A Process to Identify Military Injury Prevention Priorities Based on Injury Type and Limited Duty Days

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Background: Injuries, one of the leading public health problems in an otherwise healthy military population, affect operational readiness, increase healthcare costs, and result in disabilities and fatalities. This paper describes a systematic, data-driven, injury prevention–decision making process to rank potential injury prevention targets.

Methods: Medical surveillance and safety report data on injuries for 2004 were reviewed. Nonfatal injury diagnoses (ICD-9-CM codes) obtained from the Defense Medical Surveillance System were ranked according to incident visit frequency and estimated limited duty days. Data on the top five injury types resulting in the greatest estimated limited duty days were matched with hospitalization and Service Safety Centers' accident investigation data to identify leading causes. Experts scored and ranked the causes using predetermined criteria that considered the importance of the problem, preventability, feasibility, timeliness of intervention establishment/results, and ability to evaluate. Department of Defense (DoD) and Service-specific injury prevention priorities were identified.

Results: Unintentional injuries lead all other medical conditions for number of medical encounters, individuals affected, and hospital bed days. The top ten injuries resulted in an estimated 25 million days of limited duty. Injury-related musculoskeletal conditions were a leading contributor to days of limited duty. Sports and physical training were the leading cause, followed by falls.

Conclusions: A systematic approach to injury prevention–decision making supports the DoD's goal of ensuring a healthy, fit force. The methodology described here advances this capability. Immediate follow-up efforts should employ both medical and safety data sets to identify and monitor injury prevention priorities.

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Introduction

The past decade has witnessed growing recognition[1,2] that injuries are a leading cause of morbidity and mortality for the U.S. military, eroding combat readiness more than any other single disease or health condition in this generally healthy and physically active population, which is relatively free of competing causes of death and severe illness. In 2004, injuries accounted for more service member hospital bed days than any other category of diagnoses.[3] Further, in three measures of the burden of injuries and diseases for the U.S. Department of Defense (DoD)—number of medical encounters, individuals affected, and hospital bed days—injuries led all diseases and other medical conditions (Figure 1).[3]

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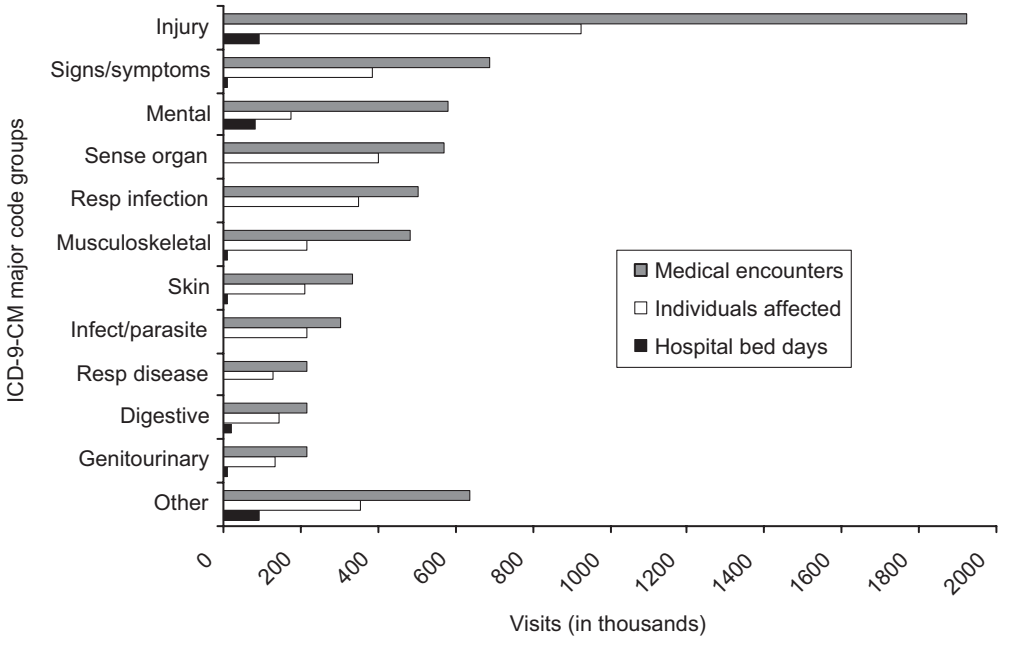

Figure 1. Burden of injuries and diseases on U.S. Armed Forces by ICD-9-CM code groups, 2004

Medical and safety data have revealed that, across all Services (army, navy, Marine Corps, air force), unintentional (accidental) injuries caused 47%–57% of all deaths; 22%–63% of all disabilities; and 22%–31% of all hospitalizations.[4–6] Further, service member injuries cost hundreds of millions of dollars annually, consuming the Services' resources (ALTARUM Institute. Economic analysis of information management requirements: injury cause coding. 2006, unpublished). The thousands of person-years of limited duty time due to injuries reduces military operational effectiveness. To address the magnitude of the injury problem in the U.S. military, in 2003 the Secretary of Defense mandated that rates of unintentional accidents and injuries must be markedly reduced[1] and established the Defense Safety Oversight Council (DSOC) to provide governance over DoD efforts to reduce preventable mishaps.

Subsequently, the DSOC requested the establishment of the DoD Military Injury Prevention Priorities Working Group (DMIPPWG) to develop a systematic, coordinated approach to injury prevention similar to the public health approach, in which surveillance is used to determine the existence and magnitude of the problem, and research or research-like analyses are used to systematically identify modifiable causes, risk factors, and effective prevention strategies.[7–10]

Given the DSOC's interest in preventing injuries resulting in the greatest limited duty time, the prioritization process employed by the DMIPPWG focused on (1) identifying the frequency of injury types from available medical surveillance data; (2) estimating limited duty days by injury type; (3) identifying causes of the injury types resulting in the greatest limited duty time using existing medical and safety data sources; and (4) prioritizing these causes using predefined criteria that required evaluation of a range of factors that are known to influence prevention program and policy success. This prioritization process expands on a prior approach, which measured the magnitude of the injury burden using routinely collected causes of injury hospitalization available from medical surveillance data.[11] The purpose of this paper is to describe the working group's process and data used in the process, and to present the final results that were provided to the DSOC, which included a list of injury program and policy priorities by Service and recommendations for next steps.

Methods

Data Acquisition and Review

The DMIPPWG was formed in September 2005 and held its first meeting in October 2005. The working group was composed of approximately 30 members representing the military Services in the areas of operations, safety, medicine, epidemiology, policy, and research. The working group's steps involved identifying available data sources, obtaining and reviewing data, and outlining a process to determine the leading DoD time-loss injury types and their causes. An injury was defined as any intentional or unintentional damage to the body resulting from acute or chronic overexposure to thermal, mechanical, electrical, or chemical energy or from the absence of such essentials (e.g., heat, oxygen).[12,13]

Injury fatality data were provided by the Mortality Surveillance Division in the Office of the Armed Forces Medical Examiner. The data included cause-specific mortality rates among service personnel. The data captured active duty deaths attributable to unintentional accidents, illnesses, suicides, and homicides in garrison and in deployment settings.

Hospitalization and outpatient visit data for the most current complete year (2004) were obtained from the Defense Medical Surveillance System (DMSS),[14] which is maintained by the Armed Forces Health Surveillance Center (formerly, the Army Medical Surveillance Activity). Data were for active duty service members only, and included visits to fixed (i.e., not temporary) military treatment facilities in the continental U.S. and overseas as well as "purchased care," or visits to external providers paid for by the U.S. military health system. Data for injuries treated in deployed settings were not included in the DMSS, but deployment-related injuries that were treated in garrison were included in the data obtained. To reduce the effect of follow-ups and the resultant overestimation of injury rates, duplicate visits for the same three-digit ICD-9-CM code occurring within 30 days were removed, consistent with established recommendations.[13] Hospitalization (inpatient) data consisted of information captured in the Standard Inpatient Data Record (SIDR). Specifically, the variables obtained for each injury hospitalization were the ICD-9-CM injury diagnosis codes, number of hospital bed days, and the cause of injury associated with the visit. Injury cause codes were determined at the military treatment facility and were coded according to the coding scheme outlined in the North Atlantic Treaty Organization (NATO) Standardization Agreement (STANAG) 2050, Statistical Classification of Diseases, Injuries, and Causes of Death.[15] Outpatient data consisted of information captured in the Standard Ambulatory Data Record (SADR). Specifically, the ICD-9-CM injury diagnosis codes for the injury visit were obtained. For outpatient injuries, days of lost or limited duty and cause of injury were not captured in the electronic records.

Data Analysis

To identify leading injury types by body region, nonfatal (hospitalization and outpatient) data were aggregated by diagnosis and body region using the Barell Matrix.[16] As data on lost and limited duty days were not captured in the outpatient data, numbers of limited duty days and person-years of limited duty days were estimated for injuries treated in outpatient clinics. Orthopedic and sports medicine textbooks[17–22] were consulted for "average" recovery time by body location and diagnosis. Values for days of limited duty were reviewed and validated by a clinical review board (two military physical therapists and a medical doctor, with a combined total of over 50 years of clinical experience). As most reported recovery times fell within a range of days or weeks, generally the midpoint of the range was taken. Given the requirement for all service members to meet and maintain physical fitness standards, days of limited duty, as estimated by midpoint recovery times, result in inability to perform required work activities in most cases.

Estimated days of limited duty were calculated by multiplying the 2004 frequency of visits for each diagnosis and body location by the midpoint recovery time. For example, there were 23,911 outpatient visits for lower-extremity fractures in 2004. The estimated average recovery time for a typical lower-extremity fracture was 120 days. Therefore, the estimated days of limited duty for lower-extremity fractures in 2004 was 2,869,320 days. Person-years of limited duty were calculated by dividing the estimated days of limited duty by 365. Therefore, the estimated person-years of limited duty for lower-extremity fractures in 2004 was 7861 person-years. Given the preponderance of injury-related musculoskeletal conditions among military personnel[23] and the availability of intervention opportunities,[24] this process was completed for both acute injuries (ICD-9-CM 800-999) and injury-related musculoskeletal conditions (selected codes from ICD-9-CM 710-739),[23] as has been recommended when evaluating injuries in the U.S. military population.[13]

The top five injury diagnoses accounting for the greatest limited duty time were then identified based on the estimated total of days of limited duty. Causes of injury data on hospitalizations for the top five time-loss injury types were analyzed and reported. Because causes were not available in the medical surveillance data for a large proportion of injuries (all injuries treated on an outpatient basis), medical visit data on top injury types were also merged with Service safety data to gather additional cause of injury information. Since it is not a requirement for safety reports to be completed for chronic musculoskeletal injuries (i.e., those typically coded in the ICD-9-CM 710-739 code series), additional cause information for injury-related musculoskeletal conditions was not available from the safety data. Safety data for the army were obtained from accident reports in the Army Safety Management Information System (ASMIS), maintained by the U.S. Army Combat Readiness Center. Safety data for the navy and Marine Corps were obtained from accident reports in the navy's Web-Enabled Safety System (WESS), maintained by the Naval Safety Center. Safety data for the air force were obtained from accident reports in the Air Force Safety Automated System (AFSAS), maintained by the Air Force Safety Center. Social security numbers of injured personnel, medical visit date, and accident date were used in the merging process. When visit and accident dates did not directly correspond, if an accident report was filed within 90 days of an injury visit or an injury visit was within 7 days prior to the accident report, it was deemed a match.

Prioritization Process

After determining the top five injury types by estimated limited duty days and identifying the most frequent causes of these injuries, the DMIPPWG then prioritized these injury issues. The working group refined previously developed criteria for setting injury program and policy priorities.[11,25] These criteria were then used to evaluate each injury cause, assessing the importance of the problem (e.g., overall rates, severity of injuries, size of affected population, and degree of concern); preventability (e.g., existence of prevention strategies, effect size of existing strategies, or potential for devel-

opment of prevention strategies); feasibility of establishing programs and policies (e.g., consistency with mission success, sustainability, and resource availability); timeliness of program and policy implementation and results; and potential to evaluate program and policy outcomes (Appendix A). Each injury cause was assigned a score consisting of the sum of scores for each main criteria grouping. The highest possible score was 40. Results of the process produced a list of causes for the injury types resulting in the greatest limited duty time, ranked by their potential for establishment of successful interventions resulting in measurable decreases in the occurrence of such injuries.

Results

Fatal Injuries

It has been reported that injuries cause more deaths than any other health problem confronting military personnel, leading to substantial manpower losses.[26–28] Table 1 displays the leading causes of death for the DoD, Army, Air Force, Navy, and Marine Corps, respectively, in 2004. Although unintentional motor vehicle accidents had been the leading cause of death among service members for decades, deaths from hostile action exceeded those attributable to motor vehicle accidents in 2004. During 2004, however, motor vehicles still accounted for more service member fatalities than the next three categories of causes—suicides, neoplasms, and cardiovascular-related deaths—combined. Across DoD, motor vehicle accidents alone accounted for 22% of deaths in 2004. Motor vehicle accidents were the leading cause of death in the Navy and the second leading cause of death in the Army, Air Force, and Marine Corps (Table 1). Service differences in fatalities from hostile actions are clearly evident, with the highest percentages for the army and Marine Corps, the Services most involved in combat in Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF).

Nonfatal Injuries

Acute injuries resulting in hospitalization. Table 2 displays the distribution of the leading hospitalized acute injuries (i.e., ICD-9-CM 800-999) across the services. Fractures were the leading type of injury resulting in hospitalization across the DoD in 2004. The high frequency of lower-extremity injuries is also apparent, comprising three of the top five most frequent injury types (i.e., fracture of the ankle, fracture of the tibia and fibula, and sprains and strains of the knee and leg) for all but the Marine Corps, where sprains and strains of the lower leg fell below the top five. Across the services, fractures of the lower extremities (ankle, tibia, and fibula) account for the first, second, or third leading injury types resulting in hospitalization.

Acute injuries resulting in outpatient visits. Table 3 shows the acute injury (i.e., ICD-9-CM 800–999) frequency by location and diagnosis for DoD active duty outpatient visits in 2004. More than 500,000 outpatient records for acute injuries were identified. Injuries affecting the lower extremities represented 40.5%. Of the lower extremity–injury types, the most common were sprains and strains, followed by contusions and fractures. Upper extremities were the second leading body

Table 1. Leading causes of death for active duty service members by service, 2004[a]

Causes of death	DoD		Army		Air Force		Navy		Marine Corps	
	n	% (Rank)	*n*	% (Rank)	*n*	% (Rank)	*n*	% (Rank)	*n*	% (Rank)
Hostile	576	40 (1)	309	47 (1)	4	3 (8)	7	3 (8)	256	64 (1)
Motor vehicle	322	22 (2)	138	21 (2)	42	27 (2)	76	34 (1)	66	17 (2)
Suicide	166	12 (3)	54	8 (3)	46	29 (1)	37	17 (2)	29	7 (3)
Neoplasms	66	5 (4)	25	4 (4)	15	10 (3)	19	9 (3)	7	2 (5)
Diseases of heart	49	3 (5)	18	3 (5)	15	10 (4)	14	6 (4)	2	1 (9)
Homicide	40	3 (6)	17	3 (6)	5	3 (6)	13	6 (5)	5	1 (8)
Other transport	35	2 (7)	14	2 (9)	4	3 (7)	10	5 (6)	7	2 (6)
Aviation	33	2 (8)	16	2 (7)	2	1 (10)	3	1 (10)	12	3 (4)
Drug/alcohol	29	2 (9)	15	2 (8)	3	2 (9)	9	4 (7)	2	1 (10)
Drowning	22	2 (10)	5	1 (10)	5	3 (5)	5	2 (9)	7	2 (7)
Other	94	7	43	7	15	10	29	13	7	2

[a]Total deaths: 1432 (DoD); 654 (Army); 156 (Air Force); 222 (Navy); 400 (Marine Corps)
DoD, Department of Defense

Table 2. Distribution of the top five acute injuries resulting in hospitalized service members, 2004[a]

Army	%	Navy	%	Air Force	%	Marine Corps	%
Fracture of ankle	29.0	Fracture of ankle	26.4	Fracture of ankle	30.6	Fracture of face bones	27.2
Fracture of face bones	18.7	Fracture of tibia and fibula	26.4	Fracture of tibia and fibula	20.7	Fracture of tibia and fibula	25.9
Sprains and strains of knee and leg	17.8	Fracture of face bones	17.7	Sprains and strains of knee and leg	17.3	Fracture of ankle	22.3
Fracture of tibia and fibula	17.8	Fracture of radius and ulna	16.1	Fracture of face bones	16.1	Fracture of radius and ulna	19.5
Fracture of radius and ulna	16.6	Sprains and strains of knee and leg	13.4	Injury, other and unspecified	15.3	Open wound of hip and thigh	17.8

[a]Total acute injury hospitalizations: 3640 (Army); 1691 (Navy); 1154 (Air Force); 1388 (Marine Corps)

location, accounting for 24.1% of acute injuries. Of the upper extremity–injury types, the most common were sprains and strains, followed by fractures. Together, lower- and upper-extremity injuries account for nearly 65% of all acute injuries. The third leading body location was head and neck, accounting for 8.6% of the total frequency.

Ranking the leading DoD injuries to determine the five leading injury types based on the total number of days of limited duty was accomplished by calculating the product of the frequency of injury type and the estimated days of limited duty. The estimates for each acute injury diagnosis and body location are shown in Table 4. The leading acute injuries across the DoD based on total days of limited duty, as shown in Table 5, were (1) lower extremity fractures, (2) upper extremity fractures, (3) lower extremity sprains and strains, (4) lower extremity dislocations, and (5) spine and back sprains nad strains.

Contribution of injury-related musculoskeletal conditions. Looking at injury-related musculoskeletal diagnoses codes[23] from the 710–739 series of the ICD-9-CM Diseases of the Musculoskeletal System and Connective Tissue Section (Table 6), lower-extremity overuse injuries (e.g., pain, inflammation, and stress fractures) alone resulted in over 3 million days of limited duty for the DoD. Combining the top five acute injury types (Table 5) and the top five injury-related musculoskeletal conditions (Table 6), the top ten injuries for the DoD, ranked by estimated days of limited duty, are shown in Table 7.

Causes of leading acute injury types. The causes of the top five acute injuries were then determined by (1) matching medical surveillance data on these injuries to detailed cause of injury data available in Service safety reports, and (2) analysis of existing cause codes available in the medical surveillance data for injury hospitalizations. This additional cause information was available for acute injuries only, as injuries that are chronic in nature (i.e., those coded in the ICD-9-CM 710–739 code series) are not required to be reported to the Service Safety Centers, nor are they currently required to be cause coded in the electronic medical surveillance data.

Table 3. Acute injury frequencies by location and diagnosis, DoD active duty outpatient visits, 2004[a]

	Fracture	Dislocation	Sprains/ strains	Contusion/ superficial	Open wound	Other specified	Unspecified	Total
Lower extremities	23,911	15,206	134,137	31,668	7,231	1,601	11,258	225,012 (40.5)
Upper extremities	26,161	7,563	44,037	20,837	20,034	4,771	10,441	133,844 (24.1)
Torso	1,938	148	22,535	9,423	1,464	1,468	2,598	39,574 (7.1)
Spine and back	1,925	1,564	40,073	0	0	220	0	43,782 (7.9)
Head and neck	3,662	92	295	17,194	14,234	5,982	6,367	47,826 (8.6)
Systemwide and late effects	0	0	0	0	0	12,442	0	12,442 (2.2)
Other, unspecified	1,207	97	29,391	15,582	2,597	1,595	2,444	52,913 (10.0)
Total (%)	58,804 (10.6)	24,670 (4.4)	270,468 (48.7)	94,704 (17.1)	45,560 (8.2)	28,079 (5.1)	33,108 (6.0)	555,393 (100.0)

[a]Total injury frequency=555,393

Table 4. Acute injury frequencies and estimated DLD by location and diagnosis, DoD active duty outpatient visits, 2004[a]

	Fracture	Dislocation	Sprains strains	Contusion superficial	Open wound	Other specified	Unspecified	Totals
Lower	23,911	15,206	134,137	31,668	7231	1601	11,258	225012
DLD	120	100	14	7	7	7	7	
Upper	26,161	7563	44,037	20,837	20,034	4771	10,441	133,844
DLD	90	60	7	7	7	7	7	
Torso	1938	148	22,535	9423	1464	1468	2598	39,574
DLD	30	30	30	7	7	7	7	
Spine and back	1925	1564	40,073	0	0	220	0	43,782
DLD	180	60	30	No info	0	7	7	
Head and neck	3662	92	295	17,194	14,234	5982	6367	47,826
DLD	60	No info	30	7	7	7	7	
Systemwide	0	0	0	0	0	12442	0	12,442
DLD	7	7	7	7	7	7	7	
Other, unspecified	1207	97	29,391	15,582	2597	1595	2444	52,913
DLD	60	60	14	7	7	7	7	

[a]Total injury frequency=556,393; total DLD=13,731,568; total person-years of limited duty time=37,621
DoD, Department of Defense; DLD, days of limited duty

The services' data match rate (Table 8) between inpatient acute injury data and safety data was higher than the match rate of the outpatient and safety data. Inpatient/safety match rates were as follows: 52.7% of 423 cases, 22.7% of 580, and 14.5% of 1270 for the Air Force, Navy, and Army, respectively. The outpatient/safety data match rates were as follows: 4.2% of 46,070, 0.2% of 45,553, and 0.6% of 60,945 for the Air Force, Navy, and Army, respectively. Given the low match rates for outpatient and safety data, and the desire to obtain as much cause information from the safety data as possible on the leading injury types, inpatient and outpatient match results were combined. Table 9 shows the leading causes, as captured in safety reports, for the top five DoD acute injury types for 2004.

Operating a motor vehicle or vessel was the leading activity associated with lower-extremity fractures, upper-extremity fractures, and spine/back sprains and strains injury types, while sports and physical training lead other activities for lower-extremity dislocations and lower-extremity sprains and strains. Further, sports and physical training was the number one, two, or three activity associated with each of the five leading DoD injury types. Another activity frequently associated with injuries across the DoD was human movement, a cause category

Table 5. Top five acute injuries by total estimated DLD, DoD active duty outpatient visits, 2004[a]

Rank	Injury	Injury frequency	Estimated DLD per injury	Estimated total DLD	Person-years of limited duty	% total DLD
1	Lower extremities fractures	23,911	120	2,869,320	7,928	20
2	Upper extremities fractures	26,161	90	2,354,490	6,450	17
3	Lower extremities sprains/strains	134,137	14	1,877,918	5,144	14
4	Lower extremities dislocations (including cartilage tears)	15,206	100	1,520,600	4,166	11
5	Spine and back sprains/strains	40,073	30	1,202,190	3,293	9

[a]Total acute injuries (top 5)=239,488; total DLD (for top 5 acute injuries)=9,824,518; total person-years of limited duty time (top 5)=24,586
DoD, Department of Defense; DLD, days of limited duty

Table 6. Top five injury-related musculoskeletal conditions by total estimated DLD, DoD active duty outpatient visits, 2004[a]

Rank	Injury	Injury frequency	Estimated DLD per injury	Estimated total DLD	Person-years of limited duty	% total DLD
1	Lower extremity overuse (pain, inflammation, and stress fractures)	240,796	16	3,803,512	10,420	34.5
2	Torso overuse (pain, inflammation, and stress fractures)	154,683	14	2,165,562	5,933	19.6
3	Upper extremity overuse (pain, inflammation, and stress fractures)	93,750	14	1,314,330	3,600	11.9
4	Unspecified location overuse (pain, inflammation, and stress fractures)	44,707	22	999,035	2,737	9.0
5	Lower extremity sprains, strains, and ruptures	49,438	14	692,132	1,896	6.3

[a]Total musculoskeletal injuries (top 5)=583,374; total DLDs (for top 5 musculoskeletal injuries)=8,874,571; total person-years of limited duty time (top 5)=24,586
DoD, Department of Defense; DLD, days of limited duty

used in safety reports to group activities such as walking, entering or exiting a vehicle, and climbing or mounting an object other than a vehicle. Human movement was consistently the third leading activity associated with injury. Only for spine and back injuries does human movement fall to the fifth leading activity.

Finally, cause coded–injury hospitalization data were analyzed. Table 10 shows the leading DoD injury types matched with the cause codes for 2004 DoD injury hospitalizations. Falls were the leading cause of four of the five top hospitalized injuries (lower-extremity fractures, upper-extremity fractures, lower-extremity dislocations, and spine and back sprains and strains). Guns and explosives were the second leading cause of both lower- and upper-extremity fractures; sports and physical training (PT) were the leading cause of lower-extremity strains and sprains.

Prioritized Injury Mitigation/Prevention Program and Policies

The medical–safety data linkages were then used to develop recommendations for mitigation priorities. These recommendations fall into two critical categories: cause-specific program recommendations and DoD enterprise recommendations.

Table 7. Top 10 injuries by total estimated DLD, DoD active duty outpatient visits, 2004[a]

Rank	Injury	Estimated DLD	Person-years of limited luty	% total DLD	Injury frequency
1	Lower extremities overuse (pain, inflammation, and stress fractures)	3,803,512	10,420	15.3	240,796
2	Lower extremities fractures	2,869,320	7,861	11.5	23,911
3	Upper extremities fractures	2,354,490	6,450	9.4	26,161
4	Torso overuse (pain, inflammation, and stress fractures)	2,165,562	5,933	8.7	154,683
5	Lower extremities sprains and strains	1,877,918	5,144	7.5	134,137
6	Lower extremities dislocations (cartilage tears)	1,520,600	4,166	6.1	15,206
7	Upper extremities overuse (pain, inflammation, and stress fractures)	1,314,330	3,600	5.3	93,750
8	Spine and back sprains and strains	1,202,190	3,293	4.8	40,073
9	Unspecified overuse (pain, inflammation, and stress fractures)	999,035	2,737	4.0	44,707
10	Lower extremities sprains, strains, and ruptures	692,132	1,896	2.8	49,438

[a]Total estimated DLD=24,918,244; total estimated person-years of limited duty time (top 5)=51,500
DoD, Department of Defense; DLD, days of limited duty

Table 8. Service safety–medical data matching results[a]

	Air Force			Navy			Army		
	n	Accident–medical match[b]	Match percentage[c]	Total cases	Accident–medical match[b]	Match percentage[c]	*n*	Accident–medical match[b]	Match percentage[c]
Accident report	2,568	—	—	1,962	—	—	786	—	—
Outpatient	46,070	1,931	4.2	45,553	698	0.2	60,945	387	0.6
Inpatient	423	223	52.7	580	132	22.7	1,270	184	14.5

[a]Accident and medical data matched within 90-day time period
[b]Service members who had both inpatient and outpatient matches defaulted to inpatient
[c]Matched if unique identifiers in safety and medical data matched, and accident report was filed within 90 days of medical visit or if medical visit was within 7 days prior to accident report

Table 11 shows the service reviewers' average scores and rankings of prevention priorities. Based on this prevention prioritization process, each service identified a different number one priority. The Army ranked physical training as its number one priority; the Air Force ranked nonmilitary vehicle accidents as its number one priority; and the Marine Corps ranked guns/explosives as its number one priority. Falls were ranked as the number one priority for the Navy and the third leading priority for all the other services. The Navy, Air Force, and Marine Corps ranked sports and physical training as their second leading intervention priority, while the Army ranked parachuting as its second leading priority.

Discussion

The DMIPPWG's public health approach to answering the question, "What are the leading injuries and their causes in the DoD?" provided a foundation for prevention planning and decision making. Following the consideration of fatal injury, injury prevention efforts were prioritized based on both the scope and nature of inpatient and outpatient injuries. Using an estimated limited duty– day calculation, the net effect of each injury type on military readiness was established. In addition, cause information was obtained from safety data as well as medical data—a unique feature of this prioritization process, given that other military injury prevention–prioritization processes have relied primarily on causes of injury hospitalizations to define the magnitude of the injury burden associated with each cause.[11,29]

While critically important, previous prevention efforts have narrowly targeted particular causes of injury with high lethality to the exclusion of the more common, nonfatal injuries. This effort revealed that deaths are a relatively limited component of the overall injury problem across the DoD. Nonfatal injuries result in substantial morbidity and substantial costs in terms of hospitalization, short- and long-term health effects, and reduced military readiness. Hence, prevention efforts should focus on not only external causes of injury that are fatal, but also those nonfatal injuries associated with particularly high medical readiness and healthcare costs. Toward this end, this multi-service, multidisciplinary epidemiologic, safety, occupational-medicine, and policy effort accomplished the following:

1. Conducted a comprehensive assessment of medical surveillance data—from deaths to outpatient visits—to identify and characterize the scope of injury occurrence in the DoD military population;
2. Developed a prioritization methodology consisting of public health-, safety-, and military-specific components;
3. Assessed the full range of injuries in a military population, including injury-related musculoskeletal conditions;
4. Demonstrated the true magnitude of impact that injuries have on the physical readiness of the U.S. military by calculating, for the first time, the days of limited duty associated with these injuries; and,
5. Used criteria and a systematic evaluation process for prioritizing DoD injury prevention programs and policies.

More specifically, using available information from medical and service safety databases, this effort determined the top ten acute and chronic injuries across the DoD military service member population, which accounted for approximately 25 million days of limited duty, an indicator of and surrogate for costs to military readiness. Including injury-related musculoskeletal conditions was an important piece of this process, as the burden of injury in terms of days of limited duty was two times greater with the inclusion of injury-related musculoskeletal conditions. These conditions, coded outside the Injury and Poisoning section of ICD-9-CM (800–999), include diagnoses such as recurrent dislocations, stress fractures, and Achilles tendinitis; conditions that providers in sports medicine, occupational medicine, and other fields typically consider injuries. Based on

these findings, the DMIPPWG recommended that the greatest impact on reducing injuries across the DoD may be achieved via efforts focused initially on mitigation of sports and physical training–related injuries, and then on reducing falls.

Although the primary goal was to look at leading injury types across the DoD, service differences in types of injury shown in this analysis also provided valuable information. These differences in type and frequency probably reflect differing missions. Consequently, these differences may provide insight regarding how best to approach prevention, through detailed characterization and comparison across the services. More rigorous evaluation of these differences would further inform DoD prevention initiatives.

Several limitations must be considered in interpreting these findings. First, the study time period of 1 year (2004) provides a "snapshot" of injury occurrence in the DoD. This time frame appears to be representative of the general injury trends; an analysis was not conducted, however, to validate this assumption. As the DoD operational tempo and population changes (e.g., increased activation of National Guard and Reserve components), it is possible that injury frequency and leading injury types may also change.

Second, determination of the leading injury causes was based on the relatively small proportion of the data for which there was a medical and safety data match or for which cause of hospitalization was obtained. Although the present findings are consistent with prior, smaller efforts to assess causes, the sample may not be fully representative of the causes of the leading injuries in the DoD. The higher match percentage for hospitalizations may be attributable to the fact that injury hospitalizations frequently result in lost duty days and trigger mandatory reporting to the service member's unit. The hospitalizing injury event may also have a higher level of visibility, making it more likely to be reported to safety authorities and investigated. The individual's unit, commander, and family would also be more likely to be aware of the injury, resulting in a higher likelihood of reporting and follow-up investigation. Mandatory cause coding of outpatient medical data and/or improved safety reporting of injuries treated on an outpatient basis would greatly enhance the DoD's ability to characterize specific mechanisms of injury and appropriately focus prevention efforts on the mechanisms contributing to leading injury types. The addition of mandatory cause coding of outpatient electronic medical records data would also contribute to future prioritization efforts and assist the DoD with measuring the success or failure of mitigation strategies.

Third, misclassification and incomplete capture of injuries in the military medical surveillance data were possible given the reliance of coders on provider documentation, which may be nonspecific or unclear (e.g., nonspecific initial diagnosis of "pain" with referral, and interchangeable use of "chondromalacia patellae" and "anterior knee pain").

Finally, it is critically important to note that difficulties in data availability presented a major challenge in this effort. The lack of days of limited duty in the outpatient data required the use of estimates of days of limited duty for assessing the cost of job restrictions and inability to perform required work activities (e.g., physical training, which is necessary to meet physical fitness standards required for deployment). In addition, as mentioned previously, without medical surveillance data on causes of injuries treated in outpatient settings, a relatively time-intensive and low-yield matching to safety data was conducted in order to incorporate this information into the prioritization effort. Enhanced DoD injury surveillance would be a key tool for future prioritization efforts. Until these issues are addressed, knowledge of the true impact of future injury reduction efforts within DoD will be incomplete at best. Given the incomplete, independent, and immature nature of the existing data systems, there is an inherent degree of uncertainty in any assessment or measure of success or failure in mitigation strategies. Only through a robust military population–based surveillance program for fatal and nonfatal injuries and thorough investigation and documentation of nonfatal injuries will the military service community adequately address the injury problem.

Prioritized Opportunities for Improvement

Based on the above analysis, the following recommendations for improvement in the identification, tracking, policy and program intervention, and research related to noncombat injuries are offered. The recommendations are categorized under four headings: Data and Data System Issues, Process Recommendations, Intervention Recommendations, and Research Recommendations.

Data and Data System Issues Recommendations

DoD must harmonize service safety data systems to ensure comparable injury cause data for greater ease and accuracy of analysis. A focused effort by a group of DoD subject matter experts should develop a standardized set of injury/mishap reporting data elements and definitions, which would be incorporated into the services' automated systems and compatible with the Defense Safety Enterprise System. Specifically, a working group should be chartered to standardize reporting requirements, and

Table 9. Leading injury types and associated injury activities as noted in safety reports, by service, 2004

Injury type	Rank	Army			Air Force			Navy		
		Activity	*n*	%	Activity	*n*	%	Activity	*n*	%
Lower-extremity fractures	1	Parachuting	52	26.7	Operating vehicle/vessel	133	31.3	Operating vehicle/vessel	116	40.6
	2	Operating vehicle/vessel	38	19.5	Sports/physical training	82	19.3	Sports/physical training	93	32.5
	3	Sports/physical training	35	17.9	Human movement	72	16.9	Human movement	23	8.0
	4	Human movement	18	9.2	Passenger	23	5.4	Maintenance/repair/service	15	5.2
	5	Passenger	9	4.6	Maintenance/repair/service	5	1.2	Handling materials/pass	5	1.7
	6	Handling materials/pass	8	4.1	Handling materials/pass	3	0.7	Seamanship	4	1.4
	7	Maintenance/repair/service	7	3.6	Observing/standing	2	0.5	Security	5	1.7
	8	Other	28	14.4	Other	105	24.7	Other	25	8.7
	Total		195	100		425	100		286	99.8
Upper-extremity fractures	1	Operating vehicle/vessel	35	29.9	Operating vehicle/vessel	216	38.8	Operating vehicle/vessel	121	43.5
	2	Passenger	22	18.8	Sports/physical training	130	23.4	Sports/physical training	98	35.3
	3	Sports/physical training	18	15.4	Passenger	27	4.9	Human movement	20	7.2
	4	Human movement	15	12.8	Human movement	21	3.8	Maintenance/repair/service	10	3.6
	5	Maintenance/repair/service	6	5.1	Observing/standing	2	0.4	Handling materials/pass	4	1.4
	6	Soldiering	5	4.3	Maintenance/repair/service	1	0.2	Seamanship	5	1.8
	7	Weapons firing/hand	4	3.4	Handling materials/pass	1	0.2	Security	2	0.7
	8	Other	12	10.3	Other	158	28.4	Other	18	6.5
	Total		117	100		556	100.1		278	100
Lower-extremity sprains/strains	1	Sports/physical training	18	29.5	Sports/physical training	238	34.7	Sports/physical training	100	66.2
	2	Parachuting	15	24.6	Operating vehicle/vessel	144	21.0	Operating vehicle/vessel	28	18.5
	3	Operating vehicle/vessel	10	16.4	Human movement	49	7.1	Human movement	8	5.3
	4	Human movement	4	6.6	Passenger	21	3.1	Maintenance/repair/service	2	1.3
	5	Handling materials/pass	3	4.9	Handling materials/pass	1	0.1	Security	2	1.3
	6	Maintenance/repair/service	3	4.9	Other	233	34.0	Weapons firing/hand	1	0.7
	7	Soldiering	3	4.9	—	—	—	Other	10	6.6
	8	Other	5	8.2	—	—	—	—	—	—
	Total		61	100		686	100		151	99.9
Lower-extremity dislocation	1	Sports/physical training	5	55.6	Operating vehicle/vessel	19	37.3	Sports/physical training	12	46.2
	2	Handling materials/pass	1	11.1	Sports/physical training	21	41.2	Operating vehicle/vessel	9	34.6
	3	Operating vehicle/vessel	1	11.1	Passenger	2	3.9	Human movement	3	11.5
	4	Passenger	1	11.1	Human movement	1	2.0	Other	2	7.7
	5	Parachuting	1	11.1	Other	8	15.7	—	—	—
	Total		9	100		51	100.1		26	100
Spine and back sprains/strains	1	Operating vehicle/vessel	27	62.8	Operating vehicle/vessel	164	44.7	Operating vehicle/vessel	58	65.2
	2	Parachuting	4	9.3	Passenger	47	12.8	Sports/physical training	14	15.7
	3	Soldiering	3	7.0	Sports/physical training	27	7.4	Human movement	6	6.7
	4	Sports/physical training	3	7.0	Handling materials/pass	25	6.8	Handling materials/pass	3	3.4

(continued on next page)

Table 9. *(continued)*

Injury type	Rank	Army			Air Force			Navy		
		Activity	*n*	%	Activity	*n*	%	Activity	*n*	%
	5	Other	6	14.0	Human movement	13	3.5	Maintenance/repair/service	2	2.2
	6	—	—	—	Other	91	24.8	Security	1	1.1
	7	—	—	—	—	—	—	Seamanship	1	1.1
	8	—	—	—	—	—	—	Other	4	4.5
	Total		43	100.1		367	100		89	99.9

Total medical visits matched to safety data: 425 (Army), 2085 (Air Force), 830 (Navy)

then to revise DoD 6055.7, "Mishap Investigation, Reporting and Recordkeeping," to clarify reporting requirements. A single system or set of systems must allow for the efficient capability to evaluate existing personnel, medical, and safety surveillance data (e.g., deaths, disabilities, hospitalizations, outpatient visits, medical evacuations, safety/accident data, and other) to identify the injury problems with the greatest impact on health and readiness for each of the Services and across the DoD.

The DoD should improve injury surveillance and reporting. A first step would be to investigate opportunities to increase accuracy and capture of data elements essential to injury prevention, such as injury cause, from medical data systems. New efforts such as the Medical Affirmative Claims enhancement program may provide more robust capabilities than are currently available and should be thoroughly investigated. The DoD should also assess opportunities to increase compliance with mishap-reporting directives by linking the medical treatment event with notification of the unit safety organization. Because mishap reporting will always provide the best injury-cause information, and medical treatment data provide the best injury-type information, linking these two reporting events is vital for accurate assessment of leading causes and types of injury and measurement of the true impact of intervention efforts.

Table 10. Top ten causes of acute injury hospitalizations for leading injury types, DoD active duty, 2004[a]

	Lower-extremity fractures (*n*=736)	Upper-extremity fractures (*n*=447)	Lower-extremity dislocations (*n*=72)	Lower-extremity sprain/strain (*n*=291)	Spine and back sprain/strain (*n*=28)	Total (% of total)
Falls	206	144	23	75	10	458 (29.1)
Sports and physical training	66	40	13	128	1	248 (15.8)
Guns and explosives	100	98	0	0	0	198 (12.6)
Nonmilitary vehicle (POV)	84	66	7	8	4	169 (10.7)
Twist/turn/run/slip (without fall)	44	2	15	54	0	115 (7.3)
Parachuting	92	3	3	10	4	112 (17.1)
Tools and machinery	18	27	0	1	0	46 (2.9)
Military vehicle accident	24	15	1	1	2	43 (2.7)
Nontraffic accident (POV and military)	16	9	1	1	1	28 (1.8)
Other[b]	15	9	3	5	1	33 (2.1)
Missing STANAG	71	34	6	8	5	124 (7.9)

[a]Total top 10 cause coded injury hospitalizations=1574. Includes military treatment facilities and purchased care. Cause codes available for acute injuries (ICD-9 800-999) only.

[b]Other includes lift/push/pull, marching/drilling, air accident, water accident, poisons, and environmental

DoD, Department of Defense; STANAG, North Atlantic Treaty Organization Standardization Agreement

Table 11. Injury program and policy prioritization results by service

Causes of injury	Air Force		Army[a]		Marine Corps		Navy	
	Average score (max=40)	Rank	Average score (max=40)	Rank	Average score (max=40)	Rank	Average score (max=40)	Rank
Sports and physical training (PT)[a]	29.2	2	PT: 34.0 Sports: 28.4	PT: 1 Sports: 4	28.5	2	27	2
Nonmilitary vehicle accident (POV)	32.0	1	27.2	5	24.3	4	26	3
Falls	26.3	3	30.6	3	28	3	28	1
Twist/turn (w/o fall)	21.8	6	24.6	8	20.7	7	19.3	6
Nontraffic (POV and Mil)	20.3	7	19.4	10	17.8	8	19	7
Parachuting	20.2	8	31.8	2	Not ranked	Not ranked	16	8
Guns and explosives	24.2	4	26.2	6	36.3	1	22.8	4
Military vehicle	23.0	5	26.2	6	23.5	5	Not ranked	Not ranked
Tools and machines	Not ranked	Not ranked	21.0	9	21.5	6	21.8	5

[a]The Army ranked Sports separate from Physical Training; the other services provided a combined score.
PT, physical training

Process Recommendations

Substantial process improvement opportunities exist in the DoD injury prevention efforts. The DoD would benefit from an institutionalized periodic and systematic process to identify injury programs and policy priorities, as described in this paper. The process should be conducted with a multidisciplinary team of policymakers, safety professionals, public health scientists, and others. Employing a criteria-based process is essential for the objective evaluation of proposed prevention initiatives based on factors that contribute to the eventual success or failure of programs. Criteria should include an assessment of the magnitude of the problem, the existence of necessary infrastructure to support programs, and the effect of the program on military readiness and the individual service member. A similar process to prioritize research is also necessary. Criteria to prioritize research have been suggested elsewhere.[30]

To make the most efficient use of limited resources, harmonize intervention package materials so that they can be used across the DoD by addressing issues of compatibility; ease or difficulty of use of materials; training, planning, and implementation challenges; cost–benefit ratios; adaptability; and the effect on the military mission. Use an existing or newly formed venue to better coordinate evidence-based assessment of DoD injuries, causes, and mitigation efforts, and to share valuable information throughout DoD. The effort should: (1) have multidisciplinary (safety, epidemiology, occupational health, behavioral health, and policy) membership; (2) adopt the evidence-based process described in this report; (3) enhance dissemination of effective interventions for reducing injuries; and (4) periodically report to the DSOC.

Intervention Recommendations

The working group's recommendations regarding interventions were as follows: (1) Evaluate environmental, behavioral, directive, or regulatory interventions to prevent injuries related specifically to sports and physical training; (2) endorse evidence-based recommendations from systematic reviews for physical training injury prevention, including but not limited to parachute ankle braces, mouth guards, breakaway bases for softball, and ankle braces for sports with high risk of ankle injury such as basketball; (3) provide resource and policy priority to the biggest, most preventable problems identified, which include, but are not limited to, sports and military physical training, falls, and nonmilitary vehicle accidents; (4) endorse the Joint Services Physical Training Injury Prevention Working Group's recommendations for the prevention of physical training–related injuries.[31]

Research Recommendations

This effort identified strategic research needs that could greatly enhance prevention opportunities in the DoD. These areas of research needs included the following: (1) epidemiologic research on falls and physical training in operational units; (2) enhanced methods to obtain

injury data for sports-, exercise-, and recreation-related injuries; (3) assessment of the impact of leading injuries on disability and medical separation; (4) and evaluation of current methodologies and results to ensure application in the deployed environment.

In conclusion, the prioritization process results provided valuable information to focus current DoD prevention efforts on leading causes of nonfatal injuries requiring medical treatment. This information has substantial value when used for evaluating the impact of injuries on military service members and setting priorities to determine where limited resources should be allocated to reduce injuries. In addition, the working group recommendations provided guidance for DoD leadership for potential next steps in DoD injury prevention.

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Appendix A—Department of Defense Military Injury Prevention Priorities Working Group Criteria for Prioritizing Injury Programs and Policies

Injury Problem:	
Service:	
Date:	
Rater's Initials:	

Purpose: This scorecard is a tool that provides a systematic means of assessing and quantifying the state of prevention programs and policies for a specific injury problem. The criteria and scoring were developed by military and civilian injury researchers, medical providers, and safety experts. Comparing total scores obtained using this scorecard can assist with injury program and policy prioritization efforts.

How to use this scorecard: Complete a scorecard for each injury problem under consideration. First, provide a preliminary rating for each of the *Considerations* listed under each criterion. Then, using the preliminary ratings as a guide, assign a final score for each criterion. For criteria B, C, and D, assign a final score from 1 to 10 (1=lowest score, 10=highest score). For criterion E, assign a final score from 1 to 5 (1=lowest score, 5=highest score). Adding the final scores will provide a total score. A perfect score on all criteria would result in a total score of 40.

Criterion	Preliminary rating	Final score
A. Program or policy is consistent with mission of the working group	[ ] YES	
Consideration: Reduce injury rates by 50%	[ ] NO	
B. Importance of problem to force health and readiness (10 points)		**(10 points; 1=low, 10=high)**
Considerations:		
1. Magnitude of the problem (e.g., frequency, incidence)	1. [ ] Low [ ] Medium [ ] High	
2. Severity of problem (consider its effect on personnel readiness)	2. [ ] Low [ ] Medium [ ] High	
3. Cost of the problem (consider training, property, and personnel costs)	3. [ ] Low [ ] Medium [ ] High	
4. Size of population at risk	4. [ ] Low [ ] Medium [ ] High	
5. Degree of concern (consider command concern, public and Service member concern, visibility of problem)	5. [ ] Low [ ] Medium [ ] High	
C. Preventability of problem (10 points)		**(10 points; 1=low, 10=high)**
Considerations:		
1. Proven prevention strategies that could reduce current injury rates exist[a]	1. [ ] Low [ ] Medium [ ] High	

Criterion	Preliminary rating	Final score
2. Effect size	2. [ ] Low [ ] Medium [ ] High	
3. Cause(s) are identifiable	3. [ ] Low [ ] Medium [ ] High	
4. Risk factors are modifiable	4. [ ] Low [ ] Medium [ ] High	
5. Prevention strategies that reduce existing injury rates can be designed	5. [ ] Low [ ] Medium [ ] High	
D. Feasibility of program or policy (10 points)		**(10 points; 1=low, 10=high)**
Considerations:		
1. Existence of infrastructure to support implementation and sustainability of the program or policy (consider medical staff and facilities, safety staff and resources, cadre availability)	1. [ ] Low [ ] Medium [ ] High	
2. Perceived adequacy of funding to support implementation and sustainability	2. [ ] Low [ ] Medium [ ] High	
3. Authority to implement and sustain the program or policy is held or obtainable by the implementing organization(s)	3. [ ] Low [ ] Medium [ ] High	
4. Program or policy will not undermine essential missions	4. [ ] Low [ ] Medium [ ] High	
5. Political and cultural acceptability of program or policy	5. [ ] Low [ ] Medium [ ] High	
6. Accountability and responsibility for implementation and sustainability exists or can be established	6. [ ] Low [ ] Medium [ ] High	
E. Timeliness (5 points)		**(5 points; 1=low, 5=high)**
Considerations:		
1. Implementation time[b]	1. [ ] Low [ ] Medium [ ] High	
2. Results time	2. [ ] Low [ ] Medium [ ] High	
F. Evaluation of program or policy (5 points)		**(5 points; 1=low, 5=high)**
Considerations:		
1. Ability to evaluate effects of program or policy exists (consider if a metric is possible)	1. [ ] Low [ ] Medium [ ] High	
2. Benefits of program or policy outweigh the costs of implementation and sustainability	2. [ ] Low [ ] Medium [ ] High	
3. Collateral benefits as a result of implementation (i.e., increased readiness, decreased attrition, decreased other health problems)	3. [ ] Low [ ] Medium [ ] High	
TOTAL SCORE		

[a]If systematic reviews substantiate effectiveness of a prevention strategy, score as 10 points automatically.
[b]Assign shorter implementation and response times a higher rating.