Performance of individual audit filters in predicting opportunities for improvement in adult trauma patients

A registry based cohort study

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Table 1: Table 1. Demographic and Clinical Characteristics of patients screened for OFI.

	No, (N = 7797)	**Yes**, (N = 512)	**Overall** (N = 8309)
Gender			
Female	2,411 (31%)	143 (28%)	2,554 (31%)
Male	5,386 (69%)	369 (72%)	5,755 (69%)
Age	42 (27, 61)	49 (30, 67)	43 (27, 61)
ISS	9 (1, 17)	17 (10, 25)	9 (2, 17)
ED Systolic Blood Pressure	135 (120, 150)	135 (120, 151)	135 (120, 150)
ED GCS	15.00 (14.00, 15.00)	15.00 (14.00, 15.00)	15.00 (14.00, 15.00)
Time to first CT	33 (21, 65)	39 (25, 70)	33 (21, 66)
Intubated at ED			
No	7,149 (92%)	430 (84%)	7,579 (91%)
Yes	646 (8.3%)	82 (16%)	728 (8.8%)
Dead at 30 days			
No	7,102 (91%)	469 (92%)	7,571 (91%)
Yes	686 (8.8%)	41 (8.0%)	727 (8.8%)
Time to definitive treatment	102 (49, 251)	144 (90, 289)	107 (53, 260)

Auditfilter	(N)	Specificity (%)	Sensitivity (%)	AUC
SAP < 90	512	94 (93.4-94.6)	8.2 (6.8-10.3)	0.51 (0.5-0.52)
Dead at 30 days	512	93.8 (93.2-94.4)	5.6 (3.8-7)	0.5 (0.48-0.51)
ISS > 15 and no team activation	511	94.4 (93.9-94.9)	17.5 (12.5-21.9)	0.55 (0.53-0.56)
Massiv transfusion	405	94.9 (94.3-95.6)	14.2 (9.3-18.3)	0.54 (0.52-0.55)

GCS<9 and not intubated	512	93.8 (93.2-94.5)	5.6 (2.2-8.9)	0.5 (0.5-0.5)
ISS>15 not in intensiv care unit	512	95.3 (94.7-95.7)	14 (10.8-15.9)	0.61 (0.58-0.63)
>60 min until first intervention	512	95.7 (95-96.3)	13.5 (11.6-15)	0.63 (0.61-0.65)
>30min until CT	512	95.3 (94.6-96.1)	7.8 (6.7-8.7)	0.56 (0.54-0.59)
CPR and thoracotomy	487	93.8 (93.3-94.5)	6.7 (4-10.7)	0.5 (0.49-0.51)
Liver or spleen injury	409	94.8 (94.2-95.4)	12.1 (9.5-15)	0.53 (0.52-0.55)

Definition of abbreviations: OFI = Opportunity for Improvement; ED = Emergency Department; GCS = Glascow Coma Scale; ISS = Injury Severity Score; CPR = Cardiopulmonary Resuscitation; AUC = Area under the receiver operating characteristic curve.

Introduction

Trauma is defined as a physical injury of external origin together with the associated reaction of the body. This phenomenon accounts for 9% of global deaths annually [1]. Trauma affects low- and middle-income countries at a higher rate. In addition, young people are at higher risk of trauma compared to the general population. It is the leading cause of death in people between the ages of 10 and 49 [2];[3]. The most common type of trauma for people of all ages is road traffic injuries [2];[3]. In Sweden, road traffic injuries account for about 40% of injuries and falls for 40% [4].

Trauma is broadly divided into two groups according to the underlying causal mechanism: penetrating and blunt trauma. Common examples of penetrating trauma are gunshot wounds and knife cuts. Blunt trauma, on the other hand, is caused by injuries such as road traffic accidents and falls. In general, the two types of trauma can also be characterized by the size of the force causing the injury and the area of impact. Blunt trauma is caused by a high force impact over a larger area. In contrast, penetrating trauma is caused by a force applied to a smaller area, causing greater pressure so that it is penetrating and often results in deeper lacerations to tissues and organs. However, blunt trauma with sufficient force can be penetrating in nature [5].

Impact

The effects of a trauma depend greatly on the type of trauma, where it happened and whom it affected.

Trauma is responsible for 11.9% of years of life lost (YLL) worldwide [3]. In addition, trauma is associated with a higher propensity for depression, post-traumatic stress disorder (PTSD) and negative effects on cognitive function, etc. [6];[7].

It is estimated that up to 11% of trauma patients have PTSD 3 years after the traumatic event [8]. In addition, people who witness traumatic injuries are also at a higher risk of developing PTSD.
Traumatic injuries are associated with 36% not returning to work within 1 year [9].

However, injuries are not only a burden on the person affected, but also on society as a whole [10]. One aspect of such societal impact is the economic cost. Attempts have been made to estimate the global cost of injuries, which is a complicated task due to their variability. However, it is estimated that the cost of road traffic injuries alone accounts for 2% of gross domestic product (GDP) in high-income countries [1].

Trauma Care Systems

Trauma care is a multidisciplinary, complex and time-critical healthcare service provided by specialised trauma centres. A variety of different specialties are involved in trauma care, including surgeons, orthopedists, anesthesiologists, emergency physicians and nurses. Trauma care is divided into three components: pre-hospital, in-hospital and post-hospital. The prehospital component is trauma centres have a significantly lower mortality rate compared to non-trauma centres. And the maturity of a trauma centre also correlates with lower mortality, demonstrating the importance of high-quality, specialised trauma care [11];[12]. A similar study in Sweden [13] showed that 30-day mortality is 41% lower in a mature trauma centre compared to a non-trauma centre. However, even in established trauma care systems, it is prone to error due to its complexity and susceptibility to delays [14];[15], which in turn can lead to complications and death. Studies between 1990 and 2014 have shown a pooled preventable death rate of 20%, with more recent studies showing less [16]. A recent study in a Swedish Level I trauma centre found a preventable death rate of 4% [17].

Quality Improvement

To minimize errors in trauma care, quality improvement (QI) programs have been established by the World Health Organization (WHO) programs by the World Health Organization (WHO) and the International International Association for Trauma Surgery and Intensive Care (IATSIC) [18]. These programs form the core of current trauma care systems and their development around the world.

QI programs consist of a series of recommended techniques aimed at facilitating discussion and analysis of the trauma process in order to take corrective action for future success. The following techniques are used: A multidisciplinary mortality and morbidity conference (MMC), a preventable death review panel, and the use of audit filters[18].

Morbidity and Mortality Conferences and Preventable Death Review Panels

The MMC is a central QI technique. It is a proven framework with the critical components of anonymity, focusing on specific adverse events, recognising flawed approaches, critical analysis, seeking change and implementing that change [19].

MMCs are regular meetings at which specific patient cases are presented for discussion. The conference participants are healthcare professionals involved in trauma care and its processes, but not necessarily the specific patient case. The selection of patient cases varies, but common themes for discussion are unexpected mortality, unexpected morbidity and errors [20].

It is recommended that they last about 40 minutes, but this varies from hospital to hospital [18].

Five themes have been proposed that broadly define QI-centred MMC: (1) clear definition of the role of the MMC (2), involvement of stakeholders, (3) recognising and selecting appropriate patient cases for presentation, (4) structuring focused discussions, and (5) formulating recommendations and assigning follow-up actions[21];[22].

When implemented effectively, MMCs serve as an important tool for error proofing without serving solely as a negative for individual care providers, but rather as an incentive for reporting. These conferences promote a more comprehensive, systems-based approach that emphasizes task analysis, teamwork and quality improvement[23]. The introduction of MMC has been shown to increase morbidity and mortality reporting[24].

Following MMC, there is an avoidable death review panel whose role is to determine whether a patient's death could have been avoided [25]. ### Audit filters and Opportunities for improvement

Audit filters also known as quality indicators are specific established criteria involved in trauma processes and care. It is used to detect deviation from standardized care in order to further analyse the cause behind complications in trauma patients. An audit filters can be death and the placement of 2 large bore intravenous lines within 15 minutes from arrival to a healthcare facility [18]. The purpose of audit filters is to improve quality of care.

Earlier studies showed a reduction in trauma related mortality after the implementation of audit filters [26]. However, newer studies seem to differ. In 2009 there was an extensive review made that sought to determine if audit filters could be used in improving processes of trauma care however none of the studies met established inclusion criteria [27]. The use of audit filters have also been associated with high frequencies of false positives, ranging from 24% to 80%.[28]; [29].

OFIs are the endpoint and aim of MMC. Following the review of individual patient cases there is a consensus decision made regarding the existence of an OFI. It has been shown that such review process is associated with high-quality trauma care [30]. OFIs are typically associated with failures in initial care [15], specifically in airway management, fluid resuscitation, haemorrhage control and chest injury management [28]; [29]; [31]. Some audit filters seem to not correlate with OFIs at all [32]

Aim

The aim of the study is to determine whether audit filters are good indicators for predicting OFIs.

Methods

We conducted a registry-based cohort study which uses data from the trauma registry and trauma care quality database at the Karolinska University hospital in Solna in order to evaluate the performance of individual audit filters in predicting OFIs.

Study setting and population

Karolinska University Hospital is classified as a Trauma level I hospital. Every year around 1500 patients receive treatment at the hospital. If a patient case results in team activation it is added to the Karolinska trauma registry. If no team activation occurred but the patient had ISS>9 retrospectively it is also included in the registry. The Karolinska trauma registry reports to the Swedish Trauma registry (SweTrau). The registry includes data on vital signs, times, injuries, and interventions as well as patient demographics according to the European consensus statement, the Utstein template

The Karolinska trauma registry also contains a care quality database including specific audit filters and OFIs that are determined in MMC conferences through consensus decision.

This process of determining OFIs unfolds in multiple stages, characterized by escalating levels of scrutiny. Notably, instances of mortality are directly referred to the multidisciplinary conference, where, in addition to assessing OFIs, a determination is made regarding whether the death was preventable or potentially preventable, a classification also falling under the purview of OFIs.

From 2013 to 2017 there was an effort put forward in identifying adverse outcomes which where unrelated to mortality, the review process underwent subsequent refinement and formalization during the study period. During the initial period each trauma patient case underwent individual assessments by a specialized trauma nurse in order to identify potential OFIs. It was, however not until 2017 in which this procedure was formalized and it became standardized to incorporate a preliminary individual evaluation by a specialized trauma nurse upon data registration in the trauma registry and the trauma quality database. The trauma quality data underwent screening of audit filters. All cases falling within the criteria delineated by these filters, along with those trauma patients flagged by the nurse during the initial review for possible care failures, were subjected to a secondary review by two specialized nurses. Subsequent identification of a potential OFI during this second review prompted a comprehensive evaluation of the respective trauma patient's case.

Participants

In this study, we included all who underwent screening for OFIs. Exclusion criteria were applied to individuals under the age of 15, as their clinical management process has notable distinctions compared to those applicable to the adult population.

Variables

Outcome

The outcome variable in this study is an OFI, as established by the MMC conference through unanimous decision and furthermore valued as a binary variable with "Yes - At least one OFI identified" and "No - No OFI identified".

Exposures

The exposure variable is the 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.

Data sources/measurement

The data will be retrieved from the trauma registry and the trauma care quality database during the period spanning from 2012 to 2022.

Bias

Selection bias since the outcome of this study has already occurred.
There is a possibility that concensus decisions from the MMC conferences are flawed which causes misclassification bias.

Study size

The study cohort encompasses all eligible patients treated at the hospital from 2012 to 2022. There were only two patient cases from 2012.

Statistical methods

The study results are generated by statistical analytics methods with the help of the statistical programming language, R. [33]

To calculate the sensitivity and specificity of each individual audit filter in predicting an OFI a mathematical equation is used:

The sensitivity is calculated accordingly: True positives / (true positives + false negatives)

The specificity is calculated accordingly: True negatives / (true negatives + false positives) A receiver operating curve (ROC) will be made and the area under the curve (AUC) calculated in order to compare the performance of each audit filter. In order to calculate the confidence interval for the sensitivity, specificity and AUC a bootstrap method was used. This project will link the two databases and assess the performance of each audit filter in terms of discrimination and accuracy. Logistic regression and a 5% significance level and 95% confidence level will be used.

Results

1 Participants

1.2 Study Participants and Setting

In this retrospective cohort, a total of 8312 trauma care cases were assessed. The study was conducted at Karolinska University Hospital, which is a level I trauma center specializing in trauma care.

1.3 Participant Characteristics

Table 1 presents the baseline characteristics of the study participants. A total of 8312 individuals where admitted to the hospital and also screened for an OFI. A total of 7800 of the screened individuals had no OFI and 512 had an OFI. Men constituted the majority of patients in the study. The average age for individuals presented with no OFI is 42 and with OFI, 49. The average ISS was 17 for the group presented with OFI and 9 for the group not presented with an OFI ($p < 0.001$). The average GCS at ED was 15 for both groups.

2. Individual Audit Filters

###2.1. Performance of Individual Audit Filters

Table 2 summarizes the performance of each individual audit filter in identifying opportunities for improvement in trauma care. For each filter, we report the following:

For the auditfilter systolic blood pressure < 90, the specificity was 94% (93.4%-94.5%) with a sensitivity of 8.2% (5.7%-10.7%). Dead at 30 days had a specificity of 93.8% (93.2%-94.3%), a sensitivity of 5.6% (3.8%-7.3%) and an AUC of 0.5 (0.48-0.51). ISS >15 and no team activation had a specificity of 94.4% (93.9%-94.9%), a sensitivity of 17.5% (13.6%-21.3%) and an AUC of 0.55 (0.53-0.56). three of the ten auditfilters, "Dead at 30 days", "GCS<9 and not intubated" and "CPR and thoracotomy" showed a performance in predicting an OFI equal to that of coincidence. >60 min until first intervention had the highest AUC.

10. Limitations 10.1. Limitations

We acknowledge several limitations in our study, including [enumerate the study limitations, e.g., potential selection bias, data quality, and generalizability]. These limitations should be considered when interpreting the results. # Discussion The aim of the study was to determine the performance of individual audit filters in predicting OFI in order to assess wether they should be used as screening method or not.

Earlier review articles sought to review the evidence for audit filters found no studies that met inclusion criterias [evans2009audit]. This shows that even though auditfilters are widly used there is not much support for the use of it.

The auditfilters that did not prove to be better than randomness ("Dead at 30 days", "GCS<9 and not intubated" and "CPR and thoracotomy") suggest that their use as a screening method for determining OFI is not valuable and should not be used for that purpose.

The possible reason behind the auditfilters having a high specificity relative to their sensitivity may be due to the outcome being rather uncommon whilst every individual audit filter miss the majority of OFI. Theoretically, adding all audit filters together would result in the sensitivity increasing.

Both audit filters measuring delay (>60 until first intervention and >30min until CT) showed promising results in predicting opportunities which is in line with earlier studies[32] # References

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#Appendices