Frequency and Causes of Nonbattle Injuries Air Evacuated from Operations Iraqi Freedom and Enduring Freedom, U.S. Army, 2001–2006

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Introduction: Medical information systems during past military deployments had limited injury surveillance capability as data were not accessible during deployments and did not capture causes of injury. This paper describes nonbattle injury (NBI) results from an ongoing surveillance program that identifies injury occurrences and causes during deployments for Operations Iraqi Freedom (Iraq) and Enduring Freedom (Afghanistan).

Methods: U.S. Army soldiers medically air evacuated from Iraq (March 2003–December 2006) or Afghanistan (October 2001–December 2006) were identified from air evacuation records that provided demographics, casualty type, diagnosis, and patient history. For NBI cases, the patient history was used to identify and code injury cause, incident circumstances, and body region. Descriptive statistics were used to describe and compare NBIs evacuated from Iraq and Afghanistan.

Results: In all, 27,563 soldiers in Iraq and 4165 in Afghanistan were air evacuated. NBIs accounted for 35% and 36% of cases, respectively, and were the largest single category of evacuations for both operations. Distributions for leading categories of NBI diagnosis (fracture, inflammation/pain, and dislocation) and body region (back, knee, and wrist/hand) were similar for both operations. Leading NBI causes were the same for both operations—sports/physical training (19%–21%), falls/jumps (18%), and motor vehicle–related incidents (12%–16%)—but the proportion of motor vehicle incidents was higher in Iraq ($p<0.001$).

Conclusions: Routinely collected air evacuation records provided the basis for ongoing injury surveillance for Iraq and Afghanistan. NBI was the largest category of evacuations from both operations. Leading NBI causes were similar to those identified for previous deployments and many should be preventable.

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Introduction

Nonbattle injuries (NBIs) have become a major cause of morbidity and mortality during combat operations. Whereas infectious disease was the leading cause of nonbattle hospitalizations in World Wars I and II and the Korean War,[1–3] beginning with the Vietnam War, injuries have been the leading cause of nonbattle admissions.[4–6] This shift in relative importance of NBIs has been described for marines,[1,4,5] sailors,[1] and soldiers.[2,7–10] During Operations Desert Shield and Storm (ODS&S) in 1990–1991 and Operation Joint Endeavor (OJE) in Bosnia (1995–1996), NBI was the leading category of hospitalizations, accounting for 25% and 20%, respectively.[6,7,11] Musculoskeletal and connective tissue conditions made up the second leading category of hospitalizations in ODS&S (14%) and the fourth leading category in OJE (10%). Motor vehicle crashes (19%), falls (19%), and sports (18%) were the top

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three causes of NBI admissions in ODS&S.[6,11] Moreover, in ODS&S, the number of nonbattle deaths from unintentional trauma (n=183) exceeded the number of battle-related deaths (n=147).[12]

Even though the impact of NBIs during military operations is well recognized, the epidemiology of these injuries is poorly understood. During past military operations, analyses to describe injury incidence, types, severity, causes, and treatment outcomes were conducted at the completion of the operations when copies of the medical records were centralized for review. Lessons learned from these retrospective analyses led to major advancements in medical evacuation, treatment, and rehabilitation that have greatly benefited injured service members. This retrospective approach to injury surveillance did not, however, allow identification of injury problems early in the deployments when changes in practice and policy could have lowered the injury risk for deployed soldiers.

Even today, limitations in the electronic medical record system used during military deployments affect our ability to conduct high-quality, responsive injury surveillance during deployments. These limitations include the inability to identify all injury occurrences and inadequate recording of precipitating causes. Efforts are underway to improve existing medical record systems, but, in the meantime, these limitations reduce the effectiveness of injury surveillance efforts. Given these limitations, it was necessary to identify other sources of medical information that could be used to conduct routine injury surveillance.

In 2004, the Injury Prevention Program of the U.S. Army Center for Health Promotion and Preventive Medicine demonstrated that routinely collected air medical evacuation records could be used to conduct ongoing injury surveillance during Operations Iraqi Freedom (Iraq) and Enduring Freedom (Afghanistan).[13] Two previous reports described the benefits of using the air evacuation records for general medical surveillance during military operations.[14,15] The air evacuation record system—U.S. Transportation Command (TRANSCOM) Regulating and Command & Control Evacuation System (TRAC^{2}ES)—is used to request and coordinate air evacuation of service members with serious injuries and diseases. Characteristics of these records important for injury surveillance include: (1) complete capture of injuries (nonbattle and battle injuries) and illnesses (diseases) serious enough to require evacuation from the theater; (2) data completeness—all data elements must be entered before the patient can be air evacuated; (3) use of standardized diagnosis codes; (4) descriptions of the injury incident and cause in the patient history; (5) accessibility of the records (monthly); and (6) potential to link with data from other systems. Since 2004, air evacuation records have been used to monitor the frequency, rates, types, and causes of serious injuries (NBIs and battle injuries) and diseases during current military operations.

The purpose of this paper is to (1) demonstrate the utility of air evacuation records for injury surveillance during military deployments and (2) describe the frequency, rate, types, and causes of NBIs that required medical air evacuation of U.S. Army soldiers since the beginning of the operations in Iraq (March 2003) and Afghanistan (October 2001) to December 2006.

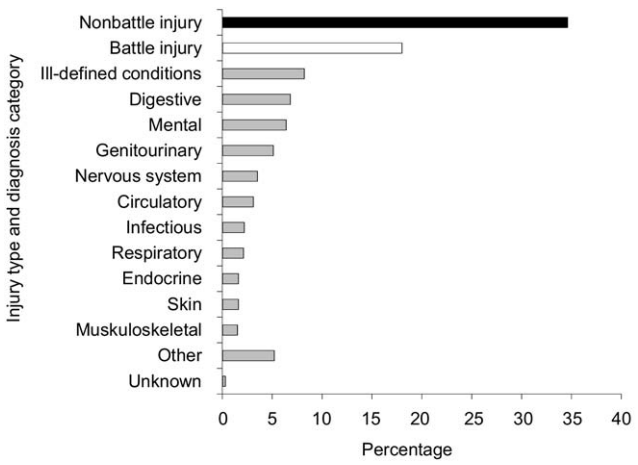

Figure 1. Distribution of air evacuation cases by injury type and diagnosis category for Iraq (2003–2006)[a,b]
[a]Air evacuation cases: n=27,563
[b]Percentages represent the percentages of all evacuation cases within each group

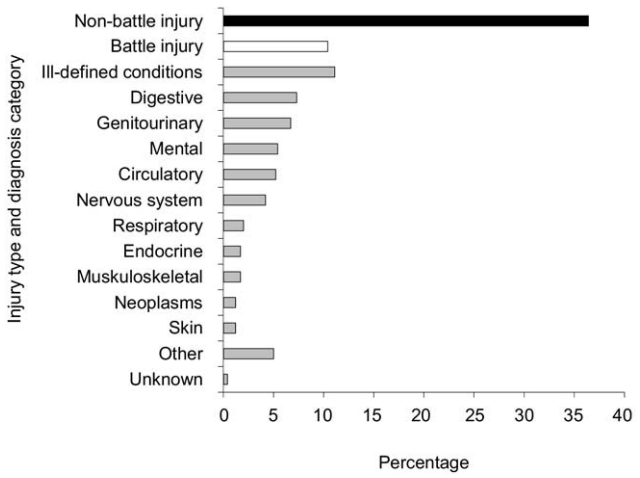

Figure 2. Distribution of air evacuation cases by injury type and diagnosis category for Afghanistan (2001–2006)[a,b]
[a]Air evacuation cases: n=4165
[b]Percentages represent the percentages of all air evacuation cases within each category

Methods

Army soldiers who were air evacuated from Iraq or Afghanistan to a military hospital in Germany or the U.S. were identified from air evacuation records provided by the TRAC[2]ES Program Office at Brooks Air Force Base. For this analysis, an air evacuation case was any deployed soldier (regular Army, Army Reserve, or Army National Guard) who required air evacuation for an injury (NBI or battle injuries) or disease between October 2001 and December 2006. If a previously air-evacuated soldier deployed again (i.e., a second deployment) to Iraq or Afghanistan after recovering from the first injury or disease, and required air evacuation for a different injury or disease, both air evacuation episodes were included as cases.

The following data were abstracted for each case: age, gender, rank, operation (Iraq or Afghanistan), date of air evacuation, origin and destination of each air evacuation movement, casualty type, diagnosis, anatomical location of injury, and narrative patient history. When available, accident (Army Safety Management Information System) and casualty reports (Defense Casualty Information Processing System) were linked to air evacuation records for injury cases. These reports provided additional details about the incident circumstances and injury cause.

Trained injury coders used a computerized data-entry tool to review the combined data elements for each case. Some of the most important data elements were the diagnosis and text fields that described the patient history and incident circumstances. After a thorough review of each case, important details were re-coded for this analysis. Based on the diagnosis, casualty type, patient history, and incident circumstances, each case was classified as an NBI, battle injury, or disease. For injury cases (NBI and battle injury), cause of injury was determined whenever possible, and was coded using a standardized scheme described in the North Atlantic Treaty Organization (NATO) Standardization Agreement (STANAG) No. 2050, 5th Edition and commonly referred to as the STANAG codes.[16] Other important details about injury incidents were also coded using variables developed for this analysis.

Descriptive statistical methods were used to describe the (1) distribution of injury types (NBI and battle injury) and diagnosis categories for diseases, (2) demographic characteristics of soldiers air evacuated for NBIs, (3) frequency and rates of air-evacuated NBIs, (4) distribution

Table 1. Age, gender, and military rank of soldiers air evacuated for nonbattle injuries from Iraq (2003–2006) and Afghanistan (2001–2006) and for all deployed soldiers (2001–2006)[a]

Characteristic and category	Iraq (*n*=9530)		Afghanistan (*n*=1515)		*p*-value[b]	All deployed soldiers[a]
	n	%	*n*	%		%
Age group (years)						
17–19	256	2.7	51	3.4	0.13	5.8
20–29	4661	48.9	751	49.6	0.63	56.0
30–39	2904	30.5	452	29.8	0.62	26.7
40–49	1381	14.5	204	13.5	0.29	9.7
50–59	310	3.3	51	3.4	0.82	1.8
≥60	2	0.0	0	0.0	—	0.01
Unknown	16	0.2	6	0.4	0.11	0.00
Gender						
Male	8712	91.4	1399	92.3	0.23	89.8
Female	814	8.6	115	7.6	0.22	10.2
Unknown	4	0.0	1	0.1	0.52	0.01
Military rank						
Junior enlisted[c]	4486	47.1	666	44.0	0.02	47.9
Noncommissioned officer[d]	3997	41.9	613	40.5	0.28	35.6
Senior noncommissioned officer[e]	184	1.9	49	3.2	<0.01	2.4
Commissioned officer[f]	580	6.1	111	7.3	0.06	10.0
Warrant officer[g]	162	1.7	44	2.9	<0.01	1.8
Unknown	121	1.3	32	2.1	<0.01	2.3

[a]Distribution by demographic categories for all soldiers (includes injured and non-injured) who deployed to Iraq and Afghanistan from October 2001 to December 2006
[b]*p*-value comparing the demographic category for Iraq and Afghanistan
[c]Includes enlisted ranks E-1 to E-4
[d]Includes enlisted ranks E-5 to E-7
[e]Includes enlisted ranks E-8 to E-9
[f]Includes commissioned officers O-1 to O-7
[g]Includes warrant officers WO-1 to WO-4

of NBI types and anatomical locations, and (5) distribution of NBI causes. The chi-square test of proportions was used to compare these distributions for Iraq and Afghanistan. To calculate estimated NBI rates (injuries/1000 deployed person-years), the estimated deployed person-time for each year (2001 to 2006) of each operation was obtained from the Armed Forces Health Surveillance Center. All results were reported separately for Iraq and Afghanistan.

Results

From October 2001 to December 2006, some 31,197 soldiers were air evacuated from Iraq or Afghanistan for an injury or disease. Including air evacuations during subsequent deployments to Iraq and/or Afghanistan, 515 of these soldiers were air evacuated twice and eight were air evacuated three times for different (new) injuries and/or diseases. Including these additional cases, the total number of cases was 31,728 (NBI: $n=11,045$; battle injury: $n=5401$; diseases: $n=15,282$). Ninety-two soldiers with an NBI were air evacuated for two different injuries that occurred during different deployments.

There were 27,563 air evacuation cases from Iraq that included 9530 NBIs, 4968 battle injuries, and 13,065 diseases. Figure 1 shows the distribution of these cases by injury type (NBI or battle injury) or diagnosis category for diseases. NBI was the largest single category (34.6%), followed by battle injury (18.0%).

From Afghanistan, there were 4165 air evacuation cases, including 1515 NBIs, 433 battle injuries, and 2217 diseases. Figure 2 shows the distribution of these cases by injury type (NBI or battle injury) or diagnosis category for diseases. Similar to the findings for Iraq, NBI was the largest single category (36.4%) for Afghanistan. The proportion of NBI cases was 3.3 times higher than the next largest category, ill-defined signs and symptoms (11.1%). Battle injury was the third leading category (10.4%) in Afghanistan and accounted for a smaller proportion of cases than in Iraq ($p<0.001$).

Demographic characteristics including age, gender, and military rank of the soldiers who were air evacuated from Iraq and Afghanistan for an NBI are described in Table 1. There were no differences in the age and gender distributions for soldiers from Iraq and Afghanistan. Overall, more than half of soldiers were under the age of 30 (Iraq: 51.6%; Afghanistan: 53.0%) and more than 80% were under the age of 40 (Iraq: 82.1%; Afghanistan: 82.8%). Female soldiers accounted for only 8.6% and 7.6% of NBIs in Iraq and Afghanistan, respectively. More injured soldiers in Iraq were junior enlisted rank ($p=0.02$), while more soldiers in Afghanistan were senior noncommissioned officers ($p=0.001$) or warrant officers ($p=0.001$). For comparison, the age, gender, and rank distributions for all soldiers (includes injured and non-injured) who deployed to Iraq and Afghanistan between October 2001 and December 2006 are also included in Table 1.

While the overall NBI rates (NBIs/1000 deployed person-years) for Iraq (2003–2006) and Afghanistan (2001–2006) differed ($p<0.001$) (Table 2), the combined yearly rates for years 2003 to 2006 when both operations were ongoing were the same (Iraq: 18.4/1000 person-years; Afghanistan: 18.4/1000 person-years; $p=0.93$). Different patterns were noted, however, when comparing yearly rates between and within Iraq and Afghanistan. In 2003, the rate for Iraq was at its highest level and was two times higher than the rate for Afghanistan ($p<0.001$). The rate for Iraq then decreased 29% in 2004 and continued to decrease in subsequent years (p trend <0.001). The rate for Afghanistan was lowest during the first 1/4 years of the operation (October 2001–2002), then increased in subsequent years (p trend <0.001). Afghanistan's rates were higher than Iraq's in 2004 through 2006.

The NBIs were classified by general diagnosis and anatomical location. For Iraq and Afghani-

Table 2. Rates (injuries per 1000 deployed person-years) for air-evacuated nonbattle injuries for Iraq (2003–2006) and Afghanistan (2001–2006)

Calendar year	Iraq[a] ($n=9530$)		Afghanistan[b] ($n=1515$)		p-value[d]
	Frequency (n)	Rate[c]	Frequency (n)	Rate[c]	
2001–2002[e]	NA	NA	215	9.31	—
2003	3333	27.16	273	13.41	<0.001
2004	2395	19.25	356	24.15	<0.001
2005	2236	15.47	300	17.93	0.02
2006	1566	12.40	371	19.89	<0.001
Total/overall	9530	18.40	1515	16.19	<0.001

[a]Iraq (Operation Iraqi Freedom): March 2003–December 2006
[b]Afghanistan (Operation Enduring Freedom): October 2001–December 2006
[c]Rate is the number of nonbattle injuries per 1000 deployed person-years
[d]p-value comparing the yearly rate for Iraq and Afghanistan
[e]Frequency for Afghanistan includes October 2001 to December 2002

Table 3. Barell Matrix for air-evacuated nonbattle injuries for Iraq (2003–2006)[a]

Injury location	Fracture	Dislocation	Sprain/ strain	Internal	Open wound	Amputation	Blood vessel	Contusion/ superficial	Crush	Burns	Nerve	Unspecified	Systemwide and late effects	Total	% total	% body region
HEAD AND NECK																
Traumatic brain injury																
Type 1	1	—	—	17	—	—	—	—	—	—	0	—	—	18	0.4	1.2
Type 2	10	—	—	30	—	—	—	—	—	—	—	—	—	40	0.8	
Type 3	1	—	—	—	—	—	—	—	—	—	—	—	—	1	0.0	
Other head, face, neck																
Other head	—	—	—	—	9	—	—	—	—	0	1	48	—	58	1.2	5.1
Face	90	0	0	—	13	—	—	—	—	28	—	—	—	131	2.6	
Eye	—	—	—	—	18	—	—	8	—	3	0	—	—	29	0.6	
Neck	0	—	0	—	2	—	—	—	0	0	10	—	—	12	0.2	
Head, face, neck unspecified	—	—	—	—	—	—	2	0	2	8	0	15	—	27	0.5	
SPINE AND BACK																
Spinal cord																
Cervical	4	—	—	8	—	—	—	—	—	—	—	—	—	12	0.2	1.0
Thoracic/dorsal	2	—	—	0	—	—	—	—	—	—	—	—	—	2	0.0	
Lumbar	2	—	—	15	—	—	—	—	—	—	—	—	—	17	0.3	
Sacrum coccyx	0	—	—	4	—	—	—	—	—	—	—	—	—	4	0.1	
Spine, back, unspecified	4	—	—	10	—	—	—	—	—	—	—	—	—	14	0.3	
Vertebral column																
Cervical	21	2	32	—	—	—	—	—	—	—	—	—	—	55	1.1	2.6
Thoracic/dorsal	4	1	1	—	—	—	—	—	—	—	—	—	—	6	0.1	
Lumbar	34	0	26	—	—	—	—	—	—	—	—	—	—	60	1.2	
Sacrum coccyx	3	0	1	—	—	—	—	—	—	—	—	—	—	4	0.1	
Spine, back unspecified	8	0	—	—	—	—	—	—	—	—	—	—	—	8	0.2	

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Table 3. *(continued)*

Injury location	Fracture	Dislocation	Sprain/ strain	Internal	Open wound	Amputation	Blood vessel	Contusion/ superficial	Crush	Burns	Nerve	Unspecified	Systemwide and late effects	Total	% total	% body region
Torso																
Chest (thorax)	21	1	7	17	6	—	1	3	0	1	0	—	—	57	1.1	4.1
Abdomen	—	—	—	11	10	—	1	1	—	0	6	—	—	29	0.6	
Pelvis, urogenital	52	2	8	2	4	—	0	0	0	1	1	—	—	70	1.4	
Trunk	2	—	—	—	0	—	—	2	0	2	2	7	—	15	0.3	
Back, buttock	—	—	28	—	0	—	—	3	4	0	—	—	—	35	0.7	
EXTREMITIES																
Upper																
Shoulder, upper arm	91	218	225	—	12	0	—	17	1	3	—	18	—	585	11.6	34.5
Forearm, elbow	198	28	18	—	8	0	—	3	4	5	—	—	—	264	5.2	
Wrist, hand, fingers	279	62	43	—	146	53	—	13	36	28	—	110	—	770	15.3	
Other and unspecified	4	—	—	—	3	1	2	2	3	8	87	7	—	117	2.3	
Lower																
Hip	20	12	13	—	—	—	—	5	0	—	—	—	—	50	1.0	39.6
Upper leg, thigh	47	—	—	—	—	0	—	2	0	4	—	—	—	53	1.1	
Knee	32	719	64	—	—	—	—	18	2	1	—	—	—	836	16.6	
Lower leg, ankle	384	20	89	—	—	1	—	2	3	7	—	—	—	506	10.0	
Foot, toes	187	16	13	—	35	3	—	17	19	4	—	—	—	294	5.8	
Other and unspecified	4	—	111	—	39	0	8	6	3	2	—	80	—	253	5.0	
UNCLASSIFIED BY SITE																
Other, unspecified																
Other/multiple	1	—	—	—	—	—	1	—	—	1	9	—	—	12	0.2	8.1
Unspecified site	272	30	20	1	17	—	1	7	2	15	18	13	—	396	7.9	
Systemwide and late effects	—	—	—	—	—	—	—	—	—	—	—	—	195	195	3.9	3.9
Total	1778	1111	699	115	322	58	16	109	79	121	134	298	195	5035		
% total	35.3	22.1	13.9	2.3	6.4	1.2	0.3	2.2	1.6	2.4	2.7	5.9	3.9		100.0	100.0

[a]Includes ICD-9-CM codes 800–995

Table 4. Barell Matrix for air-evacuated nonbattle injuries for Afghanistan (2001–2006)[a]

Injury location	Fracture	Dislocation	Sprain/ strain	Internal	Open wound	Amputation	Blood vessel	Contusion/ superficial	Crush	Burns	Nerve	Unspecified	Systemwide and late effects	Total	% total	% body region
HEAD AND NECK																
Traumatic brain injury																
Type 1	2	—	—	2	—	—	—	—	—	—	0	—	—	4	0.5	1.1
Type 2	4	—	—	1	—	—	—	—	—	—	—	—	—	5	0.6	
Type 3	0	—	—	—	—	—	—	—	—	—	—	—	—	0	0.0	
Other head, face, neck																
Other head	—	—	—	—	4	—	—	—	—	0	0	12	—	16	2.0	6.9
Face	13	0	0	—	5	—	—	—	—	1	—	—	—	19	2.3	
Eye	—	—	—	—	8	—	—	2	—	0	0	—	—	10	1.2	
Neck	0	—	0	—	0	—	—	—	1	0	2	—	—	3	0.4	
Head, face, neck unspecified	—	—	—	—	—	—	2	1	0	2	0	3	—	8	1.0	
SPINE AND BACK																
Spinal cord																
Cervical	2	—	—	2	—	—	—	—	—	—	—	—	—	4	0.5	1.5
Thoracic/dorsal	1	—	—	0	—	—	—	—	—	—	—	—	—	1	0.1	
Lumbar	1	—	—	1	—	—	—	—	—	—	—	—	—	2	0.2	
Sacrum coccyx	1	—	—	0	—	—	—	—	—	—	—	—	—	1	0.1	
Spine, back, unspecified	0	—	—	4	—	—	—	—	—	—	—	—	—	4	0.5	
Vertebral column																
Cervical	4	0	2	—	—	—	—	—	—	—	—	—	—	6	0.7	2.2
Thoracic/dorsal	1	0	0	—	—	—	—	—	—	—	—	—	—	1	0.1	
Lumbar	5	0	5	—	—	—	—	—	—	—	—	—	—	10	1.2	
Sacrum coccyx	0	0	0	—	—	—	—	—	—	—	—	—	—	0	0.0	
Spine, back unspecified	1	0	—	—	—	—	—	—	—	—	—	—	—	1	0.1	
TORSO																
Chest (thorax)	1	0	0	1	1	—	0	0	0	0	0	—	—	3	0.4	2.4
Abdomen	—	—	—	3	1	—	0	0	—	0	0	—	—	4	0.5	
Pelvis, urogenital	7	0	0	0	0	—	0	0	0	0	0	—	—	7	0.9	
Trunk	0	—	—	—	0	—	—	1	1	0	0	2	—	4	0.5	
Back, buttock	—	—	1	—	0	—	—	0	1	0	—	—	—	2	0.2	

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Table 4. *(continued)*

Injury location	Fracture	Dislocation	Sprain/ strain	Internal	Open wound	Amputation	Blood vessel	Contusion/ superficial	Crush	Burns	Nerve	Unspecified	Systemwide and late effects	Total	% total	% body region
EXTREMITIES																
Upper																
Shoulder, upper arm	12	32	47	—	2	1	—	1	0	0	—	2	—	97	11.9	36.1
Forearm, elbow	26	4	2	—	1	1	—	0	1	1	—	—	—	36	4.4	
Wrist, hand, fingers	71	10	12	—	10	9	—	2	7	4	—	11	—	136	16.6	
Other and unspecified	0	—	—	—	0	1	1	0	0	1	22	1	—	26	3.2	
Lower																
Hip	5	3	5	—	—	—	—	0	0	—	—	—	—	13	1.6	41.2
Upper leg, thigh	7	—	—	—	—	0	—	1	1	0	—	—	—	9	1.1	
Knee	1	135	8	—	—	—	—	0	0	0	—	—	—	144	17.6	
Lower leg, ankle	72	3	21	—	—	1	—	0	0	1	—	—	—	98	12.0	
Foot, toes	23	1	3	—	4	1	—	3	5	0	—	—	—	40	4.9	
Other and unspecified	0	—	10	—	3	1	1	1	0	1	—	16	—	33	4.0	
UNCLASSIFIED BY SITE																
Other, unspecified																
Other/multiple	0	—	—	—	—	—	0	—	—	0	4	—	—	4	0.5	5.9
Unspecified site	21	5	8	0	2	—	0	1	0	3	1	3	—	44	5.4	
Systemwide and late effects	—	—	—	—	—	—	—	—	—	—	—	—	—	22	22	2.7
Total	281	193	124	14	41	15	4	13	17	14	29	50	22	817	100.0	
% total	34.4	23.6	15.2	1.7	5.0	1.8	0.5	1.6	2.1	1.7	3.5	6.1	2.7			100.0

[a]Includes ICD-9-CM codes 800–995

Table 5. Injury-related musculoskeletal condition matrix for air-evacuated nonbattle injuries for Iraq (2003–2006)[a]

Body region	Inflammation and pain (overuse)	Joint derangement	Joint derangement with neurological involvement	Stress fracture	Sprain/ strain/ rupture	Dislocation	Total	% total	% by body region
Vertebral column									
Cervical	66	84	37	—	—	—	187	7.0	55.4
Thoracic/dorsal	—	6	34	—	—	—	40	1.5	
Lumbar	331	161	37	—	—	—	529	19.8	
Sacrum, coccyx	2	—	—	—	—	—	2	0.1	
Spine, back unspecified	448	76	194	1	—	—	719	27.0	
EXTREMITIES									
Upper									
Shoulder	211	25	—	—	71	7	314	11.8	14.5
Upper arm, elbow	19	3	—	0	—	0	22	0.8	
Forearm, wrist	7	5	—	3	—	0	15	0.6	
Hand	13	4	—	—	18	0	35	1.3	
Lower									
Pelvis, hip, thigh	20	0	—	2	6	0	28	1.0	23.1
Knee, lower leg	72	190	—	7	191	0	460	17.2	
Ankle, foot	105	19	—	—	4	0	128	4.8	
UNCLASSIFIED BY SITE									
Others and unspecified									
Other specified/multiple	19	3	—	1	1	0	24	0.9	7.0
Unspecified site	54	2	65	13	30	0	164	6.1	
Total	1367	578	367	27	321	7	2667		
% total	51.3	21.7	13.8	1.0	12.0	0.3		100.0	100.0

[a]Includes a subset of ICD-9-CM codes 716–739

stan, the distributions and rank order for diagnosis and anatomical location categories were similar. The top five diagnosis categories were:

1. fracture (Iraq: 18.9%; Afghanistan: 18.8%; $p=0.91$);
2. inflammation and pain– overuse (Iraq: 14.3%; Afghanistan: 14.1%; $p=0.82$);
3. dislocation (Iraq: 11.7%; Afghanistan: 12.9%; $p=0.18$);
4. sprain/strain (Iraq: 10.7%; Afghanistan: 11.6%; $p=0.29$); and
5. internal joint derangement (Iraq: 11.3%; Afghanistan: 12.1%; $p=0.70$).

The top five categories for anatomical location were:

1. back (Iraq: 18.0%; Afghanistan: 16.6%; $p=0.19$);
2. knee (Iraq: 15.4%; Afghanistan: 15.9%; $p=0.62$);
3. wrist/hand (Iraq: 12.9%; Afghanistan: 12.3%; $p=0.50$);
4. ankle/foot (Iraq: 11.3%; Afghanistan: 10.7%; $p=0.55$); and
5. shoulder (Iraq: 9.3%; Afghanistan: 10.2%; $p=0.24$).

Nonbattle injuries were further categorized by their primary (first listed) diagnosis into two major subgroups—acute traumatic injuries (Iraq: $n=5035$; Afghanistan: $n=817$) and injury-related musculoskeletal conditions (Iraq: $n=2667$; Afghanistan: $n=428$)—that together accounted for 80.8% of NBIs for Iraq and 82.2% of NBIs for Afghanistan. The remainder of the NBIs did not allow classification into meaningful subgroups. The larger subgroup, acute traumatic injuries, included NBIs with a diagnosis classified in Chapter 17 (Injury and Poisoning) of the ICD-9-CM. This subgroup accounted for similar proportions of the NBIs in Iraq and Afghanistan (52.8% and 53.9%, respectively; $p=0.43$). The other subgroup, injury-related musculoskeletal conditions, was a subset of musculoskeletal conditions classified in Chapter 13, ICD-9-CM (Diseases of the Musculoskeletal System and Connective Tissue) and accounted for 28.0% of NBIs in Iraq and 28.3% in Afghanistan ($p=0.83$).

Table 6. Injury-related musculoskeletal condition matrix for air-evacuated nonbattle injuries for Afghanistan (2001–2006)[a]

Body region	Inflammation and pain (overuse)	Joint derangement	Joint derangement with neurological involvement	Stress fracture	Sprain/ strain/ rupture	Dislocation	Total	% total	% by body region
Vertebral column									
Cervical	7	16	14	—	—	—	37	8.6	49.8
Thoracic/dorsal	—	1	7	—	—	—	8	1.9	
Lumbar	68	24	6	—	—	—	98	22.9	
Sacrum, coccyx	0	—	—	—	—	—	0	0.0	
Spine, back unspecified	37	23	9	1	—	—	70	16.4	
EXTREMITIES									
Upper									
Shoulder	33	9	—	—	11	3	56	13.1	15.4
Upper arm, elbow	4	0	—	0	—	0	4	0.9	
Forearm, wrist	1	0	—	1	—	0	2	0.5	
Hand	0	1	—	—	3	0	4	0.9	
Lower									
Pelvis, hip, thigh	7	0	—	0	1	0	8	1.9	27.6
Knee, lower leg	30	26	—	1	30	0	87	20.3	
Ankle, foot	20	2	—	—	1	0	23	5.4	
UNCLASSIFIED BY SITE									
Others and unspecified									
Other specified/multiple	1	1	—	0	2	0	4	0.9	7.2
Unspecified site	6	0	16	1	4	0	27	6.3	
Total	214	103	52	4	52	3	428		
% total	50.0	24.1	12.1	0.9	12.1	0.7		100.0	100.0

[a]Includes a subset of ICD-9-CM codes 716–739

Tables 3 and 4 are Barell Matrices[17] for Iraq (n=5035) and Afghanistan (n=817), respectively. These matrices provide a standardized format to describe the acute traumatic injuries (the first subgroup of NBIs) by their injury type (horizontally, across the top) and body region (vertically, on the left side). Comparing Iraq and Afghanistan, the proportion of injuries accounted for by each injury type was similar. The three largest injury-type categories for both were fractures, dislocations, and sprains/strains. Combined, these three categories accounted for 71.3% of traumatic injuries for Iraq and 73.2% in Afghanistan. Fractures accounted for nearly one third of the acute traumatic injuries.

There were differences in the body region distributions for the acute traumatic injuries in Iraq and Afghanistan. There were more injuries involving the head, face, and neck in Afghanistan (p=0.04), but more injuries to the torso (p=0.02) and unspecified sites (p=0.03) in Iraq. The distributions for the other body regions were similar for Iraq and Afghanistan. Three fourths of the injuries involved the upper and lower extremities. The knee was the largest subcategory of the lower extremity and overall, while the wrist/hand/fingers was the largest subcategory of the upper extremity and the second largest of all subcategories.

Tables 5 and 6 are similarly formatted matrices that categorize the injury-related musculoskeletal conditions (second subgroup of NBIs) for Iraq (n=2667) and Afghanistan (n=428), respectively. Comparing Iraq and Afghanistan, the proportion of injuries accounted for by each injury type was similar. The four leading injury types, in descending order, were (1) inflammation and pain (overuse) (p=0.63); (2) joint derangement (p=0.27); (3) joint derangement with neurologic involvement (p=0.37); and (4) sprain/strain/rupture (p=0.95). Comparing the major body region categories for Iraq and

Afghanistan, Iraq had a larger proportion of injuries involving the vertebral column ($p=0.03$) and a smaller proportion involving the lower extremity ($p=0.04$).

Using the air evacuation records for all NBI cases and supplemented, when available, with information from accident ($n=813$) and casualty reports ($n=1838$), cause of injury was identified for 6291 NBIs in Iraq (66.0%) and 950 NBIs in Afghanistan (62.7%). The distribution and ranking of the causes of injury were based on injuries with a specified cause (Table 7). The four leading categories for Iraq and Afghanistan were the same, consisting of (1) sports and physical training, (2) falls/jumps, (3) motor vehicle–related incidents, and (4) crushing or blunt trauma. Although differences were noted when comparing cause proportions for Iraq and Afghanistan, these differences were significant only for motor vehicle–related incidents ($p<0.001$) and cutting/piercing ($p=0.03$), both of which were higher in Iraq. The "other specified" cause category (Table 7) included other identified causes, each accounting for less than 2% of the total, that could not be grouped into larger categories.

Table 7. Distribution and ranking of causes of injury for air-evacuated nonbattle injuries for Iraq (2003–2006) and Afghanistan (2001–2006)[a,b]

Cause of injury[c]	Iraq			Afghanistan			*p*-value[d]
	n	%	Rank	*n*	%	Rank	
Sports and physical training	1163	18.5	1	195	20.5	1	0.13
Falls/jumps	1114	17.7	2	170	17.9	2	0.89
Motor vehicle–related incidents	1020	16.2	3	109	11.5	3	<0.001
Crushing or blunt trauma	533	8.5	4	85	8.9	4	0.63
Lifting, pushing, pulling	517	8.2	5	66	6.9	6	0.18
Twisting, turning, slipping	425	6.8	6	67	7.1	5	0.73
Shoes, clothing, body armor	263	4.2	7	29	3.1	8	0.10
Cutting and piercing	194	3.1	8	17	1.8	10	0.03
Handling weapons and explosives	191	3.0	9	31	3.3	7	0.71
Environmental	171	2.7	10	24	2.5	9	0.73
Other specified	700	11.1	—	157	16.5	—	—
Total	**6291**	**100.0**		**950**	**100.0**		

[a]Includes injuries for which the nonbattle injury cause was specified for Iraq (66.0%)
[b]Includes injuries for which the nonbattle injury cause was specified for Afghanistan (62.7%)
[c]Causes of injury are listed in descending order based on their distribution for Iraq.
[d]*p*-value comparing the cause category proportions for Iraq and Afghanistan

Discussion

From October 2001 to December 2006, some 27,563 U.S. Army soldiers deployed in Iraq and 4165 soldiers deployed in Afghanistan were air evacuated to a U.S. hospital in Germany or the U.S. Of these, 35% in Iraq and 36% in Afghanistan had a nonbattle injury, making nonbattle injury the largest injury or diagnosis category for air evacuations. Characteristics of soldiers with NBIs were similar for Iraq and Afghanistan. They were predominately male (91%, 92%), younger than 40 years (82%, 83%), and either junior enlisted (44%, 47%) or noncommissioned officer (41%, 42%). Leading injury types and anatomic locations for NBIs were similar for Iraq and Afghanistan, as were the leading injury causes—sports/physical training, falls/jumps, and motor vehicle–related incidents.

Comparable (complete) air evacuation data from previous military operations are not available. Direct comparison of air-evacuated NBI rates, types, and causes is, therefore, not possible. However, two reports from medical treatment facilities that treated air-evacuated soldiers during ODS&S were reviewed. Both described similarly high proportions of NBIs among air evacuees.[18,19] At the 13th Evacuation Hospital in Saudi Arabia, 721 evacuees were treated as outpatients.[18] Of these, 48% had NBIs, 20% had musculoskeletal conditions which were probably NBIs, 8% had battle injuries, and 24% had a disease/illness. Of the 435 evacuees who were hospitalized at the 13th Evacuation Hospital, 39% had NBIs, 14% had battle injuries, and 47% had a disease/illness. Travis described 180 patients air evacuated from ODS&S and treated at Madigan Army Medical Center.[19] Of these, 46% had orthopedic NBIs, 6% had orthopedic battle injuries, and 48% were admitted by other specialties and included some (number not reported) NBIs and battle injuries.

Leading injury types that were air evacuated from Iraq and Afghanistan, in decreasing rank order, were fractures, inflammation and pain (overuse), dislocations, and sprain/strain. As comparable air evacuation data from previous operations are not available, hospitalization data provides the only possible comparison. For ODS&S,

Writer reported that fractures (25%) were the leading type of NBI requiring hospitalization and were also the leading contributor to hospitalization days.[6] The next leading injury categories (in decreasing rank order) were sprains/strains, other injury, and dislocations. Writer's findings are consistent with the findings of this current analysis.

The overall NBI rate for Iraq (2003–2006) was higher than the rate for Afghanistan (2001–2006), but when the rates were compared for the same timeframe (2003–2006), the rates were similar. When yearly rates were compared between and within operations, important differences were seen. Except for 2003, the yearly rates for Afghanistan were higher than for Iraq. Rates for Iraq gradually decreased over time from their high in 2003. This decrease may have been related to improvements in military facilities and services for soldiers in Iraq, including access to higher levels of medical care. The Afghanistan rate was lowest during the first 2¼ years of the operation (2001–2003) and increased in subsequent years.

Several factors most likely contributed to these rate differences for Iraq and Afghanistan. It is possible that criteria used to determine if and when an injured soldier should be air evacuated changed over time and may have been different for Iraq and Afghanistan. Injury rates may also be related to different injury risks and hazards that are dependent on time frame and operation. For example, certain factors inherent with deployment to Afghanistan may have increased these soldiers' NBI risk, while other factors associated with deployment to Iraq appear to have lowered the injury risk over time. Some of the factors affecting these differences may have been: (1) accessibility and level of medical care available in-theater, (2) terrain (rural, mountainous versus urban), (3) weather conditions, (4) road conditions, (5) usage and types of military vehicles, (6) permanence and quality of facilities and installations, and (7) maturity of logistical support. Differences in these factors may individually or, most likely, in combination influence the NBI risk for deployed soldiers. However, differences in these potential risk factors have not been quantified and evaluated for Iraq and Afghanistan.

Combat intensity may be another factor that influenced the NBI rates in Iraq and Afghanistan. Three reports have evaluated the association between combat intensity and NBI injury rates during previous operations.[20–22] Two of these found that higher combat intensity was associated with higher NBI rates.[20,22] Blood compared disease/nonbattle injury rates among marines involved in different phases of the assault on Okinawa (World War II) and among marines assigned to rifle, weapons, and headquarter units during the Korean War.[20] Higher combat intensity was associated with a higher disease/nonbattle injury (DNBI) incidence. However, when the same author evaluated the relationship between combat intensity and DNBI rates during the Hue offensive in Vietnam, battle intensity did not affect DNBI incidence.[21] Wojcik compared the disease rates and NBI rates during the three phases of ODS&S—the build-up, ground combat, and post-combat phases.[22] There were no differences in the disease rates for these three periods, but the NBI rate for the combat phase was 2.7 times higher than the rate for the build-up phase and 2.6 times higher than the rate for the post-combat phase. The degree to which the different levels of combat intensity in Iraq compared to Afghanistan, or during different timeframes for each operation, may have influenced NBI rates is unknown. Data for this type of analysis are not currently available.

A unique strength of this analysis was the ability to identify and classify causes of injury for NBIs that were medically evacuated from Iraq and Afghanistan. Overall, cause of injury was identified for 66% of the injuries. The leading causes of injury for Iraq and Afghanistan were identical. The top three causes were sports/physical training (19%–21%), falls/jumps (18%), and motor vehicle–related incidents (11%–16%). Again, since there are no comparable reports of injury causes for air-evacuated NBIs from previous deployments, comparisons will be made to hospitalization data. In ODS&S, the leading NBI causes of hospitalization were motor vehicle crashes (19%), falls (19%), and sports/athletics (18%).[6] These three leading causes of NBIs for hospitalization were the same as the leading three causes for air evacuation from Iraq and Afghanistan.

At first look, it may be surprising that sports and physical training was the leading cause of nonbattle injury in Iraq and Afghanistan considering the nature and combat intensity of these operations. Participation in sports activities, however, is an important and appropriate leisure time activity during deployments, as in garrison. Soldiers are required to participate in physical training. Participation in sports is encouraged and allows soldiers to enhance their physical fitness and encourages a healthy lifestyle, including weight and stress management. Sports also improve esprit de corps and morale. However, there is a recognized injury risk with participation in these activities.[23–29] Garrison and peacetime sports injury rates for the military are also high. Between 1989 and 1994, the sports-related injury hospitalization rate for soldiers was 36 injuries/10,000 person-years.[28] Among nondeployed soldiers (2004–2005), sports were the fourth leading cause of injury hospitalizations in the Army, comprising 10% of injury hospitalizations (Michelle Canham-

Chervak, U.S. Army Center for Health Promotion and Preventive Medicine, unpublished data, 2005).

Four other reports have recognized sports as an important cause of injury during deployments. A recent report described a suspected increase in basketball-related injuries among soldiers after a concrete basketball court was opened at a forward operating base in Afghanistan.[30] In ODS&S, sports and athletics accounted for 18% of NBI hospitalizations.[6] McKee reported that sports injuries accounted for 21% of primary care visits for orthopedic NBIs among U.S. forces participating in Operation Joint Guard during 2007.[8] Similarly, among British troops deployed in Bosnia for Operation Resolute in 1995–1996 (same timeframe as OJE for U.S. forces), sports accounted for 11% of all NBIs.[31] It was also noted that the incidence of sports injuries increased steadily as this operation progressed.

Injury surveillance is critical during military deployments in order to determine the magnitude and causes of the injury problem, and to monitor the injury incidence, types, and causes over time.[7] In addition to the adverse effects of injuries for soldiers, injuries during military deployments directly affect the soldier's military unit and its ability to be combat ready at all times. For NBIs that required air evacuation from Iraq and Afghanistan, these negative effects were prolonged. Efforts to reduce the injury risk for soldiers and prevent injuries rely on this surveillance process to focus attention on the most important causes of injury and to assess the effectiveness of interventions.

Routinely collected air evacuation records, supplemented with information from accident investigations and casualty reports, have enabled ongoing injury surveillance during the current operations in Iraq and Afghanistan. Even though the cause was identified for only two thirds of the air-evacuated NBIs, this surveillance has provided the most complete reporting of serious nonbattle injuries and their causes for the current deployments. Greater details from this surveillance about the causes of injury, as well as injury types and locations associated with specific causes, have been reported to Army leaders and commanders. This has allowed them to focus attention on these leading causes as they work to develop and evaluate prevention policies and countermeasures that may lower injury risk for currently deployed soldiers.

Conclusion

Routinely collected air evacuation data provided the basis for deployment injury surveillance during current Army deployments in Iraq (Operation Iraqi Freedom) and Afghanistan (Operation Enduring Freedom). From this surveillance and analysis, NBI occurrences, rates, types, anatomical locations, and causes were reported for 2001–2006. Clear from this analysis, NBIs were the leading category of medical evacuations, accounting for 35% of air-evacuated cases from Iraq and 36% of cases from Afghanistan. The leading causes of NBI in Iraq and Afghanistan were sports and physical training, falls/jumps, motor vehicle–related incidents, and crushing or blunt trauma. These causes were similar to those reported for past deployments and many should be preventable. Routine injury surveillance conducted during these operations enabled early detection of injury rates, types, and causes, and allowed commanders and army leaders to focus on prevention policies and countermeasures while the operations were ongoing.

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