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Rehospitalization in the First Year following Veteran and Service Member TBI: A VA TBI Model Systems Study

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Abstract

Objective—Determine the incidence and causes of rehospitalization following Military or Veteran TBI.

Setting—VA Veterans Health Administration's Polytrauma Rehabilitation Centers (VHA PRC).

Participants—Consecutive sample of VHA TBI Model System participants (N=401)

Design—Prospective observational cohort study.

Main Measures—Number and type of rehospitalizations in first year post-TBI.

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Results—41% of 401 participants were rehospitalized. Rehospitalization status was associated with greater injury severity and receipt of TBI while active duty. Of those rehospitalized, 30% had 2 or more readmissions. Participants experiencing multiple rehospitalizations (2+) were more likely to have sustained their TBI during deployment compared to those with none or single rehospitalization. This group also sustained more severe injuries and spent more time in VA PRC inpatient rehabilitation. Common reasons for rehospitalization included inpatient rehabilitation (33%), unspecified (26%), orthopedic (10%), seizures (8%), infection (8%), psychiatric (7%).

Conclusion—This is the first study examining military and Veteran rehospitalization following TBI requiring inpatient rehabilitation at a VA PRC. Findings suggest frequent rehospitalization in the first year post-injury suggesting the need for preventative models of health maintenance following inpatient rehabilitation discharge. Greater surveillance of those with deployment-related TBI or active duty at time of injury and greater TBI severity may be warranted.

Keywords

TBI; Rehospitalization; Readmission; Rehabilitation; Veterans' Administration; Military

Traumatic brain injury (TBI) is a persistently disabling condition that requires multi-faceted intervention strategies for successful recovery and return to the community; this issue has significant implications for post-TBI systems of care.¹ It has been suggested that rehospitalization after TBI may in part result from inadequate post discharge care.² Previous studies have not addressed readmission in Veteran and Service Member populations with TBI. Prior studies have, however, examined data from the civilian TBI Model Systems (TBIMS) Registry that collects rehospitalization information via follow-up interviews. Among these, Cifu et al identified an annual rehospitalization incidence of 20–23% in the first 3 years after injury.³ In the first year after injury, the most common causes for readmission were orthopedic/reconstructive, general health maintenance (reflecting a variety of medical and surgical indications), infections, and seizures.³ In a subsequent TBIMS Registry study, Marwitz et al found a similar rehospitalization rate in a larger sample and identified similar causes.⁴

In a more recent study focused on patients with disorders of consciousness, Nakase-Richardson et al studied 9028 individuals during the first year after TBI inpatient rehabilitation, reporting a similar rehospitalization rate of 21%.⁵ Patients who did not follow commands at the time of entry into rehabilitation were found to have a 2-fold higher rate of rehospitalization compared with those who were able to follow commands at admission. The reasons for readmission varied by injury severity, but infections, inpatient rehabilitation, and seizures were common causes.

The civilians TBIMS Registry patient population is comprised of individuals treated at academic medical centers which are generally in urban areas and may not be representative of other rehabilitation systems such as the Veterans' Administration Polytrauma Rehabilitation Centers. Another recently published multi-center prospective longitudinal study by Hammond et al of 1850 patients with TBI utilized a database that was similar to the civilian TBIMS, with the added advantage of increased specificity in the reasons for the rehospitalization.² The most common causes for readmission were infection, neurologic

(mostly seizures), neurosurgery (mostly cranioplasty), injury/external causes (mostly falls or medication toxicity).

Finally, a recent study using an administrative database suggested that re-injury and adverse drug effects were the main contributors to rehospitalization.⁶ In general, research in this area to date has demonstrated rehospitalization to be a substantial problem that reflects a need for a more detailed understanding of the risk factors as well as proximal causes for return to the acute setting. Identifying key intervention points for the prevention of relapses is essential to permit more successful outcomes for TBI patients.

The purpose of this prospective longitudinal study is to report the incidence and causes of readmissions in individuals with TBI in a patient cohort treated in the Veterans Health Administration's (VHA) Polytrauma Rehabilitation Centers system of care. No studies to date have addressed the rehospitalization needs of primarily Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) Service Members and Veterans who sustain TBI. This is the first study to examine the incidence and nature of rehospitalizations for Veterans and active duty Service Members with acute TBI who are in their first year post-injury.

Methods

Participants

Participants were enrolled prospectively in the Veterans Affairs (VA) TBI Model Systems National Database-- a multicenter, longitudinal study of TBI outcomes. Currently, there are 5 sites across the country enrolling subjects in the database, which has been in existence since 2010. All TBIMS enrollees are age 18 or older, and were transferred to comprehensive rehabilitation program at a Polytrauma Rehabilitation Center in VHA. All participants provided informed consent directly or by legal proxy, depending on their capacity to consent for research at the time of study enrolment. Within the VHA TBIMS sites, patient inclusion criteria are 1) medically documented or clinician-confirmed TBI at any severity level (including disorders of consciousness); 2) age 18 or older at time of TBI; and 3) presentation to a VHA Polytrauma Rehabilitation Center for comprehensive inpatient TBI rehabilitation. Because the VHA TBIMS project does not require rehabilitation admission within a specified period of time after the TBI and includes mild TBI cases, some Veterans may have sought care months or years post-injury. Exclusion criteria include presenting for care related to another neurological condition and already being enrolled in either the VHA TBIMS or NIDILRR TBIMS study at another site. See Lamberty et al. (2013) for VHA TBIMS inclusion and exclusion criteria.⁷ This analysis was conducted with a subset of participants who were 1) enrolled into the VHA TBIMS and discharged from rehabilitation between 2010 and June 2015, 2) within one-year of index TBI at time of enrollment and 3) eligible for and completed a one-year post-injury follow-up. Individuals were excluded if deceased, refused interview, or withdrew from the study at the time of one-year post-injury follow-up. Individuals with missing rehospitalization data were also excluded from analyses.

Measures

Baseline demographic and injury characteristics—Data on demographic (i.e. age, sex, education, and race at time of injury) and injury characteristics (i.e. cause of injury, place where injury occurred, and injury severity) were obtained during inpatient rehabilitation at the time of study enrollment. Injury severity indicators were abstracted from medical records or prospectively collected during inpatient rehabilitation (e.g., initial Glasgow Coma Scale score; time to follow commands; duration of altered consciousness/post-traumatic amnesia). Injuries obtained while a participant was deployed during active military service were coded as deployment-related injuries and active duty reflects status at the time of index-TBI warranting inpatient rehabilitation.

TBI Model System Form 2 Follow-Up Question Regarding Rehospitalization—

“Since your discharge from the rehab center” *or* “In the past year, have you stayed overnight in a hospital because you were ill or injured?”

If YES, ask for each admission... “What was the reason for your admission?”

Trained research assistants then code hospitalizations into the following categories: Inpatient Rehabilitation; Seizures; Neurologic Disorder (Non-Seizure); Psychiatric; Infectious; Orthopedic; General Health Maintenance; Other (Not Specified Elsewhere); Not Applicable (No Rehospitalization/No Further Rehospitalizations); Rehospitalized (Reason Unknown); and Unknown. Examples associated with categories are described in Table 1.

Procedure

The VHA TBIMS was approved by locally designated Institutional Review Boards (IRB) at each VA study site. IRB approval from the Department of Defense was sought at study sites where DOD personnel were involved in the conduct of the TBIMS study. Following IRB-approved protocols, participants or their caregivers provided written informed consent following admission to inpatient rehabilitation at a VHA Polytrauma Rehabilitation Center. Trained VA TBIMS research assistants collected information regarding injury severity (GCS, time to follow commands [TFC]) from hospital and emergency medical service records. Demographic information such as date of birth, education, and premorbid functioning were collected in interview with the participants or family/significant others. Duration of unconsciousness (TFC) was defined as the time from injury to the occurrence of 2 consecutive days of command following as documented in medical record review.

Participants are contacted at fixed intervals post-injury (1, 2, 5 years post-injury and every 5 years thereafter) to collect psychosocial, vocational, economic, and rehabilitation outcomes paralleling the civilian TBI Model System database. This study analyzed participant and family responses at one year post-injury to document rehospitalization status. One-year follow-up measures are collected within a two-month window before or after the anniversary date of injury.

Statistical Analysis

Data were analyzed using statistical software R v3.2.2 (R Foundation for Statistical Computing, Vienna, Austria). Descriptive statistics were expressed as 1st quartile; median; 3rd quartile for continuous variables and percentage (count) for categorical variables. Comparisons were made between those with no rehospitalization (Rehospitalization No) to those with one or more rehospitalizations (Rehospitalization Yes). Next, group comparisons were made between those with no rehospitalization, a single rehospitalization, and two or more rehospitalizations. The distributions of continuous variables were compared between two groups using the Mann-Whitney U tests, and between three groups using the Kruskal-Wallis H tests. The proportions of categorical variables were compared using the chi-square tests. P-values ≤ 0.05 were considered to indicate statistical significance.

Results

Study population

A total of 712 participants were enrolled in the Veterans TBIMS database at the time of analyses. Individuals were ineligible for study analyses if enrolled after one year post-injury (N=164), ineligible for (N=18) or actively in the one-year post injury follow-up window (N30), or expired by time of analysis (N=4) resulting in an eligible sample of N=496. A total of 51 participants were lost to follow-up, withdrew, or refused interview, and an additional N=44 were missing the primary outcome (rehospitalization) resulting in a final sample size of N=401 participants. Figure 1 shows a consort diagram describing how the sample was derived from the VA TBI Model System dataset.

Rehospitalization rates

Among 401 individuals, N=164 (41%) of them had at least one rehospitalization at one year follow-up. Among N=164 individuals with at least one rehospitalization, N=115 had only one rehospitalization, N=28 had two rehospitalizations, N=8 had three rehospitalizations, N=1 had four rehospitalizations, and N=12 had five or more rehospitalizations. The number of hospitalizations variable was truncated at a maximum of 5. Therefore for the purpose of this analysis, all participants with 5 or more were recorded as a value of 5. This resulted in a total sum of 295 rehospitalizations from N=164 individuals. The overall summary of reasons for all rehospitalizations in descending order is shown in Table 2a with inpatient rehabilitation as the leading cause. Frequency of each type of rehospitalization is shown in Table 2b with inpatient rehabilitation as the most frequent reason for rehospitalization. Sub-analyses revealed that N=42 of the N=85 rehabilitation readmissions were due to participation in the Inpatient Polytrauma Transitional Rehabilitation Program (PTRP)⁸ to facilitate higher level rehabilitation goals (i.e., community reintegration).

Rehospitalization comparison

The demographic and clinical data were summarized for all individuals (N=401), rehospitalization No (N=237), rehospitalization Yes (N=164), one rehospitalization (N=115) and two or more rehospitalizations (N=49) (Table 3). Individuals with at least one rehospitalization had significantly longer PTA duration and time to follow commands

compared to those without any rehospitalization (PTA duration: 28 days vs. 19 days, $p=0.016$; time to follow commands: 9 days vs. 2 days, $p<0.001$). Significantly more individuals with at least one rehospitalization were on active duty at the time of their index TBI compared to those without any rehospitalization (67% vs. 56%, $p=0.041$).

Individuals with two or more rehospitalizations were more likely to have more than a high school education and sustain their TBI during deployment compared to those with one rehospitalization and to those without any rehospitalization (more than high school education: 65% vs. 45% vs. 44%, $p=0.023$; injury during deployment: 47% vs. 30% vs. 27%, $p=0.018$). Individuals with two or more rehospitalizations had longer time to follow commands compared to those with one rehospitalization and to those without any rehospitalization (14 days vs. 6 days vs. 2 days, $p<0.001$). Individuals with two or more rehospitalizations had longer rehabilitation length of stay compared to those with one rehospitalization and to those without any rehospitalization (66 days vs. 42 days vs. 44 days, $p=0.039$).

Discussion

The current study examined rates, reasons, and correlates of rehospitalization in the first year after TBI among individuals who received comprehensive inpatient TBI rehabilitation in the VA Polytrauma Rehabilitation Systems of Care. This study builds on previous research on rehospitalization after inpatient rehabilitation for TBI in the TBIMS civilian National Database and is the first to examine rehospitalization in Veterans and Service Members using the VHA TBIMS standard outcome measurement procedures. Results suggest a high (41%) rate of rehospitalization in the first year after TBI, and 30% of this subgroup was rehospitalized two or more times over this interval. The most common reason for rehospitalization was Inpatient Rehabilitation (33% of all rehospitalizations), followed closely by Other/Unspecified (26% of all rehospitalizations).

Several factors were associated with being rehospitalized two or more times. One of these was related to the clinical feature of increased time to follow commands following injury, reflecting the severity of acute injury. Time to command following was, on average, quite brief (2 days) among individuals who were not rehospitalized in the first year, and increased in a graded fashion for those who were rehospitalized once (6 days) and two or more times (14 days). Post-injury treatment factors that were associated with rehospitalization included a greater length of stay in the rehabilitation hospital among those who were later rehospitalized compared to those who were not. Finally, one demographic factor was deployment status of participants, with those being injured during deployment more likely to be rehospitalized than other participants who were not deployed at the time of injury. The reasons for this finding are not totally clear, but one can speculate that a deployed Service Member may not have immediate access to the highest tier of care or may be at higher risk for co-injury with the index TBI.

Compared to the civilian TBIMS NDB, of whom 28% were rehospitalized at least once between the time of inpatient rehabilitation discharge and first year injury anniversary,⁹ the rates of rehospitalization reported here are somewhat higher in a Veterans Health

Administration sample treated at Polytrauma Rehabilitation Centers that is (on average) younger and less severely injured. One third of the rehospitalizations in the current study were for inpatient rehabilitation, which could be attributable to a variety of factors. For example, it is possible that patients improved to a point where they could benefit from further intensive TBI rehabilitation, but equally possible that patients deteriorated neurologically or medically and then required additional rehabilitation for TBI management or general debility. A recent one year follow up study of 366 patients who were not following commands at the time of rehabilitation admission found that inpatient rehabilitation was the second most common cause for readmission.⁵ Finally, the findings in the present study may also represent unique differences in the Veterans Health Administration and Department of Defense systems of care.

This study is unique given that the sample included active duty Service Members and captured deployment history. Many of the rehospitalizations were for unspecified medical or surgical reasons that could have been attributed to additional treatments for musculoskeletal or other non-TBI related injuries that occurred during deployment or active duty. Given that the third most common cause of rehospitalization was related to orthopedic indications, there may be an additional burden of generalized injury severity in a Service Member sample relative to the civilian studies.

Study strengths and limitations

As suggested above, the ability to further delineate the sources of relatively unspecified hospitalizations in this sample would strengthen the ability of the finding to inform future strategies to enhance the successful recovery of TBI patients. An additional limitation of this study is the nature of the setting as relevant only to Polytrauma Centers within the Veterans Health Administration system; however, these findings may be highly relevant to adapting the VA system of care to better serve its population. Like previous civilian studies, the data were derived from patient interviews. Future work that includes medical record based data will provide an important avenue to better address the trajectory of recovery in the TBI patient.

The strengths of this study include a prospective evaluation of a large, consecutive sample of patients with TBI who were followed longitudinally for at least one year yielding a representative picture of the nature of rehospitalization at 1-year post injury. This sample is representative of Veterans and active duty Service Members followed at the regional Polytrauma Rehabilitation Centers and the sample consisted of a range of TBI etiology and severity using consistent outcome measures. The limitations of this study are important to recognize. Of the 712 patients enrolled in the VHA TBIMS, 496 were eligible for study analyses with a 10% (N=51) lost to follow-up, withdrew, or refused data collection. An additional N=44 (9%) were missing the primary outcome (rehospitalization) leaving a sample of 401 or 81% of the eligible sample. Participants were lost due to missing data, timing ineligibility, withdrawal from study, refusal to participate, or death. In addition, it is uncertain if these readmissions were elective or unplanned due to medical necessity. The data reflect family/participant self-report rather than review of medical records. Finally, many of the inpatient rehospitalizations involved a continuation of the rehabilitation process

in the journey to final disposition that may be unique to the VA system of care. Thus the generalizability of the findings in this study to the non-VA population is somewhat limited though informative of the VA and DOD healthcare systems.

Conclusion

Approximately 41% (164/401) of had at least one hospitalization within one year of acute PRC discharge, of which, 30% (49/164) had two or more hospitalizations. The most common reason was for hospitalization for Veterans and Service Members was readmission for inpatient rehabilitation followed by other surgical, medical and psychiatric hospital admissions. These data suggest that the need for longitudinal follow-up and patient management is paramount to understand the long-term outcomes in this unique patient population. Future research should evaluate preventable cause of rehospitalizations and provide targeted therapeutic interventions to improve health outcomes and mitigate rehospitalization.

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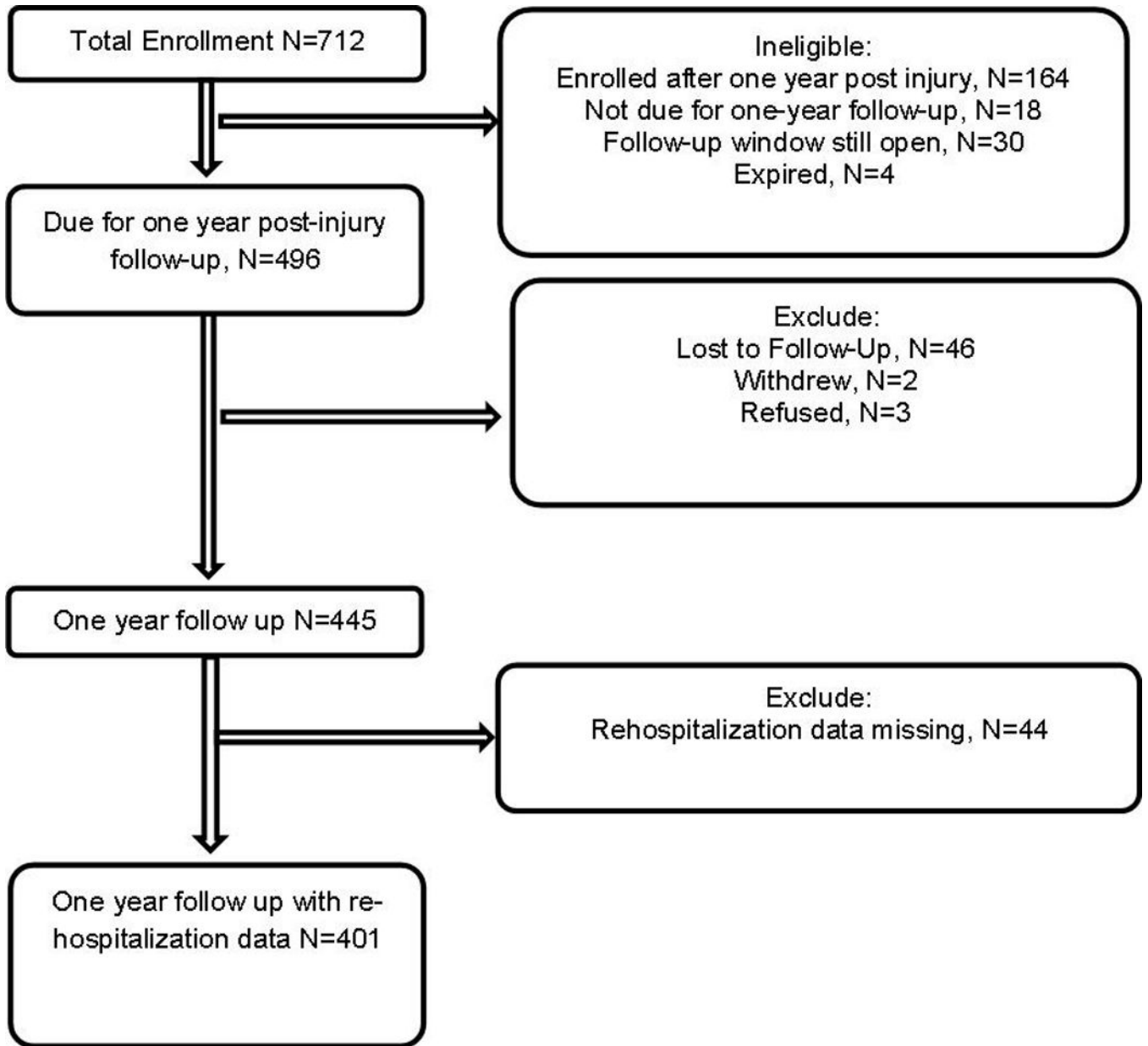


Figure 1.
Flowchart describing study sample

Table 1

Examples for Rehospitalization from the VA TBIMS National Data and Statistical Center

Category	Example
Rehabilitation (inpatient)	Rehabilitation, Community Re-integration treatment within the residential VA Polytrauma Transitional Rehabilitation Programs (PTRP)
Seizures	seizures
Neurologic disorder (non-seizure)	repeat traumatic brain injury (TBI); shunt-related; Headaches
Psychiatric	behavior modification; violent outburst; depression; inpatient chemical dependency unit
Infectious	blood infection; high fever; lung infection; meningitis; upper respiratory infection
Orthopedic and reconstructive surgery	cranioplasty; removal of hardware; tracheostomy removal; feeding tube displacement; neck fusion; fracture; rotator cuff repair; plastic surgery eye surgery; ear surgery
General health maintenance/OB-GYN	Medical - asthma, acute kidney injury, acute myocardial infarction (AMI), dehydration, diarrhea, deep vein thrombosis (DVT), fecal impaction/bowel obstruction, gastrointestinal bleeding (GIB), respiratory distress, urologic
	Surgical – abdominal surgery, including cholecystectomy (CCY), hernia repair; heart surgery; obstetric/gynecological (OB/GYN): childbirth, hysterectomy

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Table 2

a: Summary of reasons for all rehospitalizations in descending order.		
Reason	Count	Percentage (%)
Rehabilitation: inpatient	85	33
Other: not specified elsewhere	68	26
Orthopedic	26	10
Seizures	21	8
Infectious	20	8
Psychiatric	18	7
General health maintenance or OB/GYN	14	5
Neurologic disorder: non-seizure	7	3
Major amputation: mid-hand/mid foot or greater	0	0
Total	259	100

b: Frequency of each type of rehospitalization for N= 164 participants with at least one rehospitalization following inpatient rehabilitation discharge.		
Rehospitalization Type	Frequency	
Inpatient Rehabilitation	None	54% (89)
	1	41% (68)
	2	4% (6)
	3-4	0% (0)
	5 or more	1% (1)
Seizure-Related	None	88% (144)
	1	12% (19)
	2	1% (1)
	3+	0% (0)
Neurologic (Non-Seizure)	None	96% (157)
	1	4% (7)
	2+	0% (0)
Psychiatric	None	90% (147)
	1	10% (16)
	2	1% (1)
	3+	0% (0)
Infection-Related	None	92% (151)
	1	6% (10)
	2	1% (1)
	3	0% (0)
	4	1% (2)
	5 or more	0% (0)
Orthopedic	None	85% (140)
	1	13% (22)

b: Frequency of each type of rehospitalization for N= 164 participants with at least one rehospitalization following inpatient rehabilitation discharge.

Rehospitalization Type		Frequency
	2	1% (2)
	3+	0% (0)
General Health	None	91% (150)
	1	9% (14)
	2+	0% (0)
Major Amputation-Related	None	100% (164)
Not-Otherwise Specified	None	77% (127)
	1	16% (27)
	2	1% (1)
	3	1% (2)
	4	1% (2)
	5 or more	3% (5)

Table 3

Summary of study variables by rehospitalization status.

Covariates	Full Sample		Rehospitalization (N=401)		Rehospitalization Yes (N=164)		Significance of Comparisons
	N	(N=401)	No (N=164)	Yes (N=115)	One (N=49)	Two or More	
Age (years)	401	23.0;28.0;43.0	23.0;27.0;42.2	23.0;28.0;40.5	23.0;26.0;44.0	0.951	0.958
Male	400	96% (384)	96% (158)	96% (110)	98% (48)	0.771	0.756
Race	286					0.581	0.401
White		72% (205)		70% (61)	67% (24)		
Black or African American		9% (25)	11% (13)	13% (11)	6% (2)		
Other		20% (56)	20% (25)	17% (15)	28% (10)		
Education	400					0.193	0.023
<= High school diploma		56% (132)	49% (80)	55% (63)	35% (17)		
> High school diploma		47% (188)	51% (83)	45% (51)	65% (32)		
Glasgow Coma Scale	330	3; 8; 14	3; 7; 14	3; 7; 14	3; 7; 14	0.105	0.23
PTA duration (days)	322	1.0; 22.0; 50.5	1.0; 28.0; 124.0	5.0; 25.0; 76.0	0.0; 32.5; 169.2	0.016	0.054
Time to follow commands (days)	316	0.0; 4.0; 19.0	0.0; 2.0; 13.0	0.00; 6.00; 29.75	0.25; 14.00; 42.25	<0.001	<0.001
Cause of injury	399					0.223	0.204
Vehicular		50% (199)	45% (74)	49% (56)	38% (18)		
Fall		11% (44)	9% (15)	9% (10)	10% (5)		
Violence: penetrating		7% (29)	9% (15)	7% (8)	15% (7)		
Violence: blast		22% (88)	26% (43)	24% (28)	31% (15)		
Other		10% (39)	10% (16)	11% (13)	6% (3)		
Active duty	331	61% (202)	67% (95)	67% (66)	67% (29)	0.041	0.125
Injury during deployment	401	30% (121)	35% (58)	30% (35)	47% (23)	0.06	0.018
Mental health utilization prior	396					0.065	0.065
Yes		20% (79)	14% (23)	16% (18)	10% (5)		

Covariates	N	Full Sample		Rehospitalization (N=401)		Rehospitalization Yes (N=164)		Significance of Comparisons
		(N=401)	(N=237)	No	Yes	One	Two or More	
No		13% (50)	12% (28)	(N=164) 14% (22)	(N=115) 11% (12)	(N=49) 21% (10)		p- value [‡]
Not applicable		67% (267)	64% (151)	72% (116)	73% (83)	69% (33)		
Rehab length of stay (days)	400	22.8; 45.0; 83.2	23.0; 44.0; 70.0	21.0; 47.0; 117.5	20.0; 42.0; 115.8	35.0; 66.0; 119.0	0.072	0.039

[†]P-values were obtained for comparisons between rehospitalization No and rehospitalization yes using the Mann-Whitney U tests for continuous variables, and chi-square tests for categorical variables.

[‡]P-values were obtained for comparisons among rehospitalization No, one rehospitalization and two or more rehospitalizations using the Kruskal-Wallis H tests for continuous variables, and chi-square tests for categorical variables.

Note: N column means the count of non-missing records for each variable.

No rehospitalization is defined as individuals without any rehospitalization; Yes rehospitalization is defined as individuals with at least one rehospitalization; one hospitalization is defined as individual with only one rehospitalization; two or more rehospitalizations is defined as individuals with two or more rehospitalizations).