Redefining Projections of Disease and Nonbattle Injury Patient Condition Code Distributions with Casualty Data from Operation Iraqi Freedom

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14. ABSTRACT
Modeling and simulation applications require accurate estimates of the frequency and types of illnesses and injuries incurred during military operations in order to assess medical resource needs. Data from the NavyMarine Corps Combat Trauma Registry and the Joint Patient Tracking Application were used to identify US military disease and nonbattle injury casualties from Operation Iraqi Freedom during the time period of 01 March 2003 to 30 April 2005. Casualties were categorized by the 17 major ICD-9 diagnostic groups. Frequencies, standardized residuals, and chisquare statistics were used to compare the diagnostic categories among casualties by phase of operation, branch of service, and gender. The diagnostic categories varied by phase of Operation Iraqi Freedom, branch of service, and gender. Overall, there were a higher percentage of nonbattle injuries during the Major Combat Phase and a higher percentage of musculoskeletal disorders during the Post Combat Phase. Compared with all other services, the US Marine Corps had the highest percentage of injuries as well as the lowest percentage of musculoskeletal disorders. Men had more injuries than women, whereas women had more diseases of the genitourinary system than men. The Patient Condition Occurrence Frequency tool was developed to account for these differences in patient streams.

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Summary

Problem

Modeling and simulation applications require accurate estimates of the frequency and types of illnesses and injuries incurred during military operations in order to assess medical resource needs. These estimates, or patient streams, include projections of the wounded in action, as well as projections of disease and nonbattle injury (DNBI) patient condition code frequencies. Although the primary focus of military medical personnel is to treat combat casualties with life-threatening injuries, historically there have been more DNBI casualties during military operations. As such, military medical planners need a systematic, structured methodology that can be used to generate patient streams for DNBI injury casualties.

Objective

The objective of this study was to describe DNBI distributions among Marine Corps personnel in Operation Iraqi Freedom (OIF) by (1) phase of the operation, (2) branch of service, and (3) gender. These results were then used to develop a methodology that would allow users to project DNBI patient streams.

Approach

Data from the Navy–Marine Corps Combat Trauma Registry database and the Joint Patient Tracking Application were used to identify US military DNBI casualties during the time period of 01 March 2003 to 30 April 2005 from OIF. Casualties were categorized by the 17 major ICD-9 diagnostic groups. Frequencies, standardized residuals, and chi-square statistics were used to compare the diagnostic categories among casualties by phase of operation, branch of service, and gender.

Results

The diagnostic disease categories varied by phase of OIF, branch of service, and gender. Overall, there were a higher percentage of nonbattle injuries during the Major Combat Phase and a higher percentage of musculoskeletal disorders during the Post Combat Phase. Compared with all other services, the US Marine Corps had the highest percentage of injuries as well as the lowest percentage of musculoskeletal disorders. Men had more injuries than women, whereas women had more diseases of the genitourinary system than men. The Patient Condition Occurrence Frequency tool was developed to account for these differences in patient streams.

Conclusion

This paper describes the different characteristics and distributions of DNBI patient streams, and provides a tool that military medical planners can use to generate scenario-specific patient streams for future military operations.

INTRODUCTION

Forecasting medical resource requirements for military operations necessitates reliable casualty estimates, as well as estimates of the threat to the Health Service Support (HSS) system. Casualty estimates consist of absolute numbers, the distribution of illness and injury types, possible mass casualty situations, and percent evacuated. Hospitalization estimates and other support requirements are derived from these data and are then incorporated into HSS planning tools.

HSS planning tools currently in use include the Medical Analysis Tool (MAT),[1] Estimating Supplies Program (ESP),[2] and Tactical Medical Logistics Planning Tool (TML+).[3] MAT is a medical resource planning tool used that was developed to provide theater-wide medical and clinical decision support during planning, programming, and deployment. MAT provides medical planners with the level and scope of medical support needed for a joint operation, as well as provides the capability of evaluating probable courses of action for a variety of scenarios. ESP and TML+ are used to estimate and configure the Authorized Medical Allowance Lists, determine the required number of medical specialists, provide overall medical system analysis, and assist in risk assessment and capability-based planning.

MAT, ESP, and TML+ use patient condition (PC) codes as the diagnostic nomenclature for injuries and illnesses. PC codes were developed under the Deployable Medical Systems (DEPMEDS) project, which was initiated to provide a standardized deployable hospital system for the military services. DEPMEDS consisted of deployable medical assets in the form of modular assemblages of standardized equipment and supplies.[4] In addition, DEPMEDS contains information about the providers, tasks, and supplies required for the individual PC codes.

To our knowledge, there is not a validated methodology used to estimate disease and nonbattle injury (DNBI) patient streams. Our recent study estimated patient streams for wounded-in-action (WIA) casualties with the PC code nomenclature.[5] In the analysis of the study, WIA casualties from Operation Iraqi Freedom (OIF) and other combat operations were examined and incorporated in the Patient Condition Occurrence Frequency (PCOF) tool to generate patient streams.

Although the primary focus of military medical personnel is to treat combat casualties with life-threatening injuries, historically there have been more DNBI casualties during military operations.[6] The objective of the present study is to examine DNBI patients by branch of service, phase of the operation, and gender. The results of these analyses will be incorporated into the PCOF tool to refine previous DNBI PC code distributions,[7] as well as to derive scenario-specific patient streams that will be used in the HSS decision tools.

METHODS

The Navy–Marine Corps Combat Trauma Registry (CTR), Transportation Command Regulating and Command and Control Evacuation System (TRAC2ES), and Joint Patient Tracking Application (JPTA) were searched for US Marine Corps (USMC), US Army, US Air Force, and US Navy DNBI casualties (including reserves) in support of OIF. DNBI casualties were defined as an initial patient visit or hospitalization at a Level III medical facility (e.g., combat support hospital) with a disease or injury that was not related to a hostile event. In the event that the data were not classified as hostile or nonhostile, the related incident report was read to make the assessment. All data related to hostile events or missing diagnostic information were removed from analysis. Data were categorized by three primary phases of OIF: (1) Major Combat Phase (21 March to 30 April 2003), (2) Post Combat Phase (1 May to 30 August 2003), and (3) Support and Stability Phase II (OIF-II) (1 March 2004 to 30 April 2005). Data were also categorized by gender and branch of service. Data were not available for the time period of 1 September 2003 to 29 February 2004.

Data for the Major Combat Phase and Post Combat Phase were obtained from the Navy–Marine Corps CTR and TRAC2ES for the time period of 21 March to 30 August 2003. The Navy–Marine Corps CTR is a data warehouse composed of data sets describing casualty events from the point of injury through the medical chain of evacuation and on to long-term rehabilitative outcomes.[8] TRAC2ES provides documentation on patient regulation/movement for the USMC, Army, Navy, and Air Force in the theater of operations, and is currently used in OIF.

Data for OIF-II were obtained from the JPTA for 1 March 2004 to 30 April 2005. The JPTA is a Web-based patient tracking and management tool that collects, manages, analyzes, and reports data on patient transfers, and provides information about the transportation, treatment, and disposition of patients from OIF and Operation Enduring Freedom. The JPTA also serves as an information interface between commanders, case managers, service liaisons, and health care providers to facilitate shared decision making for optimal disposition of patients.

Statistical Analysis

Chi-square tests of independence (X^2) were performed to examine distributions of DNBI casualties by combat phase, branch of service, and gender. Standardized residuals were calculated and analyzed to assess the differences among *International Classification of Diseases*, 9th Revision (ICD-9) category distributions. Residuals greater than 2.5 or less than -2.5 were considered statistically significant. All statistical analyses were performed using SPSS software version 12.0.2 (SPSS Inc., Chicago, IL).

Patient Condition Occurrence Frequency Tool

The PCOF tool incorporated differences among DNBI casualties by combat phase, service, and gender in order to provide the necessary calculations and adjustments needed to refine the PC streams. The different methods

used in the PCOF tool to estimate DNBI PC streams are described in the following sections. Categorizing the data by DNBI casualties enabled a greater percentage of the data to be represented by PC codes. Using this approach, over 95% of the nonbattle injury casualties mapped to ICD-9 codes. However, the disease casualties were much more difficult to map. The major ICD-9 diagnoses that did not map to PC clusters were Musculoskeletal, Nervous System and Sense Organs, and Ill-defined Conditions. Therefore, the PC codes for disease casualties need to be expanded and/or reevaluated to include conditions that are not currently defined.

Nonbattle Injury

In order to project the PC code streams for nonbattle injury casualty types, trauma category percentages were estimated, and then anatomical location frequencies within each trauma category were estimated. This was achieved by grouping PC codes into comparative ICD-9 categories. As shown in Figure 1, the trauma categories were amputation, insect bites, burn, cold-related injury, crushing injury, dislocation, fractures, heat-related, intracranial injury, sprain/strain, and wounds. Initially, each PC code was assigned to one of these trauma categories. Then, for each trauma category, anatomical location frequencies were calculated to correspond to the PC nomenclature. The multiplication rule for independent events, which determines the probability that two events (A and B) both occur, was used to calculate the PC codes. In many instances, several PC codes resulted in the same trauma–anatomical location combination but varied by severity level. For these cases, the Defense Medical Standardization Board (DMSB) proportions were used to distinguish PC codes by severity levels.

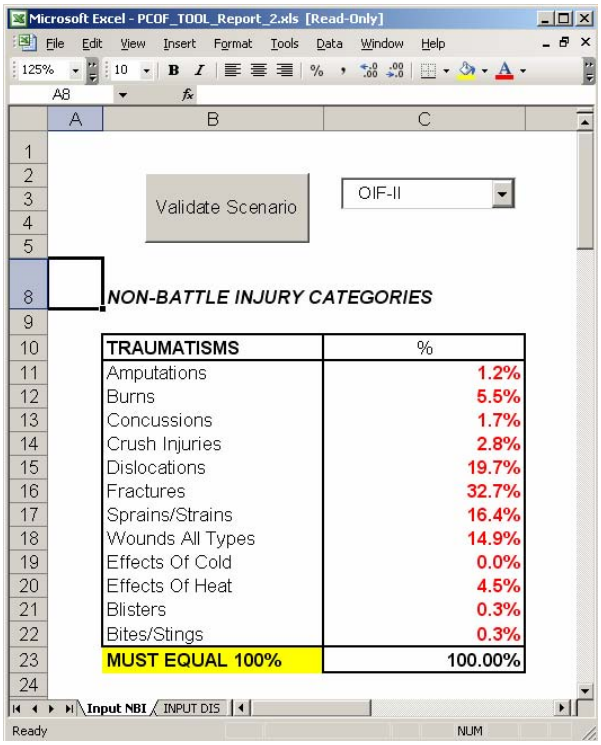

Figure 1. The Patient Condition Occurrence Frequency Tool generates nonbattle injury casualty types.

Disease

For disease PC streams, diagnoses were mapped into PC clusters, and then the percentage for each PC code within a given cluster was estimated. The ICD-9 disease distributions were estimated by excluding the injury ICD-9 category and recalculating the percentages (see Figure 2). ICD-9 category percentages were then mapped to the appropriate PC cluster. The PC disease clusters are 11 broad categories of illness grouped largely along resource requirement lines set forth and developed by the DMSB.[5] The specific PC cluster categories were surgical, dermatological, eye/ear, respiratory, gastrointestinal, cardiovascular, sexually transmitted diseases, genitourinary (female), infectious/parasitic, neuropsychiatric, and miscellaneous. Although considerable overlapping existed between the two coding formats (PC and ICD-9), there was no one-to-one equivalence between the categorical nomenclatures. Thus, PC cluster to ICD-9 category mapping required examination of the individual ICD-9 diagnoses. Additionally, some ICD-9 categories, such as Endocrine and Blood Diseases, do not map to PC clusters, and, therefore, were excluded from the distribution projections.

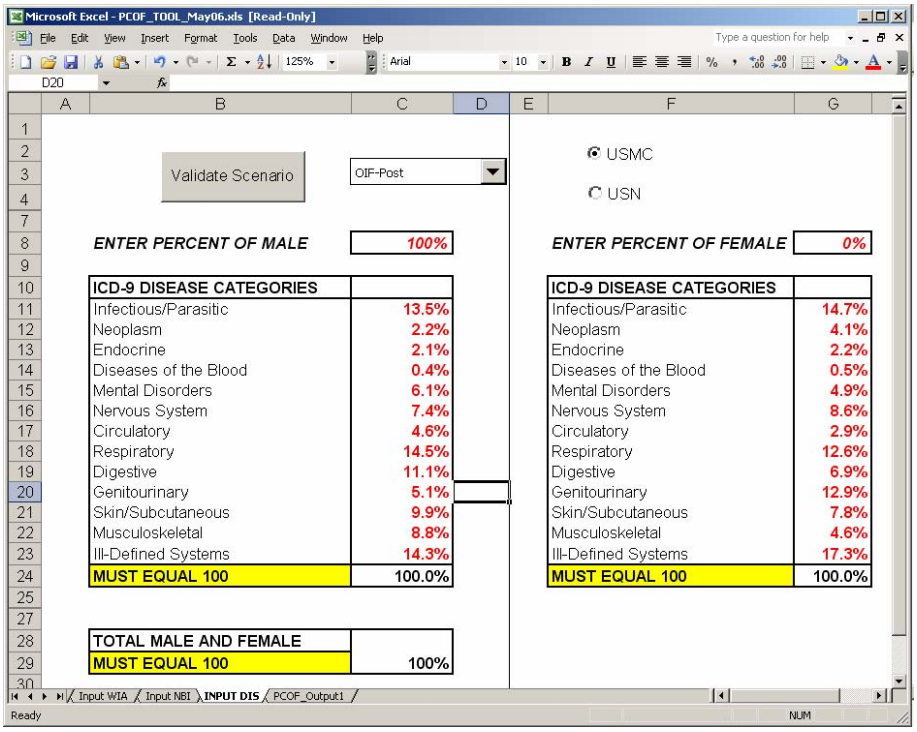

Figure 2. The Patient Condition Occurrence Frequency Tool generates disease casualty types.

RESULTS

A total of 16,069 military personnel DNBI casualties were identified for analysis. Of the 16,069 casualties, 6497 were identified in the Navy–Marine Corps CTR for the Major Combat Phase (n = 1060) and Post Combat Phase (n = 5437), and 9572 were identified in the JPTA for the OIF-II phase.

The distribution of DNBI casualties among the 17 major ICD-9 diagnostic categories differed by phase of the operation ($X^2 = 331.2$, df = 32, $p < .001$). Overall, injury was the most common diagnosis during each phase of the operation (24.3%; see Table 1). Injury was more common during the Major Combat Phase (37.5%) than the Post Combat (25.8%) or Support and Stability (22%) phases. Musculoskeletal injury was more common during the Support and Stability Phase (19.2%) than the Major (10.7%) or Post Combat (13.2%) phases.

Table 1. Distribution of ICD-9 Categories During the Major, Post, and Support and Stability (OIF-II) Combat Phases of Operation Iraqi Freedom

	Major		Post		OIF-II		Total
ICD-9 Category	**n (%)**	**Std Residual**	**n (%)**	**Std Residual**	**n (%)**	**Std Residual**	**n (%)**
Infectious	10 (0.9)	-1.9	80 (1.5)	-1.3	183 (1.9)	1.6	273 (1.7)
Neoplasm	16 (1.5)	-0.3	98 (1.8)	1.0	147 (1.5)	-0.7	261 (1.6)
Endocrine	14 (1.3)	-0.9	84 (1.5)	-0.8	173 (1.8)	0.9	271 (1.7)
Blood	2 (0.2)	-0.3	15 (0.3)	0.7	20 (0.2)	-0.4	37 (0.2)
Mental Disorders	84 (7.9)	1.8	412 (7.6)	3.1*	551 (5.8)	-2.9*	1047 (6.5)
Sense	46 (4.3)	-2.4	348 (6.4)	0.7	595 (6.2)	0.2	989 (6.2)
Circulatory	42 (4.0)	-0.3	185 (3.4)	-2.8*	444 (4.6)	2.2	671 (4.2)
Respiratory	39 (3.7)	1.0	197 (3.6)	1.9	271 (2.8)	-1.8	507 (3.2)
Digestive	75 (7.1)	-3.7*	606 (11.1)	0.6	1065 (11.1)	0.8	1746 (10.9)
Genitourinary	62 (5.8)	-1.0	406 (7.5)	2.3	600 (6.3)	-1.4	1068 (6.6)
Pregnancy	16 (1.5)	3.2*	54 (1.0)	2.7*	41 (0.4)	-3.1*	111 (0.7)
Skin	24 (2.3)	-0.9	145 (2.7)	-0.1	264 (2.8)	0.4	433 (2.7)
Musculoskeletal	113 (10.7)	-4.7*	720 (13.2)	6.2*	1834 (19.2)	-6.1*	2667 (16.6)
Congenital	8 (0.8)	0.7	37 (0.7)	0.8	51 (0.5)	-0.8	96 (0.6)
Ill defined	97 (9.2)	-1.1	506 (9.3)	-2.1	1041 (10.9)	2.0	1644 (10.2)
Injury	397 (37.5)	8.7*	1404 (25.8)	2.2	2110 (22.0)	-4.6*	3911 (24.3)
Supplementary	15 (1.4)	-1.5	140 (2.6)	2.4	182 (1.9)	-1.3	337 (2.1)
Total	1060 (100)		5437 (100)		9572 (100)		16,069 (100)

OIF-II, Operation Iraqi Freedom Support and Stability Phase II; ICD-9, *International Classification of Diseases*, 9th Revision.
*Statistically significant standardized residuals.

The distribution of ICD-9 diagnostic categories among DNBI casualties also differed by patient's branch of service ($X^2 = 329.7$, df = 48, $p < .001$). The most notable differences were the high percentage of injuries and low percentage of musculoskeletal disorders among the USMC, where the standardized residual and percentage for injuries and musculoskeletal disorders was 12.9 (41.3%) and -5.3 (10.9%), respectively.

Table 2. Distribution of ICD-9 Categories by Branch of Service

	US Army		US Air Force		US Marine Corps		US Navy		Total
ICD-9 Category	**n (%)**	**Std Residual**	**n (%)**	**Std Residual**	**n (%)**	**Std Residual**	**n (%)**	**Std Residual**	**n (%)**
Infectious	234 (1.7)	0.3	10 (1.3)	-0.8	22 (1.6)	-0.4	7 (1.7)	0.0	273 (1.7)
Neoplasms	224 (1.7)	0.3	11 (1.5)	-0.3	18 (1.3)	-1.0	8 (1.9)	0.5	261 (1.6)
Endocrine	238 (1.8)	0.7	8 (1.1)	-1.3	16 (1.1)	-1.6	9 (2.2)	0.7	271 (1.7)
Blood	30 (0.2)	-0.2	6 (0.8)	3.3*	0 (0.0)	-1.8	1 (0.2)	0.0	37 (0.2)
Mental Disorders	878 (6.5)	0.0	57 (7.6)	1.2	71 (5.0)	-2.2	41 (9.9)	2.7*	1047 (6.5)
Sense	834 (6.2)	0.1	45 (6.0)	-0.1	87 (6.1)	0.0	23 (5.5)	-0.5	989 (6.2)
Circulatory	580 (4.3)	0.7	44 (5.9)	2.3	28 (2.0)	-4.1*	19 (4.6)	0.4	671 (4.2)
Respiratory	446 (3.3)	1.0	22 (2.9)	-0.3	26 (1.8)	-2.8*	13 (3.1)	0.0	507 (3.2)
Digestive	1491 (11.1)	0.7	62 (8.3)	-2.1	147 (10.4)	-0.6	46 (11.1)	0.1	1746 (10.9)
Genitourinary	927 (6.9)	1.0	44 (5.9)	-0.8	76 (5.4)	-1.9	21 (5.0)	-1.3	1068 (6.6)
Pregnancy	99 (0.7)	0.6	4 (0.5)	-0.5	5 (0.4)	-1.5	3 (0.7)	0.1	111 (0.7)
Skin	363 (2.7)	0.0	15 (2.0)	-1.1	48 (3.4)	1.6	7 (1.7)	-1.3	433 (2.7)
Musculoskeletal	2316 (17.2)	1.6	134 (17.9)	0.9	154 (10.9)	-5.3*	63 (15.1)	-0.7	2667 (16.6)
Congenital	88 (0.7)	0.8	2 (0.3)	-1.2	2 (0.3)	-1.5	2 (0.5)	-0.3	96 (0.6)
Ill-defined	1,390 (10.3)	0.3	103 (13.8)	3.0*	109 (7.7)	-3.0*	42 (10.1)	-0.1	1644 (10.2)
Injury	3059 (22.7)	-3.9*	163 (21.8)	-1.4	585 (41.3)	12.9*	104 (25.0)	0.3	3911 (24.3)
Supplementary	292 (2.2)	0.5	17 (2.3)	0.3	21 (1.5)	-1.6	7 (1.7)	-0.6	337 (2.1)
Total	13,489 (100)		747 (100)		1417 (100)		416 (100)		16,069 (100)

ICD-9, *International Classification of Diseases*, 9th Revision.
*Statistically significant standardized residuals.

ICD-9 distributions were also compared between genders (see Table 3). Of the 16,069 casualties, 86% (13,869) were male and 14% (2,200) were female. The distributions of DNBI casualties by ICD-9 diagnostic category were statistically different between men and women (X^2 = 1432.5, df = 16, $p < .001$). The primary difference among gender was the higher percentage of injuries among males (26.0%) and higher percentage of diseases of the genitourinary system among females (17.1%).

Table 3. Distribution of ICD-9 Categories by Gender

	Male		Female		Total
ICD-9 Category	**n (%)**	**Std Residual**	**n (%)**	**Std Residual**	**n (%)**
Infectious	252 (1.8)	1.1	21 (1.0)	-2.7*	273 (1.7)
Neoplasms	202 (1.5)	-1.6	59 (2.7)	3.9*	261 (1.6)
Endocrine	233 (1.7)	-0.1	38 (1.7)	0.2	271 (1.7)
Blood	25 (0.2)	-1.2	12 (0.5)	3.1*	37 (0.2)
Mental Disorders	881 (6.4)	-0.8	166 (7.6)	1.9	1047 (6.5)
Sense	892 (6.4)	1.3	97 (4.4)	-3.3*	989 (6.2)
Circulatory	612 (4.4)	1.4	59 (2.7)	-3.4*	671 (4.2)
Respiratory	418 (3.0)	-0.9	89 (4.1)	2.4	507 (3.2)
Digestive	1610 (11.6)	2.6*	136 (6.2)	-6.6*	1746 (10.9)
Genitourinary	693 (5.0)	-7.5*	375 (17.1)	18.9*	1068 (6.6)
Pregnancy	0 (0.0)	-9.5*	111 (5.0)	23.8*	111 (0.7)
Skin	373 (2.7)	0.0	60 (2.7)	0.1	433 (2.7)
Musculoskeletal	2363 (17.0)	1.3	304 (13.8)	-3.2*	2667 (16.6)
Congenital	81 (0.6)	-0.2	15 (0.7)	0.5	96 (0.6)
Ill defined	1374 (9.9)	-1.2	270 (12.3)	3.0*	1644 (10.2)
Injury	3613 (26.0)	4.1*	298 (13.6)	-10.2*	3911 (24.3)
Supplementary	247 (1.8)	-2.6*	90 (4.1)	6.5*	337 (2.1)
Total	13,869 (100)		2200 (100)		16,069 (100)

International Classification of Diseases, 9th Revision.
*Statistically significant standardized residuals.

Although male and female distributions were different, similar trends existed among them. Additional comparisons were made separately for females and males by branch of service and by phase of the operation. For example, the total number of injuries among women was 298 and 3613 for men; and the total number of musculoskeletal disorders was 304 for female and 2363 and for male personnel (Table 4). Percentage of injuries was the highest during the Major Combat Phase, and diseases of the musculoskeletal system were the highest during

OIF-II for both men and women. Also the injury percentage among USMC was highest when compared with the other services for both male and female troops (Table 5).

Table 4. Distribution of Musculoskeletal and Injury ICD-9 Categories by Phase of Operation and Gender

		Major		Post		OIF-II		Total
		n	(%)	n	(%)	n	(%)	
Musculoskeletal	Male	104	(11.2)	640	(13.9)	1619	(19.4)	2363
	Female	9	(6.7)	80	(9.8)	215	(17.2)	304
Injury	Male	367	(39.7)	1307	(28.3)	1939	(23.3)	3613
	Female	30	(22.2)	97	(11.9)	171	(13.7)	298

OIF-II, Operation Iraqi Freedom Support and Stability Phase II; ICD-9, *International Classification of Diseases*, 9th Revision.

Table 5. Distribution of Musculoskeletal and Injury ICD-9 Categories by Branch of Service and Gender

		US Army		US Air Force		US Marine Corps		US Navy		Total
		n	(%)	n	(%)	n	(%)	n	(%)	
Musculoskeletal	Male	2035	(17.6)	118	(19.2)	151	(11.2)	59	(16.0)	2,363
	Female	281	(14.4)	16	(12.1)	3	(4.6)	4	(8.3)	304
Injury	Male	2812	(24.4)	138	(22.4)	568	(42.0)	95	(25.8)	3,613
	Female	247	(12.6)	25	(18.9)	17	(26.2)	9	(18.8)	298

ICD-9, *International Classification of Diseases*, 9th Revision.

Generating a DNBI Patient Stream Using the Results From OIF-II

The ICD-9 distributions were summarized among USMC for OIF-II phase shown in Table 6. The PC code nomenclature requires casualties to be categorized as DNBI. Thus, the Injury category was removed and divided into subcategories to estimate the nonbattle casualties, and the remaining ICD-9 categories were used to estimate the disease casualties. Although all data were used in estimating the patient streams, the following section illustrates how the patient stream was derived from USMC data for OIF-II.

Table 6. Distribution of ICD-9 Categories Among US Marine Corps by Gender During OIF-II

ICD-9 Diagnostic Categories	Male		Female		Total	
	n	(%)	n	(%)	n	%
Infectious	13	(1.7)	0	(0.0)	13	(1.7)
Neoplasms	9	(1.2)	0	(0.0)	9	(1.2)
Endocrine	10	(1.3)	0	(0.0)	10	(1.3)
Blood	0	(0.0)	0	(0.0)	0	(0)
Mental Disorders	41	(5.5)	3	(10.0)	44	(5.6)
Sense	57	(7.6)	3	(10.0)	60	(7.7)
Circulatory	17	(2.3)	0	(0.0)	17	(2.2)
Respiratory	13	(1.7)	0	(0.0)	13	(1.7)
Digest	73	(9.7)	3	(10.0)	76	(9.7)
Genitourinary	33	(4.4)	3	(10.0)	36	(4.6)
Pregnancy	0	(0.0)	1	(3.3)	1	(0.1)
Skin	29	(3.9)	0	(0.0)	29	(3.7)

Musculoskeletal	96	(12.8)	1	(3.3)	97	(12.4)
Congenital	3	(0.4)	0	(0.0)	3	(0.4)
Ill-defined	56	(7.4)	9	(30.0)	65	(8.3)
Injury	290	(38.6)	6	(20.0)	296	(37.9)
Supplementary	12	(1.6)	1	(3.3)	13	(1.7)
Total	752	(100)	30	(100)	782	(100)

OIF-II, Operation Iraqi Freedom; ICD-9, *International Classification of Diseases*, 9th Revision.

Nonbattle Injury

For the nonbattle injury methodology, the Injury category shown in Table 6 was expanded into the trauma subcategories shown in Table 7. Of the 296 USMC casualties, 97% of the ICD-9 diagnoses were mapped to the derived PC codes' trauma categories. Those ICD-9 diagnoses that did not map to the derived trauma categories were excluded from analysis.

Table 7. Distribution of ICD-9 Injury Subcategories Among US Marine Corps During OIF Support and Stability Phase II (OIF-II)

Traumatism	n	(%)
Fracture	137	(46.3)
Sprain	54	(18.2)
Wound	37	(12.5)
Dislocation	27	(9.1)
Burn	18	(6.1)
Heat-related injury	7	(2.4)
Other	5	(1.5)
Concussion	3	(1.0)
Contusion	2	(0.7)
Crushing injury	2	(0.7)
Head injury	2	(0.7)
Amputation	1	(0.3)
Bite	1	(0.3)

ICD-9, *International Classification of Diseases*, 9th Revision.

Although the overall trauma distributions varied by service, some of the individual trauma categories by anatomical location did not vary. Specifically, the three most frequent major trauma categories, fractures (46.3%), sprains (18.2%), and wounds (12.5%), were compared by anatomical location between USMC and Army personnel. The chi-square tests demonstrated that the overall distribution of anatomical locations did not vary among these branches of service, which implied that the frequency distribution of the location of a fracture, sprain, or wound was similar for a Marine or soldier. The US Navy and US Air Force did not have sufficient cell size counts and were excluded from the comparisons.

Similarly, the overall DNBI distributions varied among gender. However, when the injury ICD-9 subcategories were compared, male and female personnel had similar distributions. The chi-square tests indicated

that the overall distribution among men and women were not significantly different, which implied that gender did not have an impact on the injury subcategory distributions.

Given that the anatomical location distributions for wounds and fractures did not vary by branch of service or gender, the diagnoses were combined. This resulted in larger sample sizes for each cell, which reduced the margins of error. This approach was used for all trauma categories. Chi-square tests were not performed for the other trauma categories due to insufficient cell sizes. Additionally, the anatomical frequency distributions for each trauma category were calculated (see Table 8).

Table 8. Distribution of OIF-II Patient Condition Trauma Categories by Anatomical Location

Trauma Category	Anatomical Location*	%
Amputations	Hand/fingers	95
	Foot/toes	5
Burns	Upper extremity	42
	Head	40
	Lower extremity	14
	Trunk	5
Crushing injuries	Arm	50
	Leg	50
Dislocations	Shoulder	50
	Ankle	17
	Finger	10
	Elbow	8
	Knee	7
	Hip	5
	Hand/wrist	3
	Toes	<1
Fractures	Foot/ankle	26
	Hand/finger	19
	Tibia/fibula	17
	Radius/ulna	11
	Facial	5
	Spine	5
	Clavicle	4
	Humerus	4
	Femur	4
	Pelvis	3
	Ribs	1
	Skull	1
Sprains	Foot/ankle	59
	Hand/finger	15
	Tibia/fibula	12
	Radius/ulna	11
	Facial	3
	Spine	<1
Wounds	Hand/finger	39
	Arm	13
	Leg	13
	Abdomen	7
	Face/neck	6

Foot/ankle/toe	6
Eye	5
Head	3
Knee	3
Thorax	3
Buttocks	2
Shoulder	1

OIF-II, Operation Iraqi Freedom, Support and Stability Phase II.
*Anatomical locations with 0% not shown.

Applying the multiplication rule for independent events, which determines the probability that two events, A and B, both occur, was used in calculating the PC codes. For example, calculating the probability of dislocation of the shoulder for Marines was derived by multiplying the overall percentage of dislocations among Marines (9.1%; Table 7) by the percentage of dislocated shoulder injuries (50%; Table 8). This resulted in:

*P (PC 64 Dislocation of the shoulder) = 9.1% * 50% = 5% or 0.05*
where P = probability

Although PC code 64 was a straightforward calculation P (64) = *(trauma % * anatomical location %),* many PC codes have multiple PCs that correspond to a single "traumatism by location" combination. For example, as shown in Table 9, "burns to the upper extremity" have six individual PCs that correspond to this particular "traumatism by anatomy" combination. These PC codes differ by total body surface area and severity of the burn. The frequency distribution proportions of PCs 75–80 were derived by DMSB subject matter expert panel. These proportions were applied to the overall percentage of "burns to the upper extremity" to determine the individual percentages for PC codes. This process needed an additional step to calculate the PC codes, which can be summarized as:

*PC = Trauma % * Anatomical location % * DMSB frequency %*

This same strategy was employed wherever multiple PCs for a single traumatism by anatomical location combination were presented.

Table 9. Defense Medical Standardization Board Patient Condition Code Distribution by Severity of Burns to the Upper Extremities

PC Code	Description	%
75	Burn/superficial/upper/10–20% TBSA	11
76	Burn/superficial/upper/0–10% TBSA	11
77	Burn/partial thickness/upper/10–20% TBSA	30
78	Burn/partial thickness/upper/0–10% TBSA	20
79	Burn/full thickness/upper/10–20% TBSA	20
80	Burn/full thickness/upper/0–10%	8

PC, patient condition; TBSA, total body surface area.

Disease

For disease methodology, the Injury category was removed and the other ICD-9 categories were readjusted to 100%. The methodology for projecting disease PC codes involved estimating the disease distribution for ICD-9 categories, mapping ICD-9 categories to PC clusters, and deriving the percentages for each PC code within each PC cluster.

Unlike the nonbattle injury casualties, disease distributions were calculated separately for male and female personnel. Table 10 shows the ICD-9 distributions among USMC males and females. Due to the small number of USMC female disease casualties as illustrated in Table 6, the ICD-9 distribution for women had to be estimated. This was achieved by first calculating a ratio for each ICD-9 category between men and women obtained from the percentages in Table 3. These ratios were then multiplied by the percentages in each ICD-9 category among male distribution to derive the USMC female distributions.

Table 10. Distribution of ICD-9 Categories Among US Marine Corps by Gender.

ICD-9 Categories	Males	Females
Infectious	2.8%	1.3%
Neoplasm	1.9%	3.1%
Endocrine	2.2%	1.9%
Blood	0.0%	0.0%
Mental Disorders	8.9%	9.0%
Sense	12.3%	7.2%
Circulatory	3.7%	1.9%
Respiratory	2.8%	3.2%
Digestive	15.8%	7.2%
Genitourinary	7.1%	20.8%
Pregnancy	0.0%	5.9%
Skin	6.3%	5.4%
Musculoskeletal	20.8%	14.4%
Congenital	0.6%	0.6%
Ill defined	12.1%	12.8%
Supplementary	2.6%	5.1%

ICD-9, *International Classification of Diseases*, 9th Revision.
*Estimated; total < 100%.

For each ICD-9 category, equivalent PC clusters were identified and the percentage of ICD-9 diagnoses that mapped to PC clusters was derived (see Table 11). For example, individual diagnoses that fell within the ICD-9 category of Infectious Diseases (e.g., food poisoning, streptococcus, herpes, hepatitis, gonococcal infections) mapped to five separate PC clusters: Infectious/Parasitic, Gastrointestinal, Dermatological, Respiratory, and Sexually Transmitted Disease. In addition, ICD-9 diagnoses that did not map to any of the clusters were excluded.

Thus, approximately 39.5% of disease ICD-9 diagnoses did not map to the PC code nomenclature. The resulting clusters for men and women are shown in Table 12.

Table 11. ICD-9 Categories Mapping to PC Clusters for Disease Distributions

ICD-9 Categories	PC Clusters	Male PC Cluster Percent	Female PC Cluster Percent
Infectious/Parasitic	Infectious/Parasitic	59.6%	59.6%
	Gastrointestinal	6.0%	6.0%
	Dermatological	5.5%	5.5%
	Sexually Transmitted Disease	7.1%	7.1%
	Respiratory	0.5%	0.5%
	n/a	21.3%	21.3%
Neoplasms	Surgical	53.1%	53.1%
	Miscellaneous	46.9%	46.9%
Mental Disorders	Neuropsychiatric	100%	100%
Nervous System/Sense Organs	Eye/Ear	49.4%	49.4%
	Infectious/Parasitic	1.0%	1.0%
	n/a	49.6%	49.6%
Circulatory	Cardiovascular	68.2%	68.2%
	Surgical	7.2%	7.2%
	n/a	24.5%	24.5%
Respiratory	Respiratory	100%	100%
Digestive	Gastrointestinal	19.3%	19.3%
	Surgical	76.2%	76.2%
	n/a	4.5%	4.5%
Genitourinary	Genitourinary	82.5%	14.9%
	Female-Specific	0.0%	49.0%
	Surgical	5.4%	3.1%
	n/a	12.1%	33.0%
Skin	Dermatological	76.9%	76.9%
	Surgical	21.2%	21.2%
	n/a	1.9%	1.9%
Musculoskeletal	Sprains/Strains	53.7%	53.7%
	n/a	46.3%	46.3%
Ill-defined	Gastrointestinal	17.2%	39.8%
	Respiratory	1.8%	1.9%
	Infectious/Parasitic	2.0%	1.2%
	Dermatological	0.9%	1.2%
	Cardiovascular	42.0%	24.2%
	Female-Specific	0.0%	6.2%
	Genitourinary	1.7%	1.9%
	n/a	34.3%	23.6%

PC, Patient Condition; ICD-9, *International Classification of Diseases*, 9th Revision.

Table 12. ICD-9 Categories Mapping to PC Clusters

PC Cluster Disease Categories	Male*	Female*
Surgical	26.6%	21.2%
Dermatological	9.1%	9.9%
Eye/Ear	10.8%	8.3%
Respiratory	5.4%	7.5%
Gastrointestinal	9.4%	4.0%
Cardiovascular	13.5%	3.4%
Sexually Transmitted Disease	0.4%	0.2%
Genitourinary	10.7%	7.3%
Infectious/Parasitic	3.7%	2.0%
Neuropsychiatric	8.9%	9.0%
Miscellaneous	1.6%	3.4%
Female-Specific	0.0%	23.9%
Sprains/ Strains (Mapped to NBI)	11.2%	7.7%
Total	100.0%	100.0%

ICD-9, *International Classification of Diseases*, 9th Revision; PC, patient condition; NBI, nonbattle injury.
*Rescaled to total 100%.

Once the PC cluster percentages were derived and rescaled to 100%, the frequency percentages for each PC code within the various PC clusters were determined. A list of the estimated PC code frequency percentages within each disease PC cluster can be found in Appendix A. Individual PC code percentages were estimated by multiplying the estimated PC cluster percentage by the percentage for individual PC codes within that cluster.

Summary

This study identified significant relationships among the branches of service, phases of the operation, and gender among DNBI casualties during OIF. In addition, this study emphasized how such factors need to be incorporated in the medical planning process.

Overall, the Major Combat Phase had significant effects on the Mental Disorders, Injury, and Musculoskeletal Disorders ICD-9 categories. Injuries were the highest during the Major Combat Phase (37%), compared with the Post Combat (25%) and OIF-II (22%) phases. The Musculoskeletal category was the lowest during the Major Combat Phase (10.7%) and increased for the Post Combat (13.2%) and OIF-II (19.2%) phases. In addition, for all three phases combined, injuries and musculoskeletal problems were the two most frequent ICD-9 categories.

Branch of service had a significant impact on injury and musculoskeletal disorders as well. The most notable difference was the number of injuries sustained by USMC personnel (41.3%) compared with all other branches of service. In addition, the Army had the most DNBI casualties (84%), followed in consecutive order, by the USMC (9%), Air Force (5%), and Navy (2%).

Gender had significant effects on several of the ICD-9 categories as well. The most notable were Injury and Diseases of the Genitourinary System. The injury percentage for men (26%) was approximately twice as high as for women (13.6%), and the genitourinary percentage for women (17.1%) was approximately three times higher than that of men (5.0%). This resulted in the overall ICD-9 distribution being skewed due to both of these categories. However, when the Injury category was compared independently among gender, the results yielded similar distributions among male and female personnel. The Injury subcategories had similar distributions for gender and by anatomical location distributions; however, they differed by phase and branch of service.

For further comparison of the ICD-9 categories, it is imperative that rates be calculated. In addition, accurate population-at-risk numbers need to be provided on a daily basis, which are usually unavailable or remain classified. Future work should attempt to compare various command elements, which will provide more granularities on the differences among the ICD-9 categories.

A limitation of this study was that a large portion of the data provided for this analysis came from Level III medical treatment facilities, which included casualties who required evacuation. The data set included outpatients, inpatients, and evacuees who were seen at a reporting facility in the TRACE2S and JPTA systems. It is likely that the calculated ICD-9 percentage distributions are biased toward more serious and severe injuries and illnesses and may not be reflective of sick call-data or surveillance reporting systems in the forward area treatment facilities.

To allow for the various differences in patient streams, the PCOF tool was used to estimate patient distributions based on phase of operation, branch of service, and gender. The PCOF tool provided the necessary calculations and adjustments needed to refine the PC streams. The PCOF tool also provided the much-needed mapping of ICD-9 diagnoses to PC nomenclature. Categorizing the data by DNBI casualties enabled a greater percentage of the data to be represented by PC codes. Using this approach, over 95% of the nonbattle injury casualties mapped to ICD-9 codes. However, the disease casualties were much more difficult to map. The major ICD-9 diagnoses that did not map to PC clusters were Musculoskeletal, Nervous System and Sense Organs, and Ill-defined Conditions. Therefore, the PC codes for disease casualties need to be expanded and/or reevaluated to include conditions that are not currently defined.

It is essential that patient streams be estimated for the entire workload of casualties, which include WIA and DNBI patients. Along with the estimated counts of casualties, patient streams are the impetus of projecting the resources to sustain the Health Support System. It is critical that empirical data be used in deriving the patient streams so factors such as gender, branch of service, and phase of an operation, which affect overall estimations, can be identified. Furthermore, quantitative methods need to be employed to facilitate manageable and efficient methods of projection resources. The PCOF tool demonstrates an efficient and easy method to generate scenario-specific patient streams for future military operations.

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Appendix A. Estimated Distributions of PC Codes by Cluster and Gender for Disease and Nonbattle Injury Casualties during Operation Iraqi Freedom-II.

PC Code	Diagnoses by PC Clusters	Male	Female
	Surgical Cluster		
196	Appendicitis acute with perforation rupture peritonitis	1.67%	2.11%
197	Appendicitis acute without perforation rupture peritonitis	2.48%	3.12%
198	Inguinal hernia complicated direct or indirect sliding incarceration of bowel	1.40%	1.76%
199	Inguinal hernia uncomplicated direct or indirect no sliding no incarceration of bowel	8.70%	10.96%
212	Pilonidal cyst/abscess requiring major excision	2.22%	2.80%
213	Pilonidal cyst/abscess requiring minor incision	0.00%	0.00%
249	Peptic ulcer gastric or duodenal penetrating and/or perforating	0.08%	0.11%
256	Hemorrhoidal disease all cases	1.27%	1.60%
277	Ureteral calculus causing obstruction impacted	0.44%	0.56%
285	Cholecystitis acute with stones all cases	1.25%	1.57%
290	Neoplasms benign	1.65%	2.08%
		21.16%	**26.68%**
	Dermatological Cluster		
202	Eczema dermatitis seborrheic contact others affecting weight bearing or pressure areas	0.96%	0.88%
203	Eczema dermatitis seborrheic contact others not affecting weight bearing areas	2.87%	2.63%
204	Boils furuncles pyoderma requiring surgery	0.70%	0.64%
205	Boils furuncles pyoderma all other cases	0.49%	0.45%
206	Cellulitis involving face or weight bearing areas	1.41%	1.29%
207	Cellulitis other than face or weight bearing areas	2.07%	1.90%
208	Dermatophytosis severe - affecting feet	0.14%	0.13%
209	Dermatophytosis all other cases	0.33%	0.30%
210	Pediculosis all cases	0.08%	0.08%
211	Scabies all cases	0.08%	0.08%
216	Herpes simplex and zoster without encephalitis all types all cases	0.30%	0.28%
219	Hyperhidrosis all cases	0.44%	0.40%
		9.89%	**9.06%**
	Eye/Ear Cluster		
220	Blepharitis all cases	0.71%	0.92%
221	Conjunctivitis severe - all cases	0.36%	0.47%
222	Conjunctivitis moderate - all cases	0.65%	0.85%
223	Corneal ulcer	0.77%	1.00%
225	Iridocyclitis acute marked visual impairment	0.55%	0.72%
226	Iridocyclitis acute minimal visual impairment	0.41%	0.53%
227	Refraction and accommodation disorders refraction required	0.40%	0.52%
228	Refraction and accommodation disorders replacement of spectacles required	0.40%	0.52%
229	Otitis externa all cases	0.90%	1.17%
230	Otitis media acute suppurative all cases	3.15%	4.08%
		8.31%	**10.78%**

Appendix A. Estimated Distributions of PC Codes by Cluster and Gender for Disease and Nonbattle Injury Casualties During Operation Iraqi Freedom-II

PC Code	Diagnoses by PC Clusters	Male	Female
	Respiratory Cluster		
232	Allergic rhinitis all cases	0.27%	0.20%
233	Upper respiratory infections acute all cases	2.33%	1.67%
234	Bronchitis acute all cases	0.27%	0.20%
235	Asthma with disabling symptoms or repeated attacks	0.65%	0.46%
236	Asthma other cases	1.78%	1.27%
239	Acute respiratory disease severe	0.43%	0.31%
240	Acute respiratory disease moderate	1.78%	1.28%
		7.52%	**5.38%**
	Gastrointestinal Cluster		
243	Food poisoning all organisms disabling symptoms	0.25%	0.58%
244	Food poisoning all organisms moderate symptoms	0.04%	0.09%
245	Diarrheal disease severe	0.14%	0.34%
246	Diarrheal disease moderate	0.80%	1.88%
248	Gastritis acute all cases	1.69%	4.00%
250	Peptic ulcer gastric or duodenal uncomplicated	0.28%	0.67%
251	Regional ileitis disabling symptoms unresponsive to treatment	0.14%	0.32%
252	Regional ileitis responds to treatment	0.32%	0.75%
253	Helminthiasis all cases	0.07%	0.17%
286	Pancreatitis acute all cases	0.14%	0.33%
287	Cirrhosis all cases	0.12%	0.27%
		3.99%	**9.40%**
	Cardiovascular Cluster		
11	Intracranial hemorrhage spontaneous nontraumatic all cases	0.05%	0.19%
258	Severe hypertension	2.33%	9.33%
259	Ischemic heart disease	0.58%	2.32%
260	Phlebitis deep vein involvement	0.41%	1.66%
		3.37%	**13.50%**
	STD Cluster		
269	Sexually transmitted diseases urethritis	0.19%	0.30%
270	Sexually transmitted diseases genital ulcers and/or adenopathy	0.03%	0.04%
271	Sexually transmitted diseases complicated	0.00%	0.01%
		0.22%	**0.35%**

Appendix A. Estimated Distributions of PC Codes by Cluster and Gender for Disease and Nonbattle Injury Casualties During Operation Iraqi Freedom-II

PC Code	Diagnoses by PC Clusters	Male	Female
	Genitourinary Cluster		
272	Glomerulonephritis acute	1.31%	0.94%
273	Glomerulonephritis chronic	1.56%	0.83%
274	Pyelonephritis acute secondary to obstruction	0.40%	0.27%
275	Pyelonephritis acute no obstruction	0.12%	0.34%
276	Nephrotic syndrome all cases	1.23%	1.39%
278	Ureteral calculus not causing obstruction	2.65%	3.89%
279	Epididymitis cystitis prostatitis acute all cases	0.00%	2.12%
280	Balanoposthitis all cases	0.00%	0.98%
		7.27%	**10.76%**
	Infectious/Parasitic Cluster		
263	Meningo-encephalitis uncomplicated	0.16%	0.30%
264	Meningo-encephalitis complicated	0.07%	0.13%
282	Infectious mononucleosis all cases	0.03%	0.06%
283	Hepatitis infectious viral all cases	0.38%	0.69%
329	Trachoma all cases	0.00%	0.00%
330	Schistosomiasis all cases	0.00%	0.00%
331	Malaria severe - all species	0.00%	0.00%
332	Malaria moderate - all species	0.05%	0.09%
333	Febrile illness acute severe - except malaria and pneumonia	0.03%	0.06%
334	Febrile illness acute moderate	0.36%	0.65%
339	Cutaneous ulcers including leishmaniasis	0.90%	1.63%
		2.00%	**3.61%**
	Neuropsychiatric Cluster		
301	Psychosis	0.86%	0.84%
302	Misconduct	4.27%	4.01%
303	Non-psychotic mental disorders	3.72%	3.49%
306	Alcohol related syndromes	0.05%	0.18%
307	Alcohol misuse simple intoxication - deleted by the panel and incorporated into Alcohol (306)	0.05%	0.13%
317	Drug related syndromes renamed by panel and incorporated into drug misuse (other than alcohol)	0.00%	0.25%
		9.00%	**8.90%**
	Miscellaneous Cluster		
214	Ingrown toenails bilateral with secondary infections unresolvable at level 2	1.36%	0.63%
215	Ingrown toenails without secondary infection	1.36%	0.63%
289	Neoplasms malignant	0.68%	0.32%
		3.40%	**1.58%**

Appendix A. Estimated Distributions of PC Codes by Cluster and Gender for Disease and Nonbattle Injury Casualties During Operation Iraqi Freedom-II

PC Code	Diagnoses by PC Clusters	Male	Female
	Female -Specific Cluster		
291	Abnormal uterine bleeding	1.86%	0.00%
292	Dysmenorrhea amenorrhea	1.10%	0.00%
293	Pelvic inflammatory disease all cases	1.63%	0.00%
294	Cervicitis endocervicitis with symptomatic leukorrhea	11.21%	0.00%
295	Vulvovaginitis	4.85%	0.00%
297	Tubal pregnancy all cases	0.00%	0.00%
299	Abortion spontaneous with hemorrhage	3.25%	0.00%
		23.90%	**0.00%**
	Musculoskeletal Cluster (Added to Nonbattle Injuries)		
31	Intervertebral disc disorders with nerve root compression resistant to bed rest/traction	0.74%	1.07%
32	Intervertebral disc disorders with nerve root compression responding to bed rest/traction	2.96%	4.28%
141	Tear ligaments knee acute complete rupture	0.03%	0.04%
142	Tear ligaments knee acute incomplete rupture	0.17%	0.25%
200	Internal derangement of knee chronic with torn meniscus and/or ligament laxity	0.63%	0.90%
262	Tenosynovitis elbow wrist shoulders etc.	1.18%	1.70%
201	Strain lumbosacral sacroiliac joint chronic all cases	1.81%	2.61%
148	Sprain ankle closed acute with complete ligament rupture	0.02%	0.03%
149	Sprain ankle closed acute grade 2 incomplete ligament rupture	0.19%	0.28%
		7.73%	**11.17%**