

Introduction

Trauma, clinically defined as physical injury and the body's associated response, cause 4.4 million deaths every year worldwide [who2021]. However, mortality and morbidity related to trauma have been significantly reduced in modern countries since the introduction of trauma systems [alharbi2021]. 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 in 1966 [choi2021]. Since then, trauma systems have been put into practice in most modern countries with the aim to coordinate and improve management of critically injured patients, from onset of injury to high-level care in designated trauma centers [nsw2023].

The American College of Surgeons (ACS) committee on trauma provide guidelines for the ideal trauma system covering all components of the system: (I) trauma centres, (II) referral hospitals, (III) rehabilitation as well as a (IV) data collection and quality improvement. Quality improvement through continuous evaluation and identification of opportunities for improvement with subsequent corrective action plans constitute a cornerstone in the trauma system and should be systematically proceeded by all trauma centres [facs2023][lazzara2022].

As injuries differ vastly by feature, risk and what constitute appropriate care, they should be separated when evaluated for comparability. For this purpose, the abbreviated injury scale (AIS) has been implemented a standardized system to categories all types of injuries and their severity [gennarelli2006]. The AIS is a 6 point scale scoring system that ranks the severity of injury for five anatomic regions [tcf2023]. The ACS has further implemented the AIS system to divide trauma patients into cohorts based on injury location and severity [shafi2009].

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 under the certain circumstances 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 [heim2016Today]. Today, two widespread systems to study preventable deaths prevail; autopsy and multidisciplinary reviews through mortality and morbidity (M&M) conferences [Sanddal2011].

Autopsy is a post-mortem examination performed of a specialized surgeon to determine cause of death. While autopsy provides an explanation to why the patient has passed, it is costly and not always feasible due to ethical, legal and religious considerations [santanello2008]. Neither does it provide information regarding the full process of care. In this regard, M&M reviews present a more comprehensive assessment of the trauma system [lazzara2022]. M&M reviews are conducted through multidisciplinary conferences at treating hospitals as part of the trauma system. At conference, qualified doctors and nurses evaluate selected patient cases to identify preventability of death and other potential errors in the care of the patient. However, when discussing preventability of death, problems arise with respect to the sensitivity of putting the burden of blame on fellow colleagues and ambiguity regarding whether mortality in fact could have been prevented. To assess OFIs unrelated to death, therefore constitute a more robust and feasible method to improve care of trauma patients [Sanddal2011].

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 [strommer2022][ghorbani2014]. While hemorrhage has been identified as the main cause of death for patients exposed to penetrating trauma, patients experiencing blunt trauma more often die from brain injuries or organ dysfunction. [ghorbani2014] Brain injuries together with burns are further the most common cause of non-preventable deaths [roy2017]

In 2022, 62% of blunt multisystem trauma deaths reviewed by a multidisciplinary team at the Karolinska University Hospital passed away due to traumatic brain injury. [ghorbani2014] This means that non-preventable brain injuries weighs on the blunt multisystem cohort, possibly masking OFIs and preventable deaths associated to other injuries of the multisystem trauma. In this regard, it would be preferable to separate blunt multisystem trauma with traumatic brain injury and blunt multisystem trauma without brain injury to disentangle relevant OFIs for correct injury types and avoid overlapping between cohorts.

Aim Hitherto, 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 actions that may improve care of trauma patients. In addition, previous studies of Swedish trauma data have used overlapping cohorts, causing a potential problem with bias. 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 actions could be taken to improve trauma care for specific patient cohorts

Methods

Study design

We conducted a registry-based cohort study on a merged dataset linking data from the Swedish trauma registry SweTrau and trauma care quality database at the Karolinska University Hospital. The combined data were further assessed through multinomial logistic regression 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. This is just on par 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 [TraumaKarolinska2023].

To detect non-optimal treatment, treating 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, orthopaedic 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. [swetrau2021]

Patients are selected for review at a M&M 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 whether 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. Selected patients 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 multidisciplinary conference for a final assessment of OFIs [SweTrau2021]. Results from the conference are stored in the Karolinska University hospital's local quality care database.

Audit filters:

- Systolic blood pressure less than 90
- Glasgow coma scale less than 9 and not intubated
- Injury severity score greater than 15 but not admitted to the intensive care unit
- Time to acute intervention more than 60 minutes from arrival to hospital
- Time to computed tomography more than 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.

At the Karolinska University Hospital, results from the conferences are stored in a local trauma care quality database where all areas of improvement are registered and collectively stored in a variable, OFI.

Study population

We will study data of patients registered in both the Swedish trauma registry from SweTrau and the trauma quality data base at the KUH meeting the following criteria:

- Older than 15 year
- A NISS > over 15 or a 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.

OFIs Identified at M&M conference: * Missed injury/ problem at triage * Problem with communication * Inadequate competence at site / No neurosurgeon at site * Problem with management (trauma criteria, logistics, problem with logistics and technique) * Problem with Tertriry survey after stabilisation/resuscitation * Wrong level of care * Inadequate resources * Exemplary treatment ta The model was adjusted for gender, age and mortalit. 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 KUH 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 as well.

Study size

Results

References

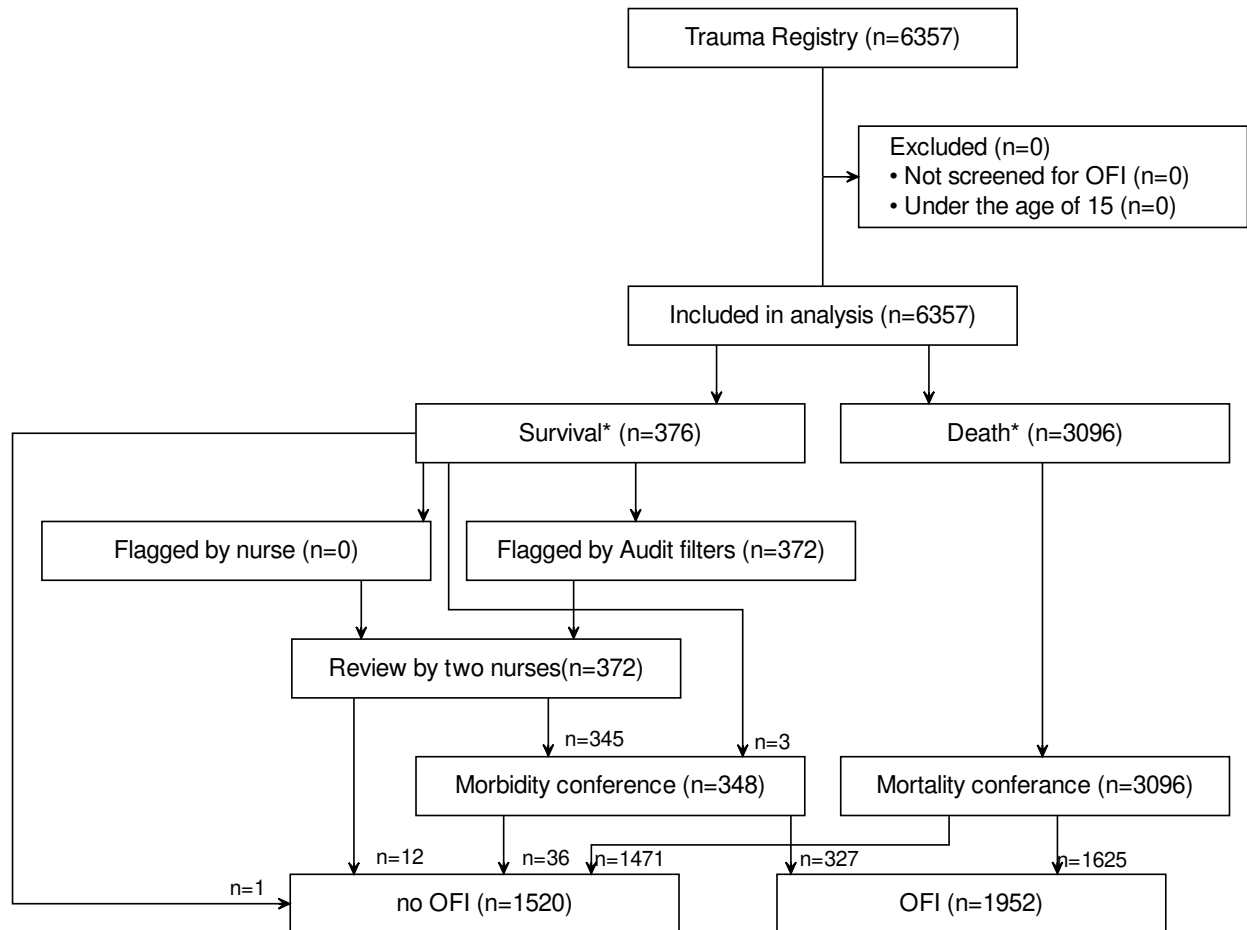


Figure 1: Flowchart describing the exclusions made and the process of trauma cases from arrival until OFI decision.