Assessment Rates and Causes of Readmissions in Military Casualties

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Assessment rates and causes of readmissions in military casualties

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Abstract

Introduction: Military medical care encompasses domains such as the long-term prognosis, morbidity, and quality of life of survivors after discharge from the hospital. The identification factors affecting hospitalization and readmissions are crucial in military settings. The study aimed to assess rates and causes of readmissions in military casualties.

Methods: We included 775 military personnel with combat-related injuries from September 2014 to October 2019. We determined readmissions if they occurred within one year since the date of discharge from the index admission. The data was included regarding the pattern and mechanism of injury, Abbreviated Injury Scale (AIS), injury severity score (ISS), primary and subsequent treatments and procedures, experienced side effects, source of admission, hospital care unit, and the length of stay in the hospital.

Results: The mean age of the patients was 27.99±7.55 years. The great majority of the investigated combat-related injuries were penetrating (N=639, 82.5%), followed by blunt (N=97, 12.5%). The most injured part of the body was the extremities (N=360, 46.5%), followed by the head and neck (N=175, 22.6%) and the abdomen and pelvis (N=106, 13.7%). The most common reason for the readmission event number 1-7 was overall wound infection. The average length of hospitalization

during the index admission was 9.48±12.07 days. There was a significant relationship between multiple readmissions and total readmission days and LOS, max AIS, ISS, side effects, and blood transfusion($P<0.001$ for all the variables). Among the variables influencing multiple readmissions, ISS>24 led to the highest risk.

Conclusion: A longer LOS within the index admission and its associated factors put patients at risk of multiple and longer readmission events in the future. The outcomes imply that patients with more severe injuries may require high-quality care for longer durations as part of the initial hospital inpatient stay, and this may motivate more effective management of combat-related injuries and the associated medical costs.

Keywords: Combat Trauma; Readmission ; Rehospitalization; Injury; Complications

Introduction

During the past decades, along with the development and use of increasingly more dangerous weapons in wars, there have been some advances in military medical care leading to life-saving treatments and better outcomes for combat-related injuries (1). Management of traumatic combat injuries is primarily focused on reducing casualties. Over time, it is also being expanded into areas such as the long-term prognosis, morbidity, and quality of life of survivors after the initial discharge from the hospital. Currently, there is a need for developing new strategies to improve prognosis and reduce morbidity experienced by wounded military personnel. This necessitates careful assessment of the quality of medical care received during the first admission, identification of factors adversely impacting this quality, and the design of medical and nursing interventions which are crucial for the development of good-quality services.

54 In terms of quality assessment, various indices have proved useful in both civilian and military
55 settings, including the length of the first stay in the hospital (LOS), experienced side effects, and
56 readmission rate (2,3). The first index, LOS, is widely used to evaluate the degree of efficiency of
57 hospital care (4,5). Many incentive schemes have been introduced to encourage hospitals to
58 decrease LOS (5), although significant reduction plans should be implemented cautiously as rapid
59 hospital discharge before ensuring the patient's medical stability might increase readmission rates
60 in the long run (4). This complicates the justification of interventions for considerably shortening
61 LOS. On the other hand, the readmission rate provides a more promising index of the quality of
62 hospital care (5). By definition, readmission is a hospital admission event within at least one month
63 of the initial admission (6). Readmissions are common (7) and more likely to be associated with a
64 poor quality of hospital care (8). Readmission rate is also deemed important from an economic
65 standpoint (9); readmissions highly utilize hospital financial resources and may place an additional
66 cost burden on patients and their families (4,7). Furthermore, they can affect other members of
67 society by preventing them from receiving their required hospital care. Consequently, a high
68 readmission rate is also a cause for concern in military settings. Many military health providers
69 around the world set a goal to reduce the overall rate of readmission events (10). There is a body
70 of research about readmission and its associated factors about trauma patients in civilian practice.
71 However, as civilian and military trauma injuries are entirely different from each other based on
72 the patterns of injury, complexity of wounds, and pathophysiologic consequences, such data may
73 not be useful in the military setting (11). Readmission events in military practice may correspond
74 to various independent variables which can be analyzed using statistical methods. Thus, war
75 wounds should be especially investigated and understood in terms of epidemiology,
76 characterization, and mechanism of injury. A full description of the medical, surgical, and nursing

needs of wounded military personnel during index admission and their possible re-hospitalization, as well as the analysis of this information, might provide a solid basis for comparing patient groups. Such assays may help identify the subgroups that are more susceptible to multiple readmissions, discover the main contributors to readmission, and assist modern hospital systems in addressing these issues.

Historically, little published information is available about the epidemiology of injuries sustained in combat (8,12,13), and little is known about the main contributory factors in military re-hospitalization. To the best of our knowledge, such resources are scarcely available about wars occurring in the Middle East. Thus, given the importance of identifying major contributors to readmission in the military setting, herein, we investigated the factors associated with multiple readmissions and total days of readmission among patients with traumatic combat injuries for the first time in Iran. The identification of these factors will lead to the formulation of better strategies for meeting particular patient needs and helping patients with their full recovery. Therefore, in addition to reducing the total number of readmission events by preventing potentially avoidable readmissions, patients' quality of life can be improved. This study presents a description and analysis of the results of investigating readmission events among wounded military personnel at a military hospital in Iran by performing logistic regression analysis. It was assumed that the number of readmission events and the total days of readmission might be influenced by factors such as the pattern and mechanism of injury, required treatments and procedures, and LOS.

Methods

Study population

This study was conducted in a military hospital in Iran. The data were collected from military personnel with combat-related injuries from September 2014 to October 2019 who had been

transferred to the hospital for receiving initial care. The patients were then followed-up for a year in terms of readmission. The data, including the patients' demographic information (age, sex, and nationality), the year of admission event, medical history (comorbidities categorized based on the International Classification of Disease, 10th Revision, Clinical Modification [ICD-10-CM] codes) as defined in the literature (14), information about trauma injuries and hospital care, discharge disposition, and possible readmissions, were extracted from the patients' medical records and collected through the ongoing observational cohort study. The data about trauma injuries and hospital care included the pattern and mechanism of injury, injury severity score (ISS), Abbreviated Injury Scale (AIS), primary and subsequent treatments and procedures (such as operation), source of admission (such as the emergency room), experienced side effects, hospital care unit (such as the critical care unit), and the LOS. The collected data on readmissions included the reason for subsequent admission(s), the number of total readmission events, the LOS during readmission, the relationship between the first readmission and the index admission (if any), and the interval between the first readmission and the index admission. The Institutional Review Board of the hospital and the associated university of medical sciences approved this study.

We determined readmissions if they occurred within one year since the date of discharge from the index admission. Admissions more than a year after an index admission discharge date was not regarded as readmission. Furthermore, the first admission events were included in the study only if there was at least one further admission event during the follow-up period, i.e., a year. The index admissions were excluded if the patient was referred to a hospital other than the index hospital for any readmission event, or if the patient passed away during the follow-up period.

Based on the definition provided by the Association for the Advancement of Automotive Medicine, the AIS is "an anatomically based, consensus derived, global severity scoring system

123 that classifies an individual injury by body region according to its relative severity on a 6 point
124 scale (1=minor and 6=maximal)" (15). The part of the body that received the maximum AIS was
125 considered as the injured part of the patient's body. The ISS is an anatomical scoring system which
126 yields an overall score for patients who have multiple injuries (16). Moreover, the LOS was
127 defined as the number of days since patient admission or readmission until discharge, and was
128 calculated as the time of discharge minus the time of admission or readmission in hours, divided
129 by 24. In addition, the total days of readmission was calculated by adding the number of days spent
130 in the hospital during each readmission event. The type of trauma was defined as penetrating,
131 blunt, and other types. The mechanism of trauma was also defined as fragments from explosive
132 munitions, bullets fired by a gun, blast, burns, and others. The definition of other independent
133 variables was obvious.

134 **Statistical analysis**

135 The association of variables of interest with multiple readmissions and total days of readmission
136 was investigated using logistic regression. With respect to the number of readmissions and total
137 days of readmission, the patients were classified into two categories: patients with a single
138 readmission and those with multiple readmissions, and patients with 1-7 day(s) and those with >7
139 days of re-hospitalization, respectively. In terms of categorical predictors which had more than
140 two levels, one of the subgroups was taken as the reference group with which the other groups
141 were compared. A Pearson chi-square contingency table analysis was performed to test the
142 relationships among qualitative variables. All the statistical analyses were performed in SPSS for
143 Windows, version 11.5 (IBM, Armonk, NY). P-values of <0.05 were deemed statistically
144 significant.

Results

Overall, 775 eligible patients were included and 431 patients had a single readmission, while the rest, i.e., 344, experienced more than one readmission event within a year. The frequency of patients based on the number of readmission events is given in Figure 1.

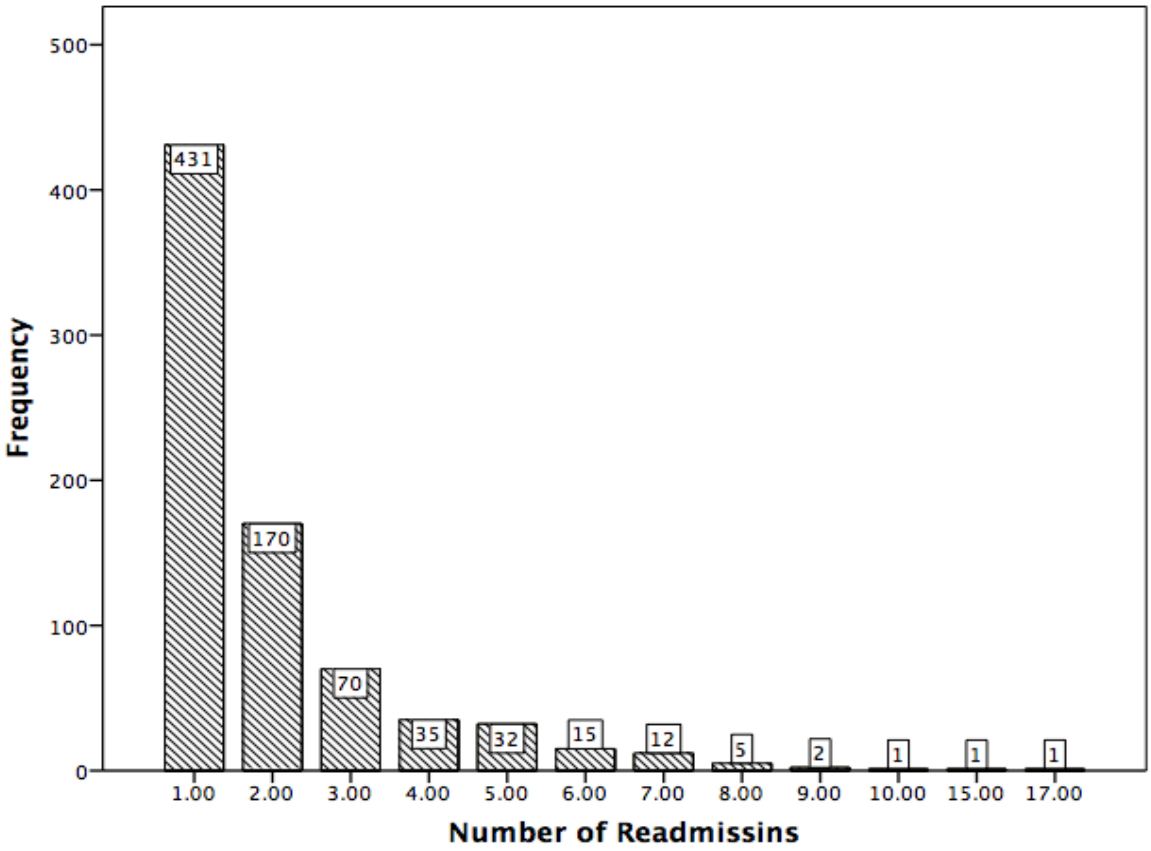

Figure 1: Frequency of patients based on the number of readmission events

The mean age of the patients was 27.99±7.55 years. Of the 775 patients enrolled, only two had a positive history of addiction, and 10 patients were current smokers. The number of patients admitted in 2014, 2015, 2016, 2017, 2018, and 2019 was 81, 277, 233, 141, 36, and 7, respectively. In the vast majority of the final cohort of patients, no comorbid condition was reported (N=757),

159 and only 2.33% demonstrated 1-3 comorbid condition(s).

160 The most common reason for the readmission event number 1-7 was overall wound infection,
161 while the second most prevalent cause of hospitalization differed among readmission groups.
162 Table 1 represents detailed data about the reason for readmission event number 1-7. For the 8th
163 readmission event, the patients were frequently admitted because of pain, but the common cause
164 of re-hospitalization 9-15 was bedsores (data not shown in the table as the number of patients was
165 <10 in each group).

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177 **Table 1. The reason for readmission for readmission numbers 1-7th.**

Reason \ Number of Readmissions	1	2	3	4	5	6	7	Sum in 1-7 th Readmission[A]	Sum in all Readmission Groups[A]
Wound infections	101(13)	50(15.2)	31(18.8)	18(18.6)	14(21.2)	8(25)	6(28.6)	230	232
Gastrointestinal	25(3.2)	11(3.3)	4(2.4)	3(3.1)	2(3)	0(0.0)	0(0.0)	45	45
Amputation stump complications	14(1.8)	7(2.1)	5(3)	3(3.1)	1(1.5)	1(3.1)	0(0.0)	31	31
Movement restrictions	64(8.3)	27(8.2)	14(8.5)	6(6.2)	2(3)	1(3.1)	1(4.8)	115	115
Deformity in head and neck	63(8.1)	31(9.4)	17(10.3)	12(12.4)	9(13.6)	7(21.9)	4(19)	143	143
After care for surgery	10(1.3)	5(1.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	15	15
Respiratory	7(0.9)	2(0.6)	1(0.6)	1(1)	1(1.5)	0(0.0)	0(0.0)	12	12
Ophthalmic	13(1.7)	7(2.1)	3(1.8)	2(2.1)	2(3)	0(0.0)	0(0.0)	28	28
New trauma	18(2.3)	5(1.5)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	23	23
Graft	32(4.1)	13(4)	8(4.8)	5(5.2)	2(3)	0(0.0)	0(0.0)	60	60
Hearing	24(3.1)	8(2.4)	3(1.8)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	35	35
Foreign Body	52(6.7)	20(6.1)	9(5.5)	3(3.1)	2(3)	0(0.0)	0(0.0)	86	86
Osteomyelitis	6(0.8)	2(0.6)	2(1.2)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	10	10
Urinary	8(1)	5(1.5)	3(1.8)	2(2.1)	2(3)	0(0.0)	0(0.0)	20	20
Closure of ostomi	18(2.3)	7(2.1)	4(2.4)	3(3.1)	2(3)	1(3.1)	0(0.0)	35	35
Bedsore	15(1.9)	6(1.8)	4(2.4)	3(3.1)	3(4.5)	2(6.3)	2(9.5)	35	46
Deep vein thrombosis (DVT)	7(0.9)	5(1.5)	3(1.8)	3(3.1)	3(4.5)	1(3.1)	1(4.8)	23	23
Laryngopathy	2(0.3)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	2	2
Neurologic	6(0.8)	4(1.2)	2(1.2)	1(1)	0(0.0)	0(0.0)	0(0.0)	13	13
Cardiologic	2(0.3)	2(0.6)	1(0.6)	1(1)	1(1.5)	1(3.1)	1(4.8)	9	9
Surgical device remove	70(9)	19(5.8)	9(5.5)	5(5.2)	5(7.6)	3(9.4)	2(9.5)	113	114
Pain	75(9.7)	34(10.3)	18(10.9)	14(14.4)	9(13.6)	4(12.5)	3(14.3)	157	161
Non-union of fracture	64(8.3)	19(5.8)	7(4.2)	1(1)	0(0.0)	0(0.0)	0(0.0)	91	91
Vascular	8(1)	2(0.6)	1(0.6)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	11	11
Psychiatric	34(4.4)	23(7)	9(5.5)	7(7.2)	5(7.6)	2(6.3)	0(0.0)	80	80
Wound unhealing	28(3.6)	12(3.6)	7(4.2)	4(4.1)	1(1.5)	1(3.1)	1(4.8)	54	54
Hernia	9(1.2)	3(0.9)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	12	12
Total	775(100)	329(100)	165(100)	97(100)	66(100)	32(100)	21(100)	8(100)	---

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Reason: the reason for the first readmission
Interval: the interval between the index admission and the first readmission
All data reported by N (%) except for [A] reported by N only.
Sum in all readmission groups: readmissions 1-15th.

Furthermore, readmission events mostly occurred without any previous medical planning. Almost all the readmissions happened because patients suffered from either additional or prolonged complications resulting from the primary trauma injury that had been received in combat. Table 2 presents information about the planning status of each readmission event, and expresses the relationship between the index admission and the next readmissions.

Table 2. Readmission condition and Relation of readmission to the index admission for each readmission.

	Readmission Condition		Relationship		Total
	Planned N (%)	Unplanned N (%)	Primary injury complications N (%)	Unrelated to first admission N (%)	
Readmission Number					
1	231(29.8)	544(70.2)	739(95.4)	36(4.6)	775(100)
2	101(30.7)	228(69.3)	313(95.12)	16(4.88)	329(100)
3	44(26.7)	121(73.3)	161(97.57)	4(2.43)	165(100)
4	24(24.7)	73(75.3)	92(94.8)	5(5.2)	97(100)
5	18(27.3)	48(72.7)	63(95.45)	3(4.55)	66(100)
6	8(25)	24(75)	29(90.62)	3(9.38)	32(100)
7	4(19)	17(81)	19(90.48)	2(9.52)	21(100)
8	1(12.5)	7(87.5)	7(87.5)	1(12.5)	8(100)
9	0(0.0)	3(100)	3(100)	0(0.0)	3(100)
10	1(50)	1(50)	2(100)	0(0.0)	2(100)
11	0(0.0)	1(100)	1(100)	0(0.0)	1(100)
12	0(0.0)	1(100)	1(100)	0(0.0)	1(100)
13	0(0.0)	1(100)	1(100)	0(0.0)	1(100)
14	0(0.0)	1(100)	1(100)	0(0.0)	1(100)
15	0(0.0)	1(100)	1(100)	0(0.0)	1(100)

193 In terms of the interval between the date of discharge from the index admission and the subsequent
194 readmission event, 373 patients were readmitted to the hospital within less than a month, and 221,
195 78, 62, and 41 cases were referred to the hospital between 1-3, 3-6, 6-12 months, and 1 year after
196 the index admission, respectively. Table 3 lists the data about the reason for the index admission
197 categorized based on the interval between the first and second admissions explained above.

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Table 3. The reason for the first readmission categorized based on the interval between the date of discharge from the index admission and the first readmission.

Reason \ Interval	≤30 days N (%)	31 days ≤ < 90 days N (%)	90≤ days<180 N (%)	180≤ days<1 year N (%)	1 year N (%)	Total N (%)
Wound infections	72(19.3)	17(7.7)	7(9)	4(6.5)	1(2.4)	101(13)
Gastrointestinal	15(4)	3(1.4)	3(3.8)	3(4.8)	1(2.4)	25(3.2)
Amputation stump complications	9(2.4)	3(1.4)	2(2.6)	0(0.0)	0(0.0)	14(1.8)
Movement restrictions	24(6.4)	24(10.9)	6(7.7)	7(11.3)	3(7.3)	64(8.3)
Deformity in head and neck	28(7.5)	22(10)	4(5.1)	5(8.1)	4(9.8)	63(8.1)
After care for surgery	5(1.3)	4(1.8)	0(0.0)	1(1.6)	0(0.0)	10(1.3)
Respiratory	5(1.3)	1(0.5)	1(1.3)	0(0.0)	0(0.0)	7(0.9)
Ophthalmic	6(1.6)	4(1.8)	1(1.3)	0(0.0)	2(4.9)	13(1.7)
New trauma	4(1.1)	4(1.8)	2(2.6)	4(6.5)	4(9.8)	18(2.3)
Graft	21(5.6)	6(2.7)	2(2.6)	1(1.6)	2(4.9)	32(4.1)
Hearing	5(1.3)	10(4.5)	2(2.6)	3(4.8)	4(9.8)	24(3.1)
Foreign Body	30(8)	11(5)	5(6.4)	2(3.2)	4(9.8)	52(6.7)
Osteomyelitis	3(0.8)	1(0.5)	1(1.3)	1(1.6)	0(0.0)	6(0.8)
Urinary	3(0.8)	0(0.0)	0(0.0)	3(4.8)	2(4.9)	8(1)
Closure of ostomi	4(1.1)	10(4.5)	4(5.1)	0(0.0)	0(0.0)	18(2.3)
Bedsore	7(1.9)	3(1.4)	1(1.3)	3(4.8)	1(2.4)	15(1.9)
Deep vein thrombosis (DVT)	7(1.9)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	7(0.9)
Laryngopathy	0(0.0)	1(0.5)	1(1.3)	0(0.0)	0(0.0)	2(0.3)
Neurologic	4(1.1)	1(0.5)	0(0.0)	1(1.6)	0(0.0)	6(0.8)
Cardiologic	1(0.3)	0 (0.0)	0(0.0)	0(0.0)	1(2.4)	2(0.3)
Surgical device remove	19(5.1)	34(15.4)	9(11.5)	6(9.7)	2(4.9)	70(9)
Pain	42(11.3)	16(7.2)	7(9)	7(11.3)	3(7.3)	75(9.7)
Non-union of fracture	18(4.8)	26(11.8)	14(17.9)	5(8.1)	1(2.4)	64(8.3)
Vascular	8(2.1)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	8(1)
Psychiatric	13(3.5)	13(5.9)	2(2.6)	3(4.8)	3(7.3)	34(4.4)
Wound unhealing	20(5.4)	3(1.4)	3(3.8)	0(0.0)	2(4.9)	28(3.6)
Hernia	0(0.0)	4(1.8)	1(1.3)	3(4.8)	1(2.4)	9(1.2)
Total	373(100)	221(100)	78(100)	62(100)	41(100)	775(100)

Reason: the reason for the first readmission

Interval: the interval between the index admission and the first readmission

Regarding the LOS, the average length of hospitalization during the index admission was 9.48±12.07 days, and 442 patients stayed less than a week. Table 4 displays the LOS for the index admission among all the participants and compares the frequency of each LOS subcategory between patients with a single readmission and those with multiple readmissions.

Table 4: Frequency of each LOS subcategory between patients with single readmission and those with multiple readmissions

	Single Readmission		**Multiple Readmission**	
	Frequency (N)	Valid percent (%)	Frequency (N)	Valid percent (%)
Length of the first stay in hospital				
0-3 days	172	39.9	109	31.7
4-7 days	120	27.8	87	25.3
8-30 days	116	26.9	129	37.5
>30 days	23	5.3	19	5.5

The number of patients belonging to the group of multiple readmissions outweighed those in the single readmission group only in the subgroup of 8-30 days of LOS. For the first readmission event, the number of patients hospitalized 1-6 days before discharge reached 603.

In addition, the great majority of the investigated combat-related injuries were penetrating (N=639, 82.5%), followed by blunt (N=97, 12.5%). Most of these injuries were caused by fragments from explosive munitions rather than from bullets fired by a gun. The most injured part of the body was the extremities (N=360, 46.5%), followed by the head and neck (N=175, 22.6%) and the abdomen and pelvis (N=106, 13.7%), in that order. Overall, patients more frequently had a maximum AIS of 4 (N=332, 42.8%), followed closely by a score of 5-6 (N=298, 38.5%).

Logistic regression was performed to study the relationship between the number of comorbidities, the type and mechanism of trauma, the most involved part of the body, LOS, maximum AIS, ISS, the type of operation (if any), patients' need for blood transfusion, side effects (all in terms of the index admission), ICU stay, and the dependent variables of interest. There was no significant relationship between the number of comorbidities, the type and mechanism of trauma, ISS, the most involved part of the body, the type of operation, side effects, and ICU stay and multiple readmissions (data not shown), although the other predictors showed a statistically significant association with multiple readmissions at least in one subcategory. Table 5 gives the results of regression analysis in terms of the odds ratio, P-value, and confidence interval. Moreover, total readmission days was associated with some of the above-mentioned independent variables, including the LOS, the type of trauma, the most involved part of the body, maximum AIS, ISS, patients' need for blood transfusion, and side effects. Table 6 summarizes these results.

Table 5. Association of multiple readmissions with LOS, max AIS, ISS, side effect, and patient's need for blood transfusion.

Variable	OR	Lower CI	Upper CI	P-value
LOS (reference: 1-3 days)				
4-7 days	1.14	0.79	1.65	0.47
8-30 days	1.75	1.24	2.48	0.001
>30 days	1.3	0.67	2.5	0.42
Max AIS (reference: 1-2)				
3	0.9	0.45	1.8	0.08
4	1.1	0.68	1.96	0.72
5-6	1.95	1.09	3.46	0.02
ISS (reference: <9)				
9-15	1.15	0.75	1.77	0.52
16-24	1.69	1.02	2.8	0.039
>24	2.24	1.46	3.44	<0.001
Side effect[+] (reference: no side effect)				
Wound infection	1.53	1.07	2.19	0.019
Patient's need for blood transfusion (no vs. yes)	1.9	1.25	2.85	0.002

LOS: length of stay in hospital, OR: odd ratio, CI: confidence interval, Max AIS: maximum amount of the abbreviated injury scale, ISS: Injury Severity Score.
+: Data not shown for other categories of side effect variable, as there was not any significant relationship with other subgroups of the variable.

Table 6. Association of total days of readmissions with LOS, the most involved part of body, max AIS, ISS, side effect, patient's need for blood transfusion.

Variable	OR	Lower CI	Upper CI	P-value
LOS (reference: 1-3 days)				
4-7 days	1.11	0.74	1.65	0.61
8-30 days	2.42	1.68	3.48	<0.001
>30 days	4.31	2.19	8.46	<0.001
The most involved part of body (reference: head and neck)				
Thorax	1.1	0.57	2.2	0.74
Abdomen and pelvic	2.09	1.28	3.42	0.003
Extremities	0.86	0.59	1.26	0.46
External	0.56	0.31	1.001	0.05
Max AIS (reference: 1-2)				
3	0.7	0.32	1.59	0.42
4	1.28	0.68	2.41	0.44
5-6	2.89	1.54	5.42	0.001
ISS (reference: <9)				
9-15	1.54	0.95	2.5	0.079
16-24	1.86	1.07	3.24	0.027
>24	3.8	2.37	6.09	<0.001
Side effect[+] (reference: no side effect)				
Wound infection	2.56	1.78	3.68	<0.001
Patient's need for blood transfusion (no vs. yes)	4.1	2.68	6.29	<0.001

LOS: length of stay in hospital, OR: odd ratio, CI: confidence interval, Max AIS: maximum amount of the abbreviated injury scale, ISS: Injury Severity Score.
+: Data not shown for other categories of side effect variable, as there was not any significant relationship with other subgroups of the variable.

It seems that a patient who stayed 8-30 days in the hospital for initial care had a 1.75-time higher chance for multiple readmissions than a patient who stayed <3 days during the index admission. Max AIS exerted another effect on multiple readmissions; those who had a maximal degree of AIS, i.e., 5-6, had about twice the chance for more than one readmission event compared to those with the minimum value of AIS, i.e., 1-2. The influence of ISS was also considerable; 1.69 and

2.24 times higher was the possibility of multiple readmissions of patients with ISS 16-24 and >24 in comparison to those with ISS<9, respectively. Also, side effect was a statistically significant variable: Patients who developed wound infection as the side effect had a 1.53-time higher chance for multiple readmissions compared to those without any side effect, although such a significant relationship was not detected in other subgroups of side effect. Similarly, in terms of multiple readmissions, the outcome was about twice worse in patients who required blood transfusion during the index admission.

It was also noted that patients with 8-30 and >30 days of LOS during the index admission had a 2.42- and 4.31-time higher chance for more than a week of readmission, respectively. The most involved part of the body was relevant, too: Patients receiving the most serious injuries to the abdomen and pelvis were nearly twice more likely to stay in the hospital for more than a week during readmissions than those sustaining a head and neck injury. Furthermore, max AIS significantly affected the period of readmission events; patients who had a maximum AIS, i.e., 5-6, had an about three-time higher chance for longer readmissions in total compared to patients with an AIS of 1-2. As for ISS, we found that patients with an ISS score of 16-24 and >24 had a 1.86- and 3.8-time higher chance of staying >7 days in the hospital within the readmission course, respectively. The odds ratio for side effects showed that patients who developed wound infection were 2.56 times more likely to stay longer in the hospital than those who did not develop any side effects. Furthermore, the odds of a long readmission period for patients who needed blood transfusion were 4.1 times higher than those for the reference group.

The results of the chi-square test revealed an insignificant relationship between the type of trauma and the mechanism of trauma on the one hand, and admission to the intensive care unit (ICU) and side effects on the other hand. Nevertheless, both the type and mechanism of trauma were

significantly related to the patients' need for transfusion (P=0.001 and P=0.008, respectively). The type and mechanism of trauma also showed significant relationships with operation, maximum AIS, ISS, and LOS (P<0.001 for all the variables). Moreover, the most involved part of the body had significant correlations with all the above-mentioned variables (P<0.001).

Discussion

Collectively, in the investigated surviving wounded population, extremity and head and neck injuries accounted for 46.5% and 22.6% of all the wounds, respectively. This pattern is similar to the observations from previous wars, e.g. Afghanistan or Chechnya War (1,11). The regression analysis revealed no significant correlation between either multiple readmissions or total days of readmissions and the number of comorbidities, mechanism of trauma, type of operation, and ICU stay. There was a significant relationship between multiple readmissions and total readmission days and some variables such as LOS, max AIS, ISS, side effects, and blood transfusion. The predictor of a significant effect only on the total days of readmission was the most involved part of the body.

Here, we focused on multiple readmissions in a one-year period and their total length since we believed that only by comparing single and multiple readmissions can the relevant explanatory factor be determined. This approach also enabled the identification of high-risk patients who are the most appropriate target group for reducing the overall number of readmission events. To date, numerous studies have examined 30-day readmission for various severe diseases and suggested that it is associated with the male sex (OR=1.83, P=0.02), ICU stay (OR=2.5, P=0.049), LOS (4), comorbidity score (17), and different socioeconomic factors (18), although similar studies are rare in military settings.

353 Given that the present study examined readmission occurrence resulting from combat-related
354 injuries, we noticed some similarities and differences in the results. First of all, almost all our
355 participants were young and without any underlying chronic disease or comorbidity, indicating
356 considerable potential for lowering readmissions after a combat injury in such circumstances.
357 Secondly, there was no difference between different groups of patients in this study in terms of
358 ICU stay. It seems that ICU stay during the initial admission is not a significant explanatory factor
359 here. In addition to very different causes for the index admission, another explanation could be the
360 fact that our sample was young and we examined a much longer readmission period. Therefore, it
361 is likely that the quality of hospital care and readmissions was affected by various factors in
362 military hospitals compared to regular ones.

363 Not surprisingly, our findings revealed that the severity of injuries defined by AIS and ISS had
364 important impacts on multiple readmissions and total days of readmission. The most severe
365 injuries led to a considerably higher risk for not only recurrent but also prolonged readmission
366 events. On the other hand, it has been well established that the extreme severity of the disease is
367 associated with high resource use outliers (18,19). Given these, the findings imply that patients
368 with severe injury or, perhaps, with severe illness might require high-quality care for longer
369 durations, especially as part of the initial hospital inpatient stay. In these patients, premature
370 discharge from the index admission may lead to subsequent readmissions and its associated costs,
371 and should thus be avoided. Even though these factors are not alterable, severity indices may be
372 helpful in identifying high-risk groups of patients.

373 We also found that longer LOS within the index admission puts patients at risk of multiple and
374 longer readmission events. This result is partially consistent with some other studies on internal
375 medicine patients conducted in civilian settings (4,17,20), which examined a much shorter post-

discharge period than the present study. Still, a longer LOS seems to be an important factor for predicting the risk of repeated future readmissions. Although there are some concerns that an earlier hospital discharge may result in higher readmission rates, a reduction in LOS has not shown any negative effect on the 30-day hospital readmission rate (4). A possible explanation can be that improvement in LOS might not necessarily affect the quality of hospital service. Such improvements can be achieved by adopting better procedures for discharge from the hospital (4). Accordingly, a reduction in LOS can be an appropriate measure for preventing repeated readmissions.

Contrary to our expectations, the type of operation was not significantly correlated with the frequency and duration of readmission events. It is more likely that this factor should indirectly exert its effect through other variables such as the need for blood transfusion, AIS, ISS, and LOS. In fact, based on the results of the chi-square test, the type of operation was correlated with these variables ($P<0.001$).

Moreover, the regression analysis found that side effects might have an impact on the duration and frequency of future re-hospitalizations. Still, this effect was only significant in the subgroup of patients who developed wound infection, and was inconsistent among other patient subgroups. It seems that wound infections can impose great demands on hospital resources by increasing readmission events and their duration. This outcome is in line with the literature that has determined trauma-related infections as a major contributor to substantial morbidity among wounded military personnel. Given the observation that wound infections were the primary cause of hospitalization, this finding highlights the importance of considering both treatment and preventive measures equally. These measures can include improvement of patients' immune system (21), prescription of effective antibiotics (22), and treatment timing (23).

399 The last factor of significant influence on both dependent variables was the patients' need for blood
400 transfusion. In the management of combat-related injuries, blood transfusion is essential because
401 uncontrollable hemorrhage is the major cause of possibly preventable casualties (24,25). Our
402 results confirm that the need for blood transfusion is linked to a poor prognosis in trauma combat
403 patients regarding the occurrence of repeated and longer readmissions. Among all the investigated
404 factors, the most involved part of the body was the only factor which correlated with total
405 readmission days but not with multiple readmissions. It seems that injury to the head and neck
406 leads to a higher risk of longer readmission courses.

407 Briefly, our results provide insight into what possible relationships exist between LOS and
408 readmission and the investigated variables. Among the statistically significant variables
409 influencing multiple readmissions, ISS>24 led to the highest risk. Regarding total days of
410 readmission, LOS>30 days and blood transfusion had the largest effects, respectively.

411 Our study had some limitations. The first was the retrospective design of the study, in which almost
412 all the data were collected from patient records. The second was the fact that the sample was
413 collected from only one center. Third, we did not evaluate factors such as social determinants and
414 having someone to help at home following discharge. We believe that our results should be
415 confirmed in studies with larger samples which examine a wider range of possible risk factors.

416 **Conclusion**

417 Differentiating between preventable and non-preventable readmissions might provide a basis for
418 the development of effective strategies to reduce the readmission rate in military settings. To this
419 end, high-risk patients for multiple readmissions must be first determined. Referring to the data,
420 we can conclude that the severity of the injury, the LOS in the hospital, developing wound

421 infection, injury to the abdomen and pelvis, and the need for blood transfusion within the index
422 admission appear to be associated with an increased risk of multiple and longer readmission events.
423 Identification of these risk factors can pave the way for attending to patients who have them and,
424 thus, for promoting the quality of hospital care. The overall outcome will be more effective
425 management of combat-related injuries and their related medical costs, which may benefit both
426 patients and society.

427 **Declarations**

428 Ethical approval and Consent to participate: This study has ethical approval from Iran national
429 committee for ethics in biomedical research (Ethics committee code: IR.BMSU.REC.1398.186)
430 All the information used in the study was extracted from the records of patients who have consent
431 to participate in the study

432 Consent for publication: All participants in the study have consent for publication of their disease
433 information.

434 Availability of data and materials: The datasets generated and analysed during the current study
435 are not publicly available because the information used in the study is related to the military
436 personnel and access to their information is a security issue but are available from the
437 corresponding author on reasonable request.

438 Competing interests: The authors declare that they have no competing interests.

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440 Authors Contributions: Hamid Reza Gharehchahi and Sadrollah Mahmoudi wrote the main

text of the manuscript. Hadi Khoshmohabat designed the study and collaborated on data collection. Hamid Reza Javadzadeh designed the figures and tables. Amin Mohamadrezapourzare analyzed the data.

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Figures

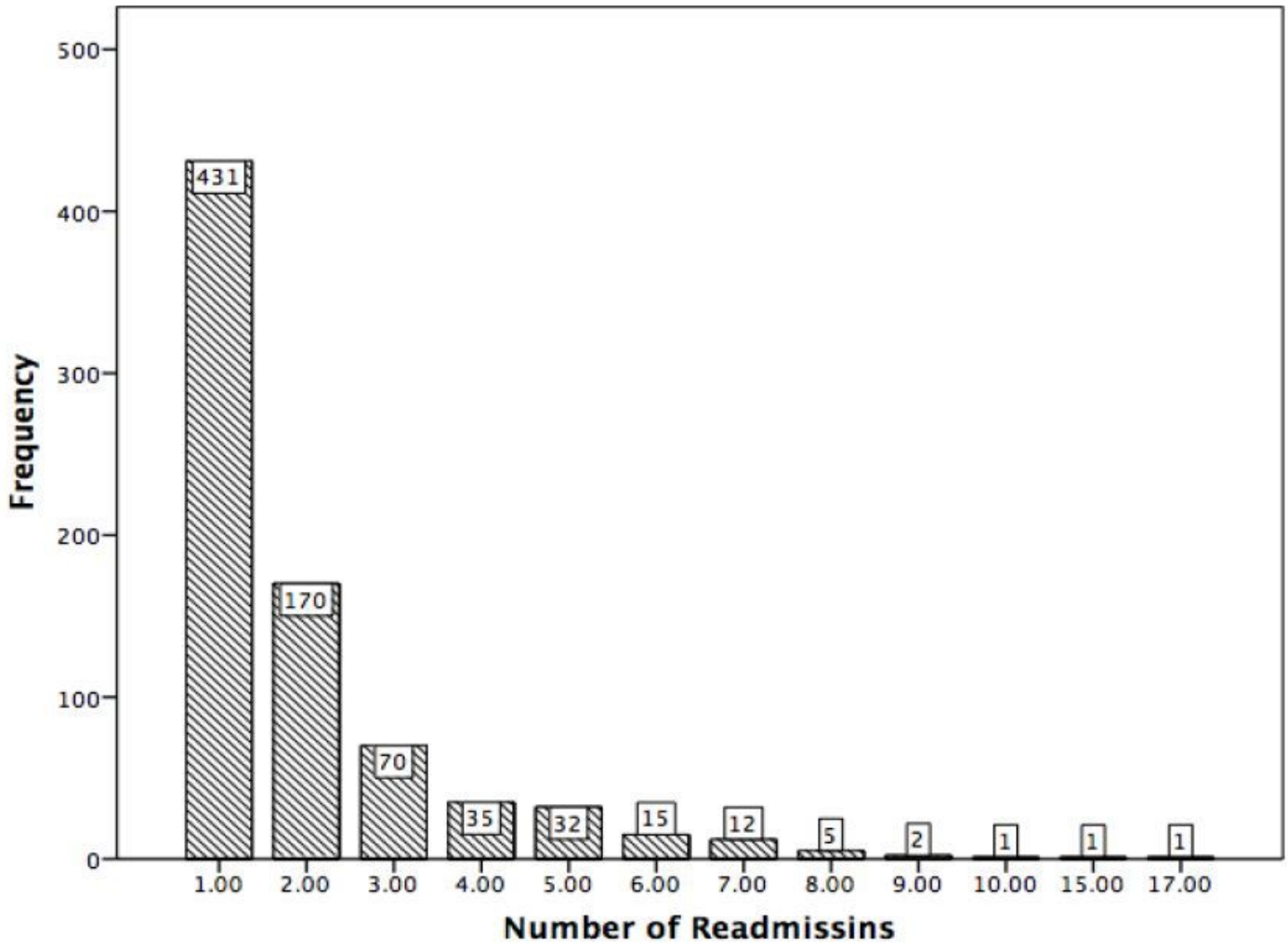

Figure 1

Frequency of patients based on the number of readmission events