

The Impact of Age on Military Trauma Outcomes: A Retrospective Analysis

Danielle Akler MD^{1*}, Daniel Gelman MD MSc^{1,2,3*}, Irina Radomislensky BSc^{1,3}, Zivan Aviad Beer MD MHA MBA^{1,2}, Avi Benov MD MHA MBA^{1,4**}, and Roy Nadler MD MHA^{1**}

¹Medical Corps, Surgeon General's Headquarters, Israel Defense Forces, Ramat Gan, Israel

²Department of Military Medicine and "Tzameret", Faculty of Medicine, Hebrew University of Jerusalem, Jerusalem, Israel

³Gertner Institute for Epidemiology and Health Policy Research, Sheba Medical Center, Tel Hashomer, Israel

⁴Azrieli Faculty of Medicine, Bar-Ilan University, Safed, Israel

*These authors contributed equally to this study.

**These authors contributed equally to this study.

ABSTRACT **Background:** Age is a well-established prognostic factor in civilian trauma, where adverse outcomes increase with ages. Whether this pattern holds true in military trauma, where populations, injury mechanisms, and systems of care differ fundamentally, remains uncertain. A large-scale mobilization of Israeli Defense Forces (IDF) reservists provided an opportunity to examine this association.

Objectives: To clarify whether older service members experienced less favorable outcomes compared with younger counterparts.

Methods: This retrospective cohort study included IDF casualties recorded in the IDF Trauma Registry and the Israel National Trauma Registry between 27 October 2023 and 19 January 2025. Participants were categorized by age: 18–21 years, 22–39 years, and \geq 40 years. Primary outcomes included 24-hour and 30-day mortality, intensive care unit admission (ICU), and hospitalization \geq 7 days.

Results: Of 4905 casualties, 40.4% were 18–21 years of age, 54.2% were 22–39, and 5.4% were \geq 40. Injury severity, evacuation times, pre-hospital interventions, and admission vital signs were similar across groups. Adjusted analyses showed no significant age-related differences in mortality, ICU admission, or prolonged hospitalization. Subgroup analysis of casualties with injury severity score \geq 16 yielded comparable results.

Conclusions: In this large military trauma cohort, no significant association was found between age and mortality, ICU admission, or prolonged hospitalization. These findings were observed in a generally healthy military population receiving organized trauma care and suggest that, within this context, chronological age alone may not be an appropriate criterion for determining reserve service eligibility.

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KEY WORDS: age, combat casualty care, military trauma, reservists, trauma outcomes

Age is a well-established prognostic factor in trauma medicine, with extensive evidence from large civilian registries demonstrating worse outcomes with advancing age after injury [1-6]. However, when age has been examined across the adult lifespan, most studies indicate that trauma-related morbidity and mortality remain largely stable throughout young and middle adulthood, with clinically meaningful increases emerging only in the late fifth to sixth decades of life and beyond [1,7,8]. Accordingly, the observed age effect in trauma has been driven primarily by older patients, with little evidence for meaningful prognostic separation within younger adult age groups.

Combat trauma populations differ from civilian trauma populations in several important ways. First, military trauma is characterized by injury mechanisms that differ substantially from civilian patterns, most notably blast-related and penetrating injuries [9,10]. Second, military systems are supported by highly organized, protocol-driven pre-hospital care that enables advanced field interventions and rapid evacuation [9,10]. Moreover, these populations consist predominantly of younger individuals with high baseline physical fitness and overall health. Even among older service members (\geq 44 years), baseline physical conditioning and general health often exceed those of age-matched civilians [11]. For these reasons, the civilian observation of minimal age-related differences within younger adults may not be directly applicable to military trauma populations. Consequently, although civilian studies suggest little prognostic separation across younger adult age groups, it remains unclear whether this holds true in military trauma, where physiological reserve, injury mechanisms, and systems of care differ substantially.

Clarifying the relationship between age and post-injury outcomes in military settings is of both clinical and manpower significance. The Iron Swords war, a large-scale conflict fought by the Israeli Defense Forces (IDF) across multiple fronts, required an unprecedented mobilization of reserve forces in Israel, including service members substantially older than typical active-duty compulsory-service soldiers. This operational reality underscored the importance of understanding how age influences combat trauma outcomes and provided a unique opportunity to examine its prognostic role in a modern military setting. Accordingly, in the present study we investigated the association between age and clinical outcomes. By addressing this question within the operational context, we aimed to clarify whether older service members experience less favorable outcomes compared with their younger counterparts.

PATIENTS AND METHODS

STUDY DESIGN AND POPULATION

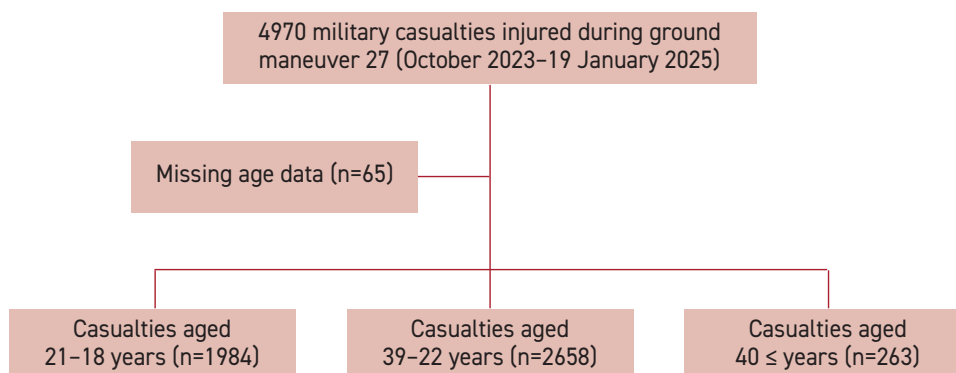
In this retrospective cohort study, we analyzed military trauma casualties treated during the Iron Swords war between 27 October 2023 and 19 January 2025. The study population was derived from the Israel Defense Forces Trauma Registry (IDF-TR), a prospectively maintained pre-hospital database that tracks all physically injured military personnel treated by IDF medical teams, based on casualty cards completed at the point of injury and subsequent provider debriefings [9,12]. Individuals recorded solely for psychiatric or mental health

complaints without physical injury were not included. All individuals recorded in the IDF-TR during the study period were considered eligible, with no minimum injury severity or age-based inclusion criteria applied. In-hospital data, including injury severity score (ISS), were obtained through linkage with the Israeli National Trauma Registry (INTR), which records all patients admitted to designated trauma centers in Israel within 72 hours of sustaining physical trauma [13]. Casualties treated and discharged from the emergency department were included in the cohort but did not have ISS data available; however, we assumed that their ISS was not above 8. Therefore, most missing ISS values can be considered to fall within the ISS 1–8 category. A total of 65 casualties were excluded due to missing age data [Figure 1].

STUDY VARIABLES

Casualty age was obtained from the IDF-TR as a continuous variable and was categorized into three groups: 18–21 years (corresponding to the typical ages of mandatory combat service), 22–39 years (aligning with the standard reserve service age), and ≥ 40 years (representing service members who volunteered for extended reserve service). The primary outcomes were extracted from the INTR and included 24-hour mortality, 30-day mortality, intensive care unit (ICU) admission, and hospitalization lasting ≥ 7 days. Additional variables included sex, type of military service, injury mechanism, event size, pre-hospital interventions, urgency at the scene, evacuation time, ISS, and clinical status with vital signs on arrival at the emergency department.

Figure 1. Participants flow chart



STATISTICAL ANALYSIS

Continuous variables are presented as median and inter-quartile range, and categorical variables are presented as frequencies. Differences were assessed using the Kruskal-Wallis rank sum test for continuous variables and chi-square or Fisher's exact tests for categorical variables.

Multivariate logistic regression analyses were performed for all four clinical outcomes. In multivariate analyses of mortality outcomes, the population included only casualties with ISS ≥ 16 , while in multivariable analyses of ICU admission and hospitalization of ≥ 7 days, the population excluded fatalities. The reference group for all analyses was the 18–21 years age group. The model was adjusted for variables previously found to affect the clinical outcomes measured: event generator (cause of injury) [14], ISS [15], treatment with whole blood or plasma [10,15], and number of casualties per event [16]. Subgroup analyses were made for the population with ISS ≥ 16 .

Statistical analyses were performed using R Statistical Software, version 4.3 (R Foundation for Statistical Computing, Vienna, Austria). A *P*-value < 0.05 was considered statistically significant.

ETHICS CONSIDERATIONS

The study was approved by the institutional ethical review board (no. 1948-2018).

RESULTS

The study included 4970 military casualties, of whom 4905 had valid age data [Figure 1]. The age range was 18–66 years. In total, 1984 (40.4%) were aged 18–21 years, 2658 (54.2%) were aged 22–39 years, and 263 (5.4%) were aged ≥ 40 years. Nearly all casualties were male (99%), and the median age was 23 years [IQR 20–28]. Injuries caused by explosion were less frequent in the ≥ 40 years age group (44%) compared with the 18–21 years age group (57%) and 22–39 years age group (69%). The number of casualties per event did not differ significantly between the groups. Similarly, no significant differences were found in casualty urgency, in the presence of profound shock, or in the time from injury to hospital arrival. Pre-hospital treatments, including tourniquet application, wound packing, administration of tranexamic acid, whole blood or plasma transfusion, and airway or chest interventions, did not differ significantly between the age groups [Table 1].

Figure 2 presents the adjusted odds ratios (ORs) for each age group with respect to four clinical outcomes: 24-hour mortality, 30-day mortality, ICU admission, and hospitalization lasting ≥ 7 days. In the 24-hour mortality analysis, the OR was 0.88 for the 22–39 year group (95% confidence interval [95%CI] 0.63–1.23; *P* = 0.50) and 0.87 for the ≥ 40 year group (95%CI 0.41–1.84; *P* = 0.70). The 30-day mortality analysis yielded similar results, with an OR of 0.93 for the 22–39 year group (95%CI 0.67–1.29; *P* = 0.70) and 0.71 for the ≥ 40 year group (95%CI 0.33–1.51; *P* = 0.40). For hospitalization lasting ≥ 7 days, the OR was 1.17 in the 22–39 year group (95%CI 0.92–1.49; *P* = 0.20) and 1.21 in the ≥ 40 year group (95%CI 0.69–2.06; *P* = 0.50). For ICU admission, the OR was 0.77 in the 22–39 year group (95%CI 0.58–1.03; *P* = 0.08) and 0.65 in the ≥ 40 year group (95%CI 0.31–1.27; *P* = 0.20).

Subgroup analysis of casualties with ISS ≥ 16 , excluding any fatalities, was made for the clinical outcome of ICU admission and hospitalization lasting ≥ 7 days. For ICU admission the OR was 0.89 for the 22–39-year group (95%CI 0.53–1.51; *P* = 0.70) and 0.88 for the ≥ 40 -year group (95%CI 0.27–3.42; *P* = 0.80). For hospitalization lasting ≥ 7 days, the OR was 0.88 in the 22–39-year group (95%CI 0.48–1.59; *P* = 0.70) and 0.77 in the ≥ 40 -year group (95%CI 0.19–3.93; *P* = 0.70).

DISCUSSION

In this retrospective cohort of 4905 combat casualties aged 18–66 years, we found no significant differences across prespecified age groups (18–21, 22–39, ≥ 40 years) in 24-hour or 30-day mortality, ICU admission, or ≥ 7 -day hospitalization. The oldest group sustained fewer explosion-related injuries, but injury severity, pre-hospital care, evacuation characteristics, and arrival vital signs were comparable across age strata. Findings were consistent among severely injured patients (ISS ≥ 16). To the best of our knowledge, this study is among the largest to examine age as a prognostic factor in a purely military trauma cohort integrating pre-hospital and in-hospital data.

Although our data did not reveal such an association, it remains physiologically plausible that age influences recovery potential in military personnel. Age-related declines in aerobic capacity and strength, as well as higher rates of non-fatal musculoskeletal injuries, have been described in military populations, particularly after the third decade of life [17,18]. However, in the combat-trauma populations examined here, such differences may be attenuated by standardized, rapid, and advanced trauma

Table 1. Casualties baseline characteristics

Characteristics	Total, n=4905	Age 18–21, n=1984	Age 22–39, n=2658	Age ≥ 40, n=263	P-value	
Age, median [IQR]	23 [20–28]	20 [20–21]	26 [23–31]	44 [42–48]	< 0.001	
Male, n (%)	4868 (99)	1964 (99)	2641 (99)	263 (100)	0.14	
Military population, n (%)	Conscript	2272 (46)	1794 (90)	462 (17)	16 (6)	< 0.001
	Military career	424 (9)	70 (4)	339 (13)	15 (6)	
	Reserve	2209 (45)	120 (6)	1857 (70)	232 (88)	
Event generator, n (%)	Explosion	2825 (58)	1136 (57)	1572 (69)	117 (44)	< 0.001
	Firearm	697 (14)	290 (15)	371 (14)	36 (14)	
	Other	1383 (28)	558 (28)	715 (27)	110 (42)	
Number of casualties per event, n (%)	1	1774 (36)	712 (36)	954 (36)	108 (41)	0.3
	2–3	1077 (22)	453 (23)	576 (22)	48 (18)	
	4+	2054 (42)	819 (41)	1128 (42)	107 (41)	
Urgency, n (%)*	Non urgent	2342 (49)	906 (47)	1302 (50)	134 (54)	0.246
	Urgent	1944 (41)	819 (43)	1033 (40)	92 (37)	
	Death on the battlefield	415 (9)	173 (9)	220 (9)	22 (9)	
	Died of wounds	53 (1)	24 (1)	28 (1)	1 (0)	
	Unknown	151	62	75	14	
Shock, n (%)	635 (14)	264 (14)	339 (13)	32 (13)	0.8	
Tourniquet, n (%)	661 (13)	260 (13)	374 (14)	27 (10)	0.2	
Packing, n (%)	155 (3)	58 (3)	89 (3)	8 (3)	0.7	
TXA, n (%)	524 (11)	207 (10)	289 (11)	28 (11)	0.9	
Whole blood/FDP, n (%)	339 (7)	144 (7)	172 (7)	23 (9)	0.3	
Intubation/coniotomy, n (%)	127 (3)	53 (3)	69 (3)	5 (2)	0.8	
Chest drain/chest needle decompression, n (%)	93 (2)	36 (2)	48 (2)	9 (3)	0.2	
Time from event to hospitalization, median [IQR]	75 [57–107]	75 [57–104]	76 [58–109]	79 [60–110]	0.3	
ISS, n (%)	1–8	1126 (47)	427 (44)	641 (50)	58 (46)	0.3
	9–14	475 (20)	197 (20)	248 (19)	39 (24)	
	16–24	261 (11)	122 (13)	129 (10)	10 (8)	
	≥ 25	516 (22)	223 (23)	264 (21)	29 (23)	
	Unknown	2527	1015	1376	136	
Systolic BP in the ED < 90, n (%)	44 (2)	22 (3)	18 (2)	4 (4)	0.11	

Missing values are reported for ISS and urgency. Percentages were calculated after excluding missing values.

*Calculated using Fisher's exact test using Monte Carlo simulation

BP = blood pressure, ED = emergency department, FDP = freeze dried plasma, ISS = injury severity score, IQR = interquartile range, TXA = tranexamic acid

care. These observations also suggest effective medical screening and role-based selection for combat assignments. Modern militaries generally apply medical and fitness standards for combat role assignments [19,20], although the recency and stringency of screening may vary by service category and age group. Older reservists who volunteered for and were accepted into combat service during this conflict may have had better physiologic re-

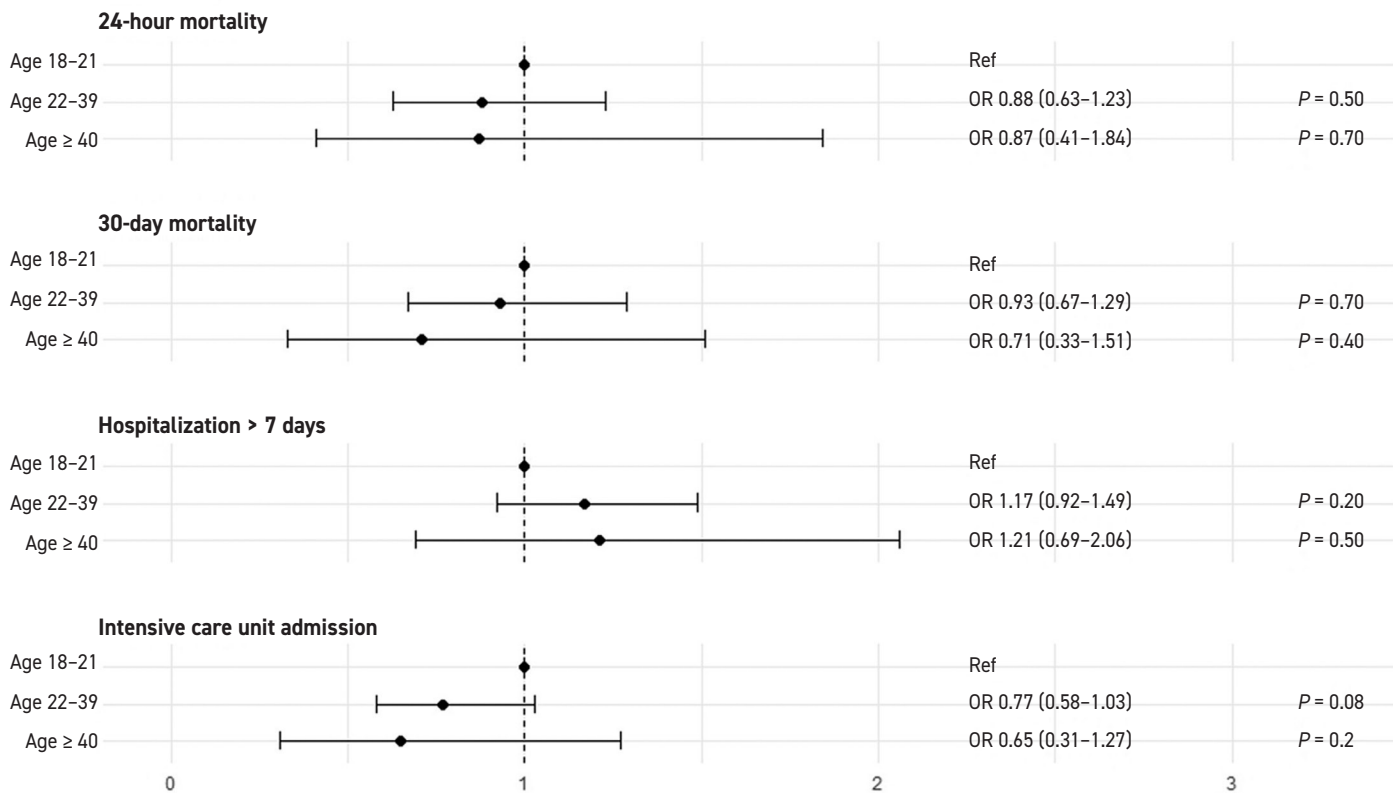
serve than age-matched civilians. Along with the highly protocolized trauma care system, this situation could help explain the absence of an independent age effect on mortality, ICU admission, or prolonged hospitalization.

These findings extend the civilian trauma literature by showing that, within a modern military trauma system, the age-related worsening of outcomes seen in older civilian populations is not evident among medically screened and

Figure 2. Risk for 24-hour mortality, 30-day mortality, hospitalization lasting ≥ 7 days, and intensive care unit admission in casualties aged 22–39 years or ≥ 40 years compared to casualties aged 18–21 years

Odds ratios and 95% confidence intervals were adjusted for event generator, injury severity score, treatment with whole blood or plasma, and number of casualties per event

OR = odds ratio



physically fit service members aged 40 years and older. In this context, injury severity, mechanism, and the performance of the trauma system appear to outweigh chronological age as determinants of outcome. This distinction has important implications for medical screening, force readiness, and reserve-force policy in contemporary militaries.

LIMITATIONS

This study has several limitations. First, the relatively small number of casualties aged ≥ 40 years limits the statistical power to detect modest but clinically meaningful age-related differences. In addition, the study was not designed as a non-inferiority or equivalence trial, further limiting the interpretation of null findings. Accordingly, the absence of statistically significant age-related differences should be interpreted as a lack of evidence for an age effect rather than as definitive evidence of equivalence between age groups. At the same time, this cohort represents one of

the largest available populations of young and middle-aged military personnel with combat-related injuries, providing important insight into the age range most relevant to contemporary military operations and manpower planning.

Second, this cohort likely reflects a healthy soldier subgroup shaped by medical screening, fitness requirements, and self-selection for combat service. This selection limits generalizability to broader civilian or unselected older populations and may underestimate age-related differences in outcomes.

Third, injury mechanisms differed by age group, with older casualties sustaining fewer explosion-related injuries, which may independently influence injury severity and clinical outcomes. In addition, the prolonged study period introduces potential temporal variability in operational tempo, evacuation logistics, and medical system strain, which could further influence outcomes and was not explicitly accounted for in the analysis. Although

multivariable models adjusted for injury mechanism, residual confounding cannot be excluded and should be considered when interpreting age-related comparisons.

Fourth, ISS values were missing for large percentage of casualties because this score is not available for casualties who were discharged from the ED. We made a rough approximation that all missing data can be considered in the ISS 1–8 category. Thus, we have restricted the mortality analyses to casualties with ISS \geq 16, and for the remaining analyses we conducted subgroup analyses for casualties with ISS \geq 16 to specifically address this issue.

Last, this cohort reflects combat-related injuries managed within a highly organized military trauma system and may not be generalizable to non-combat settings or to environments with less comprehensive trauma care.

CONCLUSIONS

In this retrospective cohort of Israeli military combat casualties, we found no evidence of a statistically significant association between age and increased mortality, ICU admission, or prolonged hospitalization. These findings reflect outcomes in a selected, generally healthy military population treated within a highly organized trauma system and should be interpreted in that specific operational and clinical context.

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Correspondence

Dr. D. Akler

Medical Corps, Surgeon General's Headquarters, Israel Defense Forces, Ramat Gan 5262000, Israel

Email: danielleak1995@gmail.com

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A compliment is something like a kiss through a veil.

Victor Hugo (1802–1885), French poet, playwright, novelist, statesman, human rights activist