Received: 18 November 2022 | Revised: 21 June 2023 | Accepted: 1 August 2023

DOI: 10.1111/nicc.12970

SYSTEMATIC REVIEW

BACCN Nursing in Critical Care WILEY

Quality assessment in initial paediatric trauma care: Systematic review from prehospital care to the paediatric intensive care unit

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Abstract

Background: Trauma is the most common cause of death and disability in the paediatric population. There are a huge number of variables involved in the care they receive from health care professionals.

Aim: The aim of this study was to review the available evidence of initial paediatric trauma care throughout the health care process with a view to create quality indicators (QIs).

Study Design: A systematic review was performed from Cochrane Library, Medline, Scopus and SciELO between 2010 and 2020. Studies and guidelines that examined quality or suggested QI were included. Indicators were classified by health care setting, Donabedian's model, risk of bias and the quality of the publication with the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) assessment.

Results: The initial search included 686 articles, which were reduced to 22, with 15 primary and 7 secondary research articles. The snowball sampling technique was used to add a further seven guidelines and two articles. From these, 534 possible indicators were extracted, summarizing them into 39 and grouping the prehospital care indicators as structure ($N = 5$), process ($N = 12$) and outcome ($N = 3$) indicators and the hospital care indicators as structure ($N = 4$), process ($N = 10$) and outcome ($N = 6$) indicators. Most of the QIs have been extracted from US studies. They are multidisciplinary and in some cases are based on an adaptation of the QIs of adult trauma care.

Conclusions: There was a clear gap and large variability between the indicators, as well as low-quality evidence. Future studies will validate indicators using the Delphi method.

Relevance to Clinical Practice: Design a QI framework that may be used by the health system throughout the process. Indicators framework will get nurses, to assess the quality of health care, detect deficient areas and implement improvement measures.

KEYWORDS
advanced trauma life support care, paediatric trauma, quality improvement, quality indicators, quality of health care

1 | BACKGROUND

Paediatric trauma represents one of the biggest challenges in health care and it constitutes the main cause of mortality and morbidity among children (28% of all deaths in the 1–14 age group[1,2]). In the United States, more than 10 million children (1 in every 6) are injured and require health care emergency services, with 10 000 deaths because of severe injuries each year.[3,4] In Europe, an average of 9 million children under the age of 15 (1 in every 10) end up in hospital for treatment of injuries from external causes, with 3000 of deaths each year. These events make up 22% of treated injuries, although the paediatric population only represents around 16% of the entire population.[1] During 2020, the mortality rate in Spain related to traumatic injuries of persons under the age of 19 years old was 18.64 in every 100 000.[5]

Paediatric trauma is bodily damage suffered by a child as a result of the transfer of energy produced in an accident. Trauma affects one or several organs or systems with enough force to put the child's life in danger or leave them with lasting consequences.[6] In response to caring for paediatric trauma patients, various paediatric trauma systems have arisen.[2]

In the trauma patient health care process, several units, services and professionals work together to provide a level of care that should ensure the continuity of care from the 'street' to the paediatric intensive care unit (PICU). Prehospital care is the first link in the chain and should consist of an emergency service, which is specially trained to provide immediate care, identify the severity of injuries, begin treatment and provide quick and efficient transport to the most appropriate health care facility. We then move immediately onto the hospital care stage, in which there is a qualified team and comprehensive programme geared towards paediatric trauma. These units have several human and material resources, as well as specialized training programmes, activity registers, multidisciplinary clinical sessions, morbidity and mortality sessions, continued protocol updates and ongoing development of research programmes.[6,7]

It is important to highlight that time plays an enormous role in multi-trauma patient prognosis, and consequently, in their quality of care. Therefore, initial paediatric trauma care must be quick, organized and efficient. It should be understood as a continuum that begins by adopting protection measures in line with the primary survey, which aims to detect and remedy life-threatening issues. The following step is a secondary survey, and later, the patient categorization, stabilization and transfer to an appropriate health care facility, as well as the definitive care steps that will be taken. There is continual reassessment throughout the entire process.[2,3]

Quality of care should be ensured throughout this process, meaning the degree to which individual and community health services increase the chances of desired health outcomes and are consistent with current professional knowledge.[8,9] Our study focuses on assessing quality improvement, which consists of a method for improving care by monitoring diagnostic elements, treatment and outcomes.[9,10] We will use quality indicators (QIs) as a research tool. QIs are based on standards of care, which are either found in the research literature and in statements of professional medical organizations or determined by an expert panel. Consequently, they should be a valid, sensitive and specific quantitative measure. According to Avedis Donabedian's model, these indicators can be grouped into three elements for analysis to improve the quality of a health system: structure, process and outcome.[9]

What is known about the topic

- In Europe, an average of 9 million children under the age of 15 end up in hospital for treatment of injuries from external causes, with 3000 of them passing away each year.
- The initial paediatric trauma care must be quick, organized and efficient because the first 30 min after an accident are crucial, and the patient's outlook depends on the care they receive at this time. Quality of care should be ensured throughout this process.
- Indicators are a valid, sensitive and specific quantitative quality measure, which can be grouped—according to Avedis Donabedian's model—into three elements: structure, process and outcome.

What this paper adds

- There is a gap and large variability when it comes to quality assessment of the initial paediatric trauma care.
- A framework of 39 indicators was created to allow the analysis of the initial paediatric trauma care process from an integral perspective throughout the health care process, suggesting a future validation of the indicators using scientific consensus with the Delphi method.
- These quality indicators will allow the assessment of the quality of health care: detecting deficient areas, implementing new measures and assessing their impact with the primary aim of improving the quality of paediatric care.

2 | AIM

This study reviewed the evidence with a view to create indicators for the quality of initial paediatric trauma care throughout the whole health care process.

3 | METHODS

In the first phase, to obtain primary sources from which to take the indicators for the quality analysis, we carried out a systematic review, following the structure of an umbrella review proposed by the Joanna Briggs Institute, checking the final report with the PRISMA 2020 statement standards.

We used the research question 'What are the best indicators for assessing quality of care in initial paediatric trauma care in multi-trauma paediatric patients?' searching in the Cochrane Library, Medline, Scopus and SciELO databases for articles related to the conceptual groups in Table 1, which were published between 2010 and 2020 and written in either English or Spanish. The gap between review dates is justified by the lack of existing literature in the field of paediatric trauma quality noted by previous report.[11]

For the inclusion criteria, we took studies that examined quality or suggested indicators, official documents from prestigious organizations, training handbooks and clinical practice guidelines (CPGs) endorsed for their scientific evidence and rigour, investigations with a quantitative or mixed focus on quality and systematic reviews or meta-analyses, which dealt with the topic of study. Grey literature was excluded, as well as studies based solely on adult care and nonevidence-based CPGs. Developing countries were also excluded, because of particularities of their health systems, as well as socioeconomic characteristics that would not make the indicators extrapolatable to our environment.[12]

In the second phase, a reviewer carried out a critical reading of the articles, extracting indicators and assessing their quality using the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) approach.[13] The risk of bias was evaluated using the Cochrane collaboration bias assessment tool, version 5.1.0 (for scientific papers[14]), the AGREE-II instrument (for CPGs and reference documents) and the AGREE-HS (Health Systems tool for trauma care facility certification criteria or quality standards[15]). When indicators were not clearly defined in the article, the review team described the indicator based on the other available data.

The other two blind reviewers were tasked with evaluating the indicators, observing how they were adapted to clinical practice and grouping them according to both settings (prehospital care, hospital care or both) and Donabedian's model (structure, process or outcome). The reviewers compared both groups and the initial reviewer who resolved any disagreements.

Once the indicators were collected and grouped, a database was developed, in which the first reviewer then did a second reading and 'tagging' to bring together the different headings into a single category. This created the final set of indicators based on summarizing the results obtained from the evidence. Finally, these indicators were reviewed once again independently by the two other authors, this time focusing attention on writing style, the explanation files created (see Appendix A) and their proper classification.

TABLE 1 PubMed search criteria.

Concepts	Search terms
Paediatric	'child' [MeSH Terms] OR 'child*' [Title/Abstract] OR 'Kid' [Title/Abstract] OR 'Baby' [Title/Abstract] OR 'Babies' [Title/Abstract] OR 'infant' [MeSH Terms] OR 'infant*' [Title/Abstract] OR 'adolescent' [MeSH Terms] OR 'adolescen*' [Title/Abstract] OR 'teen*' [Title/Abstract] OR 'pediatrics' [MeSH Terms] OR 'pediatr*' [Title/Abstract] OR 'paediatr*' [Title/Abstract]
Trauma life support	'Advanced Trauma Life Support' [Title/Abstract] OR 'ATLS' [Title/Abstract] OR 'Trauma Life Support' [Title/Abstract] OR 'TLS' [Title/Abstract] OR 'Prehospital Trauma Life Support' [Title/Abstract] OR 'PHTLS' [Title/Abstract] OR 'International Trauma Life Support' [Title/Abstract] OR 'ITLS' [Title/Abstract] OR 'advanced trauma life support care' [MeSH Terms] OR 'trauma centers' [MeSH Terms]
Quality	'quality improvement' [MeSH Terms] OR 'performance improvement' [Title/Abstract] OR 'indicator*' [Title/Abstract] OR 'benchmark*' [Title/Abstract] OR 'employee performance appraisal' [MeSH Terms] OR 'quality indicators, health care' [MeSH Terms] OR 'benchmarking' [MeSH Terms]

4 | RESULTS

Out of 686 articles identified, 545 remained after applying language and date inclusion criteria. Upon reading the abstracts and applying the inclusion and exclusion criteria, 23 were deemed eligible, 445 as ineligible and 77 were questionable. Of these 77, 10 more were considered to be eligible (see Figure 1). The main reasons for exclusion were: not including paediatric multiple trauma patients, not assessing quality and not including indicators or recommendations for improvement. In the end, seven duplicates were removed and after consulting their references, a further two were added, as well as seven reference handbooks on the topic.

Of this total of 31, we calculated the risk of bias for 17 articles with the Cochrane tool (14 with a low risk and 3 with a high risk), 4 were analysed using the AGREE-II tool, 3 using AGREE-HS and 7 could not be determined because of the lack of tools to assess some of the methods. The majority of articles were published in 2019 (25%, $N = 17$) in the United States (54%, $N = 15$) and in the form of observational analysis studies (39%, $N = 17$; see Appendix B: Table B1 for further details).

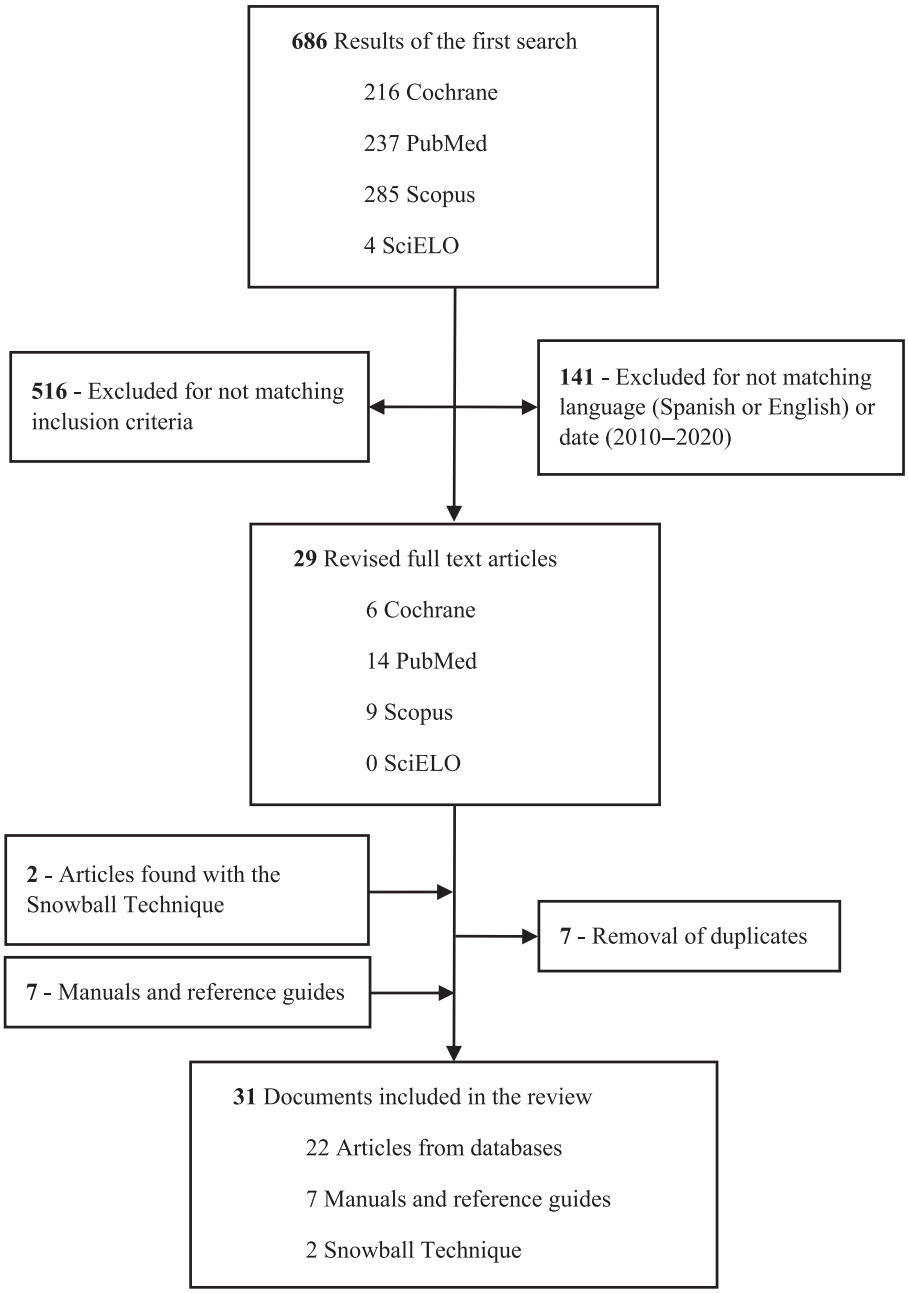

FIGURE 1 Article selection process.

From the article review, 543 indicators were extracted, grouped as follows: prehospital care ($N = 87$), hospital care ($N = 286$), both prehospital and hospital ($N = 170$). Following Donabedian's model: 'structure' ($N = 110$), 'process' ($N = 342$) and 'outcome' ($N = 91$). And finally, as per the GRADE scale: 213 as 'very low' quality, 235 as 'low' and 95 as 'moderate'. Within the prehospital care indicators, 17 were identified as structure, 202 as process and 28 as outcome. They were reduced to 5, 12 and 3, respectively, detailed in Table 2. Among hospital care indicators, there were 105 for structure, 270 for process and 81 for outcome, reducing to 4, 10 and 5, respectively, detailed in Table 3.

In summary, of the 31 initial articles, 28 contained primary indicators that allowed us to develop 39 indicators after a process of selection, synthesis and filtering.

5 | DISCUSSION

According to the most reliable evidence available, there is a gap and large variability when it comes to quality assessment of the initial paediatric trauma care. Regarding investigative quality, there were several descriptive and observational studies with varying sample sizes. As for the systematic reviews, the majority of articles contained a great deal of information, however, they also lacked both a risk of bias analysis and an indicator quality assessment. One positive aspect regarding the quality of the literature was that most publications were supported by influential scientific societies, which led to solid consensus on the indicators included in this study.

Regarding the usefulness of some of the indicators, there were a few discrepancies: mortality as a sole indicator to predict performance

TABLE 2 Prehospital care indicators.

Code	
Prehospital care structure indicators (PS)	
PS1	Hours of training in paediatric trauma undertaken by professionals in the prehospital care team.
PS2	Mobile units with the established necessary equipment to attend paediatric emergencies (of adequate size, organized, tested, not shared and strategically stored).
PS3	Number of professionals who consult the service's initial paediatric trauma care protocol.
PS4	Cases entered into the paediatric trauma register out of total paediatric trauma cases.
PS5	Transfers to the best equipped location for the patient according to service protocol.
Prehospital care process indicators (PP)	
PP1	Prehospital endotracheal intubations (ETIs) performed on patients meeting ETI criteria (A).
PP2	Ventilation with bag–valve–mask without ETI performed on patients meeting ETI criteria (B).
PP3	Life-threatening injuries detected during the primary survey, without equipment beyond monitoring (B).
PP4	Patients for whom two venous (or intraosseous) accesses have been achieved (C).
PP5	Complete prehospital care report in which all of the fields established by the service are filled out.
PP6	The prehospital care report includes the calculation of a level of consciousness scale (GCS, pGCS or AVPU) alongside a trauma score system (ISS, RTS, PRISM, TRISS or PTS).
PP7	Complete monitoring of the patient (RR, HR, SpO_2, ECG, BP and $ETCO_2$).
PP8	Patients who become hypothermic (less than or equal to 32°C) during prehospital transport.
PP9	Patients fitted with a cervical collar and head immobilizer because of a suspected cervical spine injury.
PP10	Immobilized patients with a spinal board with an occipital recess or with two elevations (2.5 cm) to support the head and back.
PP11	Prearrival notification (prewarning by the prehospital care service in 10 ± 2 min before arriving at the hospital).
PP12	Arrival time (isochronous) of the out-of-hospital services at the scene of the incident after notification.
Prehospital care outcome indicators (PO)	
PO1	Mortality adjusted to PTS.
PO2	Diagnostic correlation between prehospital care report and the emergency department discharge summary.
PO3	User and family satisfaction (satisfaction survey).

Abbreviations: AVPU, awake, verbal, pain, unresponsive; BP, blood pressure; ECG, electrocardiogram; $ETCO_2$, capnogram; ETI, endotracheal intubation; GCS, Glasgow Coma Scale; HR, heart rate; ICU, intensive care unit; ISS, Injury Severity Score; pGCS, Paediatric Glasgow Coma Scale; PRISM, Paediatric Risk of Mortality Score; PTS, Paediatric Trauma Score; RR, respiratory rate; RTS, Revised Trauma Score; SpO_2, oxygen saturation; TRISS, Trauma Injury Severity Score.

TABLE 3 Hospital care indicators.

Code	
Hospital care structure indicators (HS)	
HS1	Hours of training in paediatric trauma undertaken by professionals in the hospital care team.
HS2	Trauma bay at the emergency department with the established necessary equipment to attend paediatric emergencies (of adequate size, organized, tested, not shared and strategically stored).
HS3	Number of professionals who consult the department's IPTC protocol.
HS4	Cases entered into the paediatric trauma register out of total paediatric trauma cases.
Hospital care process indicators (HP)	
HP1	Time between arrival and massive transfusion administration.
HP2	Time between arriving and performing a CT scan in patients with TBI and a Glasgow score <13.
HP3	Underestimation of severity in hospital triage.
HP4	Overestimation of severity in hospital triage.
HP5	Complete discharge summary from the emergency department in which all of the fields established by the department are filled out.
HP6	The discharge summary from the emergency department includes the calculation of the level of consciousness (e.g., the GCS) scale alongside a trauma score system (ISS, RTS, PRISM, TRISS or PTS).
HP7	Time between arrival and entering the operating theatre.
HP8	Complete monitoring of the patient (RR, HR, SpO_2, ECG, BP and $ETCO_2$).
HP9	Time between arrival and admission to the ICU.
HP10	Time between arrival and secondary transport to another health care facility.
Hospital care outcome indicators (HO)	
HO1	Mortality adjusted to PTS.
HO2	Length of stay adjusted to PTS.
HO3	User and family satisfaction (satisfaction survey).
HO4	Length of stay in the ICU.
HO5	Readmission of the patient to the emergency department.

Abbreviations: BP, blood pressure; CT scan, computed tomographic scan; ECG, electrocardiogram; $ETCO_2$, capnogram; GCS, Glasgow Coma Scale; HR, heart rate; ICU, intensive care unit; ISS, Injury Severity Score; PRISM, Paediatric Risk of Mortality Score; PTS, Paediatric Trauma Score; RR, respiratory rate; RTS, Revised Trauma Score; SpO_2, oxygen saturation; TBI, traumatic brain injury; TRISS, Trauma Injury Severity Score.

in other aspects, prehospital management of airway compromise comparing endotracheal intubation versus bag–valve–mask ventilation or staff training and education as a positive aspect when establishing QIs. Nevertheless, there were, more importantly, convergence points found in the articles, such as those regarding the use of immobilization techniques or the importance of documentation and writing reports. Many indicators used time as a tool to measure quality, by monitoring

the mean process duration time (more exploratory) or the percentage of processes that use a fixed period of time (easier to interpret[7,11,16]).

There were some difficulties when establishing indicators regarding paediatric supplies and staffing in paediatric trauma care teams as the recommendations refer to the US model of Paediatric Trauma Centres (PTCs[3,17]). There was also an issue regarding the lack of effectiveness when analysing certain indicators, such as errors, the assessment of techniques or interventions that do not appear in the reports or the very specific indicators that focus on a specific type of condition. However, indicators related to long-term functional outcomes had to be excluded from our indicator framework, as it is very complex to calculate them. There was also variation when objectively analysing trauma severity using scaled trauma severity indices. In our case, we recommend the Paediatric Trauma Score (PTS) by Tepas et al.[18] for the investigation settings, as it was one of the most utilized during categorization. Other indicators required defined clinical criteria in order to be assessed, such as suspected cervical spine injury or the need for a massive blood transfusion or endotracheal intubation. In the future, there should be an agreed set of common criteria when calculating indicators.

It's important to emphasize that all the studies included in our review analyse the quality of the techniques, care and competencies used by the multidisciplinary team in initial paediatric trauma care. Although they might be not nurse focused, all of these skills are part of the nursing competency framework, reflecting their fundamental role in maximizing quality in the management of the polytraumatized child.

Finally, we found existing literature that also contained reviews of QIs in trauma care, such as Stelfox et al.,[11] who followed a rigorous methodology, but many of the results were not operative. Pham et al.[19] did detail the indicators in greater depth, they were structured in a confusing, less visual way. McCarthy et al.[20] analysed trauma care systems and other health outcomes in an appropriately structured way, and the results were published with the prehospital and hospital settings as separate aspects, as in our study. In the Spanish context, we found the SEUP (2018) indicator guidelines. This source focused on paediatric emergency services.[16]

5.1 | Limitations

Most of the analysed studies were carried out in the United States, a context in which trauma care is more developed on a care level. For this reason, further studies will be apt to test the validity of the indicators in the context of other developed countries, equal to those countries that provided the most evidence for our study. There were also no articles found that discussed quality assessment from the perspective of gender, nor any evaluating how family members are treated, nor prevention methods: all of which would also be potential opportunities for future study.

Many of the paediatric recommendations and indicators found in the literature, although not treated together, were based on an adaptation of the QIs of trauma care in the adult population. Ideally, they should have been developed through quality studies focusing exclusively on the paediatric population. To minimize the problem, attention was paid to the differences of the paediatric patient in order to encompass the paediatric care practice particularities in the indicators.

In the literature review, there may have been an article or indicator that was missed, as well as subtleties that may have been lost during translation. Regarding article quality, some articles lacked sufficient methodological information, and the majority of them were retrospective in nature. Despite being decided in blind review, the methodology was based on the criteria and experience of the authors, meaning that this process could not be completely objective. To offset these issues, it would be interesting to use the Delphi method to validate the indicators through expert consensus.

6 | RELEVANCE TO NURSING MANAGEMENT AND CLINICAL PRACTICE

This study has created an indicator framework to be used, either in part or in its entirety and by any interested person, to analyse the quality of the initial trauma care in paediatrics. To make implementing indicators into the auditing process easier, we have created explanatory tables that detail the formula, data sources, dimensions, term explanations, etc. Using these indicators in quality analysis allows us to measure the degree to which prehospital and hospital trauma care teams apply collected evidence-based recommendations to, in the majority of cases, trauma care protocols.

Indicators let us assess quality before and after applying any interventions to study the effectiveness of the measure. Its application, throughout the health care process, will make it possible to detect deficiencies and areas to focus improvement efforts into, as well as compare different trauma care systems in terms of quality of care. This will not only make sharing information between health care facilities possible but also research that goes beyond just one health care facility, allowing for quality assessment on a community or even state level.

The formulated indicators analyse the execution of care throughout paediatric trauma care and depend entirely on its execution by the nursing staff. The nurse, in his/her research role, is a suitable professional to lead quality analysis and improvement projects, as he/she is familiarized with the target patient and participates throughout the entire care process.

In summary, establishing indicators is the first step in being able to assess the quality of health care: detecting deficient areas, implementing new measures and assessing their impact with the primary aim of improving the quality of paediatric care.

7 | CONCLUSIONS

As a result of the review, selection, translation and composition processes, we have created a framework of 39 indicators that allow for analysis of the initial paediatric trauma care process from an integral

perspective throughout the health care process. This has allowed us to reach our overall objective and confirm that there are appropriate indicators to assess quality. During this process, we studied the most frequently used indicators in quality assessment, the divergence points and the common factors.

Regarding the methodology of the publications, the majority of them were multicentre descriptive or analytical observational studies with varying sample sizes. Handbooks and guidelines endorsed by prestigious scientific organizations were also taken into consideration. In terms of the validity and reliability of the indicators, we analysed the risk of bias and the quality of the studies as much as possible.

Therefore, we suggest that future studies continue to explore the validation of the indicators using scientific consensus both in prehospital and hospital settings in line with the Delphi method, in order to establish objective, valid and reliable indicators. We will be supported in this process by existing multidisciplinary research networks belonging to scientific societies related to paediatric trauma. As a result of this process, it will be possible to adapt the indicators to our context and the needs of the professionals who work with these patients on a daily basis.

AUTHOR CONTRIBUTIONS

Pablo Buck Sainz-Rozas was involved in bibliographic review, data interpretation, indicators elaboration, drafting the article and discussion of the final version. Pablo García Molina and Carmen Casal Angulo were involved in conception and study design, methods design, revising article critically for important intellectual content and final approval of the manuscript. All authors approved the final version to be published.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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REFERENCES

1. EuroSafe—European Association for Injury Prevention and Safety Promotion. *Injuries in the European Union. Summary of Injury Statistics for the Years 2012-2014*. EuroSafe—European Association for Injury Prevention and Safety Promotion; 2016:14.
2. Lluna González J, Aragó Domingo MD, Fernández Gallego V, García-Sala Viguer C, Lluna González J, Vázquez Estévez JJ. *Asistencia Inicial al Trauma Pediátrico (AITP) (Tercera)*. Arán; 2017.
3. American College of Surgeons. *Soporte Vital Avanzado en Trauma (ATLS). Manual del curso para estudiantes*. 10th ed. American College of Surgeons; 2018.
4. Global Burden of Diseases Pediatric Collaboration. Global and national burden of diseases and injuries among children and adolescents between 1990 and 2013: findings from the global Burden of disease 2013 study. *JAMA Pediatrics*. 2014;170:263-283. doi:10.1001/jamapediatrics.2015.4276
5. Instituto Nacional de Estadística. *Defunciones en 2020 por causas, sexo y edad*. 2021. https://www.ine.es/jaxi/Tabla.htm?tpx=49913&L=0
6. Domínguez Sampedro P, Cañadas Palazón S, de Lucas García N, Balcells Ramírez J, Martínez Ibáñez V. Asistencia inicial al traumatismo pediátrico y reanimación cardiopulmonar. *Anales de Pediatría*. 2006; 65(6):586-606. doi:10.1016/S1695-4033(06)70255-7
7. World Health Organization, International Society of Surgery, & International Association of Trauma Surgery and Intensive Care. *Guidelines for trauma quality improvement programmes*. World Health Organization; 2009.
8. Institute of Medicine (US) Committee on Quality of Health Care in America, Kohn LT, Corrigan JM, Donaldson MS. *To Err Is Human: Building a Safer Health System*. National Academies Press (US); 2000. doi:10.17226/9728
9. Institute of Medicine (US) Committee on Quality of Health Care in America. *Crossing the Quality Chasm: A New Health System for the 21st Century*. National Academies Press (US); 2001. doi:10.17226/10027
10. Institute of Medicine (US) Committee on Assessing the System for Protecting Human Research Subjects. *Preserving Public Trust: Accreditation and Human Research Participant Protection Programs*. National Academies Press (US); 2001. doi:10.17226/10085
11. Stelfox HT, Bobranska-Artiuch B, Nathens A, Straus SE. A systematic review of quality indicators for evaluating pediatric trauma care. *Crit Care Med*. 2010;38(4):1187-1196. doi:10.1097/CCM.0b013e3181d455fe
12. Mock C, Lormand JD, Goosen J, Joshipura M, Peden M. *Guidelines for Essential Trauma Care*. World Health Organization; 2004.
13. Coello PA. 4. La confianza en los resultados de la investigación y el sistema GRADE. *Quaderns de la Fundació Dr. Antoni Esteve*. 2013;26: 25-32. https://raco.cat/index.php/QuadernsFDAE/article/download/278679/366424/
14. Centro Cochrane Iberoamericano, traductores. *Manula Cochrane de Revisiones Sistemáticas de Intervenciones, versión 5.1.0 [Actualizada en marzo 2011] [Internet]*. Centro Cochrane Iberoamericano; 2012 http://www.cochrane.es/?q=es/node/269
15. Brouwers MC, Kho ME, Browman GP, et al. AGREE II: advancing guideline development, reporting and evaluation in health care. *Can Med Assoc J*. 2010;182(18):E839-E842. doi:10.1503/cmaj.090449
16. González Hermosa A, Benito Fernández FJ, Fernández Elías M, González Peris S, Luaces Cubells C, Velasco Zúñiga R. *Indicadores de Calidad SEUP. Revisión 2018*. Ergon Creación S.A; 2018. https://www.aeped.es/sites/default/files/mejora_indicadores.pdf
17. American College of Surgeons & Committee on Trauma. *Resources for Optimal Care of the Injured Patient*. American College of Surgeons, Committee on Trauma; 2014.
18. Tepas JJ, Mollitt DL, Talbert JL, Bryant M. The pediatric trauma score as a predictor of injury severity in the injured child. *J Pediatr Surg*. 1987;22(1):14-18. doi:10.1016/s0022-3468(87)80006-4
19. Pham T, Simpson A, Rivara F. Quality care in pediatric trauma. *Int J Crit Illn Inj Sci*. 2012;2(3):149-155. doi:10.4103/2229-5151.100893
20. McCarthy A, Curtis K, Holland AJA. Paediatric trauma systems and their impact on the health outcomes of severely injured children: an integrative review. *Injury*. 2016;47(3):574-585. doi:10.1016/j.injury.2015.12.028
21. Jayaraman S, Sethi D, Wong R. Advanced training in trauma life support for ambulance crews. *Cochrane Database Syst Rev*. 2014;8: CD003109. doi:10.1002/14651858.CD003109.pub3
22. Merriel A, Ficquet J, Barnard K, et al. The effects of interactive training of healthcare providers on the management of life-threatening emergencies in hospital. *Cochrane Database Syst Rev*. 2019;9: CD012177. doi:10.1002/14651858.CD012177.pub2
23. Slaar A, Fockens M, Wang J, et al. Triage tools for detecting cervical spine injury in pediatric trauma patients. *Cochrane Database Syst Rev*. 2017;12:CD011686. doi:10.1002/14651858.CD011686.pub2

24. Kwan I, Bunn F, Chinnock P, Roberts I. Timing and volume of fluid administration for patients with bleeding. *Cochrane Database Syst Rev*. 2014;3:CD002245. doi:10.1002/14651858.CD002245.pub2
25. Cooper CG, Santana MJ, Stelfox HT. A comparison of quality improvement practices at adult and pediatric trauma centers. *Pediatric Crit Care Med*. 2013;14(8):e365-e371. doi:10.1097/PCC.0b013e3182917a4c
26. Ahmed OZ, Yang S, Farneth RA, Sarcevic A, Marsic I, Burd RS. Association between prearrival notification time and advanced trauma life support protocol adherence. *J Surg Res*. 2019;242:231-238. doi:10.1016/j.jss.2019.03.032
27. Webman RB, Fritzeen JL, Yang J, et al. Classification and team response to nonroutine events occurring during pediatric trauma resuscitation. *J Trauma Acute Care Surg*. 2016;81(4):666-673. doi:10.1097/TA.0000000000001196
28. El-Shafy IA, Delgado J, Akerman M, Bullaro F, Christopherson NAM, Prince JM. Closed-loop communication improves task completion in pediatric trauma resuscitation. *J Surg Educ*. 2018;75(1):58-64. doi:10.1016/j.jsurg.2017.06.025
29. Sathya C, Burd RS, Nance ML, et al. Concordance of performance metrics among US trauma centers caring for injured children. *J Trauma Acute Care Surg*. 2015;79(1):138-146. doi:10.1097/TA.0000000000000678
30. Ma LW, Hatchimonji JS, Kaufman EJ, Sharoky CE, Smith BP, Holena DN. Failure to rescue as a center-level metric in pediatric trauma. *Surgery*. 2019;165:1116-1121. doi:10.1016/j.surg.2019.03.004
31. Curtis K, Kennedy B, Holland AJA, et al. Identifying areas for improvement in paediatric trauma care in NSW Australia using a clinical, system and human factors peer-review tool. *Injury*. 2019;50(5):1089-1096. doi:10.1016/j.injury.2019.01.028
32. Davidson GH, Maier RV, Arbabi S, Goldin AB, Rivara FP. Impact of operative intervention delay on pediatric trauma outcomes. *J Trauma Acute Care Surg*. 2012;73(1):162-167. doi:10.1097/TA.0b013e31825699b4
33. Ibáñez Pradas V, Pérez Montejano R. Calidad asistencial en la atención inicial al trauma pediátrico. *Anales de Pediatría*. 2017;87(6):337-342. doi:10.1016/j.anpedi.2017.02.007
34. Jensen AR, McLaughlin C, Subacius H, et al. Simulation-based training is associated with lower risk-adjusted mortality in ACS pediatric TQIP centers. *J Trauma Acute Care Surg*. 2019;87(4):841-848. doi:10.1097/TA.0000000000002433
35. Polovitch S, Muertos K, Burns A, Czerwinski A, Flemmer K, Rabon S. Trauma nurse leads in a level I trauma center: roles, responsibilities, and trauma performance improvement outcomes. *J Trauma Nurs*. 2019;26(2):99-103. doi:10.1097/JTN.0000000000000431
36. Fendya DG, Snow SK, Weik TS. Using system change as a method of performance/quality improvement for emergency and trauma care of severely injured children: pediatric system performance improvement. *J Trauma Nurs*. 2010;17(1):28-33; quiz 34-35. doi:10.1097/JTN.0b013e3181d9155c
37. Allen CJ, Wagenaar AE, Horkan DB, et al. Predictors of mortality in pediatric trauma: experiences of a level 1 trauma center and an assessment of the International Classification Injury Severity Score (ICISS). *Pediatr Surg Int*. 2016;32:657-663. doi:10.1007/s00383-016-3900-7
38. Vachon CM, Aaland M, Zhu TH. Readmission of trauma patients in a nonacademic level II trauma center. *J Trauma Acute Care Surg*. 2012;72(2):531-536. doi:10.1097/TA.0b013e3182326172
39. National Association of Emergency, American College of Surgeons Committee on Trauma, Campos V, Garcia Roig F. *PHTLS soporte vital de trauma preshospitalario*. Jones & Bartlett Learning; 2020.
40. Dietrich AM, Shaner S, Campbell J. *Pediatric Trauma Life Support: For Prehospital Care Providers*. International Trauma Life Support; 2009.

How to cite this article: Buck Sainz-Rozas P, Casal Angulo C, García Molina P. Quality assessment in initial paediatric trauma care: Systematic review from prehospital care to the paediatric intensive care unit. *Nurs Crit Care*. 2023;1-11. doi:10.1111/nicc.12970

APPENDIX A: SAMPLE OF THE EXPLANATION FILE ABOUT ONE OF THE INDICATORS

PP6/HP6	Prehospital care report/discharge summary from the emergency department that includes the calculation of the level of consciousness (e.g., the AVPU) scale alongside a trauma score system (ISS, RTS, PRISM, TRISS or PTS).
Quality (GRADE)	Moderate
Dimension	Effectiveness, adaptation, risk, continuity.
Rationale	The trauma scores that have been used for over 40 years are an extremely useful tool both in clinical and investigative contexts. Anatomical scales are good at both measuring the severity of patient injuries and predicting outcomes. Physiological scales measure the dynamic components after trauma, with a huge impact on the prognosis of trauma patients.
Formula	$\frac{\text{Reports on the Population} \times \text{that include a level of consciousness scale} + \text{TSI}}{\text{Total reports on the Population}*} \times 100$
Explanation of terms	*The Glasgow Coma Scale (GCS)* allows health care professionals in several settings and various levels of training to communicate about the mental state of a patient. It has been shown to have a statistical correlation with a wide range of adverse neurological outcomes, including brain lesions, the need to brain surgery and mortality (Borgialli et al., 2016). *The Paediatric Glasgow Coma Scale (pGCS)* allows health care professionals to obtain, track and communicate the mental state and level of consciousness of preverbal children (<2 years of age, although this can vary depending on the consulted literature) (Borgialli et al., 2016). *The AVPU Score* is useful to rapidly grade a patient's gross level of consciousness: Awake, Verbal, Pain, Unresponsive. *The Paediatric Trauma Score (PTS/ITP)*: This paediatric trauma assessment system is made up of six items: three describing anatomical problems and the other three describing functional abnormalities. Each component has a value assigned to it, and the score is the algebraic sum of each value. The prognosis varies by the score, increasing in mortality as the PTS decreases to below 8 points.[18] *The Paediatric Risk of Mortality (PRISM) score* was developed from the physiologic stability index (PSI) to reduce the number of physiologic variables required for paediatric ICU (PICU) mortality risk assessment. The resulting PRISM score consists of 14 routinely measured variables in all PICUs on admission day. Data was assessed using logistic regression analysis, demonstrating excellent predictor performance (area under the ROC curve = 0.92; Pollack et al., 1988). *Other adult-centred scales*: the Injury Severity Score (ISS), the Revised Trauma Score (RTS) and the TRISS (the Trauma and Injury Severity Score).
Population*	Paediatric trauma patients
Type	Process
Data source	Prehospital care report/discharge summary from the emergency department
Standard	100%
References	Borgialli DA, Mahajan P, Hoyle JD, et al. Performance of the pediatric Glasgow coma scale score in the evaluation of children with blunt head trauma. *Acad Emerg Med*. 2016;23(8):878-884. doi:https://doi.org/10.1111/acem.13014 Pollack MM, Ruttimann UE, Getson PR. Pediatric risk of mortality (PRISM) score. *Crit Care Med*. 1988;16(11):1110-1116. doi:https://doi.org/10.1097/00003246-198811000-00006 Tepas JJ, Mollitt DL, Talbert JL, et al. The pediatric trauma score as a predictor of injury severity in the injured child. *J Pediatr Surg*. 1987;22(1):14-18. doi:https://doi.org/10.1016/s0022-3468(87)80006-4

The asterisk completes the definition of 'Population'. The formula includes the entire population, which in this case is 'paediatric trauma patients'.

APPENDIX B

TABLE B1 Description of the articles included in the review which included indicators.

Source	Context	Type	Bias	Objectives	ST	PR	OU
Advanced training in trauma life support for ambulance crews[21]	Multicentre	Cochrane systematic review	Low risk	To compare mortality and morbidity outcomes of victims of trauma treated by ambulance crews with ALS training to outcomes of those treated by crews without ALS training.	2	0	0
The effects of interactive training … on the management of life-threatening emergencies …[22]	Multicentre	Cochrane systematic review	High risk	To find out if health care workers who work in hospitals and receive training where they can interact with learning materials and other workers give better health care during emergency situations.	6	0	0
Triage tools for detecting cervical spine injury in pediatric trauma patients[23]	Multicentre	Cochrane systematic review	Low risk	To determine the diagnostic accuracy of the NEXUS criteria and the Canadian C-spine Rule in a paediatric population evaluated for CSI following blunt trauma.	0	2	0
Spinal immobilisation for trauma patients[24]	Multicentre	Cochrane systematic review	High risk	To compare different immobilization strategies on trauma patients with suspected spinal cord injury.	0	3	0
A Comparison of Quality Improvement Practices at Adult and Pediatric TCs[25]	USA Canada Australia	Prospective observational study	Low risk	To compare quality improvement practices at adult and paediatric trauma centres.	2	22	7
Association Between Prearrival Notification and ATLS Protocol Adherence[26]	WA-DC USA	Prospective observational study	Low risk	To analyse the association between prearrival notification and ATLS protocol adherence.	0	2	0
Classification and team response to nonroutine events[27]	WA-DC USA	Therapeutic study	Low risk	To identify errors of any type during paediatric trauma resuscitation and evaluate team responses to their occurrence.	0	2	0
Closed-Loop Communication Improves Task Completion in PTR[28]	NY USA	Prospective observational study	Low risk	To evaluate the ability of closed-loop communication to improve time-to-task completion in paediatric trauma activations.	0	2	0
Concordance of performance metrics among US TCs caring for injured children[29]	USA	Retrospective observational study	Low risk	To evaluate whether centre performance in one area of quality predicted similar performance in other areas of quality.	0	0	3
Failure to rescue as a center-level metric in pediatric trauma[30]	USA	Retrospective cohort study	Low risk	To define the relationship between rates of mortality, complications and failure-to-rescue at centres caring for paediatric trauma patients in the NTDB.	0	1	3
Identifying areas for improvement in paediatric trauma care in NSW Australia[31]	NSW, Australia	Retrospective observational study	Low risk	To review paediatric trauma cases across the most populous Australian State to identify factors contributing to clinical incidents.	1	0	0
Impact of operative intervention delay on pediatric trauma outcomes[32]	USA	Therapeutic case–control study	Low risk	To ascertain whether timing of craniotomy, ICP monitoring for traumatic brain injury and abdominal operation for solid organ injury correlates with other quality indicators.	0	3	0
Paediatric trauma systems and their impact on the health outcomes …[20]	Multicentre	Integrative review	Indet.	To review the processes of care and describe the impacts of a regionalized trauma system on the outcomes of severely injured children.	0	5	1
Calidad asistencial en la AITP[33]	Valencia, Spain	Retrospective cohort study	High risk	Assess a paediatric trauma training programme on the quality of paediatric trauma care.	0	5	0
Simulation-based training is associated with lower risk-adjusted mortality …[34]	USA	Therapeutic cross-sectional study	Low risk	To determine if the use of simulation-based training for trauma resuscitation (using a survey) is associated with improved performance (using clinical data from the ACS TQIP registry).	1	8	1

TABLE B1 (Continued)

Source	Context	Type	Bias	Objectives	ST	PR	OU
Trauma Nurse Leads in a Level I Trauma Center …[35]	SC USA	Retrospective observational study	Low risk	To assess a Trauma Nurse Lead programme to allow for consistent, expert clinical nursing care across the trauma continuum.	1	6	3
Pediatric System Performance Improvement[36]	USA	Panel of experts	Indet.	To develop performance measures in paediatric emergency care.	8	2	0
Predictors of mortality in pediatric trauma[37]	Miami, USA	Therapeutic cross-sectional study	Low risk	To compare the predictive value of the ICISS to expert consensus-derived scoring systems for trauma mortality in a paediatric population.	0	2	0
Readmission of trauma patients in a non-academic Level II TC[38]	ND, USA	Retrospective observational study	Low risk	To determine the rate, cause and preventability for readmission and to identify predictors of readmission in a non-academic trauma centre.	0	0	1
A systematic review of quality indicators for evaluating PTC[11]	Multicentre	Integrative review	Indet.	To systematically review the literature on quality indicators for evaluating paediatric trauma care.	6	85	40
Quality care in pediatric trauma[19]	Multicentre	Integrative review	Indet.	To identify key quality indicators for all phases of care in paediatric trauma.	1	7	10
Resources for Optimal Care of the Injured Patient[17]	USA	Certification guide	Yes, with mods.[a]	Develop and certify a paediatric trauma care system (specific chapter).	41	1	2
Guidelines for trauma quality improvement programmes[7]	Worldwide	Recommendation guide	Yes, with mods.[a]	Focus on the ways in which medical care institutions can implement quality improvement programmes aimed at strengthening care.	2	19	8
Indicadores de calidad SEUP[16]	Spain	Indicator guide	Yes[a]	Provide all sectors involved in caring for children with urgent pathologies with a way of analysing the adaptability of care.	12	26	9
Soporte Vital Avanzado en Trauma[3]	USA	Course handbook	Yes, with mods. 5/7[b]	Offer an easy-to-remember focus so that any medical staff can assess and treat the trauma patient.	9	63	1
Prehospital Trauma Life Support[39]	USA	Course handbook	Yes, with mods. 4/7[b]	Constitute a more comprehensive and recognized source of information for techniques and knowledge surrounding prehospital trauma care.	1	23	0
Pediatric Trauma Life Support[40]	USA	Course handbook	Yes, with mods. 4/7[b]	Gather the special needs of young trauma patients.	1	5	0
Asistencia Inicial al Trauma Pediátrico[2]	Spain	Course handbook	Yes 5/7[b]	Develop the theoretical content of the paediatric trauma care courses.	17	48	1

Abbreviations: ACS TQIP, American College of Surgeons Trauma Quality Improvement Program; ALS, advanced life support; ATLS, advanced trauma life support; COT-ACS, Committee on Trauma—American College of Surgeons; CSIs, cervical spine injuries; ICISS, International Classification of Disease Injury Severity Score; ICP, intracranial pressure; Indet., indeterminable; Mods., modifications; NTDB, National Trauma Data Bank; OU, outcome indicators provided; PR, process indicators provided; PTC, paediatric trauma care; SEUP, Spanish Society of Paediatric Emergencies; ST, structure indicators provided; TC, trauma centre.

[a]The AGREE-HS was used.

[b]The AGREE-II was used.