Performance of Individual Audit Filters in Predicting Opportunities for Improvement in Adult Trauma Patients

A single-center registry-based retrospective cohort

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## [1] 11
## [1] "gcs"
## [1] 107
## [1] 283
## [1] 56
## [1] 5
## [1] 0
## [1] 0
## [1] "ISS ej iva"
## [1] 1295
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## [1] 400
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## [1] 0
## [1] "TBI"
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## [1] 241
## [1] 0
## [1] 1768
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## [1] FALSE  TRUE
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Abstract

Background

Trauma audit filters, based on standards of care, serve as screening tools for patient cases to be assessed at interdisciplinary mortality and morbidity conferences. These conferences aim to identify potential opportunities for improvement in the care of trauma patients. This study aimed to assess the effectiveness of individual audit filters in predicting opportunities for improvement and their relevance as screening tools for morbidity and mortality conferences.

Methods

We conducted a single-centre registry-based retrospective cohort study based on register data from 8,309 patient cases at the Karolinska University Hospital in Sweden. The sensitivity, specificity and Cohen's kappa coefficient was calculated to assess performance. Bootstrapping of 1,000 iterations was used to calculate 95% confidence intervals.

Results

Our analysis included 8,309 patients. Audit filters showed a Cohen's kappa coefficient ranging from -0.07 for "GCS $<$ 9 and not intubated" and 0.08 for "Massive transfusion". The Cohen's kappa coefficient for all audit filters combined was 0.04 (95% CI[0.03-0.04]).

Conclusion

No individual audit filter performed well in predicting opportunities for improvement, which suggests reassessing the current method of screening for mortality and morbidity conferences.

Introduction

Trauma, defined as a physical injury and the body's associated response, causes 8-9% of global deaths annually (1,2)and ranks highest in disability-adjusted life-years (DALYs) for ages between 10-49 years (3), impacting individuals, communities and society at large (4). Road traffic injuries alone cost approximately 2% of gross domestic product (GDP) in high-income countries (1).

Quality improvement programs form the core of current trauma care systems (5) and commonly include multidisciplinary mortality and morbidity conferences and preventable death review panels to improve trauma care quality (6). Despite these programs, trauma care remains prone to errors (7–9). Studies have shown a pooled preventable death rate of 20%, with more recent studies indicating lower rates (10). A recent study in a Swedish Level I trauma centre found a preventable death rate of 4% (11).

The mortality and morbidity conferences, attended by healthcare professionals involved in trauma care, focus on anonymity, critical analysis of outcome such as mortality, morbidity and errors, recognizing flawed approaches followed by proposing and implementing improvements (12,13). The conferences have shown to foster error reduction and encourage reporting (14) without negative feedback (15).

Audit filters are a set of criteria used to identify cases for mortality and morbidity conferences. Furthermore, they function as a screening tool for potential opportunities for improvement. Deviation from audit filters should raise the attention of health care providers with the purpose of improving the quality of care (5). Audit filters can involve outcomes such as "death" or adherence to guidelines, such as "placement of two large bore intravenous lines within 15 minutes of arrival." (6). Studies have shown conflicting results on the effectiveness of audit filters in reducing trauma-related mortality. While some early studies reported a mortality reduction following the implementation of audit filters (16,17), a 2009 review by Evans et al. (18) found no high quality evidence supporting the effectiveness of audit filters in mortality reduction. Furthermore, Stelfox et al. (19) identified over 1,500 audit filters and noted a lack of a common, evidence-based set for evaluating trauma care quality. Despite the uncertainty, the perceived usefulness of audit filters remains high (20).

Opportunities for improvement encompass not only mortality but also morbidity and errors, better reflecting trauma quality gaps (5). These opportunities are typically associated with failures in initial care (8) like airway management, fluid resuscitation, haemorrhage control and chest injury management (9,21,22). Few studies have focused on non-mortality outcome measures for evaluating audit filters and the evidence still remain vague (23,24). Moreover, the use of audit filters has been associated with high frequencies of false positives, ranging from 24% to 80% (11,21,22), and some audit filters do not appear to correlate with opportunities for improvement at all (25).

The aim of this study is to determine the performance of individual audit filters used at Karolinska University hospital in predicting opportunities for improvement and assessing their relevance as a screening tool for mortality and morbidity conferences

Methods

Study design

We conducted a single-centre registry-based retrospective cohort study of all trauma patients included in both the Karolinska University Hospital trauma registry and trauma care quality database between 2012 and 2022 to compare the performance of audit filters in their ability to predict opportunities for improvement. This study was approved by Swedish Ethical Review Authority, approval number 2021-02541 and 2021-03531.

Setting

Karolinska University Hospital manages around 1,500 trauma patients annually. The Karolinska Trauma Registry, which reports to the national trauma registry SweTrau (26), includes all patient cases that result in trauma team activation or who have an Injury Severity Score (ISS) of more than 9. This registry includes data on vital signs, timings, injuries, interventions, and patient demographics as per a European consensus statement (27)

The trauma centre at the Karolinska University Hospital also keeps a local care quality database with information intended for the mortality and morbidity conferences, including identified triggered audit filters and opportunities for improvement. Opportunities for improvement are assessed in multiple stages of scrutiny. Notably, mortality is directly referred to the mortality and morbidity conferences to assess opportunities for improvement.

From 2013 to 2017, efforts focused on identifying adverse outcomes unrelated to mortality. Initially, trauma cases were individually assessed by a specialized trauma nurse for potential opportunities for improvement. In 2017, this procedure became standard practice, incorporating preliminary evaluations by specialized trauma nurses. Cases flagged by an audit filter or identified by the nurse as potential care failures underwent a second review by two specialized nurses. Potential opportunities for improvement identified in this review prompted review by the mortality and morbidity conference.

Participants

The study included all patients treated at Karolinska University Hospital from 2012 to 2022 who underwent screening for opportunities for improvement. Patients under 15 were excluded due to differences in clinical management.

Variables and data sources/measurements

The outcome was opportunities for improvement, as established by the mortality and morbidity conference, and was treated dichotomously as "Yes - At least one opportunity for improvement identified" and "No - No opportunity for improvement identified".

The ten audit filters used at the Karolinska University Hospital served as the exposure variables, as shown in Table 1. The data was retrieved from the Karolinska Trauma Registry and trauma care quality database. Patient data on vital signs, care processes and interventions, level of care and time aspects was retrieved from SweTrau while both the exposure audit filters and the outcome opportunities for improvement were retrieved from the quality database.

All data was anonymised to protect patient privacy.

Bias

Since flagging patient cases with audit filters was done manually by the specialised nurses it leads to potential selection bias. Additionally, there where multiple instances where patient cases were incorrectly flagged as "not flagged", despite not being part of the relevant cohort. For example, a patient case with ISS under 15 might still be marked as "not flagged" under the audit filter "ISS > 15 and not in the ICU" even though they do not meet the criteria for that cohort. Relying on this manual process could falsely elevate the number of false negatives and true negatives, thus skewing the results.

To address this issue, we flagged patient cases with registered data instead of relying on the manual process. We also selected the relevant cohort for each audit filter. For instance, with the audit filter "GCS < 9 and not intubated" we selected the relevant cohort with GCS below nine and examined the intubation status data for each patient case. See table 1 for the relevant cohort size for each audit filter and whether they where created with registry data or used as registered by the specialised nurse.

Statistical methods

We used R (28) for statistical analysis. Patient characteristics for cases with and without opportunities for improvement were compared using the Wilcoxon signed-rank test for continuous variables and the Chi-squared test for categorical variables. The predictive performance of audit filters was assessed by calculating the sensitivity, specificity and Cohen's kappa for each audit filter in predicting opportunities for improvement. Bootstrapping with 1,000 iterations was applied to estimate 95% confidence intervals for sensitivity, specificity, and Cohen's kappa coefficient. We selected cohorts relevant to each filter: For "ISS > 15 and no team activation" and "ISS > 15 and not in ICU" we examined patients with an ISS greater than 15. For "GCS < 9 and not intubated," we focused on patients with a GCS less than 9. Lastly, for "No anticoagulants within 72 hours after TBI" we looked at patients with head trauma. Missing values were numbered but ignored in the analysis.

Results

After excluding patients under 15 years old and patients not screened for opportunities for improvement, a total of 8,309 individuals were included in the study. 7,797 out of 8,309 (93.8%) patient cases did not have an opportunity for improvement and 512 out of 8,309 (6.2%) had an opportunity for improvement, see Figure 1.

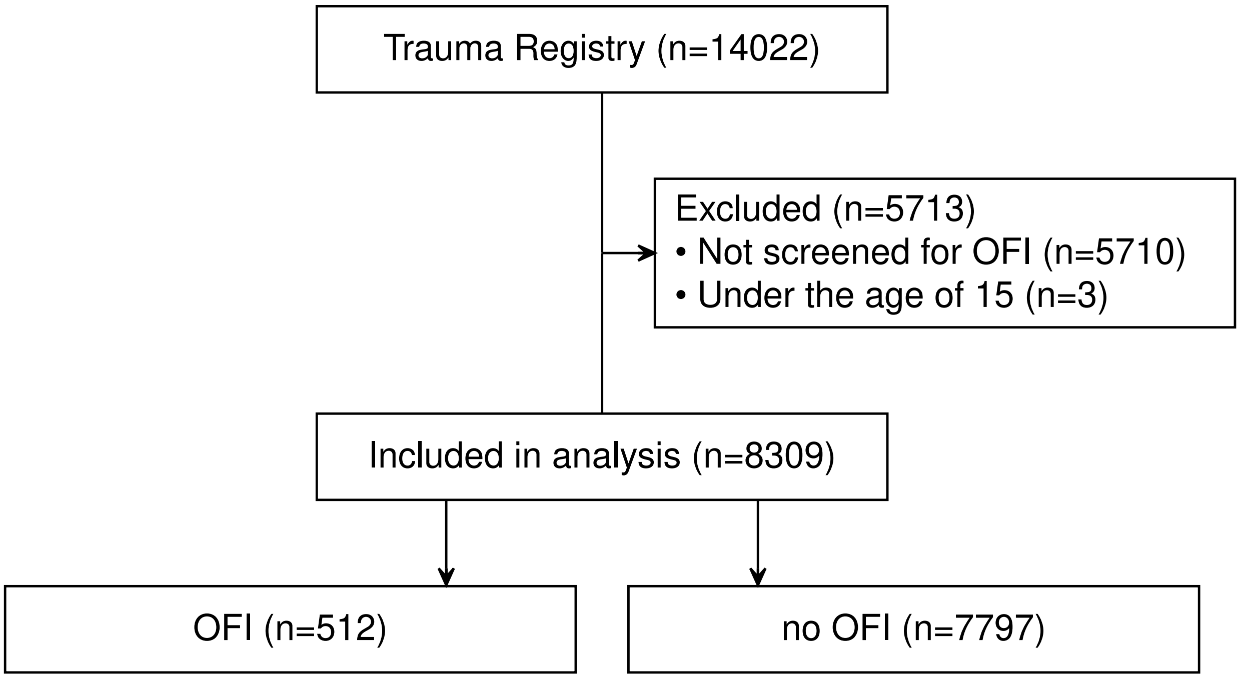
Patients with an opportunity for improvement had significantly higher mean age 49 (30, 67) vs 42 (27, 61), p<0.001, ISS 17 (10, 25) vs 9 (1, 17), p<0.001 and intubations in the emergency department (ED) 82 (16%) vs 646 (8.3%), NA. Patients with opportunity for improvement had longer times to definitive treatment from hospital arrival 144 (90, 289) vs 102 (49, 251), p<0.001. and longer times to first CT 39 (25, 70) vs 33 (21, 65), p<0.001. The number of opportunities for improvement were highest in patients admitted to the intensive care unit 171 (33%) compared to general ward 123 (24%). Gender, mean systolic blood pressure, death at 30 days and trauma team activation was not significantly correlated with opportunities for improvement (p>0.05). Notably, there was a statistically significant correlation between GCS at ED and opportunities for improvement (p < 0.001). The highest amount of missing data was observed for the audit filter "time to definitive treatment" (n = 5,990, 72.1%).See Table 2 for details of selected patient characteristics.

Performance of Individual Audit Filters

The number of patient cases flagged by each individual audit filter varied between 107 for "GCS < 9 and not intubated" and 3907 for ">30 min until CT". The highest number of missing values was observed with "> 60 min until first intervention" (n = 5990, 72,1%). The lowest number of missing values was observed with "dead at 30 days" and "ISS > 15 and not in ICU" (n = 11, 0.1%). See table 1 for missing values for each audit filter. The largest cohort was observed with "Dead at 30 days" (n = 8298, 99.9%) and the smallest cohort was observed with "GCS < 9 and not intubated" (n = 390, 4.7%). In total 5977 out of 8309 (71.9%) patient cases were flagged by at least one audit filter.

The audit filter with the highest sensitivity was "> 60 min until first intervention" (83.3%, 95% CI [79.2-87.5]). The lowest sensitivity was seen in "SBP < 90" (8%, 95% CI [5.6-10.2]) and "Dead at 30 days" (8%, 95% CI [5.6-10.2]). The audit filter with the highest specificity was "Massive transfusion" (95.8%, 95% CI [95.4-96.3]). The lowest specificity was seen in "ISS > 15 and no team activation" (21.6%, 95% CI [19.9-23.2]). The sensitivity for all audit filters combined was 92.6% (95% CI [90.5-95]) and the specificity was 29.4% (95% CI [28.4-30.5]).

The highest Cohen's kappa was seen for the audit filter "Massive transfusion" (0.08, 95% CI [0.05-0.12]). The smallest Cohen's kappa was seen in "GCS $<$ 9 and not intubated" (-0.07, 95% CI [-0.14-0]. The Cohen´s kappa for all audit filters combined was 0.04 (95% CI [0.03-0.04]. See table 3 for the performance of all audit filters using sensitivity, specificity and Cohen's kappa coefficient.



Discussion

The aim of this study was to evaluate the performance of individual audit filters in predicting opportunities for improvement and to assess their suitability as a screening tool for mortality and morbidity conferences. This study showed that audit filters had no ability to predict opportunities for improvement.

Limitations

Opportunity for improvement, while binarily defined, includes a diverse set of outcomes. This complicates the process of creating audit filters that perform well in predicting opportunities for improvement. Audit filters would favour the identification of some, but not all, errors.

Each audit filter was individually related to opportunities for improvement. Consequently, if an audit filter demonstrated a true positive correlation with an opportunity for improvement, instances where the same patient case had multiple audit filters introduce uncertainty regarding which specific audit filter truthfully predicted the opportunity for improvement.

The number of missing values differed significantly among the audit filters, resulting in varying degrees of validity for each filter.

Healthcare professionals attending mortality and morbidity conferences may not accurately recall key details impacting opportunities for improvement decisions, introducing recall bias. Furthermore, professionals, not present for specific cases might over- or underestimate opportunities for improvement. Consensus decisions at the mortality and morbidity conferences may introduce misclassification bias.

For the audit filters “Massive transfusion” and “Liver or spleen injury” we had to rely on the judgement of the specialised nurses since is there was no registered data on those criteria.

##Interpretation Higher ISS, longer times to CT, longer times to first intervention, and higher levels of care correlated with opportunities for improvement, consistent with a recent Swedish study by Albaaj et al. (29). Notably, GCS at the ED also showed a correlation with opportunities for improvement despite identical median GCS values, likely due to distribution differences outside the interquartile range (IQR).

The audit filter “GCS<9 and not intubated” showed no significant ability to predict opportunities for improvement, similarly shown by Willis et al. (30). Possibly because the audit filter might be more reflective of clinical decisions rather than quality of care (30). For instance, an abnormal GCS because of intoxication is managed differently to an abnormal GCS due to head injury.

Even though longer times to CT and longer times to first intervention was correlated with opportunities for improvement, the delay-related audit filters: “>60 min until first intervention” and “>30min until first CT”, showed no ability to predict opportunity for improvement. Contrary, Teixeira et al.(31) linked delays to preventable death and identified delay to treatment and delays to CT as common errors in trauma care. A recent study in Japan by Yamamoto et. al (32) observed significantly reduced mortality with whole-body CT scans within 10 minutes of arrival to the ED.

Audit filters vary greatly in terms of expected mortality. Some audit filters such as “Massive transfusion” and “Dead at 30 days” have a high expected mortality. In such cases reduced time frame for any potential opportunity for improvement to occur could explain their lack of predictive ability.

The sensitivity and specificity for individual audit filters varied greatly. Most audit filters displayed a high specificity relative to their sensitivity which may be attributed to the outcome being rather uncommon, whilst every individual audit filter misses the majority of opportunities for improvement. This could suggest that the audit filters are too rigid in their criteria. On the contrary, the audit filters showing high sensitivity relative to their specificity might do so as a result of too inclusive criteria, causing more patient cases to be flagged yet without opportunities for improvement (30).

Generalizability

Audit filters are widely used, but lack consensus on which to use, purpose, and application (19,20,33). They have static criteria and may therefore not adapt to evolving healthcare challenges, or upon resolution of the quality gaps they were designed for, reducing their utility over time. This underscores the need for regular evidence-based reviews of audit filter performance (34). However, these reviews might be cost-prohibitive.

While audit filters can help identify an opportunity for improvement, they might overshadow other contributing factors, leading to over-reliance and potentially failing to recognize cases outside their scope (30). For example, audit filters often focus on aspects relevant to doctors, despite the interdisciplinary nature of trauma care. Lastly, confounding variables, such as different treatment times based on injury severity, add to the uncertainty of audit filters’ effectiveness (30).

Due to the study being conducted in a single trauma centre in Stockholm it is unrealistic to assume applicability of these findings at other hospitals facing unique challenges (6). For instance, audit filters that benefit low and middle income may not benefit high income countries and vice versa (20).

Future Studies

Previous studies suggest poor performance of audit filters for improving trauma care (18,19), and the focus has been on mortality as outcome measure (16,17). Studies that have focused on non-mortality outcomes seem to display the same level of uncertainty regarding their correlation with outcome (23,24). Moreover, audit filters has been associated with high frequencies of false positives (21,22). This study showed that audit filters perform poorly in predicting opportunities for improvement as an umbrella term for mortality and non-mortality associated outcomes. Given these results, future studies should focus on new tools with higher predictive ability and consider non-mortality associated outcomes.

Conclusion

Audit filters are widely used as a tool in quality improvement programmes and should reflect the current gap in trauma care quality. In this study, no audit filter were successful in predicting opportunities for improvement, with Cohen's kappa coefficient ranging from -0.07 to 0.08. These results highlight the importance of continually evaluating the relevance of audit filters or perhaps finding new tools focused on quality improvement in trauma care.

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