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

A registry based cohort study

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## [1] "All values of t are equal to  1 \n Cannot calculate confidence intervals"
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Characteristics	**N**	**No**	**Yes**	**p-value**
Deceased	6,582	769 (49%)	2,499 (50%)	0.5
Gender	6,582			0.6
Men		780 (50%)	2,523 (50%)	
Women		792 (50%)	2,487 (50%)	
Age	6,582	56 (33, 78)	56 (34, 79)	0.6
ISS	6,447	25 (12, 42)	25 (12, 41)	0.2
SBP at ED	6,557	148 (99, 194)	143 (94, 194)	0.2
GCS at ED	6,203	10 (6, 14)	10 (6, 14)	0.9
Time to first CT	6,570	263 (118, 436)	256 (129, 431)	0.8
Intubated at ED	4,604	561 (51%)	1,753 (50%)	0.6
30 day mortality	4,942			0.5
Alive		790 (68%)	2,520 (67%)	
Dead		376 (32%)	1,256 (33%)	

Performance of auditfilters in predicting OFI

Auditfilter	Specificity (%)	Sensitivity (%)	AUC
AF__sap__less90	24.6 (22.6-26.4)	76.5 (75.2-77.8)	0.51 (0.49-0.52)
AF__death__30d	24.2 (23-25.4)	77 (75-79)	0.51 (0.49-0.52)
AF__iss__15__ej__TE	23.1 (NA-NA)	100 (21.1-25)	0.5 (0.5-0.5)
AF__mass__transf	0 (0-0)	85.9 (81.2-91.3)	0.48 (0.47-0.5)
AF__gcs__less9__ej__intubTE	23.9 (22.7-25)	75.9 (73-78.8)	0.5 (0.49-0.51)
AF__iss__15__ej__iva	24.1 (22.7-25.6)	76.4 (74.9-78)	0.5 (0.49-0.52)
AF__mer__60__min__interv	23.4 (19.8-26.9)	76.1 (75-77.1)	0.5 (0.49-0.51)
AF__mer__30min__DT	24.4 (20-29)	76.1 (75.1-77.1)	0.5 (0.49-0.51)
AF__hlr__thorak	9.9 (5.9-13.4)	86.1 (82.5-89.8)	0.46 (0.4-0.51)
AF__lever__och__mjaltskada	0 (0-0)	87.7 (82.9-93.1)	0.48 (0.47-0.5)

Introduction

Trauma is defined as a physical injury of external origin together with the body's associated response. This phenomenon constitutes 9% of global deaths annually [1]. Trauma affects lower and middle income countries to a greater degree. Furthermore, young people are at higher risk for trauma compared to the general population. It is the leading cause of death for individuals between the ages 10 to 49[2];[3]. The most common type of trauma among individuals of all ages are road traffic injuries [2];[3]. In Sweden, road traffic injuries account for around 40% of injuries and falls account for 40% of injuries [4].

Trauma is broadly categorized into two groups by the underlying causal mechanism: penetrating and blunt trauma. Common examples of penetrating trauma are bullet wounds and knife cuts. Blunt trauma, however, is attributed to injuries like road traffic injuries and falls. Generally speaking, the two types of trauma can also be characterized by the size of force causing it and the area of impact. Blunt trauma is caused by a high-force impact over a larger surface area. In contrast, penetrating trauma results from a force applied to a smaller surface area causing greater pressure thus acting in a piercing manner and often resulting in deeper lacerations to tissues and organs. Blunt trauma with enough force can however be penetrating in character [5].

Impact

The impact of trauma depends greatly on the type of trauma, where it occurred and to whom it affected.

Trauma contributes for 11.9% of global Years of life lost (YLL) [3]. Furthermore, Trauma is associated with higher tendency to depression, post traumatic stress syndrome (PTSD) and negative effects on cognitive functions etc. [6];[7].

It is calculated that up to 11% of trauma patients have PTSD 3 years after the traumatic event[8]. Furthermore, individuals who witness traumatic injuries are also subject to higher risk of PTSD.
Traumatic injuries are associated with 36% not coming back to work within 1 year [9].

Injuries are, however, not only a burden to the afflicted individual but also to society as a whole [10]. One aspect of such societal effects are the economic costs. There have been attempts to estimate the global cost of injury it is a complicated task due to its variabitity. It is however estimated that the cost of road injuries alone account for 2% of gross domestic product (GDP) in high-income countries [1].

Trauma Care Systems

Trauma care is a multidisciplinary, complex, and time-critical provision of healthcare delivered by specialized trauma centres. A myriad of different specialities are involved in trauma care, including but not limited to surgeons, orthopaedics, anaesthesiologists, emergency doctors and nurses. Trauma care is divided into three components: prehospital, hospital and posthospital. The prehospital component is Trauma centres have shown significantly less mortality compared to non-trauma centres. And the level of maturity of a trauma center is also correlated with reduced mortality which shows the significance of high quality and specialized care for trauma [11];[12]. A similar study in Sweden [13] showed 41% less 30-day mortality in a mature trauma centre compared to a non-trauma centre. However,
even with established trauma care systems, due to its complexity and sensitivity to delay, it is prone to errors [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 newer studies showing less [16]. In a more recent study in A Swedish level I trauma centre they showed a 4% preventable death rate [17].

Quality Improvement

In order to minimize errors in trauma care, Quality improvement (QI) programs were established by the World Health Organisation (WHO) and the International Association for Trauma Surgery and Intensive Care (IATSIC) [18]. These programs are at the core of current trauma care systems and its development all around the world.

QI programs consist of a set of recommended techniques that seek to enable discussion and analysis of the trauma process in order to take corrective measures for future success. Following techniques are being 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 an established framework of crucial components of anonymity, a focus on specific adverse events, realising flawed approaches, critical analysis and lastly the effort to change and practice that change [19].

The MMC are regularly scheduled meetings in which specific patient cases are brought up for discussion. The conference attendees are healthcare professionals involved in trauma care and its processes, not necessarily involved in the specific patient case. The patient case selection process varies but common themes for discussion are unexpected mortality, unexpected morbidity and errors [20].

It is recommended that they are around 40 minutes but this varies between different hospitals [18].

Five themes have been proposed that broadly define QI centred MMC: (1) clear definition of the role of MMC (2), involving stakeholders, (3) detecting and selecting appropriate patient cases for presentation, (4) structuring goal-directed discussion, and (5) forming recommendations and assigning follow-up[21];[22].

When effectively implemented, MMC serve as a crucial fault-examining tool without being solely negative marks against individual care providers, instead being incentives for reporting. These conferences promote a broader, system-based approach that emphasizes the analysis of tasks, teamwork, and quality improvement[23]. The implementation of MMC have been shown to increase reporting of morbidity and mortality[24].

Following the MMC there is a preventable death review panel with the soul purpose of determining whether the death of a patient could have been preventable [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. The following audit filters are of interest:

- 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)

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

Discussion

References

1. Organization WH et al. Injuries and violence: The facts 2014. 2014.
2. Vos T, Lim SS, Abbafati C, Abbas KM, Abbasi M, Abbasifard M, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: A systematic analysis for the global burden of disease study 2019. The Lancet. 2020;396:1204–22.
3. Roth GA, Abate D, Abate KH, Abay SM, Abbafati C, Abbasi N, et al. Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980–2017: A systematic analysis for the global burden of disease study 2017. The Lancet. 2018;392:1736–88.
4. SweTrau ST. Arsrapport - 2022. 2022.
5. Hexdall A, Miglietta MA. Mechanism of injury. In: Legome E, Shockley LWE, editors. Trauma: A comprehensive emergency medicine approach. Cambridge University Press; 2011. p. 24–34.
6. North N. The psychological effects of spinal cord injury: A review. Spinal cord. 1999;37:671–9.
7. Muscatelli S, Spurr H, O'Hara NN, O'Hara LM, Sprague SA, Slobogean GP. Prevalence of depression and posttraumatic stress disorder after acute orthopaedic trauma: A systematic review and meta-analysis. Journal of orthopaedic trauma. 2017;31:47–55.

8. Visser E, Gosens T, Den Oudsten BL, De Vries J. The course, prediction, and treatment of acute and posttraumatic stress in trauma patients: A systematic review. Journal of Trauma and Acute Care Surgery. 2017;82:1158–83.
9. David SD, Aroke A, Roy N, Solomon H, Lundborg CS, Wärnberg MG. Measuring socioeconomic outcomes in trauma patients up to one year post-discharge: A systematic review and meta-analysis. Injury. 2022;53:272–85.
10. Newnam S, Collie A, Vogel A, Keleher H. The impacts of injury at the individual, community and societal levels: A systematic meta-review. Public health. 2014;128:587–618.
11. Alharbi RJ, Shrestha S, Lewis V, Miller C. The effectiveness of trauma care systems at different stages of development in reducing mortality: A systematic review and meta-analysis. World Journal of Emergency Surgery. 2021;16:1–12.
12. Mann NC, Mullins RJ, MacKenzie EJ, Jurkovich GJ, Mock CN. Systematic review of published evidence regarding trauma system effectiveness. Journal of Trauma and Acute Care Surgery. 1999;47:S25–33.
13. Candefjord S, Asker L, Caragounis E-C. Mortality of trauma patients treated at trauma centers compared to non-trauma centers in sweden: A retrospective study. European journal of trauma and emergency surgery. 2020;1–12.
14. Nikouline A, Quirion A, Jung JJ, Nolan B. Errors in adult trauma resuscitation: A systematic review. Canadian Journal of Emergency Medicine. 2021;23:537–46.
15. Vioque SM, Kim PK, McMaster J, Gallagher J, Allen SR, Holena DN, et al. Classifying errors in preventable and potentially preventable trauma deaths: A 9-year review using the joint commission's standardized methodology. The American Journal of Surgery. 2014;208:187–94.
16. Kwon A, Garbett N, Kloecker G. Pooled preventable death rates in trauma patients: Meta analysis and systematic review since 1990. European Journal of Trauma and Emergency Surgery. 2014;40:279–85.
17. Ghorbani P, Strömmer L. Analysis of preventable deaths and errors in trauma care in a scandinavian trauma level-i centre. Acta Anaesthesiologica Scandinavica. 2018;62:1146–53.
18. Organization WH et al. Guidelines for trauma quality improvement programmes. World Health Organization; 2009.
19. Gregor A, Taylor D. Morbidity and mortality conference: Its purpose reclaimed and grounded in theory. Teaching and learning in medicine. 2016;28:439–47.
20. Orlander JD, Fincke BG. Morbidity and mortality conference: A survey of academic internal medicine departments. Journal of general internal medicine. 2003;18:656–8.
21. Giesbrecht V, Au S. Morbidity and mortality conferences: A narrative review of strategies to prioritize quality improvement. The Joint Commission Journal on Quality and Patient Safety. 2016;42:516–27.
22. Churchill KP, Murphy J, Smith N. Quality improvement focused morbidity and mortality rounds: An integrative review. Cureus. 2020;12.
23. Lazzara EH, Salisbury M, Hughes AM, Rogers JE, King HB, Salas E. The morbidity and mortality conference: Opportunities for enhancing patient safety. Journal of Patient Safety. 2022;18:e275–81.
24. Kong VY, Clarke DL. Analysis of 5 years of morbidity and mortality conferences in a metropolitan south african trauma service. South African Medical Journal. 2016;106:695–8.
25. 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;22:1–7.
26. Chadbunchachai W, Sriwiwat S, Kulleab S, Saranrittichai S, Chumsri J, Jaikwang P. The comparative study for quality of trauma treatment before and after the revision of trauma audit filter, khon kaen hospital 1998. Journal of the Medical Association of Thailand= Chotmaihet Thangphaet. 2001;84:782–90.
27. Evans C, Howes D, Pickett W, Dagnone L. Audit filters for improving processes of care and clinical outcomes in trauma systems. Cochrane database of systematic reviews. 2009.
28. Sanddal TL, Esposito TJ, Whitney JR, Hartford D, Taillac PP, Mann NC, et al. Analysis of preventable trauma deaths and opportunities for trauma care improvement in utah. Journal of Trauma and Acute Care Surgery. 2011;70:970–7.
29. 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 services research. 2017;17:1–8.
30. Santana MJ, Stelfox HT, et al. Development and evaluation of evidence-informed quality indicators for

adult injury care. Annals of surgery. 2014;259:186–92.
31. O'reilly D, Mahendran K, West A, Shirley P, Walsh M, Tai N. Opportunities for improvement in the management of patients who die from haemorrhage after trauma. Journal of British Surgery. 2013;100:749–55.
32. Lewis PR, Badiee J, Sise MJ, Calvo RY, Brill JB, Wallace JD, et al. "Delay to operating room" fails to identify adverse outcomes at a level i trauma center. Journal of Trauma and Acute Care Surgery. 2017;82:334–7.
33. R Core Team. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; 2022.

#Appendices