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Epidemiology of geriatric trauma patients in Norway: A nationwide analysis of Norwegian Trauma Registry data, 2015–2018. A retrospective cohort study

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ABSTRACT

Introduction: Geriatric patients have a high risk of poor outcomes after trauma and is a rapid-increasing group within the trauma population. Given the need to ensure that the trauma system is targeted, efficient, accessible, safe and responsive to all age groups the aim of the present study was to explore the epidemiology and characteristics of the Norwegian geriatric trauma population and assess differences between age groups within a national trauma system.

Materials and methods: This retrospective analysis is based on data from the Norwegian Trauma Registry (2015-2018). Injury severity was scaled using the Abbreviated Injury Scale (AIS), and the New Injury Severity Score (NISS). Trauma patients 16 years or older with NISS ≥9 were included, dichotomized into age groups 16–64 years (Group 1, G1) and ≥65 years (Group 2, G2). The groups were compared with respect to differences in demographics, injury characteristics, management and outcome. Descriptive statistics and relevant parametric and non-parametric tests were used.

Results: Geriatric patients proved to be at risk of sustaining severe injuries. Low-energy falls predominated in G2, and the AIS body regions 'Head' and 'Pelvis and lower extremities' were most frequently injured. Crude 30-day mortality was higher in G2 compared to G1 (G1: 2.9 vs. G2: 13.6%, $P<0.01$) and the trauma team activation (TTA) rate was lower (G1: 90 vs. G2: 73%, $P<0.01$). A lower proportion of geriatric patients were treated by a physician prehospitally (G1: 30 vs. G2: 18%, [NISS 15–24], $P<0.01$) and transported by air-ambulance (G1: 24 vs. G2: 14%, [NISS 15–24], $P<0.01$). Median time from alarm to hospital admission was longer for geriatric patients (G1: 71 vs. G2: 78 min [NISS 15–24], $P<0.01$), except for the most severely injured patients (NISS≥25).

Conclusion: In this nationwide study comparing adult and geriatric trauma patients, geriatric patients were found to have a higher mortality, receive less frequently advanced prehospital treatment and transportation, and a lower TTA rate. This is surprising in the setting of a Nordic country with free access to publicly funded emergency services, a nationally implemented trauma system with requirements to pre- and in-hospital services and a national trauma registry with high individual level coverage from all trauma-receiving hospitals. Further exploration and a deeper understanding of these differences is warranted.

Introduction

Trauma is a major cause of mortality and reduced quality of life, and accounts for approximately 10% of the global burden of disease

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[1]. To reduce avoidable death and disability, it is essential to have well-prepared systems with adequate distributions of resources, knowledge, and personnel [2,3]. Trauma systems are obliged to continuously improve quality and patient safety and in this respect epidemiological studies are important to identify high-risk populations which preventive measures can be directed towards [4,5]. Several mature trauma systems experience a demographic transition into older populations, and the impact of geriatric trauma is already showing [6-9]. Adaptation to ongoing changes in the trauma population is one of the major challenges for modern, evolving trauma systems [10].

In the UK, a study from the Trauma Audit and Research Network (TARN) demonstrated that the proportion of trauma patients above 75 years of age had increased from 8.1% in 1990 to 26.9% in 2013 [11]. Fröhlich et al. recently demonstrated that severely injured geriatric trauma patients in the TraumaRegister DGU were overrepresented compared to the general German population [12]. The global population is ageing [13] and the European Union predicts an increase of inhabitants aged 65 years and above from 101 million in 2018 to 149 million by 2050 [14]. As a consequence, the burden of geriatric trauma is uniformly expected to increase.

Multiple studies have found geriatric patients to be vulnerable within the trauma system, prone to poor outcomes. Compared with younger patients with similar injury severity, geriatric patients have a higher mortality and morbidity, a lower trauma team activation rate, higher complication rates, and high risk of a poor functional outcome [6,15-21]. In addition, decreased transfer likelihood [22], and low trauma center utilization has been found [7]. However, improvements in outcome is achievable, as demonstrated by a Norwegian study by Ringen et al. which assessed the mortality for geriatric patients in an evolving trauma system over 12 years. They found a general survival benefit, with an OR of 0.77 if admitted in the second half of the time period, possibly due to multifactorial improvements over time [23].

Geriatric patients are characterized by having limited physiologic reserves and a high incidence of comorbidity, frailty and polypharmacy [17,24] which can influence the clinical presentation after injury to appear within normal range and preclude the triage decision [25,26]. Field triage algorithms for trauma seek to use all available information about physiological parameters, anatomic injury, mechanism of injury and certain special considerations, yet older patients are consistently found to have a high risk of undertriage to trauma centers and trauma team admissions [19,27,28]. Even when meeting field triage criteria, geriatric patients are less likely to be admitted to a trauma hospital [29].

Norway has a population of 5.4 million people [30], of which approximately 12% are 70 years or older, projected to be 20% by 2060 [31]. It is a high-income country with a publicly funded health care system and a population localized in a mix of urban and rural areas with long geographic distances. Approximately eighty-six percent of the population lives in central areas, defined by proximity to workplaces and services [32]. A nationwide trauma system is implemented [33], describing uniform requirements to all ambulance services and trauma-receiving hospitals. Four level I or II equivalent trauma centers (TC) and 34 local acute care trauma hospitals (ACTH), equivalent to level III TCs [4], receive trauma patients. All these hospitals deliver data to the Norwegian Trauma Registry (NTR) which has a high coverage on hospital and patient level [34]. Rehabilitation services are offered both within specialized centers and in nursing homes in local communities.

Improvement in trauma care requires detailed knowledge of the epidemiology of trauma, patient demographics, interventions, clinical outcomes, and the patient's journey throughout the complete treatment chain [35,36]. New knowledge about the rapid-increasing and vulnerable geriatic trauma population is necessary to ensure that the system of trauma care is targeted, efficient, accessible, safe and responsive to all age groups. Given the lack of knowledge about this population in Norway, our aim was to describe the Norwegian geriatric trauma population by assessing differences in demographic and epidemiological characteristics between age groups, as well as describing injury characteristics and outcomes with data from the NTR.

Methods

Study design and data sources

A retrospective cohort study of all trauma cases in Norway between January 1, 2015 and December 31, 2018 was performed, using NTR data. The protocol for this study was published in advance [37].

Study sample

All trauma-receiving hospitals (40 hospitals in the study period) delivered data to the Norwegian Trauma Registry from all parts of the treatment chain; from the pre-hospital phase through emergency department, critical care unit (CCU) and rehabilitation phases. Patients who meet the following inclusion criteria are registered: Admitted through trauma team activation (TTA), admitted without TTA but found to have penetrating injuries to head, neck, torso, or extremities proximal to knee or elbow, head injury with Abbreviated Injury Scale (AIS) ≥3 or New Injury Severity Score (NISS) >12 [34]. An estimated 95% of patients who meet these criteria are included in the registry [34]. Patients declared dead before hospital arrival after initiation of prehospital management do also meet the inclusion criteria, but because of inadequate information, the registry has low coverage of those who die at the injury site. Fifty percent of the hospitals identified undertriaged patients, and among these are all the largest hospitals, covering the majority of patient volume [34,38].

Data collection is based on the Utstein template and includes detailed information on demographics, injury characteristics, comorbidities, pre- and in-hospital management and interventions and outcomes [39]. Injuries are coded by Association for the Advancement of Automotive Medicine (AAAM) certified registrars according to the AIS manual version 2005, update 2008 [40]. The AIS methodology assigns a code to all injuries which designates body region and injury severity, ranging from 1 (minor) to 6 (maximum and currently untreatable). This is in turn used to calculate the NISS by summarizing the square of the three highest AIS severity scores irrespective of body region [41].

The study population was dichotomized by age into 'Group 1, G1' aged 16–64 years and 'Group 2, G2' aged 65 years and above. Pre-specified sub-categories were defined as age-intervals 65–74, 75–84, and ≥85 years [37]. NISS was grouped into intervals (9–14/ 15–24/ ≥25) in accordance with the AIS severity description [40]. For analysis of proportion of severe injuries (AIS≥3) according to injury locations, patients with multiple injuries in the same body region was counted only once for each region.

Patients aged 16 years or more with NISS ≥9 registered in the NTR between January 1, 2015 and December 31, 2018 were included. Patients with missing information about age or AIS were excluded, mainly patients with foreign residency.

Norwegian Trauma Registry variables

We collected data on age, gender, pre-injury physical status as defined by the American Society of Anesthesiologists physical status classification system (PPS-ASA) [42,43], injury location, AIS, NISS and mechanism of injury (MOI), trauma team activation (TTA), mode of transportation, highest level of prehospital care, discharge

Table 1
Overview of data item operationalization from original NTR variable.

Data item	New categories
ASA	ASA 3 and 4 = ASA 3*. ASA 4 = 0.9% of the study population.
Place of injury, utilizing Centrality Index of Norway	Category 1–4: “Urban Norway”. Category 5 and 6: “Remote Norway”
Discharge destination from definitive care	“CCU (higher treatment level)” and “CCU (same level of care)” = “CCU”.
Mechanism of injury	“Traffic: Other” and “Explosions” merged with “Other”.
Type of transportation	Fixed- and rotor-wing merged to “Air ambulance”. Fixed-wing = 0.6% of the study population. “Private/public vehicle”, “walk-in” and “police” merged with “Other”.
Highest level of prehospital care provider	“Level I: No field care” = “Other”. “Level II: Basic Life Support” and “III: Advanced Life Support, no physician present” = “Ambulance personnel-led care”.
Highest level of in-hospital care	“Emergency department” and “Operating Theatre” merged with “Other”. “High dependency unit” and “Critical care unit” merged.
Time	Outliers >24 h excluded from analysis.

destination and 30-day mortality. Data on mortality appear in two different variables: *30-day mortality* and *Discharge destination; In-hospital mortality*. The latter represents patients who die before any discharge disposition could be made, while 30-day mortality include all deaths occurring within 30 days, irrespective of where it happened. Low-energy falls (LEF) are defined as falls from standing or less than 1 m height, and high-energy falls (HEF) as falls from >1 m height, with emphasis on the total amount of energy involved, not strictly restricted to meters.

Seven data items were re-categorized from its original NTR definition (Table 1). An overview of the original categories of each variable is presented elsewhere [39,44]. Each score component has a category for “unknown” information which was analyzed as “missing”. There were no missing data for *transfer status* or *definitive care*. Other variables had less than five percent missing data, except from *type of transportation* (6.4%), *highest level of prehospital care provider* (10.1%), and *time from alarm to hospital arrival* (17.9%). The distribution of missing data was significantly different between Group 1 and Group 2 for the latter two variables. No imputation was performed.

Injury location was registered on municipality level and mapped to the Centrality Index of Norway (CIN), a continuous variable which is grouped into six categories, from highest (1) to lowest (6) centrality [32]. These categories are based on the number of workplaces and service industries available within a 90-minute drive. The capital, Oslo, and its surrounding municipalities, are category 1, all the second largest cities in Norway are category 2, the surroundings to these cities and regional towns are category 3 and 4, and rural municipalities are category 5 and 6.

Data on the age distribution of the adult Norwegian population was obtained from Statistics Norway for the years of the study period (2015–2018).

Statistics

Data is reported as numbers and percentages for categorical variables and continuous variables are presented as means and standard deviations (SD) or medians and interquartile range (IQR). Differences between age groups were evaluated with Pearson’s chi-squared test or Mann-Whitney U test for categorical data. For continuous variables with large sample sizes, non-normal distribution, and unequal variances, the Welch’s t-test was performed. A P value <0.05 (two-tailed) was considered to be statistically significant. Analyses were performed using SPSS v.25 (IBM Corp., Armonk, NY, USA).

A sensitivity analysis was performed, assessing differences in 30-day mortality and TTA between age groups stratified by injury severity, after excluding patients with significant comorbidity (ASA 3–4) and those with highest age (≥85 years).

Ethical considerations

All patients receive written information about the registry, including the opportunity to access the data recorded and to deny registration. De-identified data was extracted. The study was approved by the Oslo University Hospital data protection officer (No. 19/16,593).

Results

A total of 11,403 patients met the inclusion criteria (Appendix 1), of which 7668 (67%) were 16–64 years of age (Group 1) and 3735 (33%) were 65 years or above (Group 2). Demographic data are presented in Table 2. The median age was 43 years (IQR 28–54) in Group 1 and 76 years (IQR 70–84) in Group 2. The majority of patients were men (77% of Group 1, 60% of Group 2), except in the age-intervals with highest age (≥85 years), where female patients dominated (Fig. 1). In Group 1 the median ASA score was significantly lower than in Group 2 (1 [IQR 1–2] vs. 2 [IQR 2–3]). The proportion of injuries happening in urban areas did not differ between the groups.

Patients 65 years and above constituted 33% of the study cohort but only 16.5% of the Norwegian population (Fig. 2). This overrepresentation of patients with severe trauma is seen from age 48 years, as well as from 16 to 23 years, while young adults (24–45 years) show a decreased risk of severe injuries.

Injury characteristics

Blunt trauma was significantly more prevalent in Group 2 than in Group 1 (98% vs. 94%), as demonstrated in Table 3. 58% of all patients in Group 2 had a NISS of ≥15, significantly higher than 53% in Group 1. The median NISS was 17 in both age groups.

Injury mechanisms are presented by age categories in Fig. 3, with underlying numbers presented in Appendix 2. The prevalence of low-energy falls ranged from 5% among patients aged 16–24 years to over 60% among patients ≥85 years. The three most frequent mechanisms of injury in Group 1 were high-energy falls (28%), motor vehicle injuries (17%) and bicycle injuries (12%), compared to low-energy falls (40%), high-energy falls (29%) and motor vehicle injuries (13%) in Group 2. Among all ages, high-energy falls peaked in age group 65–74 years (35%) before it decreased with increasing age. Traffic-related injuries accounted for 44% of all injuries in the 35–44 years age interval, decreasing with increasing age. Two peaks of motor vehicle injuries were found; one in age interval 16–24 years, the second in age interval 75–84 years.

The AIS body regions head, thorax, and pelvis and lower extremities were the most frequently severely injured body regions in all age intervals (Fig. 4). Geriatric patients had higher proportions of severe head and pelvis or lower extremity injuries com-

Table 2
Demographic characteristics of the two age groups.

	Group 1 16–64 years, $n = 7668$ (67%)	Group 2 ≥65 years, $n = 3735$ (33%)	P-value
Median age	43 (28–54)	76 (70–84)	NP
Male sex, n (%)	5913 (77.1)	2246 (60.1)	<0.01
Preinjury ASA physical status[a,] median (IQR)	1 (1–2)	2 (2–3)	<0.01#
ASA 1	5177 (69.7)	804 (22.2)	<0.01
ASA 2	1820 (24.5)	1620 (44.8)	
ASA 3*	432 (5.8)	1191 (32.9)	
Place of injury[b]			0.18
Urban Norway	6033 (83)	3009 (84.1)	
Remote Norway	1233 (17.0)	571 (15.9)	

Abbreviations: IQR, inter quartile range; NP, not performed; ASA, American Society of Anesthesiologists.
#Mann-Whitney *U* test.
ASA 3* includes 21 (G1) and 81 (G2) patients with ASA 4.
Missing data for G1 and G2 , respectively: [a]ASA: 3.1% and 3.2%. [b]Place of injury: 5.2% and 4.1% .

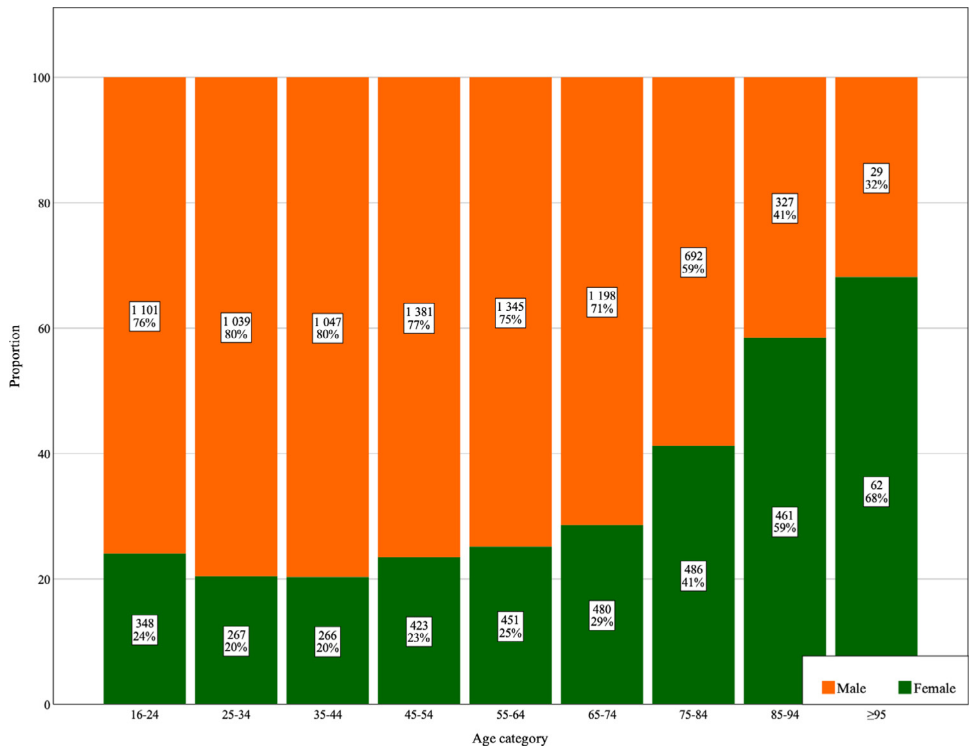

Fig. 1. Proportion and absolute numbers of male and female patients according to age category.

pared to younger age groups. Underlying numbers are presented in Appendix 3.

Level of care

Outcome and level of care stratified by injury severity and age group are presented in Table 4. The proportion of patients in Group 2 receiving physician-led care ranged from 13 to 28% with increasing injury severity, compared to 22 to 47% in Group 1. The rate of air ambulance transports (Group 2: 10 to 19% vs. Group 1: 16 to 33%) was significantly lower in all injury severity subgroups. Trauma team activation rate was significantly lower for patients in Group 2 within all injury severity groups, ranging from 71 to 79%, compared to 86 to 92% in Group 1. Crude 30-day mortality was significantly higher in Group 2, both when stratified by age (2.9 vs. 13.6%, Table 3) and injury severity ([NISS 9–14]: 0.3 vs. 6.1%, [NISS 15–24]: 0.7 vs. 7.7%, Table 4). The results of the sensitivity analysis demonstrated diminished differences after excluding patients with ASA 3-4 or age ≥85 years, but still significant in the most severely injured group (Table 5).

Patients in Group 2 with NISS≥15 or NISS ≥25 were to a significantly lesser extent transferred to a TC from an ACTH compared with patients in Group 1. The proportions of patients receiving definitive care at a TC are also significantly lower for Group 2 patients in all injury severity groups. The mean time from alarm to hospital arrival was significantly longer for patients in Group 2 with a NISS <25, however for the most severely injured, the mean time was similar between Group 1 and Group 2. There was a significant difference in discharge destination (Table 3), where 60% of patients in Group 1 was discharged home from definitive care, compared to 38% of patients in Group 2. The proportion of patients discharged to "Nursing home" was significantly higher in Group 2 (20.5%) than in Group 1 (4%), rising with increasing age to 40% for those 85 years and above.

Discussion

The aim of this study was to describe the Norwegian geriatric trauma population by assessing differences in demography, epidemiology, outcome and level of care between age groups, as well

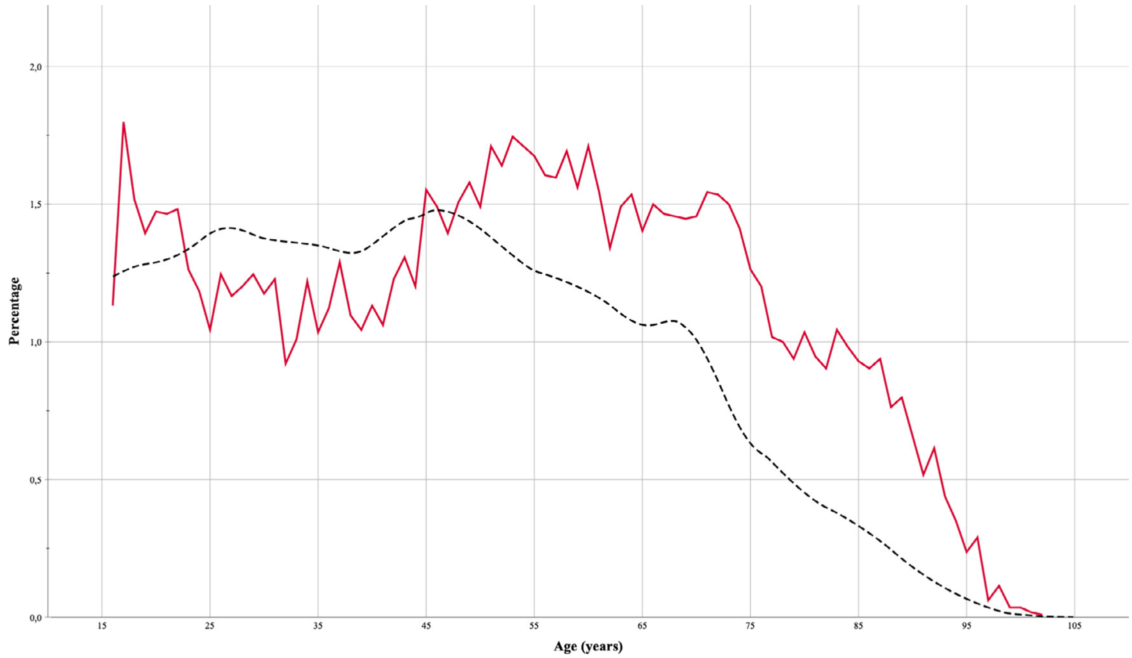

Fig. 2. The age distribution of trauma patients in the study cohort (solid line) demonstrates an increased risk of trauma from age 16–23 and from age 48. The dotted line displays the average age distribution of the Norwegian population in 2015 to 2018.

Table 3
Injury characteristics and outcome by age.

	Group 1: 16–64 years, n = 7668 (67%)	Group 2: ≥65 years, n = 3735 (33%)	P-value	65 – 74 years, n = 1678 (45%)	75 – 84 years, n = 1178 (32%)	≥ 85 years, n = 879 (23%)
Dominating type of injury[a], n (%)			<0.01			
Blunt	7053 (94.2)	3570 (98.3)		1582 (97.6)	1135 (99.0)	853 (98.6)
Penetrating	432 (5.8)	63 (1.7)		39 (2.4)	12 (1.0)	12 (1.4)
New Injury Severity Score, n (%)			<0.01			
9–14	3637 (47.4)	1560 (41.8)		688 (41.0)	475 (40.3)	397 (45.2)
15–24	2226 (29.0)	1215 (32.5)		561 (33.4)	401 (34.0)	253 (28.8)
≥25	1805 (23.5)	960 (25.7)		429 (25.6)	302 (25.6)	229 (26.1)
Median (IQR)	17 (12–22)	17 (12–25)	<0.01#	17 (12–25)	17 (13–25)	17 (13–25)
Trauma team activation[b], n (%)			<0.01			
Yes	6832 (89.8)	2711 (73.3)		1353 (81.4)	836 (71.6)	522 (60.0)
No	773 (10.2)	989 (26.7)		310 (18.6)	331 (28.4)	348 (40.0)
Discharge destination from definitive care[c], n (%)			<0.01			
Home	4564 (60.1)	1412 (38.2)		824 (49.6)	418 (35.8)	170 (19.5)
Rehabilitation	581 (7.6)	212 (5.7)		117 (7.0)	61 (5.2)	34 (3.9)
In-hospital mortality	198 (2.6)	351 (9.5)		75 (4.5)	113 (9.6)	163 (18.7)
Critical care unit	751 (9.9)	363 (9.8)		192 (11.6)	123 (10.5)	48 (5.5)
Somatic hospital ward	1200 (15.8)	602 (16.3)		295 (17.8)	200 (17.1)	107 (12.3)
Nursing home*	303 (4.0)	758 (20.5)		158 (9.5)	252 (21.6)	348 (40.0)
30-day mortality[c], n (%)			<0.01			
Dead	215 (2.9)	500 (13.6)		97 (5.9)	161 (13.9)	242 (27.8)
Alive	7270 (97.1)	3166 (86.4)		1542 (94.1)	997 (86.1)	627 (72.2)

Abbreviations: IQR, inter quartile range; TTA, trauma team activation.
*Inlcudes discharge to psychiatric institutions, prison and other [39].
#Mann-Whitney *U*.
Missing data for G1 and G2, respectively: a, Dominating injury: 2,4% and 2,7%. b, TTA: 0.8% and 0.9%. c, Discharge destination: 0.9% and 1.0%. d, 30-day mortality: 2.4% and 1.8%. .

as describing injury characteristics. We found geriatric patients (Group 2) to have consistently higher mortality than adult patients (Group 1), receive less advanced prehospital treatment and transportation, and a lower trauma team activation rate. In a country with a homogeneous population, where a national trauma plan is implemented and with a high coverage national trauma registry in place, there are strong reasons to believe that the findings represent true undertriage and inferior services to geriatric patients.

Geriatric trauma patients constituted a substantial part of the study cohort (33%) and demonstrated an increased risk of severe injury compared to the proportion geriatric patients constitute in the Norwegian population (17%), as demonstrated in

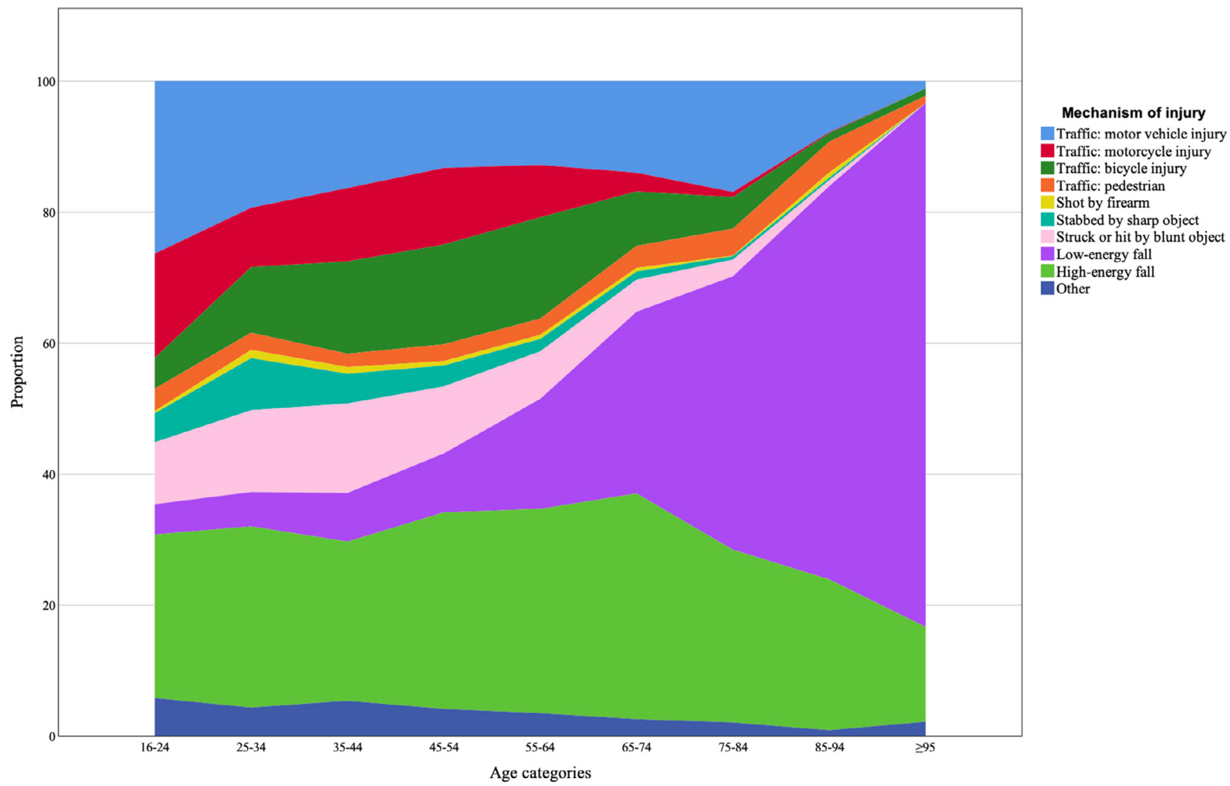

Fig. 3. Distribution of mechanism of injury according to patient age category.

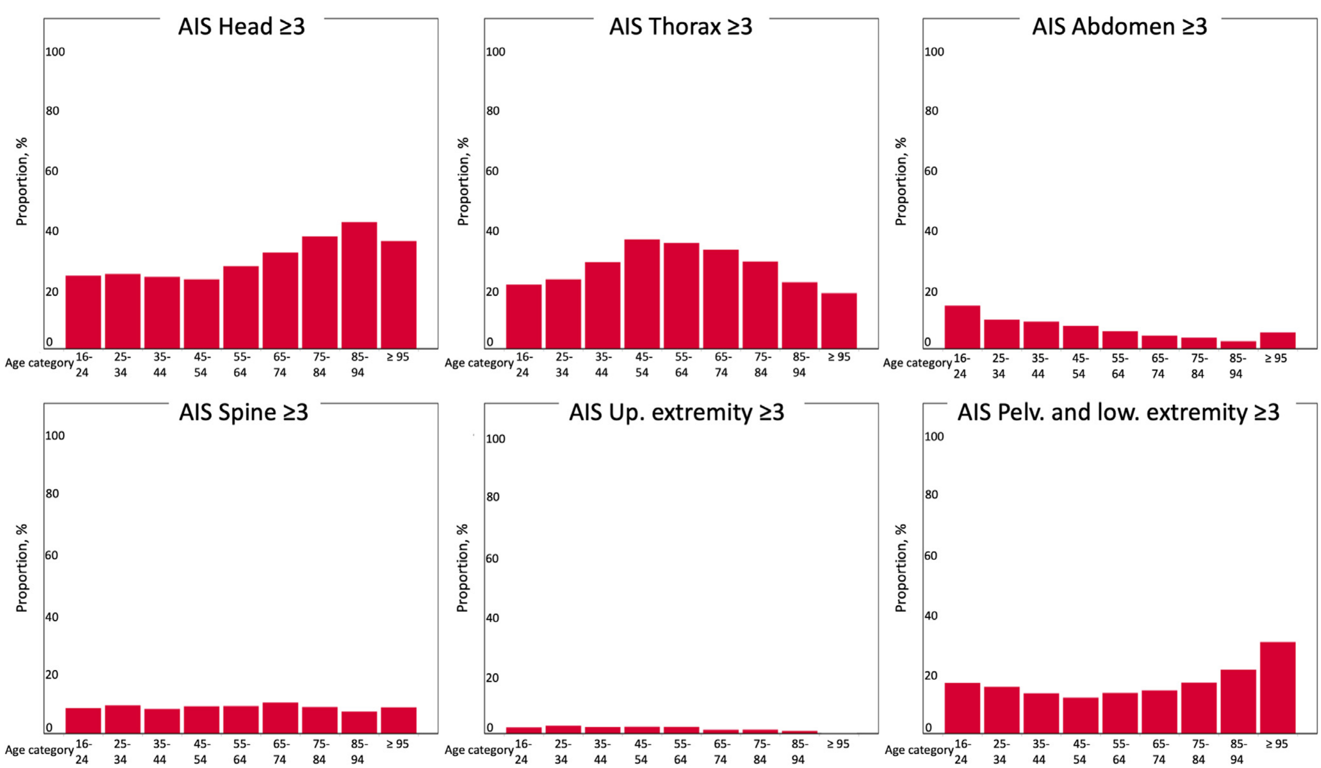

Fig. 4. Proportion of severe injury (AIS ≥3) according to injury location (head, thorax, abdomen, spine, upper extremities and lower extremities) and age intervals.

Table 4
Outcome and level of care by age group and injury severity.

	NISS 9 through 14			NISS 15 through 24			NISS 25 through 75		
	16–64 years, n = 3640 (47.5)	≥65 years, n = 1567 (41.9)	P-value	16–64 years, n = 2234 (29.1)	≥65 years, n = 1227 (32.9)	P-value	16–64 years, n = 1794 (23.4)	≥65 years, n = 941 (25.2)	P-value
Type of transportation, n (%)			<0.01			<0.01			<0.01
Ground ambulance	2734 (79.1)	1245 (84.6)		1447 (70.0)	929 (81.4)		1069 (63.7)	656 (76.0)	
Air ambulance	551 (15.9)	141 (9.6)		500 (24.2)	158 (13.8)		552 (32.9)	164 (19.0)	
Other	170 (4.9)	85 (5.8)		119 (5.8)	54 (4.7)		58 (3.5)	43 (5.0)	
Highest level of prehospital care provider, n (%)			<0.01			<0.01			<0.01
Physician-led care	717 (21.6)	180 (12.9)		597 (30.2)	199 (18.2)		770 (47.1)	227 (27.5)	
Ambulance personell-led care	2564 (77.1)	1201 (86.3)		1348 (68.3)	886 (80.9)		849 (51.9)	592 (71.8)	
Other	46 (1.4)	10 (0.7)		29 (1.5)	10 (0.9)		16 (1.0)	6 (0.7)	
Trauma team activation, n (%)			<0.01			<0.01			<0.01
Yes	3334 (92.3)	1115 (71.9)		1904 (85.9)	860 (70.8)		1594 (89.7)	736 (78.8)	
No	277 (7.7)	436 (28.1)		313 (14.1)	355 (29.2)		183 (10.3)	198 (21.2)	
Transfer status, n (%)			0.69			<0.01			<0.01
Transferred	155 (4.3)	50 (3.2)		263 (11.8)	102 (8.3)		370 (20.6)	125 (13.3)	
Not transferred	3485 (95.7)	1517 (96.8)		1971 (88.2)	1125 (91.7)		1424 (79.4)	816 (86.7)	
Definitive care, n (%)			0,03			0.02			<0.01
Acute care trauma hospital	2257 (62.1)	1018 (65.3)		1035 (46.5)	616 (50.7)		399 (22.1)	362 (37.7)	
Trauma center	1380 (37.9)	542 (34.7)		1191 (53.5)	599 (49.3)		1406 (77.9)	598 (62.3)	
30-day mortality, n (%)			<0.01			<0.01			<0.01
Dead	10 (0.3)	93 (6.1)		16 (0.7)	92 (7.7)		189 (10.7)	315 (33.4)	
Alive	3535 (99.7)	1434 (93.9)		2152 (99.3)	1105 (92.3)		1583 (89.3)	627 (66.6)	
Highest level of in-hospital care, n (%)			<0.01			<0.01			<0.01
General ward	665 (18.5)	368 (23.9)		274 (12.4)	202 (16.7)		67 (3.7)	94 (9.9)	
Critical care unit*	2590 (72.0)	996 (64.6)		1771 (80.1)	906 (75.1)		1644 (91.6)	815 (85.7)	
Other	343 (9.5)	178 (11.5)		165 (7.5)	98 (8.1)		83 (4.6)	42 (4.4)	
Time from alarm to hospital arrival (min), median (IQR)	63 (39–100)	77 (48–117.5)	<0.01#	71 (43–105)	78 (47–121)	<0.01#	67 (38–105)	69 (44–105)	0.5#

Abbreviations: NISS, New Injury Severity Score; IQR, inter quartile range.
*Including high dependency units [39].
Unequal variances *t*-test.
Missing data for G1 and G2, respectively: Type of transportation: 6.1% and 7.0%. Highest level of prehospital care provider: 9.5% and 11.4%. TTA: 0.8% and 0.9%. 30-day mortality: 2.4% and 1.8%. Highest level of inhospital care: 0.9% and 1.0%. Time from alarm to hospital arrival: 17.5% and 19.3%.

Table 5
Sensitivity analysis after excluding patients with significant comorbidity (ASA 3–4) and high age (≥85).

	NISS 9 through 14			NISS 15 through 24			NISS 25 through 75		
	16–64 years, n = 3390 (48.5)	≥65 years, n = 838 (42.2)	P-value	16–64 years, n = 2035 (29)	≥65 years, n = 691 (34.8)	P-value	16–64 years, n = 1572 (22.5)	≥65 years, n = 458 (23)	P-value
Trauma team activation rate, n (%)	3134 (92.8)	668 (79.9)	<0.01	1766 (87.0)	523 (75.8)	<0.01	1413 (90.1)	372 (81.4)	<0.01
30-day mortality, n (%)	≤5	13 (1.6%)	NA	14 (0.7)	9 (1.4)	0.12	154 (10.3)	84 (20.1)	<0.01

Abbreviations: NISS, New Injury Severity Score; NA, not applicable.
Missing data for G1 and G2, respectively: TTA: 0.8% and 0.9%. 30-day mortality: 2.4% and 1.8%.

Fig. 2. This corresponds to findings from a recent study from the German trauma registry [12]. The dominating injury mechanism among geriatric patients was, not surprisingly, low-energy falls (LEF), while for adult patients high-energy falls (HEF) or traffic-related injuries predominated (Fig. 3), comparable to results from other studies [9,45-47]. Relevant diversity existed within the geriatric group (Fig. 3); with increasing age LEFs dominated, but the second most prevalent MOI in Group 2 was HEF (29%), which is found to commonly result from falls from ladders [48]. Other studies more frequently report motor vehicle injuries as the second most frequent MOI [6,45]. Indeed, a second peak of motor vehicle injuries was found in the age group 75–84 years (Fig. 3), reaching almost the same level as age 25–34 years. Traffic-related injuries overall were most prevalent at age 35–44 (44%) while injuries resulting from pedestrian accidents remained stable in all age groups.

Despite the fact that geriatric patients were more often injured by low-energy mechanisms of trauma, we found a larger proportion of patients with NISS≥15 in Group 2 than in Group 1 (G1: 53 vs. G2: 58%, P<0.01) (Table 3). Further, the crude mortality was significantly higher (G1: 2.9 vs. G2: 13.6%, P<0.01) (Table 3) and the proportion of patients discharged home was significantly lower (G1: 60 vs. G2: 38%, P<0.01). The present and previous studies demonstrate that the AIS body regions 'Head' and 'Pelvis and lower extremity' are most frequently severely injured (AIS≥3) in geriatric patients (Fig. 4) [17,45], and traumatic brain injury is associated with high mortality and poor functional outcomes [49]. This, in addition to risk factors of poor outcomes such as age, comorbidities, and use of anticoagulants [52] are factors that may explain some of the observed difference between adult and geriatric patients.

Substantial differences were found in TTA rate between age groups, both when stratified by age and by injury severity. The highest TTA rate (92%) was found in Group 1 patients with NISS 9–14. Comparably, TTA rates from 60 to 72% were found in patients aged 75 years and higher, and geriatric patients had consistently a TTA rate below 80% for all injury severity intervals. A low TTA rate for geriatric patients has been described previously and our results correspond with these findings [19,20,28]. Sensitivity is important for the performance of the triage tool, however, some studies point to other contributing factors for undertriage of geriatric patients than low triage tool sensitivity: Chang et al. studied patients who both met formal triage criteria and was recognized as severely injured by the EMS personnel, yet still they found an undertriage rate to TC of geriatric trauma patients at nearly 50% [50]. A follow-up survey found inadequate training, unfamiliarity with protocol and possible age bias to be important explaining factors [50]. An Australian study by Cox et al. which retrospectively reviewed all trauma patients attended by a state ambulance service between 2007 and 2011 found that despite the triage tool's ability to identify both young and old trauma patients (undertriage rate of 4.5% for older patients), the likelihood of transport to a trauma hospital decreased with increasing age [29]. A Norwegian study reported that if field triage criteria were correctly applied, undertriage in a Norwegian TC could have been reduced from 10.5 to 4.0% [51]. Undertriage of geriatric trauma patients is a complex problem and improvement efforts probably need a multifactorial approach, including educating relevant personnel about the specific characteristics of geriatric trauma and a deeper understanding of the causes of undertriage.

Stratification on pre-specified age-categories was used in analyses to demonstrate clinically relevant heterogeneity in Group 2. The proportion of patients with significant comorbidity (ASA 3–4) and female sex increased with increasing age in our material. Patients 85 years or older and those with significant comorbidity (ASA 3–4) accounted for 47% of Group 2 and were excluded in a sensitivity analysis (Table 5), as these characteristics are associated with increased mortality [52]. The differences between Group 1 and 2 diminished compared to the results from Table 4, although remained statistically significant. Despite having excluded patient with ASA 3–4 and age ≥85 years, the TTA rate of the most severely injured patients (NISS≥25) in Group 2 were almost unchanged. This finding underlines the severe problems in triage of geriatric patients.

Transfer rates to TCs and the proportions of patients receiving definitive care in a TC show less disparity between age groups compared to other variables examined (Table 4). 12% of Group 1 patients with NISS 15–24 were transferred, compared to 8% of Group 2 patients. The proportions receiving care in a TC were 54% in Group 1 and 49% in Group 2 in the same NISS interval. These differences are statistically significant, however clinically they represent a noticeable similarity of in-hospital level of care. The differences in transfer rates were greater for the most severely injured patients (NISS≥25) (G1: 20.6% vs G2: 13.3%, P<0.01), and the reason for this may be the poor prognosis associated with high age and very severe injuries [52], where transport and continued care in a TC might be deemed futile. The role of withdrawal of life support and patients' or relatives' own wish to be treated as near home as possible, even if it means not being treated at the recommended specialist facility, needs to be better investigated. Well-designed qualitative studies could probably provide a broader insight of these complex processes.

The similarities in transfer rates and treatment levels between age groups contrasts with the differences in the proportions of patients transported by air ambulance, receiving prehospital physician care, and proportions of patients received by a trauma team. An explanation could be that starting the trauma treatment chain is the crux of geriatric trauma, not merely challenges with the sensitivity of the triage tool. There might be an association between a number of coexisting coincidences: Low-energy trauma does not necessarily attract as much attention as high-energy trauma, geriatric patients might present with no irregular vital signs [25,26], and the patients might have reduced cognitive abilities in conjunction with preexisting conditions or as a consequence of the trauma. In addition, low-energy falls patients can present with low levels of pain complaints and some of them may not call for pre-hospital aid. All this precludes the primary evaluation and make it hard to acknowledge the severity of the injury for both the caller and the dispatch center.

There are both strengths and limitations to this study. First of all, limitations are inherent to the retrospective design, which does not allow for exploration of causal relationships, only associations. To our knowledge this is one of few studies describing epidemiology of geriatric trauma from a uniform national trauma system using data from a national trauma registry with high patient coverage. Although the NTR has a high individual level coverage, mortality calculations are not giving the full picture as not all prehospital deaths are registered. The NTR retrospectively include patients not met by a trauma team with NISS>12. According to the sensitivity of the national triage criteria we were able to include patients with NISS≥9 due to the low threshold for trauma team activation, but patients not meeting inclusion criteria with a NISS between 9 and 12 might be underrepresented in the material. Undertriage, defined as no TTA for patients with Injury Severity Score>15, is a nationally defined benchmark [33], but despite this, only half of Norwegian hospitals identified and reported undertriaged patients [38]. Mainly these are hospitals with small patient volumes and the risk of bias is therefore limited.

Improving patient safety and quality of care for vulnerable groups is one of the central aspects of trauma system development. Comprehensive analyses of the epidemiology of trauma are necessary to ensure that the system is targeted, efficient, safe and responsive to all age groups. As demonstrated in this study, significant differences in characteristics, management and outcome between adult and geriatric patients exist in the Norwegian trauma system. As geriatric trauma incidence rates will continue to increase, improving outcome for this group might be rewarding both for the individual patient and society. Further exploration of the differences in trauma management of adult and geriatric patients is warranted.

Conclusion

In this nationwide study geriatric patients were found to have an increased risk of severe injury, a higher mortality rate, receive less frequently advanced prehospital treatment and transportation and a lower trauma team activation rate, compared to adult patients. Prehospital time was longer for geriatric patients, except for the most severely injured patients. This contrasts to the smaller differences observed in the proportions of patients transferred to trauma centers or receiving definitive care at trauma centers and may reflect true differences in prehospital and in-hospital management of geriatric trauma patients. This is surprising in the setting of a Nordic country with free access to publicly funded emergency services, a nationally implemented trauma system with requirements to pre- and in-hospital services and a national trauma registry with high individual level coverage from all trauma-receiving hospitals. Future research should be directed at providing a deeper understanding of these differences.

Declaration of Competing Interest

The authors declare no competing interests.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.injury.2020.11.007.

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