	0	0	0	**106**	**1.5**
Sacrum coccyx	18	1	0	0	0	0	0	0	0	0	0	0	0	**19**	**0.3**
Spine, back unspecified	4	0	0	0	0	0	0	0	0	0	0	0	0	**4**	**0.1**
Torso															
Chest (thorax)	66	0	1	167	18	0	4	14	0	2	0	0	0	**272**	**3.9**

Table 4. Frequency of injury hospitalizations by major ICD-9-CM injury code and body location (Barell Matrix), 2006[a,b] (*continued*)

Injury location	Fracture	Dislocation	Sprains/ strains	Internal	Open wound	Amputations	Blood vessel	Contusion/ superficial	Crush	Burns	Nerves	Unspecified	Systemwide and late effects	*n*	% total
Abdomen	0	0	0	167	19	0	1	7	0	2	0	0	0	**196**	**2.8**
Pelvis, urogenital	86	2	1	12	19	0	2	10	2	0	0	0	0	**134**	**1.9**
Trunk	3	0	0	0	3	0	0	15	0	3	0	5	0	**29**	**0.4**
Back, buttock	0	0	3	0	6	0	0	10	0	6	0	0	0	**25**	**0.4**
EXTREMITIES															
Upper															
Shoulder, upper arm	182	56	124	0	19	2	0	9	1	4	0	13	0	**410**	**5.9**
Forearm, elbow	216	6	2	0	49	0	0	3	4	12	0	0	0	**292**	**4.2**
Wrist, hand, fingers	249	19	13	0	184	27	0	11	8	20	0	12	0	**543**	**7.8**
Other and unspecified	7	0	0	0	10	0	7	12	0	8	37	4	0	**85**	**1.2**
Lower															
Hip	57	8	4	0	0	0	0	5	0	0	0	0	0	**74**	**1.1**
Upper leg, thigh	120	0	0	0	0	3	0	5	0	6	0	0	0	**134**	**1.9**
Knee	34	112	235	0	0	0	0	1	0	0	0	0	0	**382**	**5.5**
Lower leg, ankle	768	15	82	0	0	4	0	11	1	10	0	0	0	**891**	**12.8**
Foot, toes	141	8	3	0	32	2	0	12	3	7	0	0	0	**208**	**3.0**
Other and unspecified	12	0	61	0	110	0	3	28	0	6	0	36	0	**256**	**3.7**
Unclassified by site															
Other/multiple	7	0	0	0	0	0	1	0	0	0	9	0	0	**17**	**0.2**
Unspecified site	8	0	15	10	15	0	0	41	1	18	8	75	0	**191**	**2.8**
Systemwide and late effects	0	0	0	0	0	0	0	0	0	0	0	0	1,103	**1,103**	**15.9**
Total	**2,751**	**240**	**582**	**854**	**635**	**38**	**23**	**269**	**22**	**148**	**55**	**222**	**1,103**	**6,942**	
% total	**39.6**	**3.5**	**8.4**	**12.3**	**9.1**	**0.5**	**0.3**	**3.9**	**0.3**	**2.1**	**0.8**	**3.2**	**15.9**		

[a]Source: Defense Medical Surveillance System, as of December 31, 2007

[b]Primary diagnosis only. Injuries during deployment not included. Incident rule is >60 days from preceding visit for the same diagnosis (using 3-digit ICD-9-CM code)

Table 5. Frequency of injury ambulatory visits by major ICD-9-CM injury code and body location (Barell Matrix), 2006[a,b]

Injury location	Fracture	Dislocation	Sprains/ strains	Internal	Open wound	Amputations	Blood vessel	Contusion/ superficial	Crush	Burns	Nerves	Unspecified	Systemwide and late effects	*n*	% total
HEAD AND NECK															
Traumatic brain injury															
Type-1	225	0	0	2,055	0	0	0	0	0	0	5	0	0	**2,285**	**0.4**
Type-2	366	0	0	4,476	0	0	0	0	0	0	0	0	0	**4,842**	**0.9**
Type-3	77	0	0	0	0	0	0	0	0	0	0	0	0	**77**	**0.0**
Other head, face, neck															
Other head	0	0	0	0	3,699	0	0	0	0	21	55	5,367	0	**9,142**	**1.7**
Face	3,420	72	226	0	8,970	0	0	0	0	126	0	0	0	**12,814**	**2.4**
Eye	0	0	0	0	960	0	0	10,974	0	378	44	0	0	**12,356**	**2.3**
Neck	5	0	2	0	160	0	0	0	16	100	43	0	0	**326**	**0.1**
Head, face, neck unspecified	0	0	0	0	0	0	88	6,963	28	304	14	2,536	0	**9,933**	**1.8**
SPINE AND BACK															
Spinal cord															
Cervical	75	0	0	175	0	0	0	0	0	0	0	0	0	**250**	**0.0**
Thoracic/dorsal	291	0	0	26	0	0	0	0	0	0	0	0	0	**317**	**0.1**
Lumbar	53	0	0	48	0	0	0	0	0	0	0	0	0	**101**	**0.0**
Sacrum coccyx	7	0	0	11	0	0	0	0	0	0	0	0	0	**18**	**0.0**
Spine, back, unspecified	10	0	0	111	0	0	0	0	0	0	0	0	0	**121**	**0.0**
Vertebral column															
Cervical	361	129	15,191	0	0	0	0	0	0	0	0	0	0	**15,681**	**2.9**
Thoracic/dorsal	335	268	6,357	0	0	0	0	0	0	0	0	0	0	**6,960**	**1.3**
Lumbar	609	106	19,738	0	0	0	0	0	0	0	0	0	0	**20,453**	**3.8**
Sacrum coccyx	223	60	622	0	0	0	0	0	0	0	0	0	0	**905**	**0.2**
Spine, back unspecified	110	5	0	0	0	0	0	0	0	0	0	0	0	**115**	**0.0**
Torso															
Chest (thorax)	1,267	30	2,823	601	212	0	23	3,586	0	67	9	0	0	**8,618**	**1.6**

Table 5. Frequency of injury ambulatory visits by major ICD-9-CM injury code and body location (Barell Matrix), 2006[a,b] (continued)

Injury location	Fracture	Dislocation	Sprains/ strains	Internal	Open wound	Amputations	Blood vessel	Contusion/ superficial	Crush	Burns	Nerves	Unspecified	Systemwide and late effects	*n*	% total
Abdomen	0	0	0	564	346	0	15	532	0	56	44	0	0	**1,557**	**0.3**
Pelvis, urogenital	658	44	13,554	79	678	0	7	384	47	26	6	0	0	**15,483**	**2.8**
Trunk	11	0	0	0	99	0	0	1,864	3	64	7	2,908	0	**4,956**	**0.9**
Back, buttock	0	0	9,061	0	236	0	0	1,537	10	69	0	0	0	**10,913**	**2.0**
EXTREMITIES															
Upper															
Shoulder, upper arm	2,830	6,351	25,375	0	499	32	0	2,703	20	88	0	1,904	0	**39,802**	**7.3**
Forearm, elbow	3,926	294	2,300	0	1,788	40	0	2,042	41	402	0	0	0	**10,833**	**2.0**
Wrist, hand, fingers	16,934	1,696	17,395	0	16,155	314	0	12,385	952	1,258	0	3,790	0	**70,879**	**13.0**
Other and unspecified	134	0	0	0	605	13	67	2,114	10	170	1,148	1,447	0	**5,708**	**1.1**
Lower															
Hip	574	170	11,458	0	0	0	0	908	5	0	0	0	0	**13,115**	**2.4**
Upper leg, thigh	864	0	0	0	0	105	0	626	8	74	0	0	0	**1,677**	**0.3**
Knee	458	12,394	11,634	0	0	0	0	4,773	43	20	0	0	0	**29,322**	**5.4**
Lower leg, ankle	8,914	235	54,060	0	0	163	0	2,299	69	159	0	0	0	**65,899**	**12.1**
Foot, toes	9,161	339	8,717	0	2,979	38	0	12,301	312	182	0	0	0	**34,029**	**6.3**
Other and unspecified	473	0	46,246	0	3,788	95	74	4,773	11	163	0	8,532	0	**64,155**	**11.8**
Unclassified by site															
Other/multiple	48	0	0	0	0	0	1	0	0	12	397	0	0	**458**	**0.1**
Unspecified site	956	162	20,356	184	3,146	0	17	18,007	100	1,260	323	1,939	0	**46,450**	**8.5**
Systemwide and late effects	0	0	0	0	0	0	0	0	0	0	0	0	0	23,033	**4.2**
Total	**53,375**	**22,355**	**265,115**	**8,330**	**44,320**	**800**	**292**	**88,771**	**1,675**	**4,999**	**2,095**	**28,423**	**23,033**	**543,583**	
% total	**9.8**	**4.1**	**48.8**	**1.5**	**8.2**	**0.1**	**0.1**	**16.3**	**0.3**	**0.9**	**0.4**	**5.2**	**4.2**		

[a]Source: Defense Medical Surveillance System, as of December 31, 2007

[b]Primary diagnosis only. Injuries during deployment not included. Incident rule is >60 days from preceding visit for the same diagnosis (using 3-digit ICD-9-CM code).

Table 6. Frequency of injury-related musculoskeletal conditions for hospitalizations (matrix by injury type and body location), active duty DoD, 2006[a,b]

Injury location	Inflammation and pain[c] (overuse)	Inflammation/ pain with nerves[c] (overuse)	Stress fracture	Sprains/ strains/ rupture	Dislocation	Other joint derangement[c]	*n*	% total
SPINE AND BACK								
Vertebral column								
Cervical	30	59	0	0	0	250	**339**	**10.2**
Thoracic/dorsal	0	37	0	0	0	8	**45**	**1.4**
Lumbar	135	37	0	0	0	826	**998**	**30.0**
Sacrum coccyx	1	0	0	0	0	0	**1**	**0.0**
Spine, back unspecified	3	3	5	0	0	41	**52**	**1.6**
EXTREMITIES								
Upper								
Shoulder	218	0	0	16	60	157	**451**	**13.5**
Upper arm, elbow	39	0	0	0	1	3	**43**	**1.3**
Forearm, wrist	11	0	0	0	1	11	**23**	**0.7**
Hand	4	0	0	4	0	7	**15**	**0.5**
Lower								
Pelvis, hip, thigh	22	0	6	2	1	19	**50**	**1.5**
Lower leg, knee	200	0	15	530	29	160	**934**	**28.0**
Ankle, foot	92	0	0	3	13	80	**188**	**5.6**
Unclassified by site								
Other specified/multiple	13	0	1	1	1	10	**26**	**0.8**
Unspecified site	63	15	81	2	0	5	**166**	**5.0**
Total	**831**	**151**	**108**	**558**	**106**	**1,577**	**3,331**	
% total	**24.9**	**4.5**	**3.2**	**16.8**	**3.2**	**47.3**		

[a]Source: Defense Medical Surveillance System, as of December 31, 2007
[b]Primary diagnosis only. Injuries during deployment not included. Incident rule is >60 days from preceding visit for the same diagnosis (using 3-digit ICD-9-CM code).
[c]Examples of inflamation/pain musculoskeletal conditions include tendonitis, bursitis, or lumbago. Examples of pain/inflammation with nerve involvement include sciatica and thoracic/lumbosacral neuritis or radiculitis. Examples of other joint derangements include intervertebral disc disorders, meniscus tear, and joint instability.
DoD, Department of Defense

injury are not directly comparable to U.S. rates because the population of the services is predominantly men aged <30 years. Nevertheless, such a comparison should provide a conservative impression of how high or low are military rates of injury. In their book *The Incidence and Economic Burden of Injuries in the U.S.*, Finkelstein et al. (2006) breakdown the types and causes of injuries.[27] The manner in which it is done is similar to the way in which military data were tabulated for this paper. For that reason, the 2006 rates of hospitalization for the military are compared to those from Finkelstein's book. This is a reasonable comparison, since military injury rates have been relatively stable from 2000 to 2006 (Figure 2). Another set of comparison data comes from the State Injury Indicators Report.[28]

Overall rates of injury within the military services (including both acute traumatic conditions and injury-related musculoskeletal conditions) are a little over 1000 hospitalizations per 100,000 service members. However, if just the acute traumatic injury rate for the military is compared with the U.S. overall as is usually done, the rates are 584 per 100,000 for the military (late effects and

Table 7. Frequency of injury-related musculoskeletal conditions for ambulatory (outpatient) visits (matrix by injury type and body location, active duty DoD, 2006[a,b]

Injury location	Inflammation and pain[c] (overuse)	Inflammation/ pain with nerves[c] (overuse)	Stress fracture	Sprains/ strains/ rupture	Dislocation	Other joint derangement[c]	*n*	% total
SPINE AND BACK								
Vertebral column								
Cervical	24,671	4,249	0	0	0	3,208	**32,128**	**6.0**
Thoracic/dorsal	0	5,698	0	0	0	338	**6,036**	**1.1**
Lumbar	78,750	6,120	0	0	0	10,955	**95,825**	**17.8**
Sacrum coccyx	3,216	0	0	0	0	0	**3,216**	**0.6**
Spine, back unspecified	20	1,303	177	0	0	3,423	**4,923**	**0.9**
EXTREMITIES								
Upper								
Shoulder	57,416	0	0	1,990	1,641	4,756	**65,803**	**12.3**
Upper arm, elbow	12,535	0	11	0	20	195	**12,761**	**2.4**
Forearm, wrist	11,815	0	22	0	14	505	**12,356**	**2.3**
Hand	6,820	0	0	502	41	206	**7,569**	**1.4**
Lower								
Pelvis, hip, thigh	19,016	0	106	192	12	283	**19,609**	**3.7**
Lower leg, knee	124,648	0	5,449	8,017	358	12,989	**151,461**	**28.2**
Ankle, foot	86,119	0	0	240	114	4,545	**91,018**	**16.9**
Unclassified by site								
Other specified/multiple	3,019	0	271	55	9	147	**3,501**	**0.7**
Unspecified site	23,113	2,585	4,754	303	11	183	**30,949**	**5.8**
Total	**451,158**	**19,955**	**10,790**	**11,299**	**2,220**	**41,733**	**537,155**	
% total	**84.0**	**3.7**	**2.0**	**2.1**	**0.4**	**7.8**		

[a]Source: Defense Medical Surveillance System, as of December 31, 2007
[b]Primary diagnosis only. Injuries during deployment not included. Incident rule is >60 days from preceding visit for the same diagnosis (using 3-digit ICD-9-CM code).
[c]Examples of inflamation/pain musculoskeletal conditions include tendonitis, bursitis, or lumbago. Examples of pain/inflammation with nerve involvement include sciatica and thoracic/lumbosacral neuritis or radiculitis. Examples of other joint derangements include intervertebral disc disorders, meniscus tear, and joint instability.
DoD, Department of Defense

medical–surgical misadventures not included) and 676 per 100,000 for the U.S.[27] Even though the military population is composed of some of the highest-risk age groups, the rate is about the same as that for the U.S. A 2004 survey of 34 states found that overall injury hospitalization rates for those aged 15–24 years ranged from 232 per 100,000 (Rhode Island) to 650 per 100,000 (Arizona).[28] This same survey found that the rate for those aged 25–34 years ranged from a low of 208 per 100,000 (Nebraska) to a high of 545 per 100,000 (Pennsylvania). The 2006 rate of hospitalization for acute traumatic injuries for U.S. military personnel (584 per 100,000) is at the high end of the states' rates for these age groups. Considering the largely male population and the vigorous nature of military training this is a favorable comparison.

An examination of some specific types of injuries from the Barell Matrix reveals a similar pattern for the military compared to the U.S. The TBI hospitalization rates for the Services are about 55 per 100,000 service members per year compared to 57 for the U.S.[27] TBI hospitalization rates in 2004 for those aged 15–24 years, reported by 34 states, ranged from a low of 33 per 100,000 (Rhode Island)

Table 8. Hospitalized nonbattle causes of injury for active duty DoD and service, 2006[a,b]

Category	DoD			Army			Navy			Air Force			Marines		
	n	Rate[c]	%	*n*	Rate[c]	%	*n*	Rate[c]	%	*n*	Rate[c]	%	*n*	Rate[c]	%
Falls, miscellaneous other unspecified[d]	1,483	129.5 (1)	34.3	895	249.6 (1)	36.5	194	60.9	29.2	181	56.9	30.3	213	142.3	35.1
Fall/jump (stairs, same/different level)	578	50.5	13.4	285	79.5	11.6	102	32.0	15.3	91	28.6	15.2	100	66.8	16.5
Twist, turn, slip (no fall)	178	15.5	4.1	111	31.0	4.5	21	6.6	3.2	21	6.6	3.5	25	16.7	4.1
Miscellaneous other, unspecified	727	63.5	16.8	499	139.2	20.3	71	22.3	10.7	69	21.7	11.6	88	58.8	14.5
Accidents—land transport	824	71.9 (2)	19.1	383	106.8 (2)	15.6	181	56.8	27.2	174	54.7	29.1	86	57.5	14.2
Nonmilitary vehicle	666	58.2	15.4	305	85.1	12.4	153	48.0	23.0	139	43.7	23.3	69	46.1	11.4
Military vehicle	50	4.4	1.2	23	6.4	0.9	5	1.6	0.8	13	4.1	2.2	9	6.0	1.5
Nontraffic and other land transport	108	9.4	2.5	55	15.3	2.2	23	7.2	3.5	22	6.9	3.7	8	5.3	1.3
Athletics and sports	567	49.5 (3)	13.1	280	78.1 (3)	11.4	100	31.4	15.0	99	31.1	16.6	88	58.8	14.5
Complications—medical	348	30.4 (4)	8.0	206	57.5 (4)	8.4	38	11.9	5.7	24	7.5	4.0	24	16.0	4.0
Intentional injuries—nonbattle	222	19.4 (5)	5.1	136	37.9 (6)	5.5	46	14.4	6.9	33	10.4	5.5	63	42.1	10.4
Machinery, tools	221	19.3 (6)	5.1	122	34.0 (7)	5.0	28	8.8	4.2	30	9.4	5.0	41	27.4	6.8
Accidents—air transport	220	19.2 (7)	5.1	197	54.9 (5)	8.0	6	1.9	0.9	12	3.8	2.0	5	3.3	0.8
Parachute	202	17.6	4.7	189	52.7	7.7	3	0.9	0.5	8	2.5	1.3	2	1.3	0.3
Military aircraft, air transport other	18	1.6	0.4	8	2.2	0.3	3	0.9	0.5	4	1.3	0.7	3	2.0	0.5
Environmental factors	202	17.6 (8)	4.7	115	32.1 (8)	4.7	22	6.9	3.3	14	4.4	2.3	51	34.1	8.4
Guns, explosives	90	7.9 (9)	2.1	61	17.0 (9)	2.5	8	2.5	1.2	13	4.1	2.2	8	5.3	1.3
Poisons, fire, hot/corrosive substances	64	5.6 (10)	1.5	36	10.0 (10)	1.5	11	3.5	1.7	11	3.5	1.8	6	4.0	1.0
Instrumentalities of war—enemy	42	3.7	1.01	12	3.3	0.51	9	2.8	1.4	3	0.9	0.5	18	12.0	3.0
Accidents—water transport	38	3.3	0.92	11	3.1	0.47	22	6.9	3.3	3	0.9	0.5	2	1.3	0.3
Instrumentalities of war—self, accidents	2	0.2	0.05	0	0	0	0	0.0	0.0	0	0.0	0.0	2	1.3	0.3
Total[e]	4,323	377.5	100	2454	684.3	100	665	208.6	100.0	597	187.6	100.0	607	405.6	100.0

[a]Source: Defense Medical Surveillance System, 2007
[b]Population: DoD=1,145,289; Army=358,524; Navy=318,805; Air Force=318,805; Marines=149,647
[c]Rate per 100,000 person-years. Presented in descending order by DoD rate.
[d]Fighting excluded from Falls and Misc and added to Intentional injuries.
[e]Missing Standardization Agreement codes (not included in total): DoD=5171; Army=2344; Navy=952; Air Force=597; Marines=607
DoD, Department of Defense

to a high of 178 per 100,000 (Arizona).[28] For those aged 25–35 years in the same 34-state survey, rates of TBI ranged from a low of 24 per 100,000 (Rhode Island) to a high of 109 (Pennsylvania). The TBI rate for the U.S. military (55/100,000) is at the low end of this range. In examining another type of injury, fractures, a similar contrast with the U.S. as a whole is found. For the military, fractures result in hospitalizations for service members at a rate of roughly 240 per 100,000 service members per year, while for the U.S. it is 333 per 100,000 population per year.[27] These comparisons of the military with the U.S. civilian population are extremely crude. Nevertheless, they suggest that rates of injury hospitalization for TBIs and fractures among service members are not unduly high, relative to the U.S. as a whole or to similar age groups for a spectrum of states.

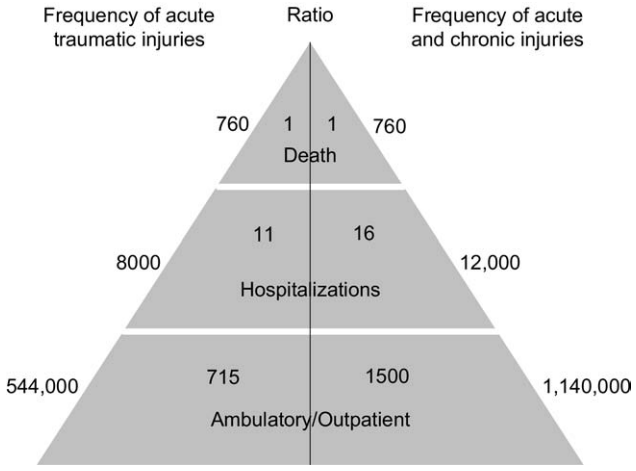

Figure 4. Unintentional injury pyramid, active duty military, 2006
Sources: Death-Defense Manpower Data Center, 2007; Hospitalizations and Ambulatory—Armed Forces Health Surveillance Center (AFHSC), 2007

In addition to the fact that hospitalization rates for military and civilian populations are similar, it is noteworthy that injury fatality rates are also similar. The crude rate of unintentional ("accidental") injury deaths overall for the military Services was 32.2 per 100,000 service members in 2006.[26] The crude rate of unintentional injury deaths for the U.S. the year before (2005) was 39.7 per 100,000.[29] More specifically, the U.S. rate among those aged 15–24 years was 37.4, while that for those aged 25–34 years was 34.9.[28] These age categories for the U.S. correspond to the age distribution of active duty military personnel, of whom more than 75% are aged <35 years.[26] Even though the comparisons are crude, these data suggest, as has been shown in the past,[30] that non–combat-related fatality rates for the military are not unduly high compared with unintentional injuries and for the U.S. population in general.

The previous paragraphs examined comparisons of types of injuries treated, but comparison of rates for specific causes of injuries for the military and the U.S. population may also be instructive. The annual rate of fall-related injury hospitalizations for the military is 50.5 per 100,000 service members, which is substantially lower than for the U.S. population, where rates for boys/men aged 15–24 years is 89 per 100,000 and for those aged 25–44 years is 125 per 100,000.[27] When looking at individual Services, rates of falls for the army (79.5 per 100,000 per year) are more similar to the civilian data than the other Services.

Annual rates of hospitalization for motor vehicle–related injuries for the military are 71.9 per 100,000. In comparison, for the U.S., the rates are 100 per 100,000.[27] Rates of injuries reported for the U.S. for those aged 15–24 years and those aged 25–44 years were 216 and 147, respectively.[27] When looking at the state level, in 2004 the range of motor vehicle–related hospitalization rates among the 34 reporting states for those aged 15–24 years were 53 to 246 per 100,000, with a median rate of 157.[28] For those aged 25–34 years, the range of motor vehicle–related hospitalization rates for the 34 states was 45 to 154 per 100,000 persons per year, with a median of 103.[28] Hospitalization rates for motor vehicle–related injuries among military personnel appear to be at the low end of the spectrum reported for states.

The rate for the Army alone, which is the best comparison population because they have greater opportunity to drive (do not spend time at sea), is 91.5 per 100,000 per year (Table 7). This rate is still on the low side, compared to state-level civilian population data on younger age groups comparable to the army population. It should not be surprising that motor vehicle–related injury hospitalization rates are lower for the military than for the U.S. Krull et al.[31] showed that fatality rates for comparable age groups of male service members are lower than for civilian men of the same age. Krull found that men of comparable age in the U.S. population were at a 14%–46% higher risk of dying in a motor vehicle crash than army men of the same age.

Participation in sports is the third leading cause of hospitalization for the military. The rate of sports injury hospitalizations cannot be readily contrasted with civilian U.S. data, due to the fact that sports/athletics do not receive a cause code in the civilian ICD-9-CM E-code system. Unlike ICD-9-CM E-coded data, the STANAG injury cause codes permit coding of specific sports (softball, basketball, football, soccer) and recreational activities (skiing, rock climbing, horsemanship, swimming). Another challenge to assessing sports and recreational injuries for both military and civilian communities is that a large portion of the injuries are overuse injuries, such as stress fractures, Achilles tendonitis, plantar fasciitis, and patello–femoral syndrome, classified in the ICD-9-CM code series 716–739.[17,20] These injury-related musculoskeletal conditions are not classified as "injuries" in the ICD-9-CM code book, or by most injury epidemiologists. However, these conditions are commonly recognized as injuries by the sports medicine community (orthopedic surgeons, physical therapists, athletic trainers, sports medicine practitioners). The DoD Military Injury Metrics Working Group in 2002 agreed that such conditions should be captured by military injury surveillance systems.[16,22] If these injury-related musculoskeletal conditions (chronic and overuse injuries) were not coded and tracked as injuries, 30% of hospitalizations and 52% of ambulatory injury visits would be missed by the military's health Services and safety officials.

For the military, physical training– or exercise-related injuries are the single biggest category of overuse injuries and would be missed altogether if not coded and tracked along with acute injury (ICD-9-CM 800–999) data. Vigorous weight-bearing physical activity is inescapable for service members, and as a result lower-extremity overuse injuries are also unavoidable. The data in Figure 3 represent lower-extremity overuse injuries and were designed to track the effects of running and other weight-bearing injuries. This is an important issue for civilian communities, where similarly young or middle-aged, vigorously active individuals would also be expected to experience these kinds of injuries.

Capabilities and Limitations of Military Injury Surveillance

Since the late 1980s, public health and injury experts have recommended surveillance of both fatal and nonfatal injuries.[6,11–14] In 1996, the AFEB recommended that the DoD develop a comprehensive medical injury surveillance system including hospitalization and outpatient data, and that surveillance of overuse/chronic injuries[32] in addition to acute injuries was needed.[1,2] As a result of these recommendations the DMSS was established in 1997[33] at the direction of the Assistant Secretary of Defense for Health Affairs; it began with surveillance of hospitalizations.[2,33] In 1998, automated outpatient surveillance data became available through DMSS for all four Services in addition to hospitalization data. The addition of outpatient injury visit data greatly expanded the recognition of how important the problem of injuries is for the military Services.

Even though the current DMSS has some limitations, it is evident from the preceding discussion that the military Services have developed a system capable of substantially contributing to the prevention of injuries. The DMSS is population-based with both inpatient (hospital) and outpatient (ambulatory) data. The data on hospitalizations of military personnel, which have the characteristics recommended for the states to incorporate,[6,23] are virtually 100% complete. All hospitalizations in military treatment facilities are captured as well as those for which the military pays for care outside the military healthcare system. All cases have diagnosis codes (ICD-9-CM N-codes). These data are linked to personnel data containing demographic, occupational, and other information on all service members. About 75% of hospitalized injury cases are cause coded with specific NATO codes (STANAG codes).

Injury and public health experts universally recommend use of hospitalization data for injury surveillance, when available.[6,11–14] The State and Territorial Injury Prevention Directors Association (STIPDA) recommends population-based surveillance that tracks both injury hospitalizations and rates (i.e., numerators, denominators, and incidences) of such hospitalizations in the U.S.[23] STIPDA provides a number of specific recommendations about how to use hospital discharge data for injury surveillance.[23] Their recommendations include: (1) checking the quality of data (completeness and percentage of diagnosed injuries with cause codes among other things); (2) including hospitalized conditions that list an injury as the principle reason for admission; (3) calculating crude, unadjusted injury discharge rates and gender-specific age-adjusted rates; (4) reporting frequencies of diagnoses by body location in the Barell Matrix format; and (5) describing causes of injury for which a valid external cause code exists using the recommended framework for presenting mortality and morbidity data. (Note: While military injury hospitalization data are cause coded, the data are not coded using ICD-9-CM E-codes, but rather NATO STANAG injury cause codes). This paper demonstrates that, with the exception of reporting ICD-9-CM E-codes, the DoD military hospitalization data can be reported in the manner suggested by STIPDA. Likewise with the exception of cause-of-injury codes, outpatient data meeting these specifications are also available.

In addition to hospitalization data, it is also recommended that other nonfatal injury data be utilized for surveillance. The most commonly recommended nonhospitalized medical data source is emergency departments.[6,11,13,34,35] Several national surveys and national hospital samples report these data.[36–40] A number of states have surveillance systems for nonfatal injuries that track hospitalizations and emergency department visits but do not track all outpatient care, as is done in the DMSS. When he published his article in 2003, Horan noted that only 17 states had developed emergency department surveillance systems, and none were reported to have the ability to conduct surveillance of all outpatient injuries.[6] As a result, direct comparisons of military outpatient data to most national or state data are not possible at this time.

As with hospitalization data, outpatient data for nondeployed military personnel treated in ambulatory care clinics are virtually 100% complete. However, as mentioned earlier, there is no cause coding for outpatient injuries. Outpatient data are also linked to demographic data for all service members. Data on age, race, gender, marital status, military occupational skills, and other specifics are available for public health purposes. However, there are differences among services in capture of health data, especially outpatient data when, for instance, shipboard medical data for the Navy are not captured. Because of its nature the army has the most complete data.

Nevertheless data are excellent for tracking rates and trends within Services.

Conclusion and Recommendations

There is a growing recognition of the value of medical surveillance to public health, safety, and injury prevention by both civilian[6,13] and military subject matter experts.[1,2] However, priorities for the military are still focused on fatal injuries—primarily motor vehicle and aviation crashes. In comparison to hundreds of thousands of injuries treated in hospitals and outpatient settings each year, there have historically been only a few hundred motor vehicle fatalities per Service each year and a few dozen aviation deaths.[1] These nonfatal injuries have a huge impact on the health and readiness of military units. It has been estimated that nonfatal injuries result in almost 25 million days of limited duty annually for the Services.[10] As shown in this paper, falls, sports, and physical fitness training result in far more nonfatal injuries than motor vehicle or aviation mishaps and should be given much higher priority for both prevention and research than they are accorded.

The data presented in this paper clearly indicate that injuries are the biggest health problem of the military services for which medical care is sought. Nevertheless, where comparisons can be made with U.S. population data, rates of injuries are similar and may in some cases be lower than for the U.S. and for some states. This suggests that while prevention of injuries should be a top priority for the military, the services are doing a good job of making military training and operations safe.

The DoD has a well-established medical surveillance system that could be used more effectively than it is now. Actions that could be taken to make more effective use of medical surveillance of nonfatal injuries are:

- Make greater use of medical data to identify the biggest problems.
- Monitor rates and trends in injuries to detect emerging injury problems, such as TBI and other injury conditions that are not currently tracked such as noise- and vision-related injuries.
- Integrate nondeployment data as shown in this paper with improved deployment and shipboard data.
- Set priorities based on data on the magnitude of nonfatal as well as fatal injuries and evidence of preventability.
- Make sure prevention of injuries related to falls, sports, physical fitness training, military-vehicle mishaps, and the handling of guns and explosives are priorities for the DoD.
- Where evidence of effective prevention strategies exists, set prevention priorities.
- Where evidence of effective prevention does not exist but large or severe problems are identified, such as falls, set research priorities.
    - For problems that military and civilian communities share, seek to ensure civilian research organizations recognize and share the priority (e.g., fall and sports injury prevention).
    - Where injury problems are unique to the military, develop processes to ensure military research priorities incorporate public health priorities (e.g., military-vehicle mishap–related injuries, falls from military vehicles, and blast-related TBIs).
- Evaluate all newly implemented injury prevention programs and policies and make sure surveillance data and metrics are available to monitor success.
- Make sure medical surveillance data and evidence of prevention effectiveness reach installation and unit commanders and installation safety and medical authorities.
- Improve nonfatal injury surveillance:
    - Integrate medical treatment data from all sites deployed and nondeployed.
    - Report rates of injury for emergency department treatment separately from other outpatient treatment to allow for comparisons to national and state data.
    - Encourage the use of the same coding systems by the military as for civilian U.S. medical care for purposes of comparability.
    - Establish cause coding of injuries treated in outpatient settings.

Current DoD attention to injury prevention offers the military medical departments a greater opportunity to contribute to the prevention of the single biggest health problem of the services. The DoD and military services have an excellent medical surveillance system to monitor injury-related health outcomes and the success of injury prevention programs. If outpatient data systems are improved, the DoD has an opportunity to perform two important actions: first, contribute tremendously to the prevention of injuries in the military services; and second, establish a model for future data-driven, evidence-based injury prevention.

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