Trauma cohorts and correlation to different opportunities for improvement

A Registry based Study

0.1 Introduction

Trauma

Trauma, clinically defined as physical injury and the body´s associated response, is the most common cause of death in the first four decades of life. It kills around 4.4 million people around the globe [1] and in Sweden, almost 10,000 people suffer from severe trauma yearly.[2] Trauma is generally divided into two categories based on the mechanism of injury; penetrating (stab wounds or gunshots) and blunt (e.g. car accidents, falls and interpersonal violence) [3]. Overall, brain injury is the most common cause of trauma related death, counting for 58,6 percent. In 2021, 62 percent of patients passing from blunt violence in Sweden did so due to damage of the brain. For penetrating trauma, the equivalent figure was 22 percent. [4]. In addition, brain injuries are largely associated with non-preventable mortality [5] and are hence weighing on mortality statistics of both cohort.Thereof, brain injuries are sometimes better separated and evaluated as a category of its own.

AIS score

The abbreviated injury scale (AIS) is a 6-point scale scoring system ranking the severity of injury for five anatomic regions, and has been implemented as standard categorization of injury for trauma patients internationally [7]. The American College of Surgeons (ASC) Trauma quality improvement program (TQIP) has further used the AIS-system to create definitions for patient cohorts (blunt, penetrating, brain injury)[8,]. This facilitates comparability and thereby studies of trauma patient data internationally.

Trauma system

A trauma system is a coordinated network of healthcare providers and resources designed to provide timely and effective care to patients with traumatic injuries. Trauma systems have a long tradition within the military but were not implemented in civil health care until the 1960s-1970s when the report "Accidental Death and Disability: The Neglected Disease of Modern Society" was published in the US [9]. Since then, trauma systems have been put into practice in most modern countries, improving mortality and morbidity for severely injured patients [10]. The ACS provides guidelines for how the system should be structured. In general, the system consists of four components; (i) pre-hospital care, (ii) hospital care at a trauma center, (iii) post-hospital care and (iv) injury prevention.[10].

Trauma centers

Trauma centers are essential to the trauma system and constitute medical facilities that meet specific criteria established by the ACS. There are five levels of trauma centers, where each level refers to the kinds of resources available at the center and number of patients admitted yearly. Level 1 trauma centers provide the highest level of care and are equipped for every aspect of injury around the clock [11]. Apart from medical resources such as operating rooms, standby trauma teams, advanced x-rays and well-stocked blood banks, level-1 trauma centers should engage in quality assessments and improvement programs for trauma care [12].

M&M conferences

Mortality and Morbidity (M&M) conferences are recurring meetings at trauma centers. At conference, a multidisciplinary team of qualified doctors and nurses evaluate selected patient cases to evaluate whether death could have been prevented in cases with fatal outcome. The team also discusses other potential errors in the care of the patient with the aim to identify Opportunities for improvement and cautionary actions to be taken for better care throughout the entire process, from onset of injury to rehab [13]. Whether a M&M conference has been held within 30 days after a trauma occasion, is often used as a quality measure of care. M&M-conferences should be an integrated part of trauma operations at all level-1 trauma centers [14].

Opportunities for improvement

Opportunities for improvement (OFI) is an established concept within trauma care evaluation and can be defined as all deficiencies or aberrations from guidelines at any stage of care in a trauma system that could be avoided through optimized action [15]. OFIs can thus be identified in all care processes regardless of whether patient outcome is in line with what could have been expected or not. In events where trauma leads to death, mortality can be sorted into either preventable or non-preventable, where preventable mortality is defined as loss of life that likely would have been avoided if one or more errors in the trauma system would have been corrected [16].

Current landscape

To date a variety of studies based on OFIs have been conducted with the aim to identify recurrent errors for specific patient cohorts or trauma facilities. Socioeconomic, cultural and geographic issues, trauma characteristics and healthcare vary between countries and rural/city areas [18]. In Sweden surgical care is highly centralized and no uniform national organization for trauma care is at place. This makes evaluation of competence and performance at site crucial to maintain high quality and avoid unnecessary risks for the patient [19]. Sweden further stand out from other western countries with cold climate, fewer cases of serious trauma annually and long distances to trauma centers, as few hospitals are equipped to treat trauma-1 patients [20].

As mentioned earlier, the ACS have sorted trauma injuries into patient cohorts according to the AIS system. To date, Swedish registry studies on OFIs have mainly looked at three cohorts: blunt multisystem/single trauma, penetrating trauma and traumatic brain injury [19]. Since the most common cause of death among patients suffering from blunt trauma is injury to the brain, an overlap between cohorts occur when studying patients suffering multisystem trauma without distinction between the brain and other areas of injury. In this study, the blunt multisystem cohort is therefore analyzed both with and without traumatic brain injury to avoid bias and to establish a clearer understanding for preventability of death.

In addition, previous studies of the trauma registry have used OFI as a composite measure for all potential lapses leading to un-optimal care. Although this approach offers insight to whether opportunities for improvement exist, it is insufficient in providing health care workers with guidance to concrete actions that may improve care of trauma patients. Hence, we have reviewed the correlation between specific OFIs and patients cohorts.

Aim

This study hence aims at identifying specific OFIs for non-overlapping cohorts (blunt multisystem trauma with brain injury, blunt multisystem trauma without brain injury, penetrating trauma, isolated traumatic brain injury) for more robust guidance in what specific actions could be taken to improve trauma care for different patient cohorts.

0.2 Material and Methods

Study design

We conducted a registry-based cohort study on a merged dataset linking data from the Swedish trauma registry SweTrau the trauma care quality database at the Karolinska University Hospital. The combined data

were further assessed a through multinominal multivariable logistic regression model to assess how clinical cohorts associate with OFIs.

Setting

From 2010, The Swedish Trauma society holds a national registry over patients suffering serious trauma in Sweden. Patients included in the registry have suffered traumatic events that have either triggered a trauma alarm or generated injuries with a new injury severity score (NISS) above 14.

In Sweden, the Karolinska University hospital covers the regions of Stockholm, Gotland, Södermanland and Västmanland, equivalent to 3 million residents, which is just on pair with the minimum number of patients needed to be recognized as a quality trauma centre internationally. The hospital is also the only facility in Sweden to qualify as a trauma-1 hospital by American standards [21].

To detect non-optimal treatment, the Karolinska University hospital evaluate trauma patients at a M&M conference held by a multidisciplinary board appointed by the hospital. The board consists of a surgeon, an anaesthetist, a trauma nurse and in presence of specific injuries (e.g., intracranial, orthopaedical or thoracic/vascular), specialists from appropriate specialties. Competences involved in the direct care of the patient are free to attend the conference but should not take part in the review [14].

Patients are selected for conference in a multistage process with escalating levels of reviews. All cases of mortality are passed directly to conference, where the cause of death and whether it was preventable or possibly preventable is decided. The review is then followed by identification of OFIs, which serve as a foundation for enhancement of care. The review process for non-mortality poor-outcomes has been subsequently improved and formalised. In the years 2014-2017, trauma patients were somewhat randomly selected and individually reviewed by a specialised trauma nurse who made the call weather patients should be escalated to conference. In 2017, the procedure was therefore formalized with the introduction of audit filters.

Audit filters, listed below, are specified conditions that all trauma patients are automatically evaluated by. All patients captured by one or more audit filters are then assessed by a nurse who identifies possible glitches in care. Patients selected by the first nurse are then reviewed again in a second round by two specialised nurses. If any OFIs are identified in the second round, the patient is brought to a M&M conference for a final assessment of OFIs [14]. Results from the conference are stored in the Karolinska University hospital's local quality care database.

Audit filters: * Systolic blood pressure < 90 * Glasgow coma scale < 9 and not intubated. * Injury severity score > 15 but not admitted to the intensive care unit * Time to acute intervention > 60 minutes from arrival to hospital * Time to computed tomography > 30 minutes from arrival to hospital * No anticoagulant therapy within 72 hours after traumatic brain injury * The presence of cardio-pulmonary resuscitation with thoracotomy * The presence of a liver or spleen injury * Massive transfusion, defined as 10 or more units of packed red blood cells within 24 hours.

Study population We studied data of patients registered in both the Swedish trauma registry from SweTrau and the trauma quality data base at the Karolinska University hospital meeting the following criteria: * Older than 15 years * A NISS $>$ over 15 or an ISS >9 * Being reviewed at an M&M conference * Belonging to one of the following cohorts: 1. blunt multisystem trauma with traumatic brain injury 2. blunt multisystem trauma without traumatic brain injury 3. penetrating trauma 4. isolated severe traumatic brain injury

Variables OFIs Identified at M&M conference: * Missed injury/ problem at triage * Problem with communication * Inadequate competence at site / No neurosurgeon at site * problem with resources * Problem with management (trauma criteria, logistics, problem with logistics and teqnique) * Problem with Tertriry survey after stabilisation/resuscitation
Wrong level of care * Exemplary treatment The model was adjusted for gender, age and mortality. All variables with exception for age were categorical.

Data sources/measurement The Swedish trauma registry SweTrau includes all trauma patients with a NISS

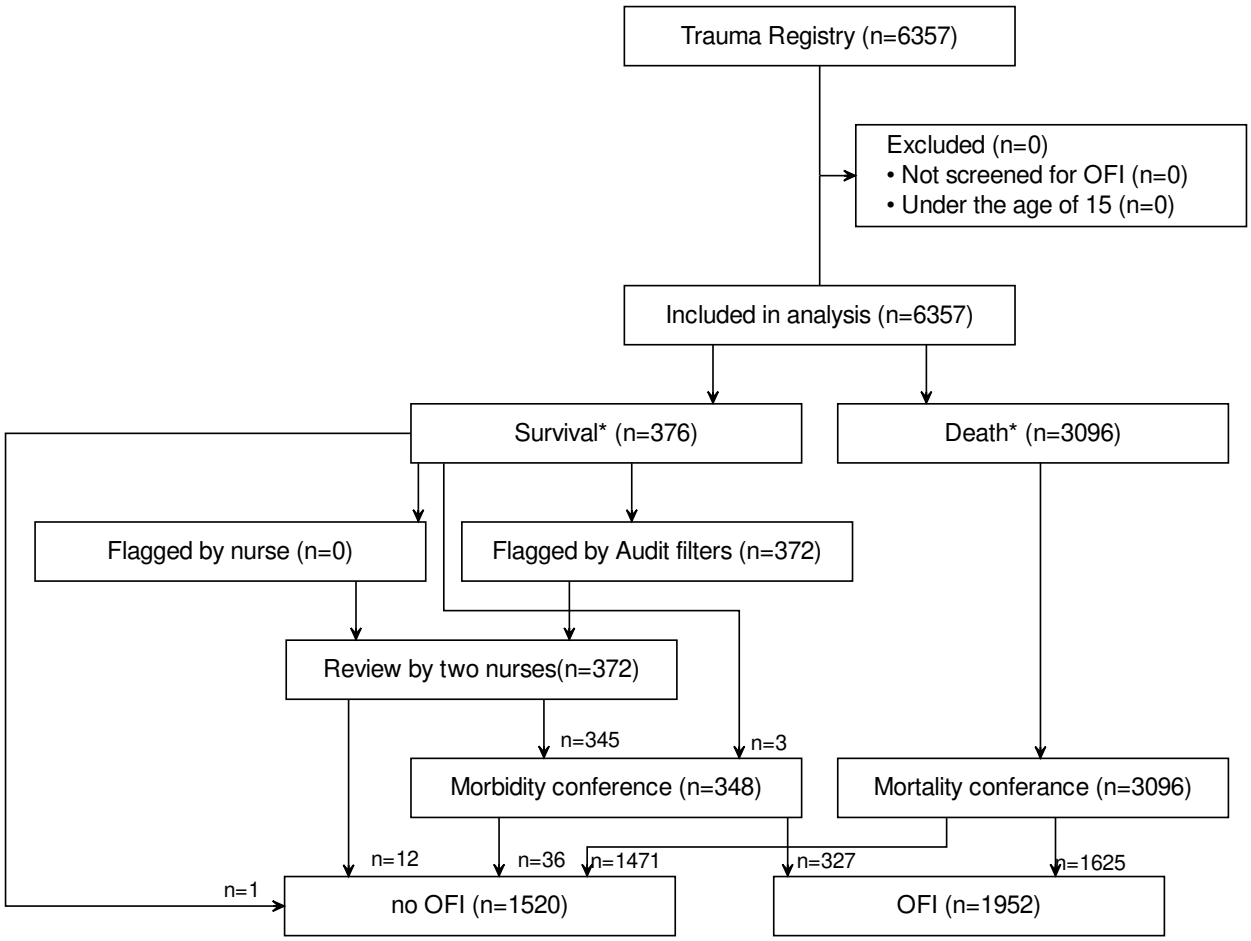

Figure 1. Flowchart describing the exclusions made and the process of trauma cases from arrival until OFI decision.

>15 or who have triggered an alarm with trauma team activation in Sweden from 2010 to date. The trauma care quality database at the Karolinska University hospital includes data from trauma patients treated at the hospital from 2014-2021. In the years 2014-2017, patients all random set of patients with an Injury severity score (ISS) of 9 or higher were included. From 2017, all patients included in the dataset have been reviewed at a M&M conference held at the the Karolinska University hospital.

In this study, all patients within the Karolinska University hospital trauma quality registry reviewed at a M&M conference were included. For these patients, data from the Swedish trauma registry by SweTrau were collected to a merged dataset. The merged dataset was then divided into four cohorts; (1) blunt multisystem trauma with traumatic brain injury, (2) blunt multisystem trauma without traumatic brain injury, (3) penetrating trauma, (4) isolated severe traumatic brain injury.

Bias

To prevent bias, the multivariable regression model was developed using a simulated scrambled dataset with random data. The algorithm for the model was developed step-by-step and then evaluated by a trained programmer and statistician before being applied on the real data. Variables such as ID-number and name were scrambled and anonymised throughout analysis of the real dataset.

Ethical considerations

Study size

Results

Of [...] patients in the Swetrau trauma registry 2017-2022, [...] were excluded from the study either in accordance with the exclusion criteria presented under methods or due to missing values. All the remaining [...] patients who were included in the study, were also presented in the trauma care quality database at the Karolinska University Hospital. All patients in the study were sorted into one of the patient cohorts presented in Table 1. [...] of the patients in the study were men. The median age was [...]. Table 2 show the excluded patients and percentages of missing values.

Table 1. Demographics

	Delays	Diagnosis	Judgement error	No ofi	Other	Preventable?	Technical
	(N=46)	(N=71)	(N=141)	(N=5882)	(N=103)	(N=34)	(N=36)
cohort							
blunt multisystem with TBI	3 (6.5%)	4 (5.6%)	2 (1.4%)	172 (2.9%)	2 (1.9%)	3 (8.8%)	1 (2.8%)
blunt multisystem without TBI	9 (19.6%)	12 (16.9%)	43 (30.5%)	493 (8.4%)	27 (26.2%)	8 (23.5%)	8 (22.2%)
Isolated severe TBI	4 (8.7%)	2 (2.8%)	6 (4.3%)	186 (3.2%)	2 (1.9%)	2 (5.9%)	1 (2.8%)
other cohort	26 (56.5%)	51 (71.8%)	78 (55.3%)	4727 (80.4%)	70 (68.0%)	15 (44.1%)	22 (61.1%)
severe penetrating	4 (8.7%)	2 (2.8%)	12 (8.5%)	304 (5.2%)	2 (1.9%)	6 (17.6%)	4 (11.1%)
pt_age_yrs							
Mean (SD)	44.0 (19.9)	45.4 (21.6)	51.5 (21.4)	44.9 (21.2)	47.0 (20.7)	56.4 (23.9)	40.9 (17.0)
Median [Min, Max]	38.0 [15.0, 86.0]	42.0 [15.0, 92.0]	54.0 [15.0, 97.0]	42.0 [13.0, 100]	45.0 [15.0, 97.0]	66.5 [19.0, 95.0]	41.5 [16.0, 74.0]
Gender							
K	10 (21.7%)	22 (31.0%)	41 (29.1%)	1814 (30.8%)	27 (26.2%)	7 (20.6%)	7 (19.4%)
M	36 (78.3%)	49 (69.0%)	100 (70.9%)	4068 (69.2%)	76 (73.8%)	27 (79.4%)	29 (80.6%)
severe_head_injury							
Yes	14 (30.4%)	13 (18.3%)	53 (37.6%)	1173 (19.9%)	23 (22.3%)	17 (50.0%)	17 (47.2%)
No	32 (69.6%)	58 (81.7%)	88 (62.4%)	4709 (80.1%)	80 (77.7%)	17 (50.0%)	19 (52.8%)
low_GCS							
FALSE	32 (69.6%)	58 (81.7%)	127 (90.1%)	4953 (84.2%)	93 (90.3%)	16 (47.1%)	31 (86.1%)
other	6 (13.0%)	3 (4.2%)	3 (2.1%)	288 (4.9%)	6 (5.8%)	9 (26.5%)	2 (5.6%)
TRUE	8 (17.4%)	10 (14.1%)	11 (7.8%)	641 (10.9%)	4 (3.9%)	9 (26.5%)	3 (8.3%)
ed_gcs_sum							
Mean (SD)	13.0 (3.24)	14.0 (2.32)	13.8 (2.68)	14.1 (2.39)	14.4 (1.52)	11.3 (5.04)	13.6 (2.28)
Median [Min, Max]	15.0 [3.00, 15.0]	15.0 [5.00, 15.0]	15.0 [3.00, 15.0]	15.0 [3.00, 15.0]	15.0 [6.00, 15.0]	14.0 [3.00, 15.0]	15.0 [7.00, 15.0]
Missing	8 (17.4%)	8 (11.3%)	5 (3.5%)	655 (11.1%)	8 (7.8%)	13 (38.2%)	2 (5.6%)
intub							
1	14 (30.4%)	11 (15.5%)	15 (10.6%)	460 (7.8%)	13 (12.6%)	12 (35.3%)	9 (25.0%)
2	25 (54.3%)	54 (76.1%)	124 (87.9%)	4949 (84.1%)	86 (83.5%)	16 (47.1%)	26 (72.2%)
3	7 (15.2%)	6 (8.5%)	2 (1.4%)	472 (8.0%)	4 (3.9%)	6 (17.6%)	1 (2.8%)
Missing	0 (0%)	0 (0%)	0 (0%)	1 (0.0%)	0 (0%)	0 (0%)	0 (0%)
pre_gcs_sum							
Mean (SD)	13.1 (3.14)	13.1 (3.66)	13.5 (2.86)	13.0 (3.69)	13.8 (2.59)	9.38 (5.17)	13.0 (3.72)
Median [Min, Max]	15.0 [6.00, 15.0]	15.0 [3.00, 15.0]	15.0 [3.00, 15.0]	15.0 [3.00, 15.0]	15.0 [3.00, 15.0]	11.0 [3.00, 15.0]	15.0 [3.00, 15.0]
Missing	5 (10.9%)	9 (12.7%)	24 (17.0%)	1166 (19.8%)	40 (38.8%)	13 (38.2%)	14 (38.9%)
pt_regions							
Yes	15 (32.6%)	21 (29.6%)	69 (48.9%)	1375 (23.4%)	47 (45.6%)	19 (55.9%)	16 (44.4%)
No	31 (67.4%)	50 (70.4%)	72 (51.1%)	4507 (76.6%)	56 (54.4%)	15 (44.1%)	20 (55.6%)
inj_dominant							
1	32 (69.6%)	67 (94.4%)	125 (88.7%)	4944 (84.1%)	91 (88.3%)	26 (76.5%)	27 (75.0%)
2	14 (30.4%)	4 (5.6%)	16 (11.3%)	938 (15.9%)	12 (11.7%)	8 (23.5%)	9 (25.0%)
Severe_penetrating							
Yes	4 (8.7%)	2 (2.8%)	12 (8.5%)	304 (5.2%)	2 (1.9%)	6 (17.6%)	4 (11.1%)
No	42 (91.3%)	69 (97.2%)	129 (91.5%)	5578 (94.8%)	101 (98.1%)	28 (82.4%)	32 (88.9%)
preventable_death							
survived	46 (100%)	71 (100%)	139 (98.6%)	5305 (90.2%)	102 (99.0%)	0 (0%)	36 (100%)
non-preventable	0 (0%)	0 (0%)	0 (0%)	555 (9.4%)	0 (0%)	0 (0%)	0 (0%)
Not reviewed	0 (0%)	0 (0%)	0 (0%)	12 (0.2%)	0 (0%)	0 (0%)	0 (0%)
possibly preventable	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (1.0%)	34 (100%)	0 (0%)
Missing	0 (0%)	0 (0%)	2 (1.4%)	10 (0.2%)	0 (0%)	0 (0%)	0 (0%)
month_surv							
alive	46 (100%)	71 (100%)	139 (98.6%)	5307 (90.2%)	103 (100%)	0 (0%)	36 (100%)
dead	0 (0%)	0 (0%)	0 (0%)	565 (9.6%)	0 (0%)	34 (100%)	0 (0%)
Missing	0 (0%)	0 (0%)	2 (1.4%)	10 (0.2%)	0 (0%)	0 (0%)	0 (0%)

Table 3 present all [...] OFIs identified by the Karolinska University multidisciplinary team at M&M conferences for patients who were alive 30 days after trauma. Possibly preventable death was included as a separate category for passed patients whose death had been assessed as preventable or possibly preventable at the mortality conference. [...] OFIs were identified in [...] per cent of the patients cases. The most common OFI for each patient cohort [...]

A multivariable multinominal logistic regression model with OFIs as the dependent variable was conducted dependent on cohorts, with and without adjustment for associated variables. The coefficients from the model, as well as odds ratios and p-values are presented in table 4. The intercept was set to no OFI. [...] OFI were statistically significant for [...] patient cohort. [...] were significant after adjustment for other factors. P-values [...]

The highest Odds ratio for the unadjustet model was found for clinical judgement errors and blunt multisystem without TBI 7.501 (p-value: 0.006)

Characteristic	OR[1]	95% CI[1]	p-value
Delays			
cohort			
blunt multisystem with TBI	—	—	
blunt multisystem without TBI	1.05	0.28, 3.91	>0.9
Isolated severe TBI	1.23	0.27, 5.59	0.8
other cohort	0.32	0.09, 1.05	0.061
severe penetrating	0.75	0.17, 3.41	0.7
Diagnosis			
cohort			
blunt multisystem with TBI	—	—	
blunt multisystem without TBI	1.05	0.33, 3.29	>0.9
Isolated severe TBI	0.46	0.08, 2.56	0.4
other cohort	0.46	0.17, 1.30	0.14
severe penetrating	0.28	0.05, 1.56	0.15
Judgement error			
cohort			
blunt multisystem with TBI	—	—	
blunt multisystem without TBI	7.50	1.80, 31.3	0.006
Isolated severe TBI	2.77	0.55, 13.9	0.2
other cohort	1.42	0.35, 5.82	0.6
severe penetrating	3.39	0.75, 15.3	0.11
Other			
cohort			
blunt multisystem with TBI	—	—	
blunt multisystem without TBI	4.71	1.11, 20.0	0.036
Isolated severe TBI	0.92	0.13, 6.64	>0.9
other cohort	1.27	0.31, 5.24	0.7
severe penetrating	0.57	0.08, 4.05	0.6
Preventable?			
cohort			
blunt multisystem with TBI	—	—	
blunt multisystem without TBI	0.93	0.24, 3.55	>0.9
Isolated severe TBI	0.62	0.10, 3.74	0.6
other cohort	0.18	0.05, 0.64	0.008
severe penetrating	1.13	0.28, 4.59	0.9
Technical			
cohort			
blunt multisystem with TBI	—	—	
blunt multisystem without TBI	2.78	0.35, 22.4	0.3
Isolated severe TBI	0.92	0.06, 14.8	>0.9
other cohort	0.80	0.11, 5.94	0.8
severe penetrating	2.26	0.25, 20.3	0.5

[1] OR = Odds Ratio, CI = Confidence Interval

Characteristic	OR[1]	95% CI[1]	p-value

Delays			
cohort			
blunt multisystem with TBI	—	—	
blunt multisystem without TBI	1.23	0.32, 4.80	0.8
Isolated severe TBI	1.57	0.32, 7.69	0.6
other cohort	0.48	0.11, 2.12	0.3
severe penetrating	0.82	0.17, 3.93	0.8
pt_age_yrs	1.00	0.98, 1.01	0.6
Gender			
K	—	—	
M	1.46	0.72, 2.99	0.3
ISS	1.01	0.99, 1.04	0.3
Diagnosis			
cohort			
blunt multisystem with TBI	—	—	
blunt multisystem without TBI	1.05	0.32, 3.43	>0.9
Isolated severe TBI	0.46	0.08, 2.73	0.4
other cohort	0.46	0.12, 1.73	0.3
severe penetrating	0.28	0.05, 1.64	0.2
pt_age_yrs	1.00	0.99, 1.01	>0.9
Gender			
K	—	—	
M	1.01	0.60, 1.68	>0.9
ISS	1.00	0.98, 1.02	>0.9
Judgement error			
cohort			
blunt multisystem with TBI	—	—	
blunt multisystem without TBI	9.47	2.24, 40.1	0.002
Isolated severe TBI	3.74	0.72, 19.3	0.12
other cohort	3.16	0.72, 14.0	0.13
severe penetrating	5.65	1.23, 26.0	0.026
pt_age_yrs	1.01	1.00, 1.02	0.002
Gender			
K	—	—	
M	1.08	0.74, 1.57	0.7
ISS	1.02	1.01, 1.04	<0.001
Other			
cohort			
blunt multisystem with TBI	—	—	
blunt multisystem without TBI	5.49	1.26, 23.8	0.023
Isolated severe TBI	1.14	0.15, 8.49	0.9
other cohort	2.01	0.42, 9.54	0.4
severe penetrating	0.68	0.09, 5.02	0.7
pt_age_yrs	1.00	0.99, 1.01	0.7
Gender			
K	—	—	
M	1.28	0.82, 2.01	0.3
ISS	1.01	1.0, 1.03	0.2
Preventable?			
cohort			

blunt multisystem with TBI	—	—	
blunt multisystem without TBI	1.42	0.35, 5.72	0.6
Isolated severe TBI	1.03	0.16, 6.77	>0.9
other cohort	0.75	0.17, 3.27	0.7
severe penetrating	2.76	0.64, 11.9	0.2
pt_age_yrs	1.03	1.01, 1.05	<0.001
Gender			
K	—	—	
M	1.67	0.71, 3.97	0.2
ISS	1.04	1.02, 1.06	<0.001
Technical			
cohort			
blunt multisystem with TBI	—	—	
blunt multisystem without TBI	4.26	0.52, 35.2	0.2
Isolated severe TBI	1.74	0.10, 29.2	0.7
other cohort	2.33	0.26, 20.8	0.4
severe penetrating	2.75	0.30, 25.3	0.4
pt_age_yrs	0.99	0.97, 1.01	0.3
Gender			
K	—	—	
M	1.61	0.70, 3.73	0.3
ISS	1.03	1.01, 1.05	0.011

[1]OR = Odds Ratio, CI = Confidence Interval

... patients sustained blunt trauma with brain injury, and ... without. The average age was ... (should we do some sort of exclusion of older people? Age / death / preventability). Patients who did not fit into any of the cohorts were excluded from the study

–>

1. Injuries and violence. https://www.who.int/news-room/fact-sheets/detail/injuries-and-violence. Accessed 2 Feb 2023.

2. Förtydligad definition av variabeln "Genomförd dödsfallsanalys" SweTrau. https://rcsyd.se/swetrau/blog/nyheter/fortydligad-definition-av-variabeln-genomford-dodsfallsanalys. Accessed 19 Jan 2023.

3. Dos C. Student course manual ATLS ® advanced trauma life support. 2018.

4. Ghorbani P, Falkén M, Riddez L, Sundelöf M, Oldner A, Strömmer L. Clinical review is essential to evaluate 30-day mortality after trauma. Scandinavian journal of trauma, resuscitation and emergency medicine. 2014;22:18.

5. Roy N, Kizhakke Veetil D, Khajanchi MU, Kumar V, Solomon H, Kamble J, et al. Learning from 2523 trauma deaths in india- opportunities to prevent in-hospital deaths. BMC Health Serv Res. 2017;17:142.

6. Gennarelli TA, Wodzin E. AIS 2005: A contemporary injury scale. Injury. 2006;37:1083–91.

7. Firm. TC. The Abbreviated Injury Scale. 2023.

8. Blackmore L Abigail R. Using the trauma quality improvement program metrics data to enhance clinical practice. Journal of Trauma Nursing. 23:121–7.

9. Choi J, Carlos G, Nassar AK, Knowlton LM, Spain DA. The impact of trauma systems on patient outcomes.

Current Problems in Surgery. 2021;58:100849.

10. Clinical Innovation A for. Trauma system. 2014.

11. Society AT. Trauma center levels explained - american trauma society.

12. Darnell T. What is a level 1 trauma center? 2022.

13. Analysis of Preventable Trauma Deaths and Opportunities for Trauma Care Improvement in Utah. The journal of trauma. 2011;70:970–7.

14. SweTrau. Fortydligad definition av variabeln ”genomford dodsfallsanalys"". 2020.

15. Bixby S, Torres D. TRAUMA PERFORMANCE IMPROVEMENT PLAN 2016.

16. Heim C, Cole E, West A, Tai N, Brohi K. Survival prediction algorithms miss significant opportunities for improvement if used for case selection in trauma quality improvement programs. Injury. 2016;47:1960–5.

17. Jiang HY, MacLean A, Yoon J, Hughes S, Kim MJ, Anantha RV, et al. Evaluation of trauma resources in rural northern alberta identifies opportunities for improvement. Can J Surg. 2020;63:E383–90.

18. Jeppesen E, Iversen VV, Hansen IS, Reierth E, Wisborg T. Trauma research in the nordic countries, 1995–2018 – a systematic review. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine. 2020;28:20.

19. Strömmer L, Lundgren F, Ghorbani P, Troëng T. Risk-adjusted mortality in severely injured adult trauma patients in sweden. BJS Open. 2022;6:zrac017.

20. Steinvik T, Raatiniemi L, Mogensen B, Steingrímsdóttir GB, Beer T, Eriksson A, et al. Epidemiology of trauma in the subarctic regions of the nordic countries. BMC Emerg Med. 2022;22:7.

21. Fernelius M. Valkommen till traumacentrum karolinska. 2022.