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## **Epidemiological Assessment of Craniofacial (CMF) Injuries in Active Duty Army Soldiers, FY 2002 - FY 2015**

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**14. ABSTRACT**  
 Craniomaxillofacial (CMF) injuries can be extensive, resulting in significant human and financial costs. A number of studies have examined CMF injuries during recent military conflicts; however, little is known about the total burden CMF injuries within U.S. Army. The primary purpose of this project is to investigate CMF fractures patterns and injury mechanisms within Active Duty U.S. Army, in both non-deployed and deployed settings, between 2002 and 2015. A retrospective epidemiological study was conducted using hospitalization records from the Soldier Performance, Health, and Readiness Database (SPHERE), a large repository of medical and demographic data on the entire Army population. CMF injuries sustained by U.S. Army Soldiers (deployed and non-deployed) were identified. Additionally, the study dataset included general demographic data (e.g., race, sex, time in service) for each Soldier suffering CMF injuries. These data allowed the identification of demographic groups within the Army at risk of CMF injuries and identified trends in CMF injuries sustained by deployed Soldiers.

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## Introduction

Craniomaxillofacial (CMF) injuries comprise some of the most devastating, debilitating, and expensive injuries seen in the modern Service Member. While these injuries vary in severity, extensive surgical intervention is often required to restore function (Brennan, 2013). In the long term, extensive facial traumas have shown to lead to decreased quality of life, altered perception of body image, as well as increased rates of post-traumatic stress disorder, alcoholism, unemployment, marital issues, and incarceration (Levine, Degutis, Pruzinski, Shin, & Pershing, 2005). An understanding of the predominant CMF injury types, along with what groups are being injured at higher rates and where these groups are sustaining CMF injuries, is critical in developing appropriate countermeasures aimed at reducing the incidence and severity of these injuries.

Military populations have unique risk factors for CMF injury. In combat environments, the head and face are more vulnerable to injury due to being exposed; therefore, higher rates of CMF injuries are being reported. The increase in CMF injuries has been attributed to the successful development of personal armor for protection of vital body regions like the torso and head and vehicle-level mitigation systems that have allowed for greater Service Member survival rates than in previous conflicts (Owens et al., 2008; Lew, Walker, Wenke, Blackbourne, & Hale, 2010). Consequently, Service Members who would have previously sustained fatal injuries are now surviving and presenting with non-fatal CMF injuries at higher rates (i.e., Soldiers with more extensive and expensive injuries who may not have previously survived are surviving). Owens et al. reported that 29.4% of combat injuries between 2001 and 2005 were to the head and neck (2008). Lew et al. reported 26% of all combat injuries between 2001 and 2007 were CMF in nature (2010). More recently, Keller, Han, Galarneau, and Gaball reported similar findings from 2004 to 2010, showing 22.7% of combat injuries to be maxillofacial injuries (2015). The increased number of CMF combat injuries reported in these recent conflicts (Owens et al., 2008; Lew et al., 2010) highlights the vulnerability of the head and face.

Though research into combat-related CMF injuries is increasing, less is known about non-combat-related CMF injuries within the U.S. Military. In non-combat military environments, different duties and training activities could occupationally put some groups of Soldiers at higher risk for CMF injury than other groups within the military. Beck and Blakeslee examined military facial fractures that occurred in non-deployed settings and were treated at an Army Medical Center over a five-year period (1989). The study identified the three main causes of facial fractures: assault, vehicular accidents, and sports (Beck & Blakeslee, 1989). More recently, two retrospective studies were conducted using the Soldier Performance, Health, and Readiness Database (SPHERE), formerly known as the Total Army Injury and Health Outcomes Database (TAIHOD), to investigate mandible fractures (Boole, Holtel, Amoroso, & Yore, 2001) and midface fractures (Shere, Boole, Holtel, & Amoroso, 2004) within the U.S. Army over 20 years (1980-2000). While these studies provide an understanding of CMF injuries incurred by Soldiers in non-deployed settings, they do not provide a total picture of CMF injuries (studying both non-deployed and deployed injuries) within the U.S. Army and are not inclusive of recent conflicts.

Understanding the types of CMF injuries (i.e., location on the head and face region) and where (non-deployed/deployed) the injuries are occurring will facilitate an improved prioritization of efforts focused on developing new injury mitigation technologies, performance

standards of facial protection devices (i.e., face shields), and modeling systems (i.e., the Facial and Ocular Countermeasure Safety [FOCUS] Headform, [Crowley, Brozoski, Duma, & Kennedy, 2009]). The current research will provide a better understanding of the total burden of CMF injuries within the U.S. Army, how non-deployed/deployed injuries contribute to that total burden, and what groups may be at higher risk of sustaining CMF injuries.

Currently, there is a need to examine the total burden of CMF injuries within the U.S. Army and define the relative contribution of non-deployed and deployed CMF injuries. The purpose of the current study is to characterize CMF injuries within the U.S. Army in non-deployed and deployed settings during a period of time that includes recent conflicts. The study will also determine the relative distribution of injuries, describe the demographic characteristics of those who were injured, and identify any risk factors helpful in reducing future CMF injuries.

### **Methods**

This study identified all Active Duty Army Soldiers from October 1, 2001 to September 30, 2015 in the Soldier Performance, Health, and Readiness Database (SPHERE). SPHERE is a comprehensive data repository within the U.S. Army that maintains linked copies of administrative and health-related datasets on Active Duty Army Soldiers (Amoroso, Yore, Weyandt, & Jones, 1999). The U.S. Army Research Institute of Environmental Medicine (USARIEM) developed that database to analyze the impact of injuries and illnesses to the U.S. Army.

During this study period, all injury types were recorded in SPHERE using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) coding system. A Soldier was identified as having a CMF injury if one of the following six ICD-9-CM codes was listed in any of the first four diagnosis fields in the medical record: ICD-9 CM code 800 (fracture of vault of skull), 801 (fracture of base of skull), 802 (fracture of face bones), 803 (other and unqualified skull fractures), 804 (multiple fractures involving skull or face with other bones), or 830 (dislocation of the jaw).

Soldiers with a CMF injury prior to October 1, 2001 or prior to their U.S. Army entry date were excluded from the study population. This study took into account only the first incident of CMF injury (including all CMF injuries diagnosed at that time) and did not account for subsequent CMF injuries to the same Soldier. In addition, the specificity of the injury may have changed, the injury may have been re-categorized, or additional injuries may have been identified in subsequent medical encounters. For example, a Soldier who was first coded as 802.2 may be coded with more specificity in an encounter a few days later (ex. 802.28) or recoded to an 804.0. An additional injury may have been identified and added to their medical record. These changes are not reflected in the results shown here, as this study only examined the first medical encounter per Soldier that coded for at least one of the six ICD codes of interest.

Descriptive statistics consisting of counts, prevalence (%), and incidence rates (IR) were calculated for the overall study population by injury and, among those with CMF injuries, by deployment status. Covariates included in analyses were sex, age, education, race/ethnicity, marital status, rank, and length of service. Due to the time period of interest, the fiscal year was defined from October 1 to September 30. Annual incidence rates were calculated among the population overall and among those who were injured by deployment status. The distributions of

injuries by ICD-9 code were calculated overall and by deployment status. Categorical variables were compared with chi-square analysis using Microsoft Excel. Significance was set at  $\alpha = 0.05$ .

## Results

There were 1,528,895 Active Duty Soldiers in the Army from October 1, 2001 to September 30, 2015. There were 1,418 (0.093%) Soldiers who had a CMF injury occurring prior to the study period that were excluded, leaving 1,527,477 Soldiers in the study population. Overall, these Soldiers contributed a total of 7,400,038.17 person-years (p-y) of service. There were 22,417 (1.47%) U.S. Army Soldiers diagnosed with at least one CMF injury during the time period this study addressed. The total cumulative incidence rate for Soldiers with a CMF injury was 30.29 injured Soldiers per 10,000 Soldiers per year [person-years (p-y)] over the 14-year study period. As shown in Table 1, males comprised 83.79% of the study population (1,279,894). Of those male Soldiers, 1.62% (20,699) sustained a CMF injury during the study. The cumulative incident rate for male Soldiers with a CMF injury was 32.54 male Soldiers per 10,000 p-y. Overall, females comprised 16.20% (247,446) of the study population. Of the total female Soldiers, 0.69% (1,718) sustained a CMF injury at some point during the study period. The cumulative incidence rate for female Soldiers with a CMF injury was 16.53 female Soldiers per 10,000 p-y. The difference between male and female cumulative incidence rates for Soldiers with a CMF injury was significant ( $p < 0.001$ ). The additional demographic breakdown of the study population by Age Group, Education, Marital Status, Race/Ethnicity, Rank, and Length of Service at the time of injury is reported in Table 1.

Table 2 reports the prevalence (percentage of the group-specific population) and annual incidence rates for Soldiers with a CMF injury by fiscal year. Figure 1 graphically displays the annual incidence rates from Table 2. Overall, the annual incidence rate declined slightly from FY2002 [2.83 Soldiers with a CMF injury per 10,000 person-months (p-m)] to FY2015 (2.29 Soldiers with a CMF injury per 10,000 p-m). The incidence rate peaked between FY2006 to FY2008, with the highest incidence rate in FY2007 (3.22 Soldiers with a CMF injury per 10,000 p-m). The lowest incidence rate occurred in FY2013 (1.97 Soldiers with a CMF injury per 10,000 p-m).

There were 23,109 CMF injuries identified during the study period. The number of CMF injuries is higher than the number of injured Soldiers due to multiple injuries being reported during the same medical encounter. One Soldier could have more than one CMF injury during one medical encounter. The ICD-9-CM code 802, fracture of face bones, accounted for 83.20% (19,227) of the total CMF injuries (Figure 2). ICD-9-CM code 801 (fracture of the base of the skull) accounted for 7.88% (1,822) of the injuries diagnosed, followed by ICD-9-CM 803 (other and 'other unqualified' skull fractures) with 3.18% (735). ICD-9-CM codes 830 (dislocation of the jaw) and 800 (fracture of the vault of skull) each accounted for 2.4% of the CMF injuries (556 and 554, respectively) with ICD-9-CM code 804 (multiple fractures involving skull or face with other bones) accounting for the remaining CMF injuries with less than 1% (215).

Of the total 22,417 injured Soldiers, 7.61% (1,706) were deployed at the time of injury, while 92.39% (20,711) were not. Shown in Table 3 are the demographic characteristics of Soldiers with a CMF injury by deployment status. Also shown in Table 3 is the number of injured Soldiers with only one CMF injury diagnosis and those with two or more CMF injuries. Overall, 97% (21,744) of Soldiers had only one CMF injury encounter, and the remaining 3%

(673) had two or more CMF injury diagnosis codes during the same medical encounter, regardless of deployment status. Those Soldiers deployed had a higher percentage of two or more injuries than not deployed (8.26% and 2.57%, respectively).

Shown in Table 4 are the annual incidence rates by deployment status. Similar to the overall trend in incident rates for all injured Soldiers (Figure 1), incidence rates for injuries for Soldiers deployed and not deployed at the time of injury had an overall trend that increased between FY2002 and FY2006 and then declined between FY2007 and FY2015 (Figure 3). For Soldiers not deployed at the time of injury, incident rates increased from 2.90 injured Soldiers per 10,000 p-m in FY2002 to a peak of 3.35 in FY2006 and then decreased to 2.32 in FY2015. The incidence rates for Soldiers deployed at the time of injury increased from 1.97 injuries per 10,000 p-m in FY2002 to a peak of 3.19 in FY2007 and declined to 1.97 in FY2015. Overall, the annual incidence rate of injury among those deployed was lower than those who were not deployed (Figure 3).

As non-deployed Soldiers comprised 92.4% (20,711) of the injured study population (Table 3), the distribution of injury types for non-deployed Soldiers was similar to the overall distribution of injury types for all injured Soldiers. Injury type distribution was more diverse among those who were deployed at the time of injury than those not deployed, as shown in Figure 4. The ICD-9-CM code 802 (fracture of face bones) still accounted for a large percentage of injuries (67.39%), but ICD-9-CM code 801 (fracture of base of skull) accounted for a higher percentage of injuries to deployed Soldiers compared to those who were not deployed (19.49% and 6.87%, respectively,  $p < 0.001$ ). When comparing the proportions of CMF injury types suffered by deployed and non-deployed Soldiers (Table 5), all CMF injury types except for ICD-9-CM code 804 (multiple fractures involving skull or face with other bones) were significantly different ( $p < 0.001$ ). The number of ICD-9-CM code 804 injuries was small in both groups and represented a similar proportion in both groups (Table 5).

## Results

*Table 1. Demographic Characteristics of Active Duty Soldiers in the Study Population and with at Least One CMF Injury (FY 2002-2015)*

		Overall (n=1,527,477) (%)	Injured (n=22,417)	Person-Years (p-y) (n=7,400,038.17)	Injury Prevalence (%)	IR (per 10,000 p-y)
Sex	Female	247,446 (16.20)	1,718 (7.66)	1,039,447.67 (14.05)	0.69	16.53
	Male	1,279,894 (83.79)	20,699 (92.34)	6,360,475.67 (85.95)	1.62	32.54
	Missing	137 (0.01)	0 (0)	114.83 (0)	0	0
Age	<20	110,488 (7.23)	2,125 (9.48)	67,018.42 (0.91)	1.92	317.08
	20-29	898,379 (58.81)	15,699 (70.03)	3,131,320.33 (42.31)	1.75	50.14
	30-39	318,902 (20.88)	3,582 (15.98)	2,433,630.42 (32.89)	1.13	14.72
	>40	199,349 (13.05)	1,010 (4.51)	1,767,809 (23.89)	0.51	5.71
	Missing	359 (0.02)	1 (0)	260 (0)	0.28	38.46
Education	<HS	17,430 (1.14)	199 (0.89)	70,725.25 (0.96)	1.14	28.14
	HS	900,530 (58.96)	15,364 (68.54)	3,841,139.33 (51.91)	1.71	40.00
	College	422,238 (27.64)	6,000 (26.77)	2,507,842.58 (33.89)	1.42	23.92
	Advanced Degree	78,762 (5.16)	490 (2.19)	642,491.00 (8.68)	0.62	7.63
	Missing	108,517 (7.10)	364 (1.62)	337,840.00 (4.57)	0.33	10.78
Marital Status	Single	655,812 (42.93)	12,286 (54.81)	1,842,265.17 (24.90)	1.87	66.69
	Married	787,660 (51.57)	9,092 (40.56)	4,957,935.17 (67.00)	1.15	18.34
	Other	82,442 (5.40)	1,029 (4.59)	595,387.33 (8.05)	1.25	17.28
	Missing	1,563 (0.10)	10 (0.04)	4,450.5 (0.06)	0.64	22.47
Race/ Ethnicity	White	927,739 (60.74)	15,296 (68.23)	4,340,789.5 (58.66)	1.65	35.24
	Black	306,505 (20.07)	3,345 (14.92)	1,616,882.58 (21.85)	1.09	20.69
	Hispanic	170,775 (11.18)	2,529 (11.28)	831,507.17 (11.24)	1.48	30.41
	Native American/Alaskan	14,893 (0.98)	270 (1.20)	68,164.67 (0.92)	1.81	39.61
	Asian Pacific Islander	83,741 (5.48)	698 (3.11)	391,123.33 (5.29)	0.83	17.85
	Other	21,098 (1.38)	248 (1.11)	140,756.5 (1.90)	1.18	17.62
	Missing	2,726 (0.18)	31 (0.14)	10,814.42 (0.15)	1.14	28.67
	Rank	E1-E4	872,651 (57.13)	14,685 (65.51)	2,394,264.08 (32.35)	1.68
E5-E6		348,002 (22.78)	5,053 (22.54)	2,437,708.75 (32.94)	1.45	20.73
E7-E9		137,240 (8.98)	1,120 (5.00)	1,373,804.25 (18.56)	0.82	8.15
Officer		142,710 (9.34)	1,368 (6.10)	959,881.5 (12.97)	0.96	14.25
Warrant		26,861 (1.76)	191 (0.85)	234,365.08 (3.17)	0.71	8.15
Missing		13 (0)	0 (0)	14.5 (0)	0	0
Length of Service	<1 year	215,160 (14.09)	4,256 (18.99)	106,276.67 (1.44)	1.98	400.46
	1-3 years	286,793 (18.78)	7,296 (32.55)	610,012.5 (8.24)	2.54	119.60
	3-5 years	350,386 (22.94)	4,116 (18.36)	1,315,270.42 (17.77)	1.17	31.29
	5-7 years	168,612 (11.04)	2,107 (9.40)	898,100.33 (12.14)	1.25	23.46
	7+ years	506,526 (33.16)	4,642 (20.71)	4,470,378.25 (60.41)	0.92	10.38

Table 2. Annual Prevalence and Incidence Rates by FY (2002-2015)

Year	Injured	N*	Total Person-Months (p-m)	Injury Prevalence (%)	IR (per 10,000 p-m)
2002	1,481	513,998	5,242,161	0.29	2.83
2003	1,241	508,231	5,314,821	0.24	2.34
2004	1,498	525,893	5,337,546	0.28	2.81
2005	1,514	516,496	5,271,777	0.29	2.87
2006	1,710	559,267	5,695,620	0.31	3.00
2007	1,923	578,202	5,978,765	0.33	3.22
2008	1,891	595,677	6,191,607	0.32	3.05
2009	1,948	650,799	6,568,605	0.30	2.97
2010	1,866	633,384	6,752,743	0.29	2.76
2011	1,754	634,792	6,802,448	0.28	2.58
2012	1,725	621,799	6,628,731	0.28	2.60
2013	1,247	615,116	6,338,917	0.20	1.97
2014	1,287	574,296	6,084,135	0.22	2.12
2015	1,332	553,089	5,808,356	0.24	2.29

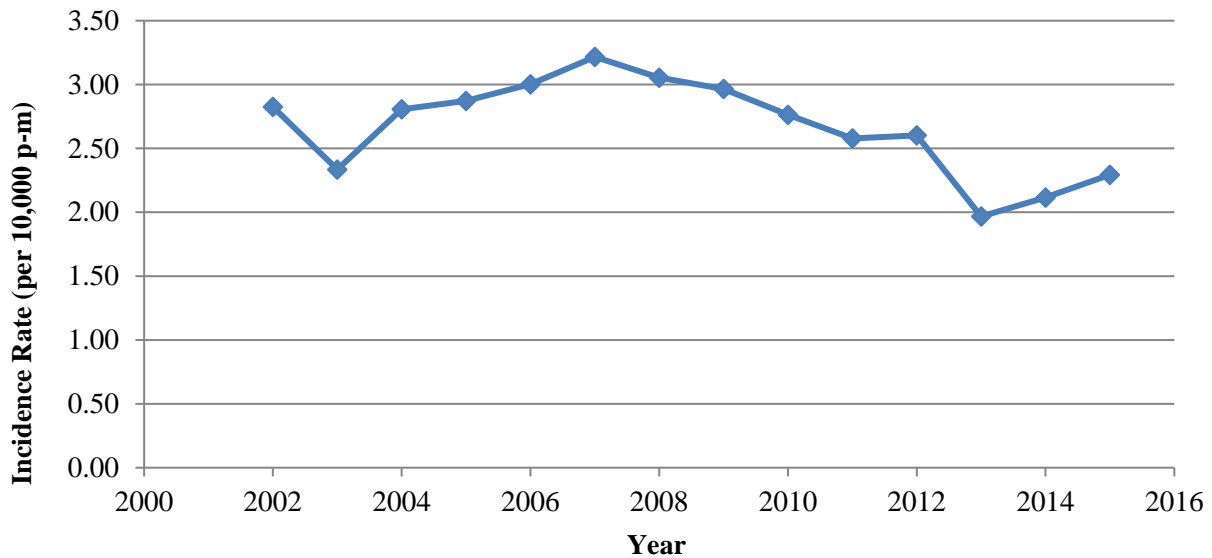
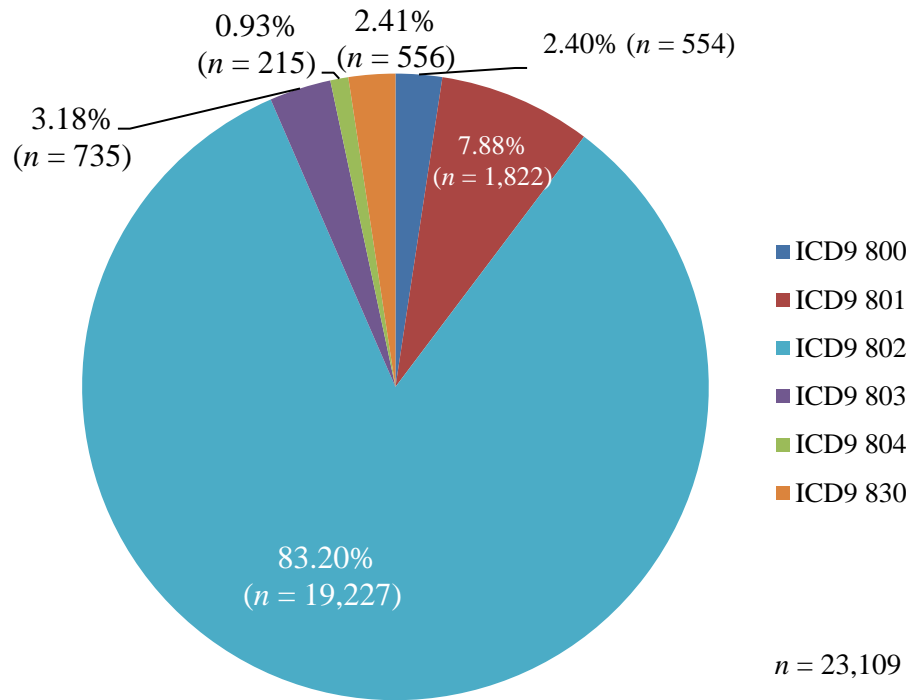


Figure 1. Annual incidence rates of Soldiers with at least one CMF injury by FY (2002-2015).



ICD-9-CM Codes	Injury Description
800.0 – 800.9	Vault of skull fracture
801.0 – 801.9	Base of skull fracture
802.0, 802.1	Nasal bone fracture
802.2, 802.3	Mandible fracture
802.4, 802.5	Malar and maxillary bones fracture
802.6, 802.7	Orbital floor fracture
802.8, 802.9	Other facial bone fracture
803.0 – 803.9	Other and unqualified skull fracture
804.0 – 804.9	Multiple fractures involving skull or face with other bones
830.0, 830.1	Dislocation of the jaw

Figure 2. Breakdown of CMF injury types (FY 2002-2015). The number of injuries is higher than the number of injured Soldiers due to multiple injuries reported during the same medical encounter.

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Table 3. Demographic Characteristics of Soldiers with a CMF Injury by Deployment Status (FY 2002-2015)

		Deployed (n=1,706) (%)	Not Deployed (n=20,711) (%)
Sex	Female	49 (2.87)	1,669 (8.06)
	Male	1,657 (97.13)	19,042 (91.94)
Age	<20	71 (4.16)	2,054 (9.92)
	20-29	1,279 (74.97)	14,420 (69.62)
	30-39	291 (17.06)	3,291 (15.90)
	>40	65 (3.81)	945 (4.56)
	Missing	0 (0)	1 (0)
Education	<HS	19 (1.11)	180 (0.87)
	HS	1,213 (71.10)	14,151 (68.33)
	College	426 (24.97)	5,574 (26.91)
	Advanced Degree	21 (1.23)	469 (2.26)
	Missing	27 (1.58)	337 (1.63)
Marital Status	Single	867 (50.82)	11,419 (55.13)
	Married	774 (45.37)	8,318 (40.17)
	Other	63 (3.69)	966 (4.67)
	Missing	2 (0.12)	8 (0.04)
Race/Ethnicity	White	1,262 (73.97)	14,034 (67.76)
	Black	172 (10.08)	3,173 (15.32)
	Hispanic	186 (10.90)	2,343 (11.31)
	Native		
	American/Alaskan	19 (1.11)	251 (1.21)
	Asian Pacific Islander	47 (2.75)	651 (3.14)
	Other	17 (1.00)	231 (1.12)
	Missing	3 (0.18)	28 (0.14)
Rank	E1-E4	957 (56.10)	13,728 (66.28)
	E5-E6	539 (31.59)	4,514 (21.80)
	E7-E9	91 (5.33)	1,029 (4.97)
	Officer	105 (6.15)	1,263 (6.10)
	Warrant	14 (0.82)	177 (0.85)
Length of Service	1 year	63 (3.69)	4,193 (20.25)
	1-3 years	687 (40.27)	6,613 (31.91)
	3-5 years	382 (22.39)	3,736 (18.03)
	5-7 years	192 (11.25)	1,915 (9.25)
	7+ years	382 (22.39)	4,260 (20.57)
Number of Injuries	1 Injury	1,565 (91.74)	20,179 (97.43)
	2 or More Injuries	141 (8.26)	532 (2.57)

Table 4. Incidence Rates of Injured Soldiers by Deployment Status and FY (2002-2015)

Year	Deployed	Person-Time (p-m)	Incidence Rate (per 10,000 p-m)	Not Deployed	Person-Time (p-m)	Incidence Rate (per 10,000 p-m)
2002	73	370,618	1.97	1,411	4,871,543	2.90
2003	347	1,935,539	1.79	894	3,379,282	2.65
2004	579	2,161,072	2.68	919	3,176,474	2.89
2005	495	1,845,916	2.68	1,019	3,425,861	2.97
2006	597	2,369,792	2.52	1,113	3,325,828	3.35
2007	763	2,389,976	3.19	1,160	3,588,789	3.23
2008	716	2,614,624	2.74	1,175	3,576,983	3.29
2009	755	2,899,534	2.60	1,193	3,669,071	3.25
2010	741	2,893,656	2.56	1,125	3,859,087	2.92
2011	575	2,578,003	2.23	1,179	4,224,445	2.79
2012	542	2,087,724	2.60	1,183	4,541,007	2.61
2013	271	1,581,737	1.71	976	4,757,180	2.05
2014	157	1,077,889	1.46	1,130	5,006,246	2.26
2015	80	406,508	1.97	1,252	5,401,848	2.32

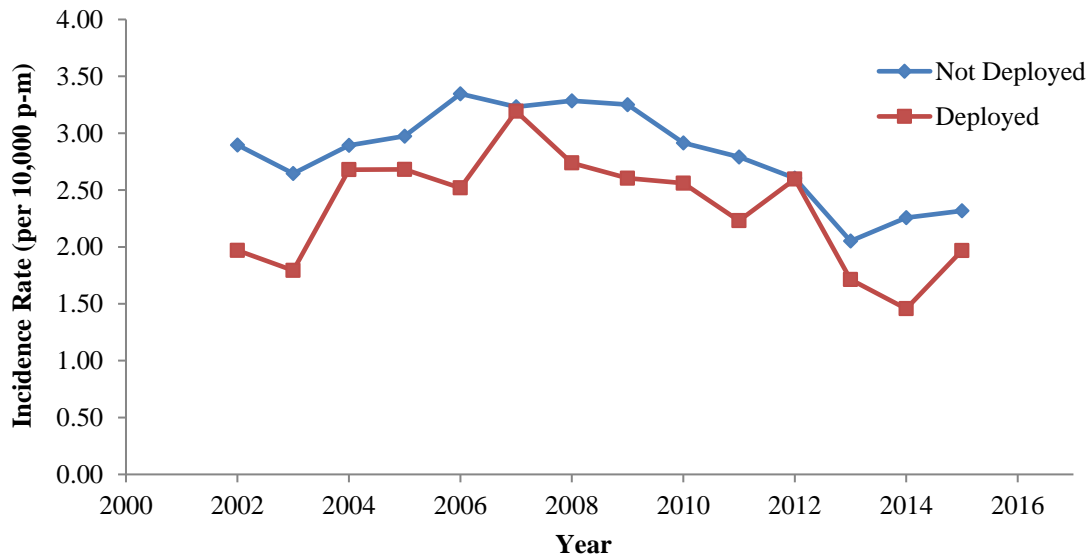


Figure 3. Annual incidence rates of CMF injury by deployment status (FY-2002-2015).

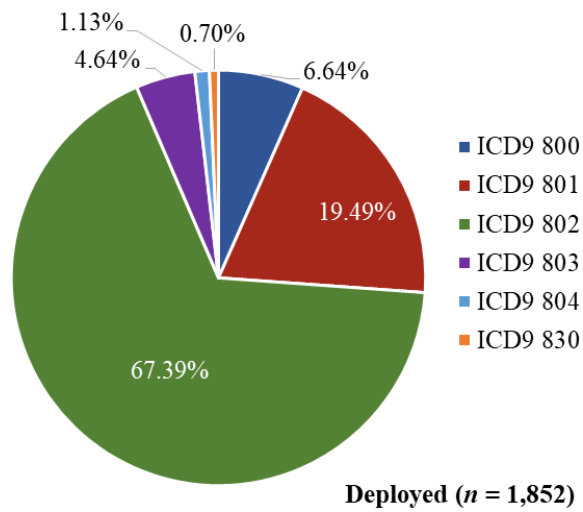


Figure 4. Breakdown of CMF injury types by deployment status at the time of injury (FY 2002-2015).

Table 5. Comparison of CMF Injured Soldiers by ICD-9 Injury Type and Deployment Status (FY 2002-2015)

	Deployed		Not Deployed		<i>p</i>
	Injured	%	Injured	%	
ICD9 800	123	6.64	431	2.03	<0.001
ICD9 801	361	19.49	1,460	6.87	<0.001
ICD9 802	1,248	67.39	17,976	84.58	<0.001
ICD9 803	86	4.64	649	3.05	<0.001
ICD9 804	21	1.13	194	0.91	0.2307
ICD9 830	13	0.70	543	2.55	<0.001

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## Discussion

Overall, the total rate of Soldiers with at least one CMF injury is 30.29 injured Soldiers per 10,000 p-y, or 30.29 Soldiers sustained a CMF injury for every 10,000 Soldiers in the study (FY 2002-2015). While it is easy to look at the group with the largest number of injuries and say that group has the highest rate or the highest risk of sustaining CMF injuries, it is important to take into account the population of that specific group and calculate group-specific rates when possible to compare those populations accurately. All incident rates in Table 1 were calculated based on the total amount of person-time for each specific group.

Male Soldiers sustained CMF injuries almost twice the rate of females when adjusted for the specific populations in the Army (32.54 and 16.53, respectively,  $p < 0.0001$ ). Comparing the incident rates by age group, Soldiers less than 20 years old had the highest rate of injuries with 317.08 Soldiers with a CMF injury per 10,000 p-y, but they also contributed the least amount of time into total person-time years; incidence rates decrease for this reason for each of the age groups. When the injured Soldiers were broken out by the highest level of education completed, those with a High School education sustained the highest rate of injuries with 40 injured Soldiers per 10,000 p-y. Single Soldiers had the highest incident rate during the study, with 66.69 injured per 10,000 p-y when broken down by marital status at the time of injury. Native American/Alaskan Natives sustained the highest rate of injured Soldiers with 39.61 injured Soldiers per 10,000 p-y, followed by White, Non-Hispanic Soldiers with 35.24 per 10,000 p-y and Hispanic Soldiers with 30.41 injured Soldier per 10,000 p-y. Soldiers with ranks E1 – E4 sustained the highest incident rate, with 61.31 injured Soldiers per 10,000 p-y. Soldier with ranks E7 – E9 sustained the lowest rate of injuries, with 8.15 injured Soldiers per 10,000 p-y. To better understand why particular age groups or Ethnic groups sustained higher rates of CMF injuries, more information on the Soldier's military occupational specialty (MOS), as well as more detailed injury descriptions and injury mechanisms, are needed.

CMF injury incidence rates for non-deployed Soldiers were consistently higher than for deployed Soldiers during the study period (Figure 3). The U.S. Army has a large population, and while the much focus is on the readiness of Soldiers in theater (i.e., deployed Soldiers), the bulk of the Army is not in a deployed status. More information about where these injuries are being sustained (i.e., during training exercises or recreational activities) is needed before any additional conclusions can be made. The higher number of non-deployed Soldiers included in the study may be reflected in the higher injury incidence rates for this segment of the study population. Again more information about the total number of deployed and non-deployed Soldiers who did not sustain an injury is needed before a more detailed comparison or understanding of differences can be made.

Despite lower incidence rates, deployed Soldiers appear to be at higher risk of sustaining multiple CMF injuries in the same injury event, and even more severe CMF injuries based on ICD codes, than non-deployed Soldiers. The proportion of deployed Soldiers sustaining two or more CMF injuries was more than three times that of non-deployed Soldiers (Table 3). Additionally, for four of the six CMF injury types, the proportions of CMF injuries for these four injury types were statistically higher for deployed Soldiers when compared to non-deployed Soldiers (Table 5). The proportions of CMF injuries characterized as basilar skull injuries (ICD-9-CM code 801) and catastrophic skull fractures (ICD-9-CM code 800) were 2.8 and 3.3 times

higher for deployed Soldiers than for non-deployed Soldiers (Table 5). The risk for greater numbers of CMF injury to an individual Soldier, as well as the higher proportions of CMF injury seen in the deployed setting, are likely due to hazards unique to the deployed environment. When deployed, Soldiers are exposed to multiple threats that are not seen in the non-deployed setting, including ballistic threats (e.g., bullets fired from handguns or rifles, high-velocity debris caused by explosions), blast events (e.g., improvised explosive devices), and accelerative events (e.g., under-body blasts, vehicle rollovers or collisions, aircraft mishaps). Additional information on the military occupational specialty (MOS) of the Soldiers sustaining CMF injuries, as well as more detailed injury descriptions and mechanisms of injury, is needed to better understand the reason for the higher injury proportions in the deployed environment.

The proportion of CMF injuries coded as ICD-9-CM 802 (fracture of face bones) were similar for deployed and non-deployed Soldiers. The overall percentage of fractures to the facial bones is large in both deployed and non-deployed setting, 67.39% and 84.58%, respectively (Table 5). The high proportion of facial fractures may be due to the face being unprotected in both settings. In the deployed environment, Soldiers wear protective eyewear and combat helmets to protect their eyes and heads from blunt impact or ballistic threats. Similarly, in the non-deployed setting, Soldiers often wear protective eyewear and activity-specific headgear (e.g., bicycle, football, or motorcycle helmets). In both settings, the face remains exposed to potential injury. To improve protection for deployed Soldiers, the Army has recently started integrating maxillofacial protection into the Soldier personal protective equipment (PPE) ensemble. The Army's Integrated Head Protection System (IHPS) includes a modular maxillofacial shield (Sheftick, 2019).

Jaw dislocations (ICD-9-CM code 830) accounted for a higher proportion of CMF injuries in non-deployed Soldiers than deployed Soldiers. Jaw dislocations accounted for 2.55% of CMF injuries in non-deployed Soldiers versus 0.70% for deployed Soldiers. The higher proportion of injuries to non-deployed Soldiers could be a function of the mechanism of injury; non-deployed Soldiers may have a greater exposure to activities or events that could cause jaw dislocations (e.g., training, recreational sports, motor vehicle injuries, or fighting). Further breakdown of the specific injury types and injury mechanisms, as well as additional information regarding the circumstances that produced the CMF injuries, are needed to identify why jaw dislocations accounted for more CMF injuries in the non-deployed setting.

## **Limitations**

The present study was limited to general demographic information and high-level injury descriptions. To fully understand these findings and to identify causal factors for the CMF injury trends noted in this report, more detailed information would be required, including Soldier MOS, detailed injury descriptions, injury mechanisms, and event descriptions.

## Conclusions

This study has identified demographic groups of Soldiers with the highest risks of sustaining CMF injuries in deployed and non-deployed environments. These groups include male Soldiers, Soldiers less than 20 years of age, Soldiers with a High School education, Soldiers with Native American, Alaskan Native, white (non-Hispanic), and Hispanic ethnicity, and Soldiers ranked E4 or below.

Deployed Soldiers have a higher risk of sustaining more severe CMF injuries than non-deployed Soldiers. Additionally, deployed Soldiers are at higher risk of sustaining two or more co-morbid CMF injuries than non-deployed Soldiers. These findings are likely related to the inherent hazards associated with being deployed to active combat theaters.

The risk of facial bone fractures is similar for deployed and non-deployed Soldiers. In both environments, the face is often left unprotected despite the presence of other head-worn PPE like helmets and protective eyewear. The integration and use of proper maxillofacial protection into the Soldier personal protective equipment (PPE) could substantially reduce facial injury risk.

To assess differences in injury risk factors (such as threats, PPE use, missions, etc.), additional analysis of detailed medical, demographic, and administrative data is needed. Until that time, this study serves to provide an overview of the total burden of CMF injuries within the U.S. Army and define the relative distribution of non-deployed and deployed CMF injuries during a period (FY 2002 – 2015) including recent conflicts. Additionally, CMF injury distributions and demographic characteristics described in this study provide insight into medical and mission burden for future planning to support U.S. Army Soldiers during deployment and beyond.

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