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Incidence of opportunities for improvement in trauma patient care: a retrospective registry-based study

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ABSTRACT

Introduction Trauma is a leading cause of death in individuals aged 45 and younger, contributing significantly to the global disease burden. Local trauma quality improvement programs have been implemented to improve clinical practice and patient outcomes. Multidisciplinary peer reviews, included in quality improvement programs, aim to identify opportunities for improvement in trauma patient care and implement corrective measures. This study assesses the incidence and trends of these opportunities across clinically important trauma cohorts.

Methods We conducted a retrospective cohort study using data from the trauma registry at Karolinska University Hospital in Solna, Sweden, between 2017 and 2022. Patients screened for opportunities for improvement were categorized into common trauma cohorts. Logistic regression was used to analyze trends in the occurrence of opportunities for improvement over the years in each cohort. The relationship between opportunities for improvement and trauma cohorts was also assessed.

Results Out of 7192 patients included, 404 (6%) had at least one opportunity for improvement. A statistically significant decrease in opportunities for improvement per year was observed overall (OR 0.90; 95% CI 0.84 to 0.95). Significant decreases were identified in patients with blunt multisystem trauma without traumatic brain injury (TBI) (OR 0.82; 95% CI 0.72 to 0.93), isolated severe TBI (OR 0.61; 95% CI 0.41 to 0.91), and severe penetrating injuries (OR 0.68; 95% CI 0.50 to 0.92). The blunt multisystem with TBI cohort showed a non-significant increase. After adjusting for Injury Severity Score, only the blunt multisystem without TBI cohort remained significantly associated with opportunities for improvement (OR 1.69; 95% CI 1.24 to 2.31).

Conclusion The incidence of opportunities for improvement in trauma care showed a significant decrease, indicating that the current trauma quality improvement program at Karolinska University Hospital may be effective in reducing opportunities for improvement. Patients with blunt multisystem trauma without TBI were at higher risk for opportunities for improvement compared with other trauma cohorts.

Level of evidence Level IV: retrospective study with up to three negative criteria.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Trauma is a leading cause of death and disability worldwide, and the implementation of trauma systems with trauma quality improvement programs has been shown to significantly reduce mortality. However, it is unknown if trauma quality improvement programs lead to better clinical practice and a reduction of opportunities for improvement over time.

WHAT THIS STUDY ADDS

⇒ This study presents evidence of a decrease over time in the incidence of opportunities for improvement in trauma care within an established trauma system, suggesting the effectiveness of the quality improvement program. The findings also highlight that patients with blunt multisystem trauma without traumatic brain injury are at a higher risk for opportunities for improvement, even after adjusting for injury severity.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study suggests that trauma quality improvement programs may be effective in improving clinical practice and reducing preventable errors in trauma care.

INTRODUCTION

Trauma is the leading cause of death in patients aged 45 and younger.[1] Approximately 4.5 million people die globally each year due to trauma, and trauma is one of the leading contributors to the global disease burden in terms of disability-adjusted life years.[2] Establishing effective trauma systems and delivering high-quality care are essential strategies for reducing trauma's impact and improving patient outcomes.[3 4]

Fundamental to trauma systems are quality improvement programs, which have been demonstrated to improve patient outcomes.[5] Various organizations, including the WHO[6] and the American College of Surgeons,[7] provide recommendations on structuring these programs. A key component of trauma quality improvement is the continuous development of clinical practices. Multidisciplinary morbidity and mortality reviews play an important role in this process by identifying opportunities for improvement in patient care and implementing corrective measures.[8–10]

Opportunities for improvement in patient care are preventable events associated with adverse clinical outcomes or recurrent deviations from safe clinical practice.[11] Opportunities for improvement often arise from shortcomings in initial care, such as airway management, fluid resuscitation,

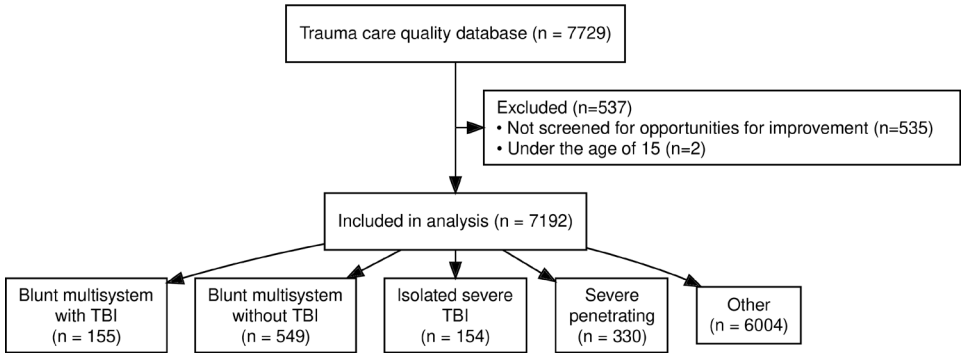

Figure 1 Flowchart of exclusion criteria and cohort categorization. TBI, traumatic brain injury.

hemorrhage control, and chest injury management.[11–15] After the identification of an opportunity for improvement, corrective measures should be implemented to prevent future errors.

The quality of trauma care can also be evaluated through benchmarking mortality rates within specific patient groups, such as those with blunt multisystem injuries, penetrating truncal injuries, or traumatic brain injuries (TBI), as recommended by the Trauma Quality Improvement Program (TQIP) introduced by the American College of Surgeons in 2006.[16] This benchmarking process enables hospitals to compare risk-adjusted mortality rates and identify areas needing improvement in specific patient groups.

Overall, TQIPs aim to refine care processes and enhance clinical outcomes, ultimately reducing the need for future improvements. Despite these efforts, there is limited knowledge about how the incidence of opportunities for improvement evolves within established trauma systems over time. The aim of this study is to assess the incidence of opportunities for improvement in clinics that implement quality programs across clinically important trauma cohorts and to investigate temporal trends in these incidences. Additionally, the relationship between opportunities for improvement and trauma cohorts will be assessed.

METHODS

Study design

We conducted a single-center registry-based retrospective cohort study using the trauma registry at Karolinska University Hospital in Solna, Sweden. The trauma registry is compliant with the Utstein template and reports to the Swedish National Trauma Registry.[17] Additionally to the Utstein variables, the registry includes data on the trauma care quality program, such as the results of the peer-review processes, including identified opportunities for improvement.

Setting

The Karolinska University Hospital in Solna is the designated trauma hospital for the greater metropolitan area of Stockholm. All patients admitted to Karolinska University Hospital with trauma team activation, as well as patients admitted without trauma team activation but retrospectively found to have an Injury Severity Score (ISS) greater than 9, are included in the Karolinska University Hospital trauma registry.

An effort to incorporate a TQIP at Karolinska University Hospital began in 2013, with multidisciplinary peer reviews playing an important role. Initially, the process was less formalized, relying on a small group of clinicians involved in trauma care who used various audit filters to identify patient cases for review. Since 2017, the current audit filters (online supplemental table A1) have been used to screen patients and flag potential opportunities for improvement, and the TQIP process has expanded to involve a wider group of clinicians.

Patients who have been flagged by the audit filters are discussed during peer-review processes. The multidisciplinary peer-review process analyzes whether any preventable event associated with adverse clinical outcomes or recurrent deviations from safe clinical practice are found in patient care. The peer-review board is a group of senior clinicians with representatives from all core specialties and professions involved in trauma care. These preventable events are also known as opportunities for improvement. Opportunities for improvement include reasons such as inadequate resources available, delays in treatment, clinical judgment errors, missed diagnoses, inadequate protocols, and preventable deaths. To minimize subjectivity, the classification as *opportunities for improvement* is decided as a consensus among all clinicians in the peer-review group. The constitution of clinicians in the peer-review group has been consistent during the study period. Furthermore, the same nurses have conducted the initial screening using the audit filters since they were officially implemented in 2017.

Participants

We included all patients between January 1, 2017, and December 31, 2022, who had been screened for opportunity for improvement. Patients younger than 15 years were excluded due to differing clinical pathways. Patients dead on arrival were also excluded.

Variables

The study outcome is binary, categorized as either "Yes—At least one opportunity for improvement identified" or "No—No opportunity for improvement identified". We assigned patients trauma cohorts by modifying the TQIP cohorts (online supplemental table A3 in the supplement).[16] The modification to the TQIP trauma cohorts was done to create non-overlapping cohorts that ensure an ample sample size that permits analysis. We categorized them into five cohorts: blunt multisystem with TBI, blunt multisystem without TBI, isolated severe TBI, severe penetrating injuries, and other injuries. Additionally, we categorized injury severity based on ISS into four different categories: mild (ISS<9), moderate (ISS 9–15), severe (ISS 16–25), and profound (ISS>25).[18]

Statistical analysis

To analyze trends in the occurrence of opportunities for improvement over time, we used a logistic regression model. In

Table 1 Demographic and clinical characteristics of patients screened for opportunities for improvement

	Blunt multisystem with TBI (n=155)	Blunt multisystem without TBI (n=549)	Isolated severe TBI (n=154)	Severe penetrating (n=330)	Other (n=6004)	Overall (n=7192)
Age (years)						
Mean (SD)	47 (21)	51 (20)	54 (21)	32 (14)	44 (21)	44 (21)
Median (min, max)	45 (15, 93)	51 (15, 96)	57 (15, 90)	27 (15, 84)	41 (15, 100)	42 (15, 100)
Sex						
Female	48 (31%)	149 (27%)	33 (21%)	30 (9%)	1,939 (32%)	2,199 (31%)
Male	107 (69%)	400 (73%)	121 (79%)	300 (91%)	4,065 (68%)	4,993 (69%)
ED GCS						
Mean (SD)	6 (2)	14 (2)	5 (2)	14 (2)	14 (2)	14 (2)
Median (min, max)	7 (3, 8)	15 (3, 15)	5 (3, 8)	15 (3, 15)	15 (3, 15)	15 (3, 15)
Missing	109 (70%)	65 (12%)	69 (45%)	70 (21%)	335 (6%)	648 (9%)
ED systolic blood pressure (mm Hg)						
Mean (SD)	103 (59)	126 (37)	136 (40)	110 (51)	137 (26)	134 (31)
Median (min, max)	115 (0, 248)	130 (0, 241)	140 (0, 240)	125 (0, 200)	136 (0, 285)	135 (0, 285)
Missing	4 (3%)	19 (3%)	5 (3%)	16 (5%)	92 (2%)	136 (2%)
ISS						
Mean (SD)	40 (14)	28 (11)	23 (11)	21 (17)	8[8]	11 (12)
Median (min, max)	38 (17, 75)	26 (9, 75)	25 (9, 75)	16 (9, 75)	5 (0, 75)	9 (0, 75)
Missing	0 (0%)	0 (0%)	0 (0%)	0 (0%)	10 (<1%)	10 (<1%)
NISS						
Mean (SD)	46 (14)	33 (11)	37 (16)	27 (19)	10 (11)	14 (15)
Median (min, max)	43 (22, 75)	29 (18, 75)	34 (9, 75)	22 (9, 75)	6 (0, 75)	9 (0, 75)
Missing	0 (0%)	0 (0%)	0 (0%)	0 (0%)	10 (<1%)	10 (<1%)
Time to first CT (min)						
Mean (SD)	39 (31)	68 (148)	31 (19)	65 (87)	69 (125)	67 (123)
Median (min, max)	32 (12, 245)	33 (0, 1338)	27 (6, 176)	30 (7, 566)	34 (0, 1,428)	33 (0, 1,428)
Missing	28 (18%)	74 (13%)	7 (5%)	73 (22%)	591 (10%)	773 (11%)
Highest level of care						
Emergency department	22 (14%)	17 (3%)	6 (4%)	26 (8%)	1,362 (23%)	1,433 (20%)
General ward	4 (3%)	87 (16%)	3 (2%)	58 (18%)	2,618 (44%)	2,770 (39%)
Operating theater	6 (4%)	151 (28%)	2 (1%)	108 (33%)	1,047 (17%)	1,314 (18%)
High dependency unit	0 (0%)	43 (8%)	2 (1%)	20 (6%)	274 (5%)	339 (5%)
Critical care unit	123 (79%)	251 (46%)	141 (92%)	118 (36%)	703 (12%)	1,336 (19%)
30-day mortality						
Yes	72 (46%)	61 (11%)	66 (43%)	59 (18%)	203 (3%)	461 (6%)
No	82 (53%)	487 (89%)	88 (57%)	271 (82%)	5,795 (97%)	6,723 (93%)
Missing	1 (1%)	1 (<1%)	0 (0%)	0 (0%)	6 (<1%)	8 (<1%)
Opportunity for improvement						
No	141 (91%)	458 (83%)	140 (91%)	311 (94%)	5,738 (96%)	6,788 (94%)
Yes	14 (9%)	91 (17%)	14 (9%)	19 (6%)	266 (4%)	404 (6%)

Time to first CT: Measured in minutes from arrival at the hospital.
ED, emergency department; GCS, Glascow Coma Scale; ISS, Injury Severity Score; NISS, New Injury Severity Score; TBI, traumatic brain injury.

this model, the binary outcome variable, indicating the presence or absence of an opportunity for improvement, was the dependent variable, whereas the year of patient admission, treated as a continuous variable, was the independent variable. The model was fitted independently for each cohort as well as for the entire population. We report ORs with 95% CIs to describe the strength and direction of change in the incidence of opportunities for improvement over time.

As a sensitivity analysis, we employed the Cochran-Armitage trend test (χ^2 test for trend) to assess the significance of the temporal trend in the incidence of opportunities for improvement. This allowed us to corroborate the findings from the logistic regression analysis.

Additionally, to explore the relationship between opportunities for improvement and trauma cohort, we used a logistic regression model where the cohort was the dependent variable, and the opportunity for improvement was the independent variable. We adjusted this model to account for injury severity using the ISS categories, as it is known to be associated with opportunities for improvement.[19] As a sensitivity analysis, we re-ran the model adjusting for injury severity using the New Injury Severity Score (NISS) instead of the ISS. The two scores can differ, particularly in cases of severe head injuries and penetrating injuries.[20 21]

Statistical significance was defined as a two-sided p value of <0.05. All statistical analyses were performed using R software (V.4.1.1; R Foundation for Statistical Computing, Vienna, Austria).[22]

RESULTS

Out of 7729 patients in the database between January 1, 2017, and December 31, 2022, a total of 7192 patients met the inclusion criteria (figure 1). Out of the included patients, 404 (6%)

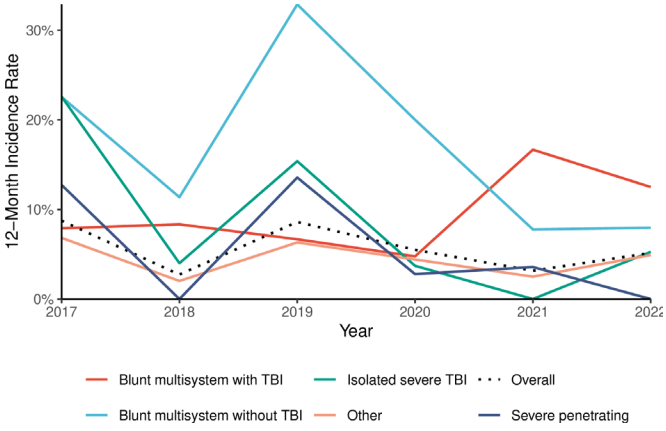

Figure 2 Incidence of opportunities for improvement from 2017 to 2022. Incidence rates of opportunity for improvement were calculated during 12 month intervals for each cohort and the overall population. The incidence was defined as the proportion of patients with opportunity for improvement among all patients within each time interval. TBI, traumatic brain injury.

patients had at least one opportunity for improvement. Patients were predominantly men (69%, n=4993) and the mean age was 44 (SD 21). As many as 6004 (83%) patients did not belong to any of the modified TQIP cohorts but were instead included in the *other* cohort, which also was the largest cohort. The *other* cohort had the lowest mean ISS of 8 (SD 8). The cohort with the highest mean ISS was *blunt multisystem with TBI* with a value of 40 (SD 14). The cohort with the highest prevalence of opportunities for improvement was the *blunt multisystem without TBI* cohort, in which 17% (n=91) of patients had at least one opportunity for improvement. The overall 30-day mortality for the population was 6% (n=461), the groups with TBI had the highest 30-day mortality with 46% (n=72) and 43% (n=66) in the blunt multisystem with TBI and isolated severe TBI, respectively. Patients with TBI underwent their first CT scan more quickly than other groups. On average, patients with isolated TBI had a scan time of 31 min (SD 19), whereas those with blunt multisystem injuries involving TBI averaged 39 min (SD 31). In comparison, the remaining cohorts had average scan times ranging from 65 to 69 min. A summarized table of patient characteristics is presented in table 1.

The overall incidence of opportunities for improvement (figure 2) varied from 3% (n=36) in 2018 to 9% (n=112) in 2017. When analyzing the incidence trends of opportunities for improvement (table 2), the overall trend was a decrease in incidence with an OR of 0.90 (95% CI 0.84 to 0.95; p<0.01). A statistically significant decrease in opportunities for improvement could be identified in the cohorts *blunt multisystem without TBI* (OR 0.82; 95% CI 0.72 to 0.93; p<0.01), *isolated severe TBI* (OR 0.61; 95% CI 0.41 to 0.91; p=0.02), and *severe penetrating* (OR 0.68; 95% CI 0.50 to 0.92; *p*=0.01). The cohort *blunt multisystem with TBI* had a non-significant increasing trend (OR 1.14; 95% CI 0.84 to 1.56; *p*=0.39). From the years 2017 to 2020 a decrease in the incidence of opportunities for improvement was seen in the *blunt multisystem with TBI* cohort (8%, n=3–5%, n=1). However, during 2021 an increase in incidence to 17% (n=3) was observed. In 2021, the occurrence of patients with *blunt multisystem trauma with TBI* was the lowest (n=18), whereas 2017 had the highest occurrence (n=38) (online supplemental table A2 in the supplement). For the sensitivity analysis, we conducted an additional test using the Cochran-Armitage trend test (a χ^2 test for trend), which confirmed the significant trends observed in our primary analysis (table 2).

Table 2 Incidence trends of opportunity for improvement split by trauma cohort

Cohort	OR (95% CI)	P value*	P value†
Blunt multisystem with TBI	1.14 (0.84 to 1.56)	0.39	0.39
Blunt multisystem without TBI	0.82 (0.72 to 0.93)	**<0.01**	**<0.01**
Isolated severe TBI	0.61 (0.41 to 0.91)	**0.02**	**0.01**
Severe penetrating	0.68 (0.5 to 0.92)	**0.01**	**0.01**
Other	0.93 (0.87 to 1)	0.06	0.06
Overall	0.9 (0.84 to 0.95)	**<0.01**	**<0.01**

Bold values indicate statistical significance (p < 0.05).
*The p value for the regression.
†The p value for the Cochran-Armitage (χ^2) test.
TBI, traumatic brain injury.

In the unadjusted analysis, the trauma cohorts *blunt multisystem with TBI*, *blunt multisystem without TBI*, and *isolated severe TBI* were all significantly associated with opportunities for improvement (table 3). When adjusting for ISS, only *blunt multisystem without TBI* remained significantly associated with opportunities for improvement (OR 1.69; 95% CI 1.24 to 2.31). The ISS was associated with opportunities for improvement in both the adjusted and unadjusted analysis. When adjusting for NISS, the results remained consistent with those obtained when adjusting for ISS (online supplemental table A4).

DISCUSSION

We found that the incidence of opportunities for improvement decreased throughout the trauma population over time. Furthermore, all defined cohorts, excluding blunt multisystem trauma patients with TBI, had a significant decrease in the incidence of opportunities for improvement. Blunt multisystem trauma patients with TBI had a non-significant increase in incidence during the study period, mainly due to a spike in identified opportunities for improvement after 2021. The incidence of opportunities for improvement in patients with severe isolated TBI decreased the most during the analysis period. Additionally, we found that patients with blunt multisystem trauma (regardless of TBI status) and patients with isolated severe TBI were more likely to have opportunities for improvement in care compared with any other trauma cohort. However, when adjusting for the differing severity of injuries, only patients with blunt multisystem trauma without TBI were at higher odds for opportunities for improvement in patient care.

The large decrease in opportunities for improvement occurred in the severe isolated TBI cohort; this may reflect previous improvement initiatives at the hospital level, such as including the neurosurgeons in the peer-review process, protocols for shorter door-to-knife time for craniotomies, revised communication protocols, and the move of the neurointensive care unit closer to the general intensive care unit. The overall decreasing incidence of opportunities for improvement could support the effectiveness of the current system in implementing corrective measures after identifying opportunities for improvement.

Patients with TBI, whether isolated or in connection with other injuries, had a faster time to first CT than other trauma cohorts. However, blunt multisystem trauma patients without TBI had a slower time to first CT compared with their TBI counterparts. A hypothesis is that opportunities for improvement in

Table 3 Association between trauma cohorts and opportunity for improvement

Characteristic	Unadjusted		Adjusted	
	OR (95% CI)	P value	OR (95% CI)	P value
Cohort				
Other	—		—	
Blunt multisystem with TBI	2.14 (1.17 to 3.63)	**<0.01**	0.92 (0.48 to 1.67)	0.80
Blunt multisystem without TBI	4.29 (3.30 to 5.52)	**<0.01**	1.69 (1.24 to 2.31)	**<0.01**
Isolated severe TBI	2.16 (1.18 to 3.66)	**<0.01**	0.96 (0.51 to 1.66)	0.88
Severe penetrating	1.32 (0.79 to 2.07)	0.26	0.65 (0.39 to 1.04)	0.09
ISS				
Minor to moderate (<9)	—		—	
Serious (9–15)	2.82 (2.08 to 3.85)	**<0.01**	2.89 (2.12 to 3.95)	**<0.01**
Severe (16–25)	7.63 (5.73 to 10.3)	**<0.01**	6.92 (5.08 to 9.47)	**<0.01**
Critical (>25)	5.85 (4.24 to 8.09)	**<0.01**	4.90 (3.31 to 7.25)	**<0.01**

Bold values indicate statistical significance ($p < 0.05$).
ISS, Injury Severity Score; TBI, traumatic brain injury.

care could occur due to missed injuries before CT, which is further exaggerated by the fact that blunt multisystem trauma patients are at a higher risk of having missed injuries during the primary survey.[23] Delayed times to CT are known to be associated with higher mortality and serve as a process factor adversely associated with opportunities for improvement.[19 24]

Our study has several limitations. First, many trauma patients were not assigned to specific cohorts, seemingly forming a heterogeneous group likely consisting of patients with isolated, low-severity injuries and severely injured patients who did not meet the binary TQIP criteria. Additionally, patient selection for the multidisciplinary peer-review process depends on audit filters that vary by institution and lack sufficient validation,[25] potentially overlooking improvement opportunities. These filters are static and cannot adapt to identify emerging at-risk cohorts. The study's external validity is limited by its single-center design, focusing solely on the Swedish trauma population, which may affect generalizability. However, we observed mortality rates similar to other Swedish hospitals and the TQIP program overall.[26 27] Finally, although a decrease in opportunities for improvement was observed, the current study design makes it challenging to draw definitive conclusions, as this trend could be influenced by external factors, such as evolving trauma care practices. Furthermore, as previously noted, the audit filters may fail to flag certain opportunities for improvement. Consequently, it is possible that some groups of opportunities for improvement are increasing or remaining constant but go unnoticed by the current audit filters.

CONCLUSION

The overall incidence of opportunities for improvement in trauma care showed a significant decrease over time, possibly due to the TQIP in place. Patients with blunt multisystem trauma without TBI appear to be at a higher risk for opportunities for improvement in patient care compared with other trauma cohorts.

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Disclaimer The lead author (the manuscript's guarantors) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval The study was approved by the Swedish Ethical Review Authority (approval numbers 2021-02541 and 2021-03531).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available. The datasets analysed during the current study are not publicly available due to containing sensitive patient information and are not available upon request.

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