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Effect of trauma quality improvement initiatives on outcomes and costs at community hospitals: A scoping review

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ABSTRACT

Background: Due to complex geography and resource constraints, trauma patients are often initially transported to community or rural facilities rather than a larger Level I or II trauma center. The objective of this scoping review was to synthesize evidence on interventions that improved the quality of trauma care and/or reduced healthcare costs at non-Level I or II facilities.

Methods: A scoping review was performed to identify studies implementing a Quality Improvement (QI) initiative at a non-major trauma center (i.e., non-Level I or II trauma center [or equivalent]). We searched 3 electronic databases (MEDLINE, Embase, CINAHL) and the grey literature (relevant networks, organizations/associations). Methodological quality was evaluated using NIH and JBI study quality assessment tools. Studies were included if they evaluated the effect of implementing a trauma care QI initiative on one or more of the following: 1) trauma outcomes (mortality, morbidity); 2) system outcomes (e.g., length of stay [LOS], transfer times, provider factors); 3) provider knowledge or perception; or 4) healthcare costs. Pediatric trauma, pre-hospital and tele-trauma specific studies were excluded.

Results: Of 1046 data sources screened, 36 were included for full review (29 journal articles, 7 abstracts/posters without full text). Educational initiatives including the Rural Trauma Team Development Course and the Advanced Trauma Life Support course were the most common QI interventions investigated. Study outcomes included process metrics such as transfer time to tertiary care and hospital LOS, along with measures of provider perception and knowledge. Improvement in mortality was reported in a single study evaluating the impact of establishing a dedicated trauma service at a community hospital.

Conclusions: Our review captured a broad spectrum of trauma QI projects implemented at non-major trauma centers. Educational interventions did result in process outcome improvements and high rates of self-reported improvements in trauma care. Given the heterogeneous capabilities of community and rural hospitals, there is no panacea for trauma QI at these facilities. Future research should focus on patient outcomes like mortality and morbidity, and locally relevant initiatives.

Introduction

Traumatic injury is a major cause of death and disability worldwide. An estimated 5.8 million people die from trauma annually, with many more experiencing substantial ongoing disability [1]. A disproportionate proportion of major trauma affect individuals in developing countries, with low socioeconomic status, certain racial and ethnic groups, and rural inhabitants [2,3,4,5]. The organization of trauma systems has been associated with a decrease in trauma-related mortality when implemented [6,7]. Such systems are far more common in high-income countries than in middle- and low-income countries [6]. Major Trauma Centers (MTCs) or the equivalent Level I and II Trauma

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Centers (TCs) are the nucleus of a trauma system, housing expertise and resources to provide definitive trauma care at all times [6,8]. Middle designation hospitals (Level III TCs or equivalent) commonly have some surgical capacity (e.g., general surgery and orthopedics), and lower designation facilities (Level IV and V TCs/ local emergency/A&E rooms) are tasked with providing 24-hour emergency coverage including patient resuscitation and stabilization.

While it is preferable to transport major trauma patients direct from scene to a MTC/Level I or II center for definitive care, geography and resources dictate that some patients are initially transported to a community hospital (with/without trauma designation) where stabilizing and potentially lifesaving interventions (e.g., intubation, tube thoracostomy, pelvis stabilization, blood product administration) are performed by on-site physicians [8,9]. Although some patients will remain at these smaller facilities, most are subsequently transferred to a higher level TC [7,10,11,12]. Despite expert supposition to the contrary [13,14], studies suggest trauma care at lower designation TCs (e.g., Level III, IV, V or equivalent), rural and non-trauma facilities can have a significant impact on outcomes, and that improvements in care at these community hospitals may improve outcomes [10,11,15] . Further, research indicates that focusing on, coordinating and optimizing trauma care at all hospitals throughout a trauma system (i.e., an inclusive trauma system) improves outcomes relative to an exclusive trauma system that depends on the MTC to provide all trauma care [16,17] .

Assessment and monitoring of health care delivery has evolved substantially over the past century, including a change in focus from assessing and providing interventions at the practitioner-level to a combined practitioner- and system-level Quality Improvement (QI) approach [6]. QI can be defined as the optimization of resources including knowledge, skills, and materials to improve medical care and produce good health. Retrospective and prospective review is used to measure the status of a target outcome and identify ways to improve it [6,18]. Designation of MTCs (Level I, II) is contingent upon centers meeting numerous criteria including ongoing QI initiatives; requirements for Level III-IV centers are less exhaustive in most areas [9,19]. The World Health Organization (WHO) and the American College of Surgeons (ACS) have developed recommendations to guide trauma care QI interventions across various levels of hospitals and TCs and outlined categories of QI techniques (see Section 4, [6]). Interventions noted to be particularly applicable to community hospitals (Level III or below) fall into categories of education, auditing, records/trauma registry, targeted feedback, and panels or reviews. QI interventions can be targeted to influence patient outcomes, process outcomes, provider knowledge and ability, and healthcare costs [6,19].

The monitoring of trauma care through QI activity is likely to impart some benefit on outcomes (e.g., mortality, morbidity, processes) regardless of TC size or designation [15,20,21,22,23]. Thus, since many trauma patients will initially be transported to the regional equivalent of a non-Level I or II TC following injury, it is important to identify interventions that improve metrics of care at these facilities. Specific target metrics for community hospitals include (but are not limited to) trauma-related mortality and morbidity, delay to critical stabilization procedures, transfer times, and critical assessment procedures (e.g., neurovascular status of limbs).

The primary objective of this scoping review was to document the nature and extent of trauma QI initiatives at community hospitals. As a secondary objective, we sought to document the effect of these interventions on patient, process, provider, and cost outcomes in the community hospital setting. The findings of this review may serve as a guide for trauma systems and community hospitals that are considering devoting resources to trauma QI initiatives at non-major TCs.

Methods

General

This review was conducted in accordance with the Joana Briggs Institute (JBI) guidelines for scoping reviews [24] and reported following the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) [25]. The protocol was registered with Open Science Framework (OSF) in August of 2022 (https://osf.io/xgpcr/). Steps in this review process included formulating the research question, identifying relevant studies for review, selecting relevant studies for inclusion and synthesis, charting the data to identify central themes, and summarizing the findings [24]

Identification and selection of literature for synthesis

We developed a database search strategy with an experienced research librarian [RP] to capture the Problem (trauma care), Concept (quality improvement initiatives), and Context (community-based emergency care settings) of the review objectives. Using appropriate index and text-word terms, we searched three electronic databases (MEDLINE, Embase, CINAHL) and the grey literature (relevant networks, organizations/associations, and conferences) from inception to July 2023 (A1.T1). The storage and sorting of citations and articles were performed using Covidence software [26]. A single reviewer performed the initial screening based on title/abstract [RM]. Full text review against the inclusion criteria was assessed by two independent reviewers. Reasons for exclusion at this stage were recorded and reported. Any disagreements between the reviewers at each stage of the selection process were resolved through discussion.

Studies were included if they evaluated the effect of implementing a trauma care QI initiative at a community hospital (Level III, IV, V TC equivalents or no trauma designation hospitals) on one or more of the following: 1) major/severe trauma patient outcomes (e.g., mortality, complication rates); 2) process outcomes (e.g., length of stay [LOS], transfer times); 3) provider perception (e.g., satisfaction/ confidence, [self-reported]); 4) provider knowledge (e.g., performance [through testing]); or 5) healthcare costs. We included articles which identified their intervention target as “major” or “severe” trauma patients, or if they used a major trauma score to categorize patients (e.g., Injury Severity Score [ISS]>12). Studies that assessed interventions for traumatic brain injury (TBI) patients were included (even without a trauma score), as were studies that grouped all severities of trauma patients. Initiatives designed and/or implemented by a Level I or II TC specifically for community hospitals were included, as were trauma network/system initiatives implemented across all community hospitals in a jurisdiction (i.e., system-wide initiative) as long as outcomes were specifically reported for community hospitals. The review excluded QI initiatives implemented solely by and at Level I and II TCs, initiatives specific to pediatric trauma patients, pre-hospital initiatives, and pre-hospital or inter-hospital transfer of patients. Data sources reporting on trauma QI in the military context were excluded to refine the scope of this review, and sources pertaining to tele-trauma QI were excluded because these topics are reviewed elsewhere [27] .

Data extraction was performed by one reviewer following the recommended method, akin to a narrative review, for synthesizing and summarizing data in scoping reviews [RM] [28]. Variables for extraction were discussed and decided on *a priori* and tested with a sample included article before a final charting template was agreed upon. When required, authors of sources were contacted to request the full text (e.g., only abstract/poster was available), and electronic databases were rechecked for full publications of these abstracts prior to submission.

We collected available data on the hospital and trauma network/system characteristics, QI initiative type, initiative scope, and initiative time frame. The type of QI initiative was categorized according to groupings presented in the WHO Guidelines for Trauma Quality

Improvement Programs. These include: Morbidity and Mortality conferences (M&Ms), Preventative Death Panels (PDPs), records and trauma registries, corrective strategies and closing the loop, statistical methods, and tracking of audit filters. We excluded the category of prehospital and system wide interventions as these are outside the scope of this review (see Section 4, [6]). Regarding outcomes, the effect of QI initiatives on patient outcomes, system outcomes, provider outcomes and healthcare costs were recorded. Barriers to implementing the QI initiative or assessing outcomes, and recommendations by authors for improvement in systems or QI methodology were also extracted. Included data sources were assessed for quality using two different tools, reflecting the heterogeneity of the sources: Quantitative studies were assessed using the NIH Quality Assessment [29] and qualitative or narrative research was assessed using the JBI qualitative study assessment tool [30].

Results

The search strategy identified 1046 data sources, of which 63 were screened by full text and 36 were included for data extraction (Fig. 1). Most were published journal articles ($n = 29$), and the remaining were abstracts or posters ($n = 7$). We reached out to authors of all these abstracts and received a response from one author to confirm that no full text was published/available for the study in question.

Study characteristics

Studies were performed between 1975 and 2020 and included 20 retrospective studies (cohorts, registry reviews, chart reviews) and 16 prospective studies (cohorts, case studies, cross sectional study). Characteristics of included studies are presented in Table 1, and more extensively in A1.T2. Most conducted quantitative analyses of intervention effects on outcomes ($n = 31$), while some presented solely qualitative and descriptive results ($n = 5$). There were 19 studies that examined QI initiatives developed by MTCs and implemented specifically in community hospitals (network/system, specific hospital application), while 8 studies investigated trauma QI initiatives developed by and implemented in community hospitals (hospital intervention). Lastly, 9 data sources reported on QI initiatives developed by a trauma system and implemented in all hospitals within that system, including community hospitals, with results presented specifically for community hospitals (system-wide initiative). Research was conducted within non-formal trauma systems, inclusive and exclusive trauma systems. Most research investigating interventions in inclusive trauma systems is from the United States.

Quality improvement structure

The most frequent category of QI intervention was corrective strategies/closing the loop ($n = 24$), with education being the most common subcategory (specifically, the Rural Trauma Team Development Course [RTTDC] in $n = 9$ studies, and Advanced Trauma Life Support [ATLS] course in $n = 4$ studies). Audits were also a common intervention ($n = 11$). Ten sources incorporated the use of trauma registries as part of a QI initiative. Many studies used a combination of interventions such as an audit with a corrective strategies/closing the loop project ($n = 21$). Preventative death panels (PDP) were the primary intervention in 2 studies. No sources reported on Morbidity and Mortality conferences.

Patient outcomes

Patient mortality/survival was reported on in 13 sources, of which 9 sources also reported on morbidity outcomes (disability, discharge home, admission to intensive care unit [ICU], radiation exposure, analgesia, reattendance). One study observed a significant decrease in mortality for severe trauma patients (ISS >15) following implementation of a dedicated trauma service (compared to the previous shared general surgery call) [31]. One study using performance improvement forms after trauma team activations did show a slight decrease in mortality, but also a decrease in the proportion of patients discharged home (effect size was not reported) [32]. Educational interventions (ATLS, RTTDC) did not have an effect on overall trauma mortality, although one of these studies did show a decrease in mortality during the first 60 min after arrival to the initial treating facility [21,33,34]. In addition, one study reported a decrease in mortality rates with use of a standard chest injury treatment pathway; however, the source was limited to an abstract and it was not possible to determine the independent effect of the guideline on these outcomes [35].

Other studies reporting on patient outcomes did not show significant effects on morbidity or mortality following interventions including the establishment of a rapid trauma response team, ensuring senior staff presence for trauma patient care, addition of a single general surgeon

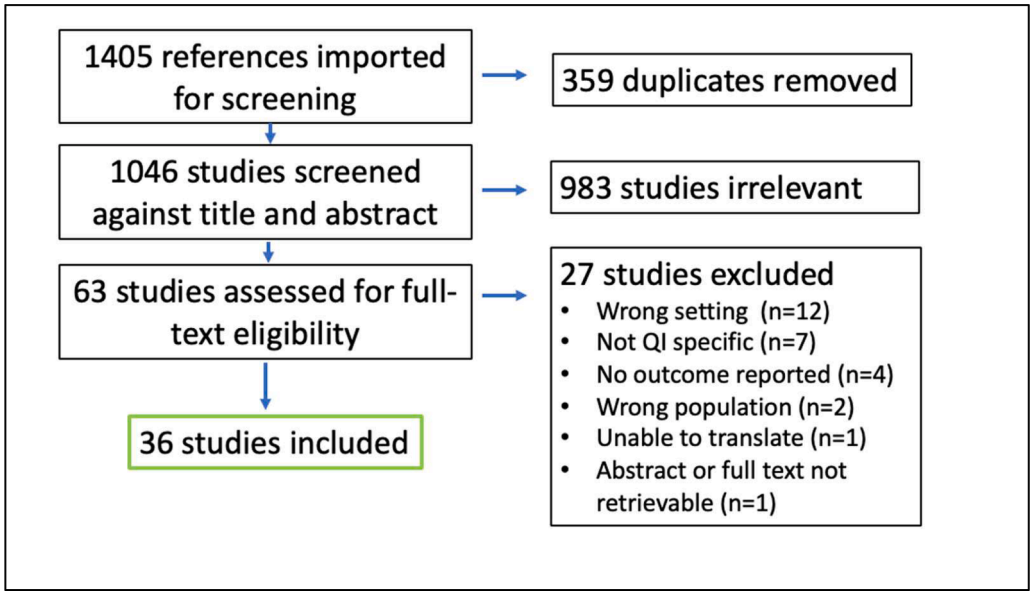

Fig. 1. Selection of articles for review, in PRISMA-ScR Flow Chart.

Table 1
Summary table of study characteristics.

Characteristic	Studies (n = 36)
Setting	
Community hospitals	8
District General Hospitals (equivalent to Level III TC)	5
Referring hospitals (<Level II TC equivalent) in network	5
Level III TCs	4
Rural non-trauma hospitals	4
Level III and Level IV TCs	3
Level V TCs	1
Resource-limited rural hospitals	3
All hospitals in the network	1
Not reported	2
Publication Date	
2011 - Present	23
2000–2010	9
Pre-2000	4
Scope of Intervention	
Network/system, specific hospital application	19
Network/system	9
Hospital	8
Trauma System	
Inclusive	15
Exclusive	10
Not reported	11
Intervention	
RTTDC	9
Guidelines for patient management	7
ATLS/Simulation training	5
Addition of trauma care providers	3
Educational feedback on treatment/outcomes	3
Assessment of trauma deaths	2
Nursing education/support	2
Intimate partner violence advocacy program	1
Installation of CT scanners	1
On-call system	1
Orthopedic trauma list	1
POCUS	1
Intervention Category	
Corrective strategies/closing the loop	
Education	18
Guidelines/pathways/protocols	8
Enhanced resources/facilities/communication	7
Actions for improvement targeting specific providers	2
Audit	10
Records and trauma registry	10
Preventable death panel	2
Outcomes	
Mortality and Morbidity	12
Length of stay	8
Transfer time	8
Provider satisfaction	8
Provider knowledge	8
Transfer rates	4
CT rate	5
Admission rate	2
Adherence to TTA criteria	2
Costs	2
Delay to medical care	1

RTTDC, Rural Trauma Team Development Course; ATLS,. Advanced Trauma Life Support; CT, computed tomography. EMS, emergency medical services; TC, trauma center; NICE,. National Institute for Health and Care Excellence; POCUS,. Point of Care Ultrasonography; TTA, trauma team activation.

(without anesthesiology support), and addition of computed tomography (CT) scanners. These studies were all limited by small sample sizes [36,37,38,39]. A single study reported a decrease in disability (84% vs. 93 % for patients with ISS>15) following implementation of a retrospective educational feedback program between the MTC and referring hospitals [40]. The 2 PDPs included in this review found that hemorrhage was responsible for the majority of both potentially preventable deaths and preventable deaths in severe trauma patients [41,42]. Only one of these PDPs described the composition and decision-making process of the PDP in detail [42] while the methodology in the other review did not describe criteria for deeming a death preventable.

Process outcomes

Process metrics (time to transfer, time to decision for transfer, LOS at first hospital, and quantity of imaging) were the most frequently reported outcomes. These outcomes were reported following corrective strategy interventions (checklists, guidelines), and educational interventions (ATLS, RTTDC). Guidelines and checklists had mixed effects on process outcomes. Some resulted in an increased rate of appropriate imaging or decreased transfer time [43,44,45]. Enhanced resources, specifically introducing an orthopedic trauma list and dedicated OR time resulted in decreased surgical wait times, and LoS as well as increased the number of surgeries conducted in regular hours [46]. Emergency department LOS was reduced by half when a trauma care bundle (WHO trauma checklist, and resuscitation record) was implemented in a single community center [20]. Conversely, a head injury guideline implemented in non-tertiary centers across a provincial health authority did not significantly effect the efficiency of engaging the provincial trauma hotline or the time to definitive tertiary care for TBI patients [44]. Even within studies, we observed variation in the effects of an intervention. For example, use of performance improvement filters for trauma benchmarking led to an improvement in trauma team activation but worsened (increased) LOS at the initial facility [47].

Educational interventions largely had positive effects on process outcomes. Studies investigating the effect of implementing the RTTDC reported improved outcomes including reductions in time to transfer decision, time to transfer, LOS at first hospital, and CT scans at first hospital, and increased Focused Assessment with Sonography in Trauma (FAST) exams [21,48-54]. One study reported that a number of process of care metrics across multiple hospitals improved following ATLS course delivery [55]. One of these studies was an abstract and magnitude of improvement could not be determined [56], but overall, there were no worsening of process outcomes with these studies.

Provider perception

Of 12 studies assessing provider perception of a QI intervention (e.g., effectiveness, usefulness, longevity), all reported improvements. Most responses (captured through surveys or interviews) indicated the training/intervention was beneficial for improving provider comfort and knowledge regarding the trauma response, improving communication between providers, and improving patient safety and outcomes [57–59]. Two of these 12 data sources also evaluated patient outcomes but found the intervention had no measurable effect [37,40].

Provider knowledge

Provider knowledge/performance following an intervention (usually educational; ATLS or RTTCC) was assessed in 10 studies. Formal testing of provider knowledge in a selection of these studies (by pre- and post-course tests) showed improvement following the educational intervention [52,53,60], though some studies did not report pre-course test scores, so comparison was not possible [49]. Most of these studies assessed post-course knowledge immediately following the course delivery [52,53,60], while one assessed it one month after delivery [49].

Healthcare costs

There were 2 studies that evaluated healthcare costs; both assessed the effect of the National Institute for Health and Care Excellence (NICE) CT Head guidelines in UK community hospitals. The findings of these the studies were contradictory regarding costs: Hassan et al., [61] noted an overall cost-saving per 100 head trauma patients after a change in

practice guidelines, while Shravat et al., [62] reported a cost increase of much higher magnitude after implementing the guidelines.

Quality of articles

Quality assessment of 26 eligible quantitative studies indicated that 5 had minimal threats to internal validity, while threats were moderate in 9 studies, and 12 had high threats to internal validity. Common reasons for increased threats to internal validity were small sample sizes impeding study power and interpretability, incomplete description of the intervention, and insufficient information provided on patient inclusion/exclusion criteria. For the 7 data sources without full text availability, methodological quality could not be assessed. The 5 qualitative data sources were evaluated using a different assessment tool with a binary outcome – include vs. exclude. We chose to include all these studies but note limitations for each of them in A1.T3.

Discussion

Interventions and outcomes – what worked, what did not

While numerous studies did measure patient mortality as an outcome of QI interventions, the only intervention showing a significant improvement in overall mortality was the implementation of dedicated full-time trauma service [31]. This is consistent with previous research reporting lower trauma mortality rates at hospitals with a dedicated trauma service [63]. Another source in this review highlighted that such an intervention needs appropriate and available services/resources including anesthesia and a blood bank to positively impact mortality [39]. Regarding morbidity, one retrospective educational feedback program between a MTC and referring community hospitals showed a decrease in morbidity (disability) for major trauma patients first seen at the community hospital [40]. Focused feedback like this has been shown to increase quality of care and guideline adherence in other medical fields [64]. Such programs are likely resource limited, however, by the availability of trauma directors and the time required for them to develop and deliver feedback on a regular basis.

While interventions like educational courses (ATLS, RTTDC), guidelines, standardized treatment pathways, and performance improvement forms may positively impact mortality at community hospitals, sources in this review evaluating for such showed non-significant effects on overall mortality and thus the magnitude of their impact is uncertain. While evidence shows that higher compliance with trauma critical care guidelines is associated with reduced mortality rates [65,66], uptake may be as low as 16–51 % [67–69] and compliance remains difficult to measure [44]. Additionally, small sample sizes of major trauma patients in community hospitals likely contributes to non-significant results and was noted as a limitation in multiple studies. Collectively these barriers may have contributed to the small effect sizes in these studies assessing patient outcomes.

Literature suggests that better process outcomes are associated with improved patient outcomes; however, this association is not necessarily definitive or measured explicitly. Instead, the association can be inferred from different studies measuring patient or process outcomes. For instance, a large proportion (nearly 46 %) of TBI patients have some sort of intracranial hemorrhage [70], and prompt treatment, surgical or otherwise is important to optimize good outcomes [71,72]. Therefore, reduced LOS at the initial facility and shorter transfer times may have important implications for patient outcomes. Many of the QI interventions described in this review led to tangible improvements in LOS and time to transfer, albeit to varying degrees across studies. Implementation of trauma benchmarking filters and educational interventions, specifically the RTTDC, resulted in the largest improvements in process outcomes [40,48,73,74].

While it has been shown that provider confidence in trauma response is optimized with increased exposure to major trauma [75], providers at small community hospitals generally see few major trauma patients during a year. Therefore, educational interventions can be used to augment on the job experience for these providers. Additionally, previous research illustrates that improved communication and teamwork are associated with reductions in time to definitive care, an important trauma quality marker as discussed earlier [76,77]. Furthermore, increased confidence is associated with improved clinical skills and decision-making [49,78]. In this review, courses such as ATLS and the RTTDC were consistently associated with positive provider perceptions, communication, and knowledge improvements. Still, the studies reporting on provider perception were based on self-reported survey data, and post-course knowledge was not reassessed more than 1 month beyond course delivery; therefore, their findings must be interpreted with caution. Providing frequent trauma-based simulation in rural environments would likely represent an additional opportunity for trauma QI.

As evident in this review, educational and training courses are common trauma QI interventions at community hospitals and can lead to improvements in process and provider outcomes. These courses were designed to optimize care within the "golden hour" for major trauma patients to maximize likelihood of survival. ATLS focuses on teaching an organized approach to the evaluation and management of major trauma patients and has been successful in educating providers in the care of injured patients [66]. One source in this review did illustrate the effectiveness of ATLS in reducing mortality within the first hour at first hospital, though effect on overall mortality was unchanged. The RTTDC was developed to help rural hospitals with trauma team development and teaches an organized systematic team-based approach to the care and transfer decisions of trauma patients [74]. Most of the published literature regarding the impact of the RTTDC shows improvements in process outcomes including time to transfer – a primary goal of the RTTDC. To date, we are unaware of any studies demonstrating a significant effect of the RTTDC on patient outcomes. These courses have become an integral part of trauma response training in North America, and as shown here, have measurable positive effects. There are limitations, however, as these courses tend to be static, one-time interventions that are not designed to provide ongoing feedback or performance improvement support. Despite these limitations, these courses are fundamental to improving the provision of trauma care at rural and community hospitals.

Barriers to rural trauma QI

Uptake and sustainability of QI interventions implemented by large trauma centers/systems at smaller community hospitals may be limited unless there is a local champion to motivate participation and ongoing compliance [20,32]. Busy provider schedules in community hospitals were noted as a common barrier to intervention dissemination and uptake, especially in relation to educational initiatives which require at least a day and potentially travel [21,37,79,80]. Small sample sizes were noted as a barrier to collecting meaningful data in many studies, especially relating to patient outcomes. The 5 system-wide studies in this review (excluding the abstract-only sources) had the benefit of larger sample sizes, affiliation with tertiary research-intensive centers, and utilization of trauma registry data. This contrasts the hospital-based studies which were limited by small patient volumes, provider availability, and lack of dedicated research faculty [20]. The networking of community sites represents a significant opportunity for increased feedback to community hospital and non-trauma centers, although the capabilities and needs of these facilities vary considerably [6].

Strengths and limitations of this study

We followed best practices for conducting scoping reviews (PRISMA-ScR and JBI) and categorized our interventions and outcomes within an existing framework [6]. To our knowledge, this is the first study to

review the effectiveness of trauma-related QI interventions at smaller community and regional facilities. Our study does have several limitations. We included abstracts and posters, and thus did not have access to the full methodology and findings from these studies. Furthermore, the evidence from included studies spans many decades (1975 to present). With the rapidity of advances in trauma care, the findings from some older studies appear to be contradicted by more recent evidence (e.g., [33,63]); however, given that trauma care has developed at varying rates in different regions, we included all articles regardless of publication date to provide a comprehensive review of trauma QI initiatives. We acknowledge that the leadership, degree of trauma specialization and resources associated with a given study varied considerably among studies. Overall, there was heterogeneity in the type and content of studies, with specificity reduced at the expense of being inclusive and comprehensive. Lastly, we recognize that patient outcomes are affected by numerous variables beyond care at the initial hospital. Overall mortality may be influenced by many factors such as discovery times, interventions at the scene, transport times to definitive care, transport modes, and other important considerations at the MTC which are outside of the scope of this review.

Conclusions and recommendations

The optimization of initial trauma care at community hospitals has important implications for the survival of major trauma patients when geography and logistics prevent direct transport to tertiary centers [10,11,15]. There is considerable heterogeneity in trauma QI efforts at community and rural hospitals. Evidence suggests the implementation of a dedicated trauma service can improve patient outcomes at these facilities, and that standardized educational courses including ATLS and the RTTDC can improve provider knowledge/confidence and process of care variables such as transfer time. The dissemination of practice guidelines, though muddied by uncertain uptake rates, may also provide some process of care improvements including decreased LOS and rates of imaging at the initial hospital. Innovative initiatives involving individual and amalgamated feedback from Level I and II TCs to referring sites is an interesting mode of QI that may also improve familiarity and trust between providers in these centers, something that may also improve patient outcomes [81]. Additionally, this type of directed feedback facilitates evidence-based guidance that is directly relevant for community hospitals and the resources available there.

Future investigations on the effect of QI initiatives in community hospital settings would benefit from a focus on patient outcomes and linkages to all outcomes (e.g. provider and process outcomes, costs) [44]. Additionally, grouping efforts between sending and receiving centers or within trauma systems may increase the resources available to community hospitals for QI studies, and may provide the trauma QI champions at individual hospitals with a network of colleagues to discuss and collaborate with. It would also serve to increase the sample size of major trauma patients studied, strengthening the interpretability of results. Finally, while the evidence base already exists regarding the benefit of trauma systems on survival [6,82], being part of a trauma network can provide community hospitals with QI oversight, feedback, education and perhaps funding, saving providers at these smaller facilities from having to assume this role in addition to their clinical responsibilities.

CRediT authorship contribution statement

Reba McIver: Writing – original draft, Project administration, Investigation, Conceptualization. **Mete Erdogan:** Writing – review & editing, Visualization, Resources, Conceptualization. **Robin Parker:** Writing – review & editing, Resources, Methodology, Conceptualization. **Allyson Evans:** Writing – review & editing, Conceptualization. **Robert Green:** Writing – review & editing, Conceptualization. **David Gomez:** Writing – review & editing, Conceptualization. **Tyler Johnston:** Writing – review & editing, Supervision, Methodology, Conceptualization.

Declaration of competing interest

None

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Supplementary materials

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