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Age-related differences in prehospital triage and critical interventions: A multicenter TraumaRegister DGU® analysis

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Abstract

Purpose

Older trauma patients are known to be undertriaged in the prehospital setting. However, it remains unclear whether these disparities translate into differences in the delivery of critical prehospital interventions. This study aimed to evaluate age-related differences in prehospital triage, allocation, and treatment within a physician-staffed emergency medical service system.

Methods

A retrospective multicenter analysis of the TraumaRegister DGU® was conducted, including trauma patients aged ≥ 20 years between 2020 and 2023 with trauma team activation and subsequent intensive care unit admission. Patients were stratified into two age groups, 20–59 vs. ≥60 years, with additional subgroups up to 90–99 years. Prehospital interventions, transport modality, and trauma center allocation were analyzed. Furthermore, predefined high-risk scenarios (severe motor vehicle trauma, traumatic brain injury with GCS ≤ 8, and pneumothorax) were evaluated.

Results

A total of 67,069 patients were included, with comparable injury severity across age groups (mean ISS 20.2). Older patients were less frequently transported by air and less often allocated to supra-regional trauma centers. While overall intervention rates were similar, differences emerged in high-risk scenarios. Older patients received endotracheal intubation and tranexamic acid less frequently despite comparable injury severity. Prehospital chest tube placement rates were low and similar across age groups.

Conclusion

Age-related differences in prehospital triage and allocation are associated with selective differences in treatment, particularly in high-risk situations. These findings suggest that prehospital care in older trauma patients is individualized rather than uniformly reduced, but highlight the need to refine triage algorithms and guideline implementation in an aging trauma population.

Introduction

With a steadily aging global population, trauma systems worldwide face increasing challenges in the care of older patients. Older trauma patients represent a particularly vulnerable group — not solely due to their chronological age, but because of age-related physiological changes, multimorbidity, and frailty. Despite these well-recognized factors, emerging data consistently indicate that geriatric trauma patients remain undertriaged in the prehospital setting. [1, 2] This undertriage is associated with delayed access

to definitive care, worse outcomes, and higher short-term mortality. [3] Recent cohort studies have highlighted that even when presenting with injury severities comparable to those of younger cohorts, geriatric patients are less likely to trigger trauma team activation (TTA), less frequently accompanied by emergency physicians and less often transported by air – in physician-staffed emergency medical systems (EMS). [1, 2, 4] Notably, such patterns persist despite higher rates of injury mechanisms and patterns associated with poor prognosis, including traumatic brain injury and pelvic fractures. [1]

Several factors may contribute to age-related differences in prehospital assessment. Atypical clinical presentations, blunted physiological responses to injury (for example, the absence of tachycardia in hemorrhagic shock) [5], and difficulty distinguishing acute injury from pre-existing functional limitations may complicate early severity assessment in older patients. In physician-staffed EMS systems, where advanced life-saving interventions are theoretically available across age groups, these factors may affect early decision-making processes.

While age-related prehospital undertriage has been well described [1–4, 6], it remains unclear whether these differences are accompanied by corresponding differences in the delivery of critical prehospital interventions. Data are limited on how frequently guideline-recommended interventions are applied in older trauma patients compared with younger adults in clinically comparable, high-risk scenarios.

The present study aimed to describe age-related patterns in prehospital triage, allocation, and critical interventions using data from the TraumaRegister DGU®. By focusing on predefined high-risk clinical scenarios, this analysis seeks to examine whether differences in the use of critical prehospital interventions are observed between older and younger trauma patients, despite equivalent clinical need. Ultimately, the findings are intended to inform the interpretation and real-world application of contemporary trauma guidelines[7, 8].

Material and Methods

This retrospective, cross-sectional multicenter study analyzed TraumaRegister DGU® data from 2020–2023.

TraumaRegister DGU®

The TraumaRegister DGU® of the German Trauma Society (Deutsche Gesellschaft für Unfallchirurgie, DGU) was founded in 1993. The aim of this multicenter database is a pseudonymized and standardized documentation of severely injured patients.

Data are collected prospectively in four consecutive time phases from the site of the accident until discharge from hospital: A) Pre-hospital phase, B) Emergency room and initial surgery, C) Intensive care unit and D) Discharge.

The documentation includes detailed information on demographics, injury patterns, comorbidities, pre- and in-hospital management, course on intensive care unit, relevant laboratory findings including data on transfusion and outcome of each individual. The inclusion criterion is admission to hospital via emergency room with subsequent ICU/ICM care or reach the hospital with vital signs and die before admission to ICU.

The infrastructure for documentation, data management, and data analysis is provided by AUC - Academy for Trauma Surgery (AUC - Akademie der Unfallchirurgie GmbH), a company affiliated to the German Trauma Society. The scientific leadership is provided by the Committee on Emergency Medicine, Intensive Care and Trauma Management (Sektion NIS) of the German Trauma Society. The participating hospitals submit their data pseudonymized into a central database via a web-based application. Scientific data analysis is approved according to a peer review procedure laid down in the publication guideline of TraumaRegister DGU®.

Trauma centers are classified as supra-regional, regional, or local according to the definitions of the German Trauma Society (DGU) within the TraumaNetzwerk DGU®. These categories reflect increasing levels of structural, personnel, and organizational resources for trauma care.

The participating hospitals are primarily located in Germany (90%), but a rising number of hospitals in other countries contribute data as well (at the moment from Austria, Belgium, China, Finland, Luxembourg, Slovenia, Switzerland, The Netherlands, and the United Arab Emirates). Currently, almost 30 000 cases from almost 700 hospitals are entered into the database per year.

Participation in TR-DGU is voluntary. For hospitals associated with TraumaNetzwerk DGU®, however, the entry of at least a basic data set is obligatory for reasons of quality assurance. Since 2018 a declaration of data protection has to be filled by every conscious patient.

The present study is in accordance with the publication guidelines of the TraumaRegister DGU® and registered as TR-DGU project ID 2025-006.

Setting and participants

The study population and selection process are illustrated in Fig. 1.

Inclusion criteria

Primary admissions to German hospitals with trauma team activation (TTA) and subsequent intensive care unit admission between 2020 and 2023 were included. Patients aged 20–99 years were required to have a maximum Abbreviated Injury Scale (MAIS) score ≥ 3. MAIS is defined as the highest abbreviated injury scale (AIS) score assigned to any single injury in a patient.

Exclusion criteria

Patients who were secondarily transferred from another hospital and those with incomplete datasets were excluded from the analysis.

Exposure definitions and group assignment

Patients were stratified into two age groups (20–59 vs. ≥60 years). The older group was further divided into the following subgroups: 60–69, 70–79, 80–89, and 90–99 years. Analyses were also stratified by injury mechanism.

To improve comparability between groups and to allow a more targeted assessment of prehospital interventions, predefined subgroup analyses were performed in clinically relevant scenarios:

1. Motor vehicle trauma with MAIS ≥ 4
2. High or low fall mechanism associated with unconsciousness, defined as an initial Glasgow Coma Scale (GCS) score ≤ 8
3. In-hospital confirmed pneumothorax during initial trauma care

Prehospital management variables

Primary variables were prehospital interventions (endotracheal intubation, chest tube placement), tranexamic acid administration, volume administration, and trauma center allocation. Secondary endpoints included transport modality (ground vs. air) and prehospital time.

Statistical analysis

Categorical variables are reported as frequencies and percentages, and continuous variables as means. The analysis focused on descriptive, scenario-based comparisons to identify clinically relevant patterns in prehospital care across age groups rather than to establish causal relationships.

Formal statistical hypothesis testing was not performed due to the large number of parameters, scenarios, and subgroups. To reduce heterogeneity and improve comparability between age groups, analyses were restricted to predefined, clinically homogeneous high-risk scenarios. Statistics were computed with IBM SPSS Statistics software (version 29, IBM Inc., Armonk, NY, USA).

Ethics

The study used pseudonymized registry data and was conducted in accordance with TR-DGU governance. The scientific dataset was further blinded for hospital name and date/time of admission. Approval for scientific evaluation of TR-DGU data is granted by the DGU Section NIS. Data were initially collected for external quality control, in accordance with applicable legal and ethical requirements.

Results

Baseline characteristics are presented in Table 1. In total, 67,069 trauma patients from 673 German hospitals met the inclusion criteria and were analyzed. Of these, 32,658 (48.7%) were aged 20–59 years, while 34,411 (51.3%) were aged 60–99 years. Within the older cohort, 11,340 patients were 60–69 years old, 9,616 were 70–79 years old, 11,097 were 80–89 years old, and 2,358 were 90–99 years old. The prevalence of severe injury with ISS ≥ 16 was comparable across age groups, ranging from 61.0% in patients aged 20–59 years to 64.7% in patients aged 60–99 years. Mean ISS was identical in both groups (20.2). Likewise, mean prehospital transport times were comparable (68.1 min vs. 66.8 min).

Table 1
Age-stratified trauma metrics

Age group (years)	**20–59**	**60–99**	**60–69**	**70–79**	**80–89**	**90–99**
Number of patients	32,658	34,411	11,340	9,616	11,097	2,358
Male Gender (%)	77.0	61.9	74.0	63.2	53.2	39.5
ISS ≥ 16 (%)	61.0	64.7	62.4	65.3	67.1	62.0
ISS (mean)	20.2	20.2	20.0	20.5	20.3	19.2
Prehospital Time (min)	66.8	68.1	67.7	67.5	68.5	68.5
Level of care						
Supra-regional TC (%)	59.3	52.1	59.3	54.6	53.7	50.0
Regional TC (%)	31.6	36.9	31.6	34.3	35.9	38.9
Local TC (%)	9.1	11.0	11.0	10.4	11.1	12.8
Mechanism of Injury (MOI)						
Car (%)	19.9	11.4	13.7	13.1	9.1	3.5
Motorcycle (%)	16.4	5.6	12.5	4.2	1.0	0.1
Bicycle (%)	13.0	11.6	15.8	13.9	7.3	1.8
Pedestrian (%)	3.7	4.4	3.9	4.8	5.0	3.1
High Fall (%)	17.6	13.7	17.4	14.4	10.5	7.8
Low Fall (%)	13.6	46.7	27.3	43.6	62.3	79.5
Other Trauma (%)	15.9	6.6	9.4	6.0	4.7	4.2

TC: Trauma center

ISS: Injury Severity Score

Differences were observed in trauma center allocation. Older patients were less frequently transported to supra-regional trauma center (TC) (52.1% vs. 59.3%) and more often to regional or local TCs. Mechanisms of injury differed between age groups: motor vehicle accidents (car or motorcycle) predominated among younger patients (36.3%), whereas low falls were the most common mechanism among older patients (46.7%).

Patients with severe motor vehicle trauma (MAIS ≥ 4)

Among the overall cohort, 6,371 patients with motor vehicle trauma (MVT) and a MAIS score ≥ 4 were identified (Table 2).

Table 2
Scenario: Motor vehicle trauma with MAIS ≥ 4

Age groups (years)	**20–59**	**60–99**	**60–69**	**70–79**	**80–89**	**90–99**
Number of patients	**4,237**	**2,134**	**1,052**	**594**	**451**	**37**
Male Gender (%)	**77.3**	**70.2**	**77.7**	**64.8**	**60.3**	**67.6**
Car n (%)	2,408 (56.8)	1,426 (66.8)	537 (51.0)	447 (75.3)	407 (90.2)	35 (94.6)
Motorcycle n (%)	1,829 (43.2)	708 (33.2)	515 (49.0)	147 (24.7)	44 (9.8)	2 (5.4)
ISS (mean)	31.0	30.5	30.2	31.0	30.5	31.5
Prehospital Time (min)	73.0	70.6	71.8	69.7	69.6	63.9
Air Transport (%)	36.6	31.3	34.6	30.4	25.7	22.2
Intubation n (%)	1,658 (40.3)	608 (29.7)	326 (32.0)	165 (29.0)	112 (26.1)	5 (15.6)
Volume Administration n (%)	3,496 (84.9)	1,700 (82.9)	844 (82.7)	471 (82.8)	358 (83.4)	27 (84.4)
Tranexamic Acid Administration n (%)	1,298 (32.8)	486 (24.9)	267 (27.4)	136 (25.2)	77 (18.9)	6 (19.4)
Level of care						
Supra-regional TC (%)	66.1	58.4	59.6	59.6	55.9	37.8
Regional TC (%)	25.6	31.7	30.9	29.8	35.3	43.2
Local TC (%)	8.3	9.8	9.5	10.6	8.9	18.9

MAIS: Maximum Abbreviated Injury Scale

TC: Trauma center

ISS: Injury Severity Score

Of these, 4,237 were aged 20–59 years and 2,134 were aged ≥ 60 years. Injury severity was comparable (mean ISS 30.5 vs. 31.0). Mean prehospital time was slightly longer in younger patients (73.0 vs. 70.6 min).

Rates of critical prehospital interventions differed by age. Endotracheal intubation was performed less frequently in patients aged ≥ 60 years (29.7%) compared with those aged 20–59 years (40.3%), with the lowest rates observed in patients aged 90–99 years (15.6%). Administration of tranexamic acid was also less frequent in older patients (24.9% vs. 32.8%). In contrast, rates of volume administration were similar across age groups (82.9% vs. 84.9%).

Use of air transport decreased continuously with increasing age, from 36.6% in patients aged 20–59 years to 22.2% in patients aged 90–99 years. A similar pattern was observed for trauma center allocation, with transport to supra-regional TC declining from 66.1% to 37.8%.

Patients with fall-related trauma mechanism and GCS ≤ 8

A total of 4,844 patients presented with a fall mechanism and a GCS score ≤ 8 (Table 3). The proportion of patients with severe head injury (AIS head ≥ 3) increased with age and peaked at 93.7% in patients aged 70–79 years.

Table 3
Scenario: Fall mechanism and Glasgow Coma Scale ≤ 8

Age groups (years)	**20–59**	**≥ 60**	**60–69**	**70–79**	**80–89**	**≥ 90**
Number of patients	1519	3325	750	874	1390	311
Male Gender (%)	75.6	58.4	70.5	62.4	52.7	42.9
ISS (mean)	29.5	26.5	26.9	27.1	26.1	26.2
AIS head ≥ 3 n (%)	1,302 (85.7)	3,045 (91.6)	673 (89.7)	819 (93.7)	1,277 (91.9)	276 (88.7)
Intubation n (%)	1,193 (78.8)	2,477 (75.2)	570 (76.5)	686 (79.1)	1,030 (75)	191 (61.8)
Prehospital time (min)	71.9	76.6	76.9	77.5	78.2	73.8
Air transport n (%)	359 (24.1)	694 (21.4)	175 (23.9)	197 (23.0)	271 (20.0)	51 (16.8)
CPR n (%)	252 (16.7)	434 (13.2)	119 (16.0)	114 (13.1)	162 (11.8)	39 (12.6)
Level of care						
Supra-regional TC (%)	80.2	75.1	76.3	77.0	74.7	68.8
Regional TC (%)	17.2	22.4	20.7	21.5	22.8	27.3
Local TC (%)	2.6	2.5	3.1	1.5	2.5	3.9

TC: Trauma center

ISS: Injury Severity Score

AIS: Abbreviated Injury Score

CPR: Cardiopulmonary resuscitation

Rates of prehospital intubation decreased across age groups, from 78.8% in patients aged 20–59 years to 61.8% in patients aged ≥ 90 years. Helicopter transport was used less frequently in older patients (24.1% in patients aged < 59 years vs. 16.8% in patients aged ≥ 90 years), and rates of cardiopulmonary resuscitation declined from 16.7% (20–59 years) to 12.6% (≥ 90 years) across age groups.

Consistent with the previous scenario, allocation to supra-regional TCs was lower in older patients (68.8% in patients aged 90–99 years vs. 80.2% in younger adults), with a corresponding increase in

transport to regional or local TCs. Mean prehospital time was longer in patients aged ≥ 60 years (76.6 minutes vs. 71.9 minutes).

Patients with in-hospital confirmed pneumothorax

A total of 8,376 patients with an early in-hospital, radiologically confirmed pneumothorax were analyzed with regard to prehospital chest tube placement (Table 4). Prehospital chest tube placement was infrequent across all age groups. While 13.2% of patients aged 20–59 years received a chest tube, rates were lower in patients aged 80–89 years (10.1%) and 14.3% in those aged ≥ 90 years. The overall rate of chest tube placement among patients aged ≥ 60 years was 12.4%.

Table 4
Scenario: In-hospital confirmed pneumothorax

Age (years)	**20–59**	**≥ 60**	**60–69**	**70–79**	**80–89**	**≥ 90**
Number of patients	4,992	3,384	1,526	972	760	126
No chest tube (%)	4,334 (86.8)	2,968 (87.7)	1,318 (86.4)	859 (88.4)	683 (89.9)	108 (85.7)
ISS	25.8	25.7	25.4	26.0	26.0	25.8
Prehospital chest tube (%)	658 (13.2)	416 (12.4)	208 (13.6)	113 (11.6)	77 (10.1)	18 (14.3)
ISS	35.4	34.2	32.8	35.8	35.9	33.7

ISS: Injury Severity Score

Discussion

This multicenter analysis of TraumaRegister DGU® data examines the relationship between prehospital triage and treatment in elderly trauma patients. Although age-related undertriage has been consistently demonstrated—particularly regarding trauma team activation, air transport utilization, and transport to supra-regional trauma centers (TC) [1, 3, 6, 9, 10] —it remains unclear whether these triage disparities translate into clinically relevant undertreatment. The present analysis demonstrates that age-related differences in prehospital triage and resource allocation are not consistently associated with reduced delivery of critical interventions, but rather reflect a selective and scenario-dependent treatment pattern in older trauma patients. However, as outcome data and treatment indications are not directly linked in this analysis, it cannot be determined whether reduced intervention rates reflect appropriate clinical decision-making or potential undertreatment.

Consistent with prior reports from Germany [1, 6] and other trauma systems [9–11] older patients in the overall cohort were less likely to be transported to supra-regional TCs and less frequently transported by air despite comparable injury severity (mean ISS 20.2). Although ISS was comparable across age groups,

it may not fully capture differences in physiological reserve, frailty, or injury patterns, which could influence both treatment decisions and outcomes.

However, when shifting the focus from triage categories to actual prehospital interventions, a more differentiated and clinically relevant pattern of care becomes apparent. Across the overall cohort, elderly trauma patients did not consistently receive fewer prehospital interventions than younger patients. Prehospital interventions such as volume administration and thoracic decompression were used with similar frequency across age groups. These findings show that differences in triage alone do not necessarily mean that older patients receive less treatment, and underline the importance of looking at actual interventions when evaluating prehospital care.

However, differences in relevant clinical characteristics between age groups should be considered when interpreting these findings. Current trauma guidelines [7] define indications for interventions based on physiological and injury-related criteria such as Glasgow Coma Scale (GCS), hemodynamic instability, or injury pattern. Variations in baseline characteristics, including sex distribution, comorbidities, pre-injury anticoagulation, or specific injury constellations, may therefore influence the clinical indication for certain interventions and could partially explain observed similarities or differences between age groups.

These findings are consistent with previously described gaps between guideline recommendations and real-world emergency care. A large systematic review by Ebben et al. [12] demonstrated wide variability in adherence to prehospital and emergency department guidelines, particularly for treatment-related recommendations, while monitoring measures showed substantially higher adherence rates. Deviations from guidelines were observed across multiple clinical domains.

Against this background, the present findings support the interpretation that prehospital EMS physicians frequently individualize treatment decisions based on clinical judgment when selecting specific interventions, rather than applying guideline recommendations in a strictly algorithmic manner.

At the same time, the predefined high-risk subgroup analyses reveal clinically relevant, scenario-dependent differences that warrant careful interpretation. In patients with severe motor vehicle trauma (MAIS ≥ 4), elderly individuals underwent endotracheal intubation and received tranexamic acid less frequently than younger patients, despite comparable injury severity. Similarly, in patients with a fall mechanism and a GCS score ≤ 8, intubation rates declined progressively with age reaching the lowest levels in the oldest cohort (61.8% vs. 78.8% in patients aged 20–59 years). These findings indicate that while older patients are not globally undertreated, selected guideline-recommended interventions—particularly airway management and antifibrinolytic therapy—are applied more selectively with increasing age.

Comparable age-associated differences in prehospital endotracheal intubation and adherence to treatment recommendations have been described previously, suggesting that these patterns are not unique to the present cohort but reflect broader decision-making trends in emergency care. [12–14] Several explanations may account for these patterns. Reduced intubation rates in elderly patients with

severe traumatic brain injury or polytrauma may reflect careful reassessment of risks and benefits rather than a failure to provide care. Age-related physiological changes, including reduced physiological reserve, altered cardiovascular responses to hemorrhage, and a higher prevalence of frailty and multimorbidity, may complicate the early assessment and management of severely injured older patients and thereby influence clinical decision-making in the prehospital setting. In addition, advance directives, presumed patient wishes, or expectations regarding neurological prognosis may lead prehospital providers to, for example, adopt a more conservative airway strategy. However, as such factors are not captured within the TraumaRegister DGU®, it remains unclear to what extent these differences represent appropriate individualization of care versus unintended age-related treatment bias.

The reduced administration of tranexamic acid (TXA) in elderly patients is particularly noteworthy. Current trauma guidelines [7, 8] recommend early antifibrinolytic therapy in patients with suspected hemorrhage, without specifying age-based restrictions. Nevertheless, TXA has recognized contraindications and requires caution in patients with conditions such as active thromboembolic disease, severe renal dysfunction, or suspected subarachnoid hemorrhage [15, 16] — clinical constellations that are more prevalent in older, multimorbid patients. Accordingly, lower TXA use in older patients may reflect individualized risk–benefit assessment, although deviation from guideline-based care cannot be excluded.

As trauma populations continue to age, optimizing prehospital triage and treatment strategies for older patients will require trauma systems to increasingly integrate clinical judgment with structured decision tools.

These findings have direct implications for trauma system design and prehospital guideline implementation. Specifically, current triage algorithms may insufficiently account for age-related physiological alterations, frailty, and comorbidity burden, potentially leading to misclassification of injury severity and intervention needs. Future strategies should therefore focus on refining and validating age-adapted triage criteria to improve decision-making and ensure equitable delivery of evidence-based interventions.

Limitations

As a retrospective analysis, the study remains vulnerable to residual confounding and selection bias. Important factors influencing prehospital decision-making—such as frailty, functional baseline, advance directives, and provider experience—are not available within the registry data. The presence of undocumented treatment limitations likely influenced clinical decision-making and may have contributed to less aggressive prehospital care in selected patients. This aspect warrants further investigation and should be considered when interpreting the findings.

Furthermore, the TraumaRegister DGU® records if an intervention was performed, but not its timing, technical quality, or clinical context. Delayed or incomplete interventions—particularly relevant for airway

and hemorrhage management—cannot be assessed and may contribute to outcome differences despite similar intervention rates.

Conclusion

In conclusion, this large multicenter analysis shows that although older trauma patients are less often allocated to supra-regional trauma centers and less frequently transported by air, these differences do not translate into uniform or systematic prehospital undertreatment. Prehospital care appears selective and context dependent, with preserved delivery of several core interventions but reduced use of others—most notably endotracheal intubation and tranexamic acid—in high-risk scenarios. These findings support the need for age-adapted triage strategies to improve decision-making in an aging trauma population.

Declarations

Funding/ Conflicts of interest/Competing interests

Prof. Dr. Lefering's institute receives funding from an ongoing service contract with AUC GmbH, the holder of the TraumaRegister DGU®. This includes statistical consultations relating to scientific evaluations.

The remaining authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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Availability of data and material

The dataset generated and analyzed during the current study is not publicly accessible.

Authors' contribution

DAK (BG Unfallklinik Frankfurt am Main - Department of Trauma and Orthopedic Surgery) is the corresponding author.

PH TJ, MM and US (BG Unfallklinik Frankfurt am Main - Department of Trauma and Orthopedic Surgery) made substantial contributions to the conception, the design of the work and substantively revised it.

LH and FP (Department of Trauma Surgery and Orthopaedics, Reconstructive Surgery, Hand Surgery and Burn Medicine - *German Armed Forces Central Hospital of Koblenz*) made substantial contributions to the conception, the design of the work and substantively revised it.

RL (University of Witten/Herdecke - Institute for Research in Operative Medicine (IFOM)) made substantial contributions to the conception, the design of the work, the analysis and interpretation of data and substantively revised it.

PF (BG Unfallklinik Frankfurt am Main - Department of Trauma and Orthopedic Surgery) made substantial contributions to the conception, the design of the work, the analysis and interpretation of data and was a contributor in writing the manuscript.

All authors read and approved the final manuscript.

Ethics approval

Participation in TraumaRegister DGU® and analysis of data are approved by the participants' institutional ethical review boards. This study has been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Consent for publication

The TR-DGU gave permission for publication. All authors read and approved the final manuscript and gave permission for publication.

Consent to participate

Informed consent was not required due to the retrospective design of the study and the use of pseudonymized data from the TraumaRegister DGU®. Data collection is conducted in accordance with national regulations and institutional ethical standards. Since 2018, a data protection declaration has been obtained from all conscious patients within the TraumaRegister DGU®.

References

1. Koch DA, Becker L, Schweigkofler U, Hagebusch P, Faul P, Waydhas C. u. a. Undertriage in geriatric trauma: insights from a multicentre cohort study. Scand J Trauma Resusc Emerg Med 10 Juli.

2025;33(1):123.

2. Bieler D, Trentzsch H, Franke A, Baacke M, Lefering R, Paffrath T. u. a. Evaluation of a standardized instrument for post hoc analysis of trauma-team-activation-criteria in 75,613 injured patients an analysis of the TraumaRegister DGU®. Eur J Trauma Emerg Surg April. 2022;48(2):1101–9.
3. Weber C, Millen JC, Liu H, Clark J, Ferber L, Richards W, Ang D. Undertriage of Geriatric Trauma Patients in Florida. J Surg Res. 2022;279:427–35. 10.1016/j.jss.2022.06.006. Epub 2022 Jul 13. PMID: 35841811.
4. Brown E, Tohira H, Bailey P, Fatovich D, Pereira G, Finn J. Older age is associated with a reduced likelihood of ambulance transport to a trauma centre after major trauma in Perth. Emerg Med Australasia. 2019;31(5):763–71.
5. Clare D, Zink KL. Geriatric Trauma. Emerg Med Clin North Am Mai. 2021;39(2):257–71.
6. Hagebusch P, Lefering R, Koch DA, Faul P, Störmann P, Bieler D, Münzberg M, Schweigkofler U. Evaluation of trauma team activation criteria in Germany. A retrospective analysis of 94.000 cases from the TraumaRegister DGU®. Injury. 2025;57(2):113010. 10.1016/j.injury.2025.113010. Epub ahead of print. PMID: 41494480.
7. S3 – Leitlinie Polytrauma / Schwerverletzten-Behandlung. Deutsche Gesellschaft für Unfallchirurgie (federführend); 2016.
8. American College of Surgeons Committee on Trauma. Resources for Optimal Care of the Injured Patient [Internet]. Chicago (IL): American College of Surgeons; 2022 [cited 2025 Dec 20].
9. Uribe-Leitz T, Jarman MP, Sturgeon DJ, Harlow AF, Lipsitz SR, Cooper Z. u. a. National Study of Triage and Access to Trauma Centers for Older Adults. Ann Emerg Med Februar. 2020;75(2):125–35.
10. Cuevas-Østrem M, Wisborg T, Røise O, Jeppesen E. Differences in time-critical interventions and radiological examinations between adult and older trauma patients: A national register-based study. J Trauma Acute Care Surg Oktober. 2022;93(4):503–12.
11. Voskens FJ, van Rein EAJ, van der Sluijs R, Houwert RM, Lichtveld RA, Verleisdonk EJ, Segers M, van Olden G, Dijkgraaf M, Leenen LPH, van Heijl M. Accuracy of Prehospital Triage in Selecting Severely Injured Trauma Patients. JAMA Surg. 2018;153(4):322–7. 10.1001/jamasurg.2017.4472. PMID: 29094144; PMCID: PMC5933379.
12. Ebben RH, Vloet LC, Verhofstad MH, Meijer S, de Groot JAM, Van Achterberg T. Adherence to guidelines and protocols in the prehospital and emergency care setting: a systematic review. Scand J Trauma Resusc Emerg Med Dezember. 2013;21(1):9.
13. Eichlseder M, Eichinger M, Hallmann B, Honnef G, Metnitz P, Prause G. u. a. A retrospective cohort study on association of age and physician decision making for or against rapid sequence intubation in unconscious patients. Sci Rep 28 Februar. 2022;12(1):3336.
14. Ebben RHA, Siqeca F, Madsen UR, Vloet LCM, van Achterberg T. Effectiveness of implementation strategies for the improvement of guideline and protocol adherence in emergency care: a systematic review. BMJ Open 25 November. 2018;8(11):e017572.

15. Post R, Germans MR, Tjerkstra MA, Vergouwen MDI, Jellema K, Koot RW, et al. ULTRA Investigators. Ultra-early tranexamic acid after subarachnoid haemorrhage (ULTRA): a randomised controlled trial. Lancet. 2021;397(10269):112–8. 10.1016/S0140-6736(20)32518-6. Epub 2020 Dec 23. PMID: 33357465.
16. Tengborn L, Blombäck M, Berntorp E. Tranexamic acid–an old drug still going strong and making a revival. Thromb Res. 2015;135(2):231–42. Epub 2014 Nov 20. PMID: 25559460.

Figures

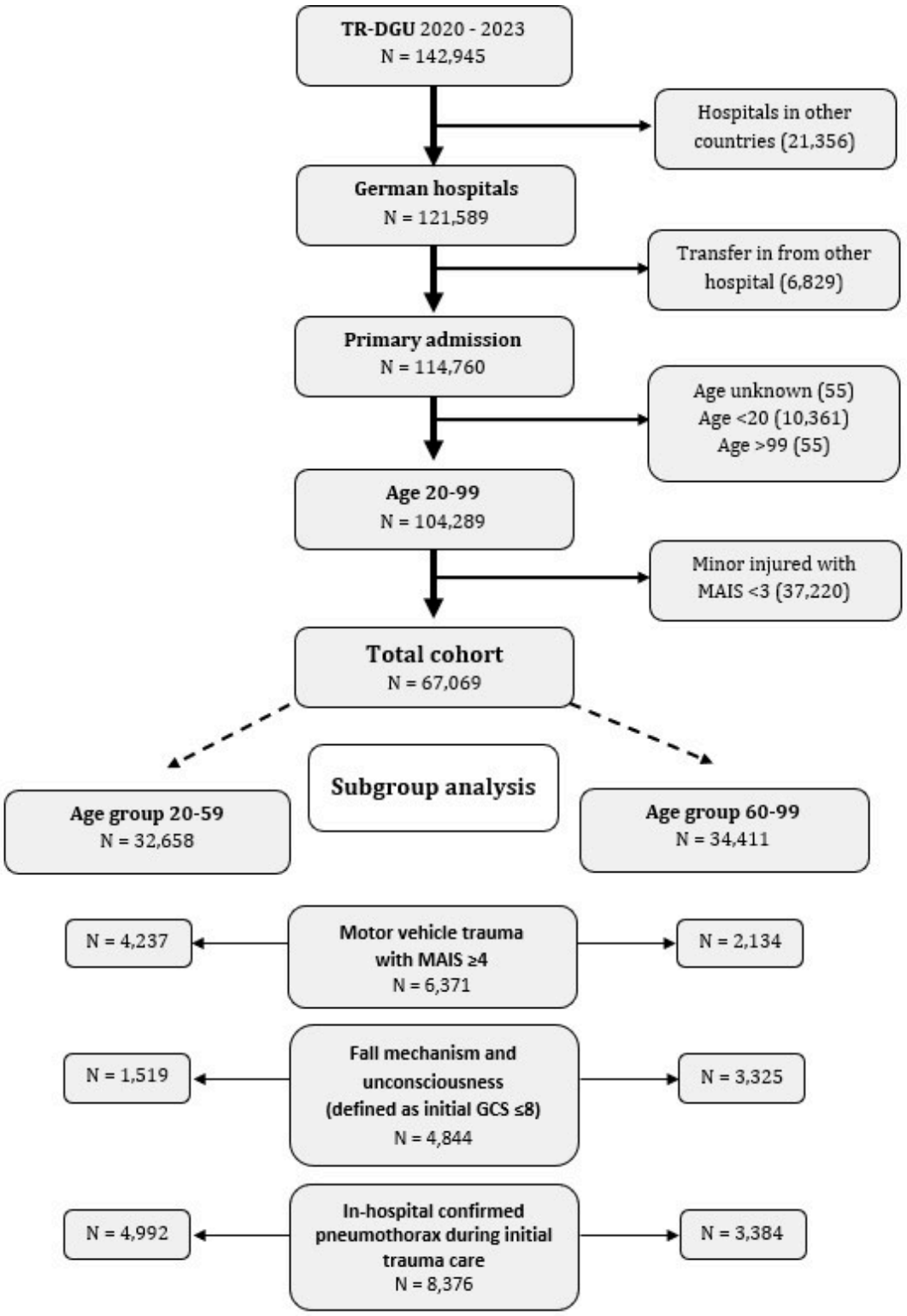

Figure 1

Flow diagram illustrating patient inclusion and exclusion from the TraumaRegister DGU® (2020–2023), the derivation of the final study cohort, and the predefined subgroup analyses.

MAIS: Maximum Abbreviated Injury Scale

GCS: Glasgow Coma Scale