Report

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#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 [@who2021] and in Sweden, almost 10,000 people suffer from severe trauma yearly.[@swetrau2021] 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) [@Santos2018]. 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. [@ghorbani2014]. In addition, brain injuries are largely associated with non-preventable mortality [@roy2017] 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 [@gennarelli2006, @AIS2023]. 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)[@Blackmore2019,]. 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 [@choi2021]. Since then, trauma systems have been put into practice in most modern countries, improving mortality and morbidity for severely injured patients [@TraumaSystem2014]. 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.[@TraumaSystem2014].

*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 [@ATS2023]. 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 [@Darnell2022].

*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 [@Sanddal2011]. 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 [@Swetrau2020].

*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 [@bixby2016]. 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 [@heim2016].

*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 [@jiang2020, @jeppesen2020]. 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 [@strommer2022]. 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 [@jeppesen2020, @steinvik2022].

As mentioned earlier, the ACS have sorted trauma injuries into patient cohorts according to the AIS system. To date, Swedish register studies on OFIs have mainly looked at three cohorts: blunt multisystem/single trauma, penetrating trauma and traumatic brain injury [@ghorbani2014, @strommer2022]. As previously discussed, the most common cause of death among patients suffering from blunt trauma is injury to the brain. However, when reviewing this cohort without respect to the main area of injury, an overlap occurs between the traumatic brain injury and blunt multisystem trauma cohorts. In this study, the blunt multisystem cohort is therefore analyzed both with and without traumatic brain injury to avoid bias and to establish better understanding for preventability of death as well as opportunities for improvement in care of patients suffering blunt multisystem trauma where brain injury is not the main area of damaged.

In addition, previous studies of the trauma registry held by the Karolinska have used the 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.

**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.

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 The primary outcome was opportunities for improvements (OFI) detected by the M&M teams at the Karolinska University hospital. The variable is categorical with the OFIs listed below as possible outcomes. The exposure were different patient cohorts grouped by mechanism of injury, (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. Each cohort studied was distinguished according to definitions provided by the ACS. 1. Blunt multisystem trauma: Blunt trauma with injuries of Abbreviated Injury Score (AIS) ≥ 3 in at least two of the following AIS body regions: head, face, neck, thorax, abdomen, spine, or upper and lower extremities. 2. Blunt multisystem trauma without traumatic brain injury: Blunt trauma with injuries of Abbreviated Injury Score (AIS) ≥ 3 in at least two of the following AIS body regions: face, neck, thorax, abdomen, spine, or upper and lower extremities, but not head. 3. Penetrating trauma: At least one AIS ≥ 3 injury in any of the following AIS body regions: neck, thorax, and abdomen. 4. Isolated severe traumatic brain injury: Best GCS within the first 24 h ≤ 8 OR Best motor score ≤ 3 within the first 24 h, and one of: a. Abnormal CT brain (hematoma, contusion, swelling, herniation, compression of basal cisterns b. Normal CT brain AND (Age > 40 y OR SBP <90 mmHg on ED arrival) OR posturing (GCS motor = 2, 3)

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 >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

summary(cars)

## speed dist   
## Min. : 4.0 Min. : 2.00   
## 1st Qu.:12.0 1st Qu.: 26.00   
## Median :15.0 Median : 36.00   
## Mean :15.4 Mean : 42.98   
## 3rd Qu.:19.0 3rd Qu.: 56.00   
## Max. :25.0 Max. :120.00

## Including Plots

You can also embed plots, for example:



Note that the echo = FALSE parameter was added to the code chunk to prevent printing of the R code that generated the plot.