

# In what trauma patient subgroups are opportunities for improvement most frequent?

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## Background

Trauma, defined as the clinical entity composed of physical injury and the body's associated response.(1) It is one of the leading causes of mortality and morbidity in the world, representing about 9 % of annual global deaths. Among people under the age of 45 trauma is the most common cause of death. Over the last decade almost 50 million people worldwide have died from trauma.(2).

Not only does trauma represent a large share of the global mortality rate, but studies have also shown a significant difference in outcome depending on where patients are treated. It has for example been shown that trauma patients in Sweden who were treated at a trauma center rather than a non-trauma center had a 41 % lower 30-day adjusted mortality rate. (3)

Some studies indicate that the number of trauma-related deaths that potentially could have been prevented are as high as 20 to over 50 %, while for example the rate of preventable deaths at the Karolinska University hospital trauma center was shown in a study to be 4.0 %.(4-6) Preventable deaths varies not only between trauma centers and non-trauma centers. There is a significant difference between high income countries and low and middle income countries (LMICs). It is estimated that 2 million lives could be saved annually if LMICs and high income countries had equal fatality numbers for severe injuries.(7).

## Trauma quality improvement

Health care quality has been a topic for research for over 100 years. However, in the earlier research the focus were mainly standards of performance connected to the skill levels of individual physicians. Meaning that when faults were made, answers were sought for in individuals rather than in the system.(8)

In the 1980s focus shifted and terms like Trauma Quality Management and Continuous Quality Improvement were introduced. These programs lead to a more management focused approach and was involving all individuals in the work for improved health care quality. This shift also meant a more continuous evaluation of the health care, leading to the possibility for quality defects to be addressed more efficiently.(8)

Since the early 2000s a term called Quality Improvement is used. Quality Improvement has a more multidisciplinary focused approach with Morbidity and Mortality conferences as an essential part. Quality improvement also further emphasizes systems role rather than clinical performances, as systems are more comparable to outcomes.(8)

In the past decades several trauma quality improvement programs have been created. One of the

more established ones is the Trauma Quality Improvement Program (TQIP) by the American College of Surgeons that was launched in 2008(9). The TQIP provides site-specific data of how well each hospital is performing in terms of trauma care. This makes it possible to compare data with same level hospitals as well as evaluating how well each hospital is performing, leading to changes in routines and practice guidelines.(10)

## **Morbidity and Mortality Conferences**

An important part of trauma care evaluation and improvement is Mortality and Morbidity Conferences (M&M). This is a multidisciplinary conference with representatives from all medical specialties and professions in the trauma team. The purpose of M&M is to learn from the care provided, identify opportunities for improvements, and implement corrective actions(11). As it is not possible to analyze every trauma case in detail audit filters are often used to decide which cases that are to be reviewed at M&M.(12)

Audit filters can be described as predefined statements that decides whether or not a certain event differ from the guidelines.(13) Such audit filter can be time frames in which a test should be taken or a Glasgow Coma Scale score under 8 without the patient being intubated(12).

## **Trauma Severity Scores**

The Abbreviated Injury Scale (AIS) defines traumatic injuries across 9 different body regions. The scale ranges from 1-5, where 1 is the least serious and 5 the most serious. (14)

The Injury Severity Score (ISS) is an anatomic severity scale developed to assess multiple-injured patients. The ISS score a patient get is based on the AIS points from the injured body regions. The higher ISS score the more serious injury the patients suffers from. The ISS does however only take into account the most severe injury in each region, meaning that you could have two different injuries in the abdomen without it affecting the ISS score.(15)

The New Injury Severity Score (NISS) is developed from the ISS. NISS also takes injuries from the same body regions as NISS into account. The NISS is the sum of the squares of the three highest AIS codes in these regions, meaning that all three injuries can be in the same region or in separate regions. As the AIS can vary from 1-5, the NISS ranges between 1-75.(16). The NISS score is also used internationally to define trauma severity. A NISS Score >15 is considered a major trauma and <15 a minor trauma.(17)

## **Trauma registry**

In Sweden there is a national trauma registry (SweTrau) holding records of trauma cases from 48 out of 49 hospitals who receives major trauma. To meet the inclusion criteria for SweTrau you must be over 15 years of age, been exposed to a traumatic event leading to trauma team activation, or have a NISS over 15 without trauma team activation. Or patients moved to a hospital within 7 days of a traumatic event with NISS over 15. (18)

## **Opportunity for improvement**

Whether there is opportunity for improvement for a specific case or not is decided during M&M where selected trauma cases are reviewed. Opportunity for improvement (OFI) is defined as when the trauma care for a patient does not match the best practice guidelines in at least one

aspect. Examples of OFI could be too long transportation time to the hospital from the site of injury, insufficient vital signs documentation at the emergency department or missing trauma surgeon/consultant. (19)

The most common cause of death after injury is hemorrhage. Among these patients, problem in decision making, technical skills and making decisions between surgery and radiology were some of the areas where OFIs were found.(20).

OFI can be a more nuanced measure for trauma care improvement than the more established terms preventable deaths and non preventable deaths. This is because there can be OFI in a case where a patient has died, even if the death was not preventable.(21) Furthermore there is no consensus for classification of preventable and non preventable death, leading authors to use different classifications.(22). The term OFI also has the advantage over the term preventable death by sounding more positive and encouraging, preventing review board members from having to classify colleagues patient care as inappropriate.(19)

## **Trauma subgroups**

Since trauma patients is a heterogeneous group, it is important to have a sufficient understanding of OFIs for different trauma subgroups.(23). Some examples of subgroups are men and women, blunt and penetrating trauma, geriatric, major and minor trauma and traumatic brain injury.(24)

In Sweden almost two thirds of trauma patients are men and just over 60% are in the age between 18-64. For example, traumatic injuries from stabbing and from shooting violence are more common in men while women are over represented in fall traumas.(24)

## **Knowledge gap**

There is a lot of existing data about subgroups regarding transportation time to hospital, NISS score at the Emergency department, rehabilitation, morbidity and mortality rate to state a few examples.(24) But despite having all this data in the trauma registers, knowledge regarding OFI patterns among different traumatizing subgroups remains unknown.

## **Aim**

In this study we aim to assess the frequency of opportunity for improvement in the following important clinical subgroups: men and women, blunt and penetrating injuries, minor and major trauma, and across body regions injured.

## **Methods**

### **Study design**

This is a registry based cohort study that uses data from two different Swedish trauma registries. The first registry is the Trauma registry at the Karolinska University Hospital in Solna. It is a part of SweTrau and contains patients from the years 2012 to 2021. The second registry is the the trauma Quality Database which is a subset of the Karolinska University Hospital Trauma Registry. It includes patients selected for review between 2014 and 2021. These registries were merged together and a complete case analysis was done. Scrambled data was used to decrease the risk for bias.

The results were presented in tables showing the frequency of OFI for the different subgroups. Bootstrapping was performed to estimate the confidence interval.

## **Setting**

The Karolinska University Hospital in Solna, Stockholm is the largest Trauma Center in Sweden. The hospital is also classified as a level 1 trauma center.(25) The Trauma department at the Karolinska University Hospital in Solna handles about 1800 trauma cases every year, out of which about 200 are children. The Karolinska University Hospital is the primary trauma center for a population of 2,8 million people.(27)

Trauma patients are divided into priority one and two by the paramedics using certain criteria, such as trauma mechanism, GCS points and blood pressure. To the Trauma Center at Karolinska Solna only those who are classified as a priority one by the pre hospital professionals are admitted. (28) A trauma priority one is considered directly life threatening. Therefore when arriving to Karolinska Solna every patient is taken care of by a full trauma team. This team consists of a trauma leader who is a general surgeon or a resident in general surgery and an anesthetist with a nurse specialized in anesthesiology. The team also has an orthopedic surgeon, radiologist, radiology nurse, emergency medicine nurse, surgical nurse and assistant nurses.(28)

Audit filters and for some cases, manual selection was used to determine which cases that should be reviewed at M&M. Some examples of audit filters that were used are GCS 8 or less but the patient was not intubated, time to CT longer than 20 minutes and time to Surgery. A manual selection was done by one or two nurses, during which some cases are removed from the group of potential OFI cases because obvious reasons for the deviation from best practice guidelines can be found. The patients who are then left are discussed at a M&M where doctors and nurses from several specialties participate. At this conference every case is carefully reviewed. When OFI is found in a case, that specific OFI is described in the trauma quality database. Then it is recoded as “Yes, at least one OFI identified” or “No, no OFIs identified”

## **Participants**

All patients are from the Karolinska University Hospital trauma registry and from the Trauma Quality Database. To be eligible for the study all patients had to meet the following inclusion criteria: Patients over 15 year old. No missing information in crucial columns in the registries. If information was missing for age, gender, OFI, trauma mechanism, NISS, or AIS code the patient was excluded.

## **Variables and data sources/measurements**

The data from the trauma registries were analyzed for OFI in separate cohorts. The cohorts were: men and women, blunt and penetrating injuries, minor and major trauma, across body regions injured, and trauma mechanism. The location of injuries will be analyzed based on AIS codes and AIS scores will be used to group patients into fitting cohorts.

The column for most severely injured region was made by selecting the the most severely injured body region among the AIS codes belonging to a specific patient. The first digit of the AIS code represents the body region for the trauma. For patient who had two or more different injuries and thereby multiple AIS codes, the most severe injury was selected, or more precisely the AIS code with the highest last digit. If more than one region had injuries of the same severity, the second

most severe injury in those regions were compared, and then the third and so on. If two or more regions had exactly the same pattern of injuries, the region was classified as “Multiple.”

To group patients with Minor versus Major Trauma the NISS score was used. Patients with a NISS > 15 were defined as major trauma and those with NISS < 15 were defined as minor trauma.

OFI was treated as a binary variable, with “yes” and “no” as the only possible outcome. For the M&M conference to put a “yes” in the OFI section a consensus decision is required regarding the presence of at least one OFI.

## **Bias**

To prevent research bias all data will be scrambled while used to write the analysis model. Meaning that the real data was not available throughout the process of writing the introduction or method. The scrambled data was also used for creating functions that later could be used on the real data in the final step to get the true results. However all results were first calculated using the scrambled data.

## **Study size**

A complete case analysis was done on all patients in the registers that met the inclusion criteria for this study.

## **Quantitative variables**

The registers hold both categorical and continuous variables. NISS, age and AIS codes were treated as continuous variables. Penetrating/ Blunt Trauma, Minor/ Major Trauma and OFI was treated as binary categorical variables. Trauma mechanism and Most severe region of injury was treated as categorical variables.

The range of NISS was 1-75, representing the number of AIS points for each patient. Penetrating/ Blunt Trauma had the values of 1 and 2. 1 represented Blunt trauma and 2 penetrating trauma. Minor/Major was derived from the NISS value. NISS>15 was considered a Major Trauma and <15 a Minor Trauma. OFI had the values of either YES or NO.

Trauma Mechanism had a value that ranged from 1-13. Each number was represented by the following trauma mechanism. 1 - “Trauma mechanism Traffic - motor vehicle accident, not motorcycle.” 2 - “Traffic - motorcycle accident.” 3 - “Traffic - bicycle accident.” 4 - “Traffic - pedestrian.” 5 - “Traffic - other.” 6 - “Shot by handgun, shotgun, rifle, other firearm of any calibre.” 7 - “Stabbed by knife, sword, dagger other pointed or sharp object.” 8 - “Struck or hit by blunt object.” 9 - “Low energy fall - fall in the same level.” 10 - “High energy fall - fall from a higher level.” 11 - “Blast injury.” 12 - “Other.” 13 - “Unknown.”

The most severe region had 10 different values: head, neck, face, thorax, upper extremity, lower extremity, abdomen, spine, multiple and unspecified. These 10 values were regrouped according to the ISS system as following. 1 - “Head and neck.” 2 - “Face.” 3 - “Chest, diaphragm or spine.” 4 - “Abdomen.” 5 - “Extremities.” 6 - “Unspecified.” 7 - “Multiple.”

## **Statistical methods**

For handling the data and making the statistical analysis the program R was used. R is a programming language used for statistical computing (29). Then all data that was not needed

for this study was removed, including columns with non essential information, patients without complete data, and those who did not meet up with the inclusion criteria. New columns were also added as listed above.

The frequencies of OFI for each subgroup was calculated by dividing the number of patients which had OFI with the total number of patients in that subgroup.

The absolute difference (delta value) in OFI frequency within each subgroup was calculated. Meaning that the absolute difference between men and women was calculated but not for example between women and blunt trauma. For estimating the confidence interval Bootstrapping was used on the data. 1000 boots were done, creating 1000 simulated datasets. The confidence interval was estimated both for the OFI frequencies and for the delta values.

## Results

### Participants

After merging the Karolinska trauma registry and the Trauma quality data base there was 11864 patients. After applying the inclusion criteria the number of patients was reduced to 2696 patients. Each step in the exclusion process is shown in the chart below.

### Descriptive data

Out of the 2696 patients included in the cohort 1358 were men. Among the men the frequency of OFI was 74.01 and among the women 76.98. The mean age for all the patients were 58 years and the average NISS score was 27.

**## Get nicer `table1` LaTeX output by simply installing the `kableExtra` package**

	Yes, atleast one opportunity for improvement	No opportunities for improvement
	(N=2035)	(N=661)
Age (years)		
Median (Min, Max)	58 (15, 102)	59 (15, 102)
Gender		
Male	1005 (49.4%)	353 (53.4%)
Female	1030 (50.6%)	308 (46.6%)
NISS		
Median (Min, Max)	25 (0, 75)	26 (0, 75)
Mechanism of injury		
Traffic - motor veichle accident, not motorcycle	160 (7.86%)	46 (6.96%)
Traffic - motorcycle accident	193 (9.48%)	54 (8.17%)
Traffic - bicycle accident	135 (6.63%)	58 (8.77%)
Traffic - pedastrian	168 (8.26%)	60 (9.08%)
Traffic - other	177 (8.70%)	39 (5.90%)
Shot by handgun, shotgun, rifle, other firearm of any calibre	173 (8.50%)	63 (9.53%)
Stabbed by knife, sword, dagger other pointed or sharp object	173 (8.50%)	47 (7.11%)

	Yes, atleast one opportunity for improvement	No opportunities for improvement
Struck or hit by blunt object	163 (8.01%)	56 (8.47%)
Low energy fall - fall in the same level	176 (8.65%)	52 (7.87%)
High energy fall - fall from a higher level	176 (8.65%)	75 (11.3%)
Blast injury	187 (9.19%)	50 (7.56%)
Other	154 (7.57%)	61 (9.23%)
Unknown	0 (0%)	0 (0%)
Minor or Major Trauma		
Minor Trauma	633 (31.1%)	209 (31.6%)
Major Trauma	1402 (68.9%)	452 (68.4%)
Dominating Type of Injury		
Blunt	1020 (50.1%)	345 (52.2%)
Penetrating	1015 (49.9%)	316 (47.8%)
Most severe region		
Head	723 (35.9%)	245 (37.2%)
Neck	1 (0.0497%)	2 (0.303%)
Face	3 (0.149%)	0 (0%)
Thorax	651 (32.3%)	210 (31.9%)
Spine	287 (14.3%)	100 (15.2%)
Abdomen	88 (4.37%)	23 (3.49%)
Lower Extremity	251 (12.5%)	77 (11.7%)
Upper Extremity	1 (0.0497%)	0 (0%)
Unspeciefied	0 (0%)	0 (0%)
Multiple	9 (0.447%)	2 (0.303%)
Missing	21 (1.0%)	2 (0.3%)

## Main results

The subgroup with the highest OFI frequency was xxxx with a frequency at 100%. The lowest OFI frequency was measured in the xxx cohort with a frequency at 69.95%. In the entire cohort there was a 75% frequency of OFI.

Subgruops

OFI.Frequency....

Men

74.01

Women

76.98

Blunt Trauma

74.73

Penetraiting Trauma

76.26

Traffic - motor vehicle accident, not motorcycle  
77.67

Traffic - motorcycle accident  
78.14

Traffic - bicycle accident  
69.95

Traffic - pedestrian  
73.68

Traffic - other  
77.78

Shot by handgun, shotgun, rifle, other firearm of any calibre  
73.31

Stabbed by knife, sword, dagger other pointed or sharp object  
78.64

Struck or hit by blunt object  
74.43

Low energy fall - fall in the same level  
77.19

High energy fall - fall from a higher level  
70.12

Blast injury  
78.90

Other Trauma Mechanism  
71.63

Minor Trauma  
75.18

Major Trauma  
75.62

MSR - Head or Neck  
74.56

MSR - Face  
100.00



MSR - Chest, Diaphragm or Spine

75.16

MSR - Abdomen

79.28

MSR - Extremities

76.60

MSR - Unspecified

100.00

MSR - Multiple

81.82

You can also mix text and code, so called inline code, like this: 7.->

## Discussion

## Conclusion

## Ethical considerations

People who are included in the registers we use have not given their consent. However measures have been taken to prevent personal information to leaked about the patients. For example all data was scrambled for as long as possible, and to get access to the unscrambled data a VPN had to be used.

This is a study based on data from severely injured and deceased people. But since trauma patients were the patient group that needed to be studied, no other patient group would have been sufficient.

As this is a registry based study no interventions were made that could effect the patients.

Possible benefits from these type of studies are the possibility that the result can improve the trauma care and by that decrease morbidity and hopefully save lives. Therefore the possible benefits exceeds the risks.

Ethical permission has been granted for this project. Dnr number for this permission is 2021-02541 and 2021-0253.

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