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Research Article

A 5-Year Review on the Trauma Population and Trauma-Related Mortality, in Stockholm, Sweden

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Abstract

Purpose: Trauma remains a leading cause of premature mortality worldwide, with changing demographic patterns and injury mechanisms necessitating continuous evaluation of trauma systems. This study aimed to compare characteristics of survivors and non-survivors in a contemporary trauma population at a Level I trauma centre in Stockholm, identify causes of trauma-related death, and assess the proportion of preventable and potentially preventable deaths.

Methods: This retrospective registry-based study included all trauma patients aged ≥15 years admitted to Karolinska University Hospital between 2018 and 2022, identified through the Swedish Trauma Registry (SweTrau). Demographic variables, injury characteristics, comorbidity burden, injury severity scores, and clinical outcomes were analysed. All trauma-related deaths within 30 days were reviewed by multidisciplinary peer-review committees and classified as preventable, potentially preventable, or non-preventable. Logistic regression was used to identify factors associated with 30-day mortality.

Results: A total of 6,483 trauma patients were included, of whom 396 (6.1%) died within 30 days. Non-survivors were significantly older than survivors (mean age 60 vs. 44 years, $p<0.001$). Traumatic brain injury was the leading cause of death. Potentially preventable and preventable deaths accounted for 7.0% and 0.5% of fatalities, respectively. Delayed time to surgery or definitive treatment was the most frequently identified care-related error. Age ≥60 years, ASA physical status 3-4, Glasgow Coma Scale <9 at admission, high injury severity scores, and intentional injury were independently associated with increased 30-day mortality.

Conclusion: Trauma-related mortality in Stockholm is increasingly concentrated among elderly patients and those with severe neurological injury. The low proportion of preventable deaths suggests continued improvements in trauma care delivery. Targeted interventions addressing geriatric trauma and system-level delays may further reduce trauma-related mortality.

Keywords: Injury Severity Score; Trauma; Trauma Registry; Preventable Death

Introduction

Trauma represents a major global public health burden and remains the leading cause of death among adults under 45 years of age, while its incidence and associated mortality are steadily increasing in older populations [1-3]. Worldwide, approximately 4.4 million injury-related deaths occur annually, with marked regional variation reflecting demographic, socioeconomic, and healthcare system differences [3,4]. High-income countries have demonstrated reductions in trauma-related mortality through the implementation of structured trauma systems, standardized protocols [5], and continuous quality improvement initiatives [1,6]. In Sweden, the Swedish Trauma Registry (SweTrau) provides a national platform for monitoring trauma epidemiology, outcomes, and system performance [5]. Karolinska University Hospital (KUH) is Sweden's largest Level I trauma centre, serving a catchment area of approximately 2.5 million inhabitants, and the local trauma registry is a part of the national SweTrau database [7-

9]. Previous studies from KUH reported a predominance of elderly male patients, blunt injury mechanisms—particularly falls—and a gradual reduction in preventable trauma deaths between 2007 and 2016 [7,8]. Since then, Stockholm's population has continued to grow, and trauma activation criteria and care pathways have evolved [9,10]. However, contemporary data describing trauma epidemiology, mortality patterns, and preventability in Stockholm are lacking. The assessment of preventable trauma deaths remains a cornerstone of trauma quality improvement. Systematic peer review of trauma-related mortality enables identification of modifiable errors and informs targeted interventions [1,8]. The present study aimed to (1) describe current trauma demographics at KUH, (2) compare characteristics of survivors and non-survivors, (3) identify causes of trauma-related death, and (4) evaluate the proportion and nature of preventable and potentially preventable deaths over a recent five-year period.

Methods

Study Design and Setting

This retrospective observational study analysed data from the Trauma Registry at the Karolinska University Hospital, Solna, Sweden, covering the period from January 1, 2018, to December 31, 2022.

Study Population

Eligible patients were aged ≥15 years and met at least one of the following criteria: trauma team activation, New Injury Severity Score (NISS) >15, or inter-hospital transfer within seven days of injury. Patients with burns, drowning, or hypothermia as primary diagnoses were excluded.

Data Collection

Extracted variables included age, sex, injury mechanism and intent, comorbidities (ASA physical status), injury severity scores (ISS and NISS), prehospital cardiac arrest, Glasgow Coma Scale (GCS) at admission, hospital length of stay, and 30-day mortality.

Mortality Review and Classification

All deaths occurring within 30 days of injury were reviewed in multidisciplinary morbidity and mortality conferences in accordance with World Health Organization trauma quality improvement guidelines [1]. Deaths were classified as preventable, potentially preventable, or non-preventable. Causes of death were determined using ICD-10 codes and clinical chart review.

Statistical Analysis

Data normality was assessed using the Shapiro-Wilk test. Continuous variables were analysed using independent t-tests or Mann-Whitney U tests as appropriate, and categorical variables using χ^2 tests. Binary logistic regression was performed to identify factors associated with 30-day mortality. In addition to hypothesis testing, crude (unadjusted) associations between selected binary variables and 30-day mortality were summarized using odds ratios (OR) with 95% confidence intervals derived from 2×2 tables. Annual proportions of potentially preventable deaths and traumatic brain injury (TBI)-related deaths were summarised with 95% confidence intervals, and linear trend tests were applied to evaluate temporal change. Statistical significance was defined as $p<0.05$. Analyses were conducted using IBM SPSS Statistics version 29.0.1.0.

Ethical Considerations

The study was approved by the Swedish Ethical Review Board in Stockholm (Dnr 2024-03805-01). The requirement for informed consent was waived due to the retrospective registry-based design.

Results

Patient Characteristics

During the study period, 6,483 trauma patients were admitted, of whom 396 (6.1%) died within 30 days. Non-survivors were significantly older than survivors (mean age 60 vs. 44 years, $p<0.001$). Male patients predominated in both groups. Blunt trauma accounted for the majority of injuries in survivors and non-survivors. Falls were the most common injury mechanism overall, with low-impact falls more frequent among non-survivors. Intentional self-inflicted injuries were more prevalent among non-survivors than survivors (12.9% vs. 6.9%, $p<0.001$). Crude effect size estimates demonstrated markedly increased odds of 30-day mortality among patients with prehospital cardiac arrest (crude OR 143.15, 95% CI 91.96-222.84) and among those presenting with GCS <9 (crude OR 6.00, 95% CI 4.39-8.20). Increased crude odds were also observed for ASA physical status 3-4, low-impact falls, and self-inflicted injuries, whereas stabbing injuries were associated with lower crude odds of death.

Injury Severity and Clinical Outcomes

Non-survivors had significantly higher injury severity scores, with 77% presenting with ISS >15 compared with 28% of survivors. Prehospital cardiac arrest occurred in 42.6% of non-survivors. A GCS score <9 at admission was observed in 36% of non-survivors versus 3% of survivors.

Predictors of 30-Day Mortality

Logistic regression identified age ≥60 years, ASA physical status 3-4, GCS <9, high injury severity scores, and intentional injury as independent predictors of 30-day mortality.

Preventability and Causes of Death

Of the 396 deaths, 28 (7.0%) were classified as potentially preventable and 2 (0.5%) as preventable. The annual proportion

of potentially preventable deaths declined from 12.3% in 2018 to approximately 5% in 2021-2022, although the trend did not reach statistical significance. Delayed time to surgery or definitive treatment was the most frequently identified error. Traumatic brain injury was the leading cause of death and accounted for an increasing proportion of fatalities from 2018 to 2022, rising from 32.9% to 47.4% of trauma-related deaths.

Discussion

This study provides a contemporary, five-year overview of trauma epidemiology, mortality patterns, and preventability at a Swedish Level I trauma centre. Several important findings emerge. First, trauma-related mortality remains strongly associated with advanced age, severe injury, and impaired neurological status at admission. Second, traumatic brain injury (TBI) continues to be the dominant cause of death and appears to constitute an increasing proportion of trauma fatalities over time. Third, the proportion of preventable and potentially preventable deaths is low and has declined compared with earlier reports, although system-level delays—particularly delayed access to definitive surgical or interventional care—remain a recurring contributor to potentially preventable mortality [7,8].

Demographic shift and the growing burden of geriatric trauma

Age was one of the strongest predictors of 30-day mortality in this cohort. Patients aged ≥60 years had more than fourfold higher odds of death compared with younger patients, even after adjustment for injury severity and physiological derangement [11-18]. This finding is consistent with prior Scandinavian and international studies demonstrating that chronological age, comorbidity burden, and reduced physiological reserve substantially worsen trauma outcomes [7,13,14,16]. Older trauma patients are also more susceptible to in-hospital complications, including infections, which may further contribute to adverse outcomes in this population [15]. The predominance of low-impact falls among non-survivors further highlights the shifting epidemiology of trauma in high-income countries. Falls from standing height or similar mechanisms are often perceived as low-energy injuries, yet in older adults they frequently result in devastating intracranial injury. These findings support prioritization of fall-prevention initiatives and targeted risk-reduction strategies in elderly populations [18].

Neurological injury as the principal driver of trauma mortality

Traumatic brain injury was the leading cause of death across all study years and accounted for an increasing proportion of fatalities from 2018 to 2022. Although the observed temporal trend did not reach statistical significance, the consistent increase aligns with broader epidemiological observations of declining haemorrhage-related deaths and a relative rise in deaths due to severe neurological injury [16]. Severe neurological impairment at admission, reflected by a GCS score <9, was among the strongest predictors of mortality.

Injury severity, physiological derangement, and prehospital cardiac arrest

Markers of injury severity and physiological collapse were strongly associated with mortality. Patients presenting with ISS or NISS >15 had markedly increased odds of death. Prehospital cardiac arrest was associated with extremely high mortality, reflecting the profound physiological insult and limited salvageability of this subgroup. These findings support continued investment in advanced prehospital care and rapid access to definitive trauma services.

Intentional injury and mechanism-specific patterns

Intentional injuries, particularly self-inflicted trauma, were more frequent among non-survivors and independently associated with increased mortality. This observation is consistent with prior studies demonstrating higher lethality and complexity among patients presenting after self-harm [11,12]. These patients may present with severe physiological compromise, complex injury patterns, and concomitant psychiatric illness, complicating both acute management and post-resuscitation care.

Preventability, system performance, and opportunities for improvement

The low proportion of preventable and potentially preventable deaths suggests continued improvement in trauma system performance [7,8]. Nevertheless, delays in definitive care remain a recurring issue, indicating residual vulnerability in time-critical pathways [8]. Advances in haemorrhage control and resuscitation strategies, including the use of tranexamic acid, may also influence evolving patterns of trauma mortality in mature systems [17].

Limitations

This study is limited by its retrospective, single-centre design. Although SweTrau provides high-quality registry data, misclassification and missing data cannot be entirely excluded [5]. The classification of preventability is inherently subjective, although standardized multidisciplinary peer review mitigates this limitation [1,8].

Conclusion

Trauma-related mortality at Karolinska University Hospital is increasingly driven by advanced age, severe injury, and traumatic brain injury. The continued decline in preventable deaths reflects effective trauma system development, yet delays in definitive care persist. Focused strategies addressing geriatric trauma and system-level inefficiencies may further improve outcomes.

Conflict of interest: The authors declare that they have no conflicts of interest

Ethical approval and consent to participate: Ethical approval for this study was obtained from the Swedish Ethical Review Authority in accordance to Swedish and European ethical guidelines (DNR 2024-03805-01). Consent for participation was deemed not required as per the ethical review guidelines as all data was coded and cannot be traced to individual persons.

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Appendices: Tables and Figures

	Non-survivor, n= 396	Survivor, n= 6087	P-value
Age; Mean (±SD, range)	60; (±23, 15-100)	44; (20, 15-102)	**<0.001**
Gender Female; n(%)	118 (29.8)	1823 (29.9)	0.955
Gender Male; n(%)	278 (70.2)	4264 (70.1)	0.5
Type of injury; n(%)			
Blunt	327 (82.6)	5085 (83.5)	0.625
Penetrating	69 (17.4)	1002 (16.5)	0.625
Intent of injury			
Unintentional	266 (67.2)	4567 (75)	**<.001**
Intentional (self-inflicted)	51 (12.9)	419 (6.9)	**<.001**
Intentional (assault)	64 (16.2)	1055 (17.3)	0.583
Other	13 (3.3)	35 (0.6)	**<.001**
Injury mechanism; n(%)			
MVA	33 (8.3)	856 (14.1)	**<0.01**
MC	10 (2.5)	478 (7.9)	**<0.001**
Bicycle	10 (2.5)	546 (9)	**<0.001**
Vulnerable road user	16 (4)	211 (3.5)	0.571
Other vehicle	0 (0)	69 (0.036)	0.036
Gunshot	42 (10.6)	209 (3.4)	**<0.001**
Stabbing	26 (6.6)	792 (13.0)	**<0.001**
Hit by a blunt object	23 (5.8)	637 (10.5)	**<0.01**
Low impact fall	102 (25.8)	829 (13.6)	**<0.01**
High impact fall	106 (26.8)	1355 (22.3)	**<0.05**
Explosion	2 (0.5)	22 (0.4)	0.648
Other	4 (1)	21 (0.3)	0.063
ASA pre-injury; n (%)			
01-Feb	205 (53)	5050 (83)	**<0.001**
03-Apr	182 (47)	1037 (17)	**<0.001**
Prehospital card arrest	147 (42.6)	25 (0.5)	**<0.001**
NISS; Median (IQR)	37 (32)	9 (16)	**<0.001**
NISS>15; n=(%)	326 (83)	2097 (34)	**<0.001**
ISS; Median (IQR)	26 (21)	8 (13)	**<0.001**

ISS>15; n=(%)	303 (77)	1724 (28)	**<0.001**
GCS <9; n=(%)	60 (36)	176 (3)	**<0.001**
Time to scene; median (IQR)	9 (7)	10 (8)	0.591
Time to hospital; median (IQR)	49 (22)	50 (23)	0.625
Hospital length of stay; median (IQR)	2 (4)	3 (5)	0.648
GOS at discharge			
Death	339 (85.6)	0 (0)	**<0.001**
Vegetative state	5 (1.3)	4 (0.1)	**<0.001**
Severe disability	39 (9.8)	1676 (27.5)	**<0.001**
Moderate disability	7 (1.8)	2314 (35.1)	**<0.001**
Recovery from Trauma	6 (1.5)	2269 (37.3)	**<0.001**

SD Standard Deviation, MVA Motor Vehicle Accident, MC Motorcycle, ASA American Society of Anesthesiologists, NISS New Injury Severity Score, IQR Interquartile Range, ISS Injury Severity Score, GCS Glasgow Coma Scale, GOS Glasgow Outcome Scale.

Table 1: Demographics of the trauma population divided by non-survivor and survivor (30-day mortality).

	30-day Mortality n (%)	**Univariable/ OR (95% CI)**	**p-value**
Age			
<60 years	171 (3.5)		
≥60 years	225 (13.8)	4.4 (3.6-5.4)	**<0.001**
Male	278 (6.1)		
Female	118 (6.1)	0.9 (0.8-1.2)	0.949
ASA-PS			
1-2	205 (3.9)		
3-4	182 (14.9)	4.3 (3.5-5.3)	**<0.001**
GCS			
9-15	107 (1.9)		
1-8	60 (25.4)	17.7(12.5-25.2)	**<0.001**
NISS			
1-15	67 (1.7)		
>15	326 (13.5)	8.8 (6.7-11.5)	**<0.001**
ISS			
1-15	90 (2)		
>15	303 (17.6)	10.6 (8.3-13.5)	**<0.001**
Injury mechanism			

Penetrating	69 (6.2)		
Blunt	327 (6)	0.9 (0.7-1.2)	0.617
Intent of injury			
Non-intentional	266 (5.5)		
Intentional	117 (7.2)	1.3 (1.1-1.7)	0.012

ASA-PS American Society of Anesthesiologists- Physical Status, GCS Glasgow Coma Scale NISS New Injury Severity Score, ISS Injury Severity Score

Table 2: Binary logistic regression to evaluate factors associated with 30-day mortality.

Year	Deaths reviewed by a peer review committee	Of which, potentially preventable n%	Of which, preventable n%
2018	73	9 (12)	
2019	89	8 (9)	
2020	85	3 (3.5)	2 (2.3)
2021	74	4 (5.4)	
2022	76	4 (5.2)	
Total	396	28 (7)	2 (0.5)

Table 3: Percentage of potentially preventable and preventable deaths.

	Errors in potentially preventable deaths (n=32)	Errors in preventable deaths (n=2)
Delayed time to surgery/treatment	11 (34.4%)	
Delay in transport	4 (12.5%)	1 (50%)
Inappropriate treatment	9 (28.1%)	
Inappropriate monitoring	1 (3.1%)	
Error in interhospital communication	4 (12.5%)	
Missed diagnosis	3 (9.4%)	1 (50%)

Table 4: Recorded errors in both potentially preventable and preventable deaths.

	2018	2019	2020	2021	2022
TBI	24 (33)	36 (40.4)	32 (37.6)	31 (41.9)	36 (47.3)
Hemorrhage	1 (1.4)	3 (3.4)	12 (14.1)	9 (12.2)	9 (11.8)
Multi-organ failure	1 (1.4)	5 (5.6)	7 (8.2)	3 (3.5)	1 (1.3)
Other/Unknown	14 (19.2)	23 (25.8)	34 (40)	31 (41.9)	30 (39.5)
Missing records	33 (45.2)	22 (24.7)			
Trauma-related	51 (69)	66 (74)	76 (89)	60 (81)	60 (78)
DOA	8 (10)	28 (31)	21 (24)	17 (22)	17 (22)

Total deaths	73	89	85	74	76

TBI Traumatic Brain Injury DOA Dead on Arrival

Table 5: Causes of death in numbers (%) distributed by the years 2018-2022.

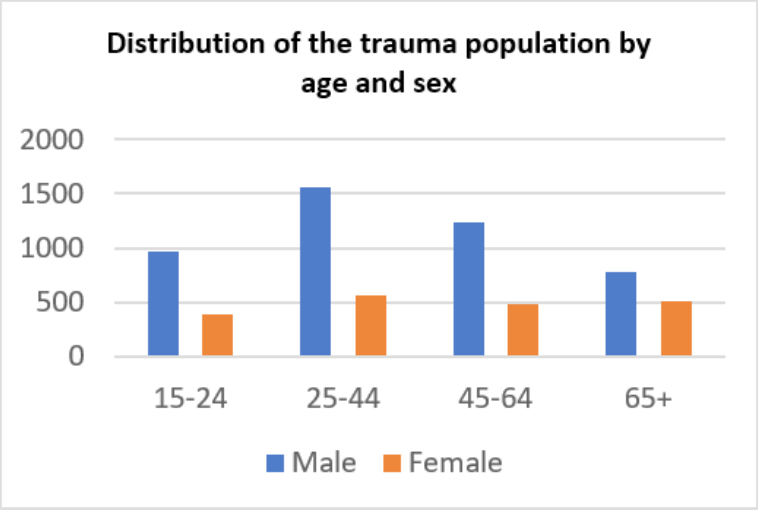

Figure 1: Distribution of the trauma population by age and sex

Factor	Deaths with factor	Survivors with factor	Crude OR	95% CI
Prehospital cardiac arrest	147	25	143.15	91.96-222.84
GCS <9	60	176	6	4.39-8.20
ASA 3-4	182	1037	4.14	3.36-5.10
Gunshot	42	209	3.34	2.36-4.73
Low-impact fall	102	829	2.2	1.74-2.79
Self-inflicted intent	51	419	2	1.47-2.73
High-impact fall	106	1355	1.28	1.01-1.61
Assault intent	64	1055	0.92	0.70-1.21
Unintentional intent	266	4567	0.68	0.55-0.85
Stabbing	26	792	0.47	

Crude ORs are based on aggregated counts from Table 1 and do not account for confounding; adjusted associations are presented in Table 2.

Table S1: Crude associations with 30-day mortality.