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Airmen with mild traumatic brain injury (mTBI) at increased risk for subsequent mishaps ☆

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ABSTRACT

Background: Little is known regarding long-term performance decrements associated with mild Traumatic Brain Injury (mTBI). The goal of this study was to determine if individuals with an mTBI may be at increased risk for subsequent mishaps. *Methods:* Cox proportional hazards modeling was utilized to calculate hazard ratios for 518,958 active duty U.S. Air Force service members (Airmen) while controlling for varying lengths of follow-up and potentially confounding variables. Two non-mTBI comparison groups were used; the second being a subset of the original, both without head injuries two years prior to study entrance. *Results:* Hazard ratios indicate that the causes of increased risk associated with mTBI do not resolve quickly. Additionally, outpatient mTBI injuries do not differ from other outpatient bodily injuries in terms of subsequent injury risk. *Conclusions:* These findings suggest that increased risk for subsequent mishaps are likely due to differences shared among individuals with any type of injury, including risk-taking behaviors, occupations, and differential participation in sports activities. Therefore, individuals who sustain an mTBI or injury have a long-term risk of additional mishaps. *Practical applications:* Differences shared among those who seek medical care for injuries may include risk-taking behaviors (Cherpitel, 1999; Turner & McClure, 2004; Turner, McClure, & Pirozzo, 2004), occupations, and differential participation in sports activities, among others. Individuals with an mTBI should be educated that they are at risk for subsequent injury. Historical data supported no lingering effects of mTBI, but more recent data suggest longer lasting effects. This study further adds that one of the longer term sequelae of mTBI may be an increased risk for subsequent mishap.

1. Background

Studies consistently highlight that military personnel are at increased risk for traumatic brain injury (TBI; Arthur et al., 2007; Tanielian et al., 2008; Terrio et al., 2009). This association exists because the military is disproportionately comprised of young and active men and women. Results of the WHO collaborating task force on mild traumatic brain injury indicate that mTBI is more common in males, as men have almost twice the risk of women for mTBI (Cassidy et al., 2004). The risk is also greater in teenagers and young adults as a result of motor vehicle accidents, falls, and recreational sports injuries (Cassidy et al., 2004).

Trauma to the brain may cause long-term mechanical and biochemical damage that may lead to neurological diseases (AFHSC, 2007; Hoge et al., 2008; Schulte, Burnett, Boeniger, & Johnson, 1996), psychiatric diseases (Kersel, Marsh, Havill, & Sleigh, 2001), or an increased likelihood of disability (Kreutzer, Seel, & Gourley, 2001). While there are several national civilian initiatives tracking the sequelae of moderate and severe TBI, less is known about mTBI and its potential impact on civilian and military populations.

An mTBI, commonly known as a concussion, occurs when trauma to the head is combined with one or more of the following attributable symptoms: a brief alteration of mental status such as confusion or disorientation; loss of memory for events immediately before or after the injury; and/or loss of consciousness lasting less than 30 min (NCIPC, 2003). According to Guskiewicz, Weaver, Padua, and Garrett (2000), individuals who experience a concussion are about three times more likely to sustain a second concussion, within the next 3 months. Motor deficits reported shortly following mTBI include reduced strength, uncoordinated movement, postural abnormalities (Slobounov, Cao,

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Sebastianelli, Slobounov, & Newell, 2008), and gait imbalance (Catena, van Donkelaar, & Chou, 2007, 2009). Post-mTBI cognitive deficits include an inability to concentrate, reduced memory, and poor judgment (Catena et al., 2007). Given this information, it is plausible that individuals with mTBI may be at increased risk for subsequent mishaps/incidents, in which they may sustain another concussion or injury.

The term "mishaps" refers to unplanned events that result in damage to equipment or injury to an individual in one of the following ground mishap categories: afloat, motor vehicle, industrial, and sports and recreation (Air Force Audit Agency, 2010). Therefore, mishaps do include events that do not result in injury. Although important to readiness and individual safety, the long term impact of mTBI on U.S. service members' risk for subsequent mishaps post-mTBI has not been established.

Given the relative gap in current knowledge regarding the relations between mTBI and subsequent mishaps, existing Department of Defense (DoD) electronic personnel, medical and safety center data were leveraged to evaluate this association. Therefore, the objective of this study was to conduct a retrospective cohort study among male and female USAF enlisted and officer personnel (Airmen) to describe whether or not individuals who had previously experienced an mTBI had an additional mishap.

2. Methods

2.1. Population and data sources

Electronic personnel data were obtained from the Defense Manpower Data Center (DMDC) for Airmen who had served on active duty for at least 180 days between October 1, 2001 and September 30, 2008. Demographic and military specific information collected included gender, birth date, highest achieved education level, marital status, race/ethnicity, military rank, deployment, and primary occupational specialty. Electronic medical record data were obtained from the Military Health System, which is maintained by the TRICARE Management Activity (TMA) and then matched to study participants' demographic and military specific data by personal identifiers. Through a data use agreement, a listing of individuals with a documented safety mishap during the study period was developed using data from the Air Force Safety Automated System (AFSAS), the Air Force Safety Center's mishap reporting system, and then matched to study participants by personal identifiers.

The AFSAS system provides a web-based mishap reporting tool that allows tracking of mishaps and trends. Non-combat on- and off-duty military personnel and on-duty civilian employees must notify their supervisors of all work-related accidents and injuries no later than the end of the work shift or the day of occurrence. Supervisors are then required to notify their supervisory chain of command within one working day of receiving the mishap information. Unit commanders or unit safety representatives report any injuries to the Wing Safety Office. Then, safety office personnel investigate and determine whether the occurrence is reportable to the Air Force Safety Center in accordance with AFI 91-204, Safety Investigation and Reports, 24 September 2008 (Air Force Audit Agency, 2010).

The data used in this study pertains to mTBI diagnosed in a non-combat environment, and from predominantly non-blast mechanisms. To identify cases of mTBI, this study utilized the Centers for Disease Control and Prevention (CDC) Administrative Data Definition of mTBI for Surveillance or Research (NCIPC, 2003), which is comprised of a listing of International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes (NCHS, 2007) considered by an expert panel to be indicative of mTBI. Additionally, a neurologist performed a blinded medical record review to determine an estimate of the accuracy of this mTBI code assignment. To increase the probability of only including incident cases of mTBI, Airmen with a history of mTBI or other head injury in the two years prior to entering the study were removed from consideration.

Two non-mTBI comparison groups were used. The first comparison group included the entire study population without an mTBI during the study period, and with no previous history of mTBI, or other head injuries, within the two years prior to study entry. The second comparison group included a non-mTBI injured group, which was a sub-set of the original comparison group; also without an mTBI or other head injuries two years prior to entering the study. Individuals included in the injury comparison group were those who had sustained an outpatient injury to the torso, spinal cord, abdomen, pelvis, digestive tract, or genitourinary tract (ICD-9-CM 805–810, 860–870, 900–905, 922–923, 926–927, and 933–959) and were termed the "other-injured group" for the purposes of this study. The other-injured group was utilized to decrease any possible medical surveillance bias that may have occurred due to the possibility of increased medical observation that may occur with an injury.

Person-time began on either October 1, 2001, the date they entered active duty, or the date at which they were diagnosed with an mTBI or injury consistent with the reference category, whichever occurred later. Person-time ended when they left active duty, had a documentable mishap, the day before a subsequent mTBI or other head injury, or at the end of the study (September 30, 2008), whichever occurred first. Mishaps included were those occurring later than two days post-mTBI or injury, to ensure proper temporal relationship and exclude same-event diagnoses.

Table 1
Active Duty U.S. Air Force Airmen Demographics 10/1/2001–9/30/2008.[a]

Characteristic	mTBI		Injury cohort		Full cohort	
	n = 5,065		n = 44,733		n = 513,893	
	No.	(%)	No.	(%)	No.	(%)
Gender						
Male	4,158	(82.09)	33,674	(75.28)	409,076	(79.60)
Female	907	(17.91)	11,059	(24.72)	104,817	(20.40)
Race/Ethnicity						
White (non-Hispanic)	3,802	(75.06)	32,772	(73.26)	369,788	(71.96)
Black (non-Hispanic)	588	(11.61)	6,162	(13.78)	78,522	(15.28)
Asian and Pacific Islander	126	(2.49)	1,269	(2.84)	14,811	(2.88)
Hispanic	329	(6.50)	2,604	(5.82)	27,702	(5.39)
Native American	35	(0.69)	368	(0.82)	3,177	(0.62)
Other/Unknown	185	(3.65)	1,558	(3.48)	19,893	(3.87)
Birth year						
Before 1965	340	(6.71)	6,259	(13.99)	89,223	(17.36)
1966–1975	795	(15.70)	10,020	(22.40)	109,131	(21.24)
1976 or later	3,930	(77.59)	28,454	(63.61)	315,539	(61.40)
Marital Status						
Currently married	1,481	(29.24)	18,588	(41.55)	221,192	(43.04)
Never married	3,418	(67.48)	24,228	(54.16)	271,182	(52.77)
No longer married	166	(3.28)	1,917	(4.29)	21,519	(4.19)
Education						
High School or less	4,536	(89.56)	36,277	(81.10)	381,900	(74.32)
Some College/Bachelor's	364	(7.19)	5,614	(12.55)	86,775	(16.89)
Advanced degree	150	(2.96)	2,699	(6.03)	42,304	(8.23)
Unknown	15	(0.30)	143	(0.32)	2,914	(0.57)
Rank						
Enlisted	4,814	(95.04)	40,307	(90.11)	434,196	(84.49)
Officer	251	(4.96)	4,426	(9.89)	79,697	(15.51)
Deployed						
Never	2,526	(49.87)	22,163	(49.55)	287,340	(55.91)
Once	1,400	(27.64)	12,274	(27.44)	129,080	(25.12)
Twice	661	(13.05)	5,971	(13.35)	56,985	(11.09)
More than twice	478	(9.44)	4,325	(9.67)	40,488	(7.88)
Career Field						
Operations	774	(15.28)	8,196	(18.32)	101,729	(19.80)
Logistics/Maintenance	1,940	(38.30)	14,724	(32.92)	157,834	(30.71)
Support	1,466	(28.94)	12,596	(28.16)	141,039	(27.45)
Medical	381	(7.52)	4,116	(9.20)	46,382	(9.03)
Professional/Acquisitions/Finance	112	(2.21)	1,350	(3.02)	19,698	(3.83)
Other/Unknown	392	(7.74)	3,751	(8.39)	47,211	(9.19)

Abbreviations: U.S., United States; mTBI, mild traumatic brain injury.
All differences were tested with the Pearson chi-square test of association and are statistically significant at $\alpha = 0.05$.
[a] Airmen included were on active duty for six or more months during this time period.

2.2. Statistical analyses

Demographic and military specific data were analyzed using frequency distributions and Pearson's Chi-square tests to determine univariate differences (Tables 1 and 2). After investigation of population characteristics, Cox proportional hazards analyses were performed to assess the significance of associations between mTBI and succeeding mishaps while adjusting for variables in the model and accounting for differences in person-time contributed by study members (Tables 3 and 4). Before analysis, the proportional hazards assumption was examined for each independent variable using both graphical and time-dependent variable techniques.

All Cox proportional hazards models were adjusted for gender, marital status, race/ethnicity, date of birth category, deployment status, education level, rank, career field, previous mishap status, and injury severity. Previous mishap status was defined as having a documented mishap within two years prior to entering the study. The variance inflation factor (VIF) was used to check for potential multicollinearity, which represents the increase in variance of an estimated regression coefficient due to the correlation between the covariates. No significant interactions or multicollinearity were detected among any of the independent demographic variables in these models.

Table 2
Active duty U.S. Air Force airmen subsequent mishap demographics by mTBI status 10/1/2001–9/30/2008.[a]

Characteristic	mTBI	No mTBI	p-value
	n = 327	n = 16,648	
	No. (%)	No. (%)	
Gender			0.8788
Male	280 (85.63)	14,205 (85.33)	
Female	47 (14.37)	2,443 (14.67)	
Race/Ethnicity			0.0129[b]
White (non-Hispanic)	261 (79.82)	12,044 (72.35)	
Black (non-Hispanic)	25 (7.65)	2,414 (14.50)	
Asian or Pacific Islander	8 (2.45)	441 (2.65)	
Hispanic	18 (5.50)	1,044 (6.27)	
Native American	4 (1.22)	119 (0.71)	
Other/Unknown	11 (3.36)	586 (3.52)	
Birth year			<0.001[b]
Before 1965	11 (3.36)	1,227 (7.37)	
1966–1975	45 (13.76)	3,373 (20.26)	
1976 or later	271 (82.87)	12,048 (72.37)	
Marital Status			<0.001[b]
Currently married	88 (26.91)	6,099 (36.64)	
Never married	230 (70.34)	9,953 (59.78)	
No longer married	9 (2.75)	596 (3.58)	
Education			0.0035[b]
High School or less	312 (95.41)	14,828 (89.07)	
Some college/bachelor's	11 (3.36)	1,371 (8.24)	
Advanced degree	4 (1.22)	411 (2.47)	
Unknown	0 (0.00)	38 (0.23)	
Rank			0.0066[b]
Enlisted	321 (98.17)	15,787 (94.83)	
Officer	6 (1.83)	861 (5.17)	
Deployed			0.4847
Never	154 (47.09)	7,162 (43.02)	
Once	84 (25.69)	4,802 (28.84)	
Twice	50 (15.29)	2,611 (15.68)	
More than twice	39 (11.93)	2,073 (12.45)	
Career Field			0.3716
Operations	40 (12.23)	2,192 (13.17)	
Logistics/Maintenance	162 (49.54)	7,566 (45.45)	
Support	84 (25.69)	4,216 (25.32)	
Medical	20 (6.12)	1,024 (6.15)	
Professional/Acquisitions/Finance	4 (1.22)	311 (1.87)	
Other/Unknown	17 (5.20)	1,339 (8.04)	

Abbreviations: U.S., United States.
[a] Airmen included were on active duty for six or more months during this time period.
[b] Differences were tested with the Pearson chi-square test of association and are statistically significant at $\alpha = 0.05$.

Table 3
Mishaps occurring >2 days post-mTBI.

Type of mishap[a]	mTBI	Injury cohort	Full cohort
	n = 5,065	n = 44,733	n = 513,893
	n (%)	HR (95% CI)	HR (95% CI)
Overall	313 (6.18)	0.98 (0.86–1.13)	2.00 (1.78–2.26)[b]
Private motor vehicle	52 (1.03)	1.31 (0.93–1. 82)	2.92 (2.19–3.87)[b]
Government motor vehicle	0 (0.00)	[c]	[c]
Sports and recreation	116 (2.29)	1.01 (0.81–1.25)	1.96 (1.62–2.38)[b]
Industrial	80 (1.58)	0.86 (0.65–1.15)	1.73 (1.34–2.22)[b]
Miscellaneous	59 (1.16)	0.85 (0.63–1.15)	2.16 (1.64–2.84)[b]
Duty status			
On duty	120 (2.37)	0.74 (0.59–0.93)‡	1.49 (1.22–1.81)[b]
Off duty	183 (3.61)	1.13 (0.95–1.95)	2.47 (2.13–2.88)[b]
Mishap severity			
Lost time case	181 (3.57)	1.04 (0.87–1.23)	2.12 (1.83–2.46)[b]
Treated and released	22 (0.43)	1.69 (0.89–3.22)	2.69 (1.71–4.22)[b]
No lost time	81 (1.60)	0.77 (0.59–1.01)	1.69 (1.34–2.14)[b]
Other	4 (0.08)	[c]	3.73 (1.03–13.56)[b]
Body part injured			
Extremities	88 (1.74)	1.12 (0.87–1.45)	2.01 (1.61–2.52)[b]
Head and neck	24 (0.47)	0.99 (0.59–1.66)	1.60 (1.02–2.53)[b]
Spine	0 (0.00)	[c]	[c]
Torso	19 (0.36)	0.69 (0.40–1.18)	1.32 (0.81–2.17)
Unclassifiable	0 (0.00)	[c]	[c]

Abbreviations: mTBI, mild traumatic brain injury; HR, Hazard Ratio; CI, Confidence Interval.
[a] Adjusted for gender, marital status, race/ethnicity, birth year, deployment, education, rank, career field, duty status, previous mishap status, and injury severity.
[b] Differences are statistically significant at $\alpha = 0.05$.
[c] Percentage of outcome in comparison population was not sufficient to generate a hazard ratio with a 95% confidence interval.

Analyses assessed differences in post-mTBI mishap incidence rates, mishap severity, injury cause category, duty status (on or off duty), and body part injured. Adjusted hazard ratios (HRs) with 95% confidence intervals (CIs) were calculated to compare the risk of the specified outcomes between the mTBI population and the two non-mTBI populations, separately. As shown in Table 3, an overall risk for subsequent mishap was calculated for both comparison groups. This was stratified by time periods in Table 4 in order to show whether or not mTBI risk decreased with time. Time periods were not mutually exclusive; the analysis for >2 days included >2 wks, etc.

All statistical analyses were conducted using SAS® (Version 9.2, SAS Institute, Inc., Cary, North Carolina).

3. Results

The blinded medical record review by the neurologist found a moderate level of agreement (Cohen's Kappa = 0.51, 95% CI 0.29, 0.72) between the CDC recommended codes and evidence of mTBI in the medical record note that matched the date of diagnosis in the electronic data.

Of the 518,958 Airmen who met study criteria, 5,065 were classified as having an mTBI, and 327 individuals (6.5%) had sustained both an mTBI and a subsequent safety mishap during the study period. Of the Airmen who were not classified as having an mTBI, 16,648 (3.2%) sustained a safety mishap. In univariate analysis, Airmen who suffered a subsequent mishap were significantly more likely to be white (non-Hispanic), never married, enlisted, born during or after 1976, and have a high-school level of education, or less (Table 2).

Airmen with mTBI were at increased risk for subsequent mishaps for almost all categories when compared to the full cohort (Table 3). Increased risks were noted for subsequent mishaps involving motor vehicles, sports and recreation, industrial accidents, or for miscellaneous reasons. In addition to the type of mishap, Airmen (with an mTBI) were more likely to have these subsequent mishaps when they were on or off-duty, were more likely to lose time at work, and were more likely to injure extremities such as their arms, legs, or hands. When compared to the other-injured group, the mTBI group was not at increased risk for

Table 4
Hazard ratios over time.

Type of mishap[a]	mTBI	Injury cohort	Full cohort
	n = 5,065	n = 44,733	n = 513,893
	n	HR (95% CI)	HR (95% CI)
Mishaps occurring >2 days post-mTBI			
Overall	313	0.98 (0.86–1.13)	2.00 (1.78–2.26)[b]
Private vehicle	52	1.31 (0.93–1. 82)	2.92 (2.19–3.87)[b]
Government vehicle	0	[c]	[c]
Sports and recreation	116	1.01 (0.81–1.25)	1.96 (1.62–2.38)[b]
Industrial	80	0.86 (0.65–1.15)	1.73 (1.34–2.22)[b]
Miscellaneous	59	0.85 (0.63–1.15)	2.16 (1.64–2.84)[b]
Duty status			
On duty	120	0.74 (0.59–0.93)[b]	1.49 (1.22–1.81)[b]
Off duty	183	1.13 (0.95–1.95)	2.47 (2.13–2.88)[b]
Mishap severity			
Lost time case	181	1.04 (0.87–1.23)	2.12 (1.83–2.46)[b]
Treated and released	22	1.69 (0.89–3.22)	2.69 (1.71–4.22)[b]
No lost time	81	0.77 (0.59–1.01)	1.69 (1.34–2.14)[b]
Other	4	[c]	3.73 (1.03–13.56)[b]
Body part injured			
Extremities	88	1.12 (0.87–1.45)	2.01 (1.61–2.52)[b]
Head and neck	24	0.99 (0.59–1.66)	1.60 (1.02–2.53)[b]
Spine	0	[c]	[c]
Torso	19	0.69 (0.40–1.18)	1.32 (0.81–2.17)
Unclassifiable	0	[c]	[c]
Mishaps occurring >2 weeks post-mTBI			
Overall	299	0.96 (0.84–1.10)	1.93 (1.70–2.18)[b]
Private vehicle	51	1.32 (0.94–1.85)	2.90 (2.18–3.86)[b]
Government vehicle	0	[c]	[c]
Sports and recreation	107	0.93 (0.75–1.17)	1.82 (1.49–2.23)[b]
Industrial	78	0.87 (0.65–1.17)	1.69 (1.31–2.18)[b]
Miscellaneous	57	0.85 (0.62–1.15)	2.11 (1.60–2.79)[b]
Duty status			
On duty	118	0.72 (0.57–0.91)[b]	1.47 (1.20–1.80)[b]
Off duty	171	1.09 (0.91–1.30)	2.34 (2.01–2.74)[b]
Mishap severity			
Lost time case	172	1.01 (0.85–1.21)	2.04 (1.75–2.37)[b]
Treated and released	20	1.40 (0.71–2.74)	2.44 (1.52–3.92)[b]
No lost time	78	0.74 (0.57–0.98)[b]	1.64 (1.29–2.08)[b]
Other	4	[c]	7.71 (2.62–22.71)[b]
Body part injured			
Extremities	82	1.05 (0.81–1.37)	1.89 (1.50–2.38)[b]
Head and neck	22	0.91 (0.53–1.55)	1.45 (0.90–2.35)
Spine	0	[c]	[c]
Torso	18	0.66 (0.38–1.15)	1.26 (0.76–2.10)
Unclassifiable	0	[c]	[c]
Mishaps occurring >1 month post-mTBI			
Overall	291	0.95 (0.83–1.10)	1.91 (1.69–2.17)[b]
Private vehicle	47	1.26 (0.88–1.78)	2.71 (2.01–3.65)[b]
Government vehicle	0	[c]	[c]
Sports and recreation	106	0.95 (0.75–1.19)	1.84 (1.50–2.25)[b]
Industrial	75	0.86 (0.64–1.16)	1.68 (1.30–2.17)[b]
Miscellaneous	57	0.86 (0.63–1.18)	2.15 (1.63–2.85)[b]
Duty status			
On duty	115	0.75 (0.59–0.94)[b]	1.47 (1.20–1.80)[b]
Off duty	166	1.08 (0.90–1.30)	2.32 (1.98–2.72)[b]
Mishap severity			
Lost time case	167	1.01 (0.84–1.20)	2.02 (1.73–2.35)[b]
Treated and released	20	1.40 (0.71–2.74)	2.44 (1.52–3.92)[b]
No lost time	78	0.75 (0.57–0.98)[b]	1.66 (1.31–2.10)[b]
Other	3	[c]	5.73 (1.69–19.43)[b]
Body part injured			
Extremities	80	1.03 (0.79–1.35)	1.88 (1.48–2.38)[b]
Head and neck	20	0.85 (0.49–1.47)	1.39 (0.85–2.29)
Spine	0	[c]	[c]
Torso	17	0.65 (0.36–1.15)	1.20 (0.71–2.04)
Unclassifiable	0	[c]	

Abbreviations: mTBI, mild traumatic brain injury; HR, Hazard Ratio; CI, Confidence Interval.
[a] Adjusted for gender, marital status, race/ethnicity, birth year, deployment, education, rank, career field, duty status, previous mishap status, and injury severity.
[b] Differences are statistically significant at $\alpha = 0.05$.
[c] Percentage of outcome in comparison population was not sufficient to generate a hazard ratio with a 95% confidence interval.

subsequent mishap, except that Airmen with an mTBI were significantly less likely to be on-duty when the subsequent mishap occurred. Hazard ratios also showed consistent significance (or insignificance) over the three time periods for both the full cohort and the other-injured group (Table 4). Analyses based upon varying lengths of time between the mTBI event and subsequent mishap revealed few differences in risk based upon time interval between mTBI and mishap (Table 3).

4. Discussion

This study was one of the first to utilize electronically-recorded data to better understand how mTBI may adversely impact the subsequent injury risk of military personnel. We found that mTBI was associated with an increased risk for subsequent mishaps in comparison with all other individuals without an mTBI and irrespective of previous injury. However, in comparison to the other-injured group, Airmen with an mTBI were not at increased risk for subsequent injury. The risk of subsequent mishap may be more related to the shared characteristics of the injured persons—such as age, gender, participation in sports activities, and occupation. Furthermore, while previous research indicates that mTBI sequelae resolved quickly (Carroll et al., 2004), this study suggests that this may not be the case.

Finding that Airmen with mTBI were at increased risk for a mishap when compared with the full comparison group, but not when compared to the other-injured group was unexpected. Because these Airmen have non-combat related mTBIs, it is likely that mishaps that led to individuals being placed in the mTBI group or the other-injured comparison group were of similar etiology. This is further supported by the observation that there was no difference in mishap severity between the mTBI group and the other-injured comparison group. Both the mTBI injured and the other-injured group likely have similarities that place them at increased risk for a mishap compared to the full cohort, with the difference being in the possible outcomes of an mTBI versus some other injury. These disparate findings between the two comparison populations used in this study may be attributed to individual characteristics such as seeking medical care for injuries, risk-taking behaviors (Cherpitel, 1999; Turner & McClure, 2004; Turner, McClure, & Pirozzo, 2004), occupations, and differential participation in sports activities. For example, it is commonly recognized that participating in sports and being employed in certain occupations is associated with an increased risk of injury. This risk is likely to continue while the individual remains active in that sport or occupation, which directly contributes to an increased risk for re-injury. Further evidence is provided by one prospective study of over 34,000 urban emergency room users (Madden, Garrett, Cole, Runge, & Porter, 1997). In this study, having a prior injury in the preceding year was the best predictor of subsequent visit due to re-injury, after adjusting for age, race, gender, and external cause of injury.

The finding of an increased on duty mishap risk for Airmen with an mTBI compared with the full group, but a decreased risk for an on duty mishap compared with the other injured group may be important. Having an increased on duty mishap risk when compared with the full group implies that Airman with mTBI are at increased risk for a mishap even though the individual should be under supervision and following routine safety procedures. This finding may reflect baseline differences in mishap risk by occupational category between Airmen with an mTBI and the full group. Alternatively, it may simply reflect increased risk for subsequent mishap among those with a first mishap. Finding a decreased risk for subsequent on duty mishap among Airmen with an mTBI and the other injured group is difficult to interpret and suggests further study is warranted to add clarity to this finding.

Study findings should be interpreted within possible limitations. Most importantly is the use of ICD-9-CM codes to identify health outcomes. First, there is no ICD-9-CM code for mTBI. This study utilized a series of codes that were recommended in the CDC's 2003 report to Congress (NCIPC, 2003). While this study's blinded medical record review found a moderate level of agreement between CDC recommended codes and evidence of mTBI in the medical record, it is quite possible that mTBI codes may not always be assigned accurately (Bazarian, Veazie, Mookerjee, & Lerner, 2006). The extent to which this occurred could not be accurately assessed, but is most likely non-differential with respect to mTBI status, and would most probably have biased findings towards the null. It is also important to note that studies support that not all of those with an mTBI or subsequent mishap actually seek health care (Hoge et al., 2004).

An audit of the Air Force Ground Safety Program established that personnel at 11 of 13 installations inspected did not report 401 (23%) of 1,747 mishaps (such as knee injuries, scalp lacerations, strains, and sprains) reviewed to the safety office (Air Force Audit Agency, 2010). Although all Airmen are required by current guidance to report safety mishaps in which they are involved, there is not consistent enforcement of these requirements at all safety offices worldwide. Further, safety personnel at nine installations did not report 197 (11%) reportable mishaps in AFSAS or clearly document why 200 (11%) of the mishaps were not reported (Air Force Audit Agency, 2010). In addition, certain types of safety mishaps, due to their perceived sensitive or embarrassing nature, or those that do not result in injuries, may have a tendency to be underreported. Again, there is little reason to suspect that under-reporting was differential with respect to mTBI status.

This study has several strengths. The use of DoD electronic data eliminated the possibility of recall bias and resulted in a large sample size of over 50,000 Airmen. The study population was comprised of mostly young men, who are known to be at greatest risk for traumatic brain injuries, and the entire group was quite homogeneous due to military selection processes and equal access to health care for all active duty Airmen. Although this study used a military population of USAF Airmen, deployment data containing blast injuries was unavailable. Thus, deployment medical encounters were deliberately not captured in this study, making this population more comparable to one in which individuals are not necessarily in the military but are similar in demographic composition. Additionally, the use of the other-injured group decreased the likelihood of a medical surveillance bias that may have occurred as a result of seeking health care associated with the mTBI event. Excluding those that had a previous diagnosis of mTBI or head-injury in the two years prior to study entry increased the probability of including only incident cases of mTBI.

5. Conclusions

United States Airmen with mTBI were at increased risk for subsequent mishaps when compared to the full cohort. However, they were at similar or decreased risk for subsequent mishaps compared to the other-injured cohort. These conflicting findings suggest that increased risk for subsequent mishaps is likely not the result of a cognitive deficit, as may be expected among those with mTBI.

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