

BMJ Open Effectiveness of trauma care systems at different stages of development in reducing mortality: a systematic review and meta-analysis protocol

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To cite: Alharbi RJ, Lewis V, Shrestha S, *et al.* Effectiveness of trauma care systems at different stages of development in reducing mortality: a systematic review and meta-analysis protocol. *BMJ Open* 2021;**11**:e047439. doi:10.1136/bmjopen-2020-047439

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2020-047439>).

Received 28 November 2020
Accepted 18 May 2021



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ABSTRACT

Introduction The introduction of trauma systems that began in the 1970s resulted in improved trauma care and a decreased rate of morbidity and mortality of trauma patients. Worldwide, little is known about the effectiveness of trauma care system at different stages of development, from establishing a trauma centre, to implementing a trauma system and as trauma systems mature. The objective of this study is to extract and analyse data from research that evaluates mortality rates according to different stages of trauma system development globally.

Methods and analysis The proposed review will comply with the checklist of the 'Preferred reporting items for systematic review and meta-analysis'. In this review, only peer-reviewed articles written in English, human-related studies and published between January 2000 and December 2020 will be included. Articles will be retrieved from MEDLINE, EMBASE and CINAHL. Additional articles will be identified from other sources such as references of included articles and author lists. Two independent authors will assess the eligibility of studies as well as critically appraise and assess the methodological quality of all included studies using the Cochrane Risk of Bias for Non-randomised Studies of Interventions tool. Two independent authors will extract the data to minimise errors and bias during the process of data extraction using an extraction tool developed by the authors. For analysis calculation, effect sizes will be expressed as risk ratios or ORs for dichotomous data or weighted (or standardised) mean differences and 95% CIs for continuous data in this systematic review.

Ethics and dissemination This systematic review will use secondary data only, therefore, research ethics approval is not required. The results from this study will be submitted to a peer-review journal for publication and we will present our findings at national and international conferences.

PROSPERO registration number CRD42019142842.

INTRODUCTION

Traumatic injury is a major health problem for all age groups.^{1 2} It is responsible for the deaths of more than five million people each year,³ with 90% of the fatal injury burden occurring in low-income to middle-income countries.^{4 5} However, the burden

Strengths and limitations of this study

- We report this protocol in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols 2015 statement.
- The study inclusion criteria will enable the systematic review to highlight the effectiveness of continual adaptation and development of trauma system on patient mortality.
- We have chosen not to review literature published before 2000 because clinical healthcare and systems have changed rapidly in the last three decades.
- This review will include primary studies involving trauma patients and people of all ages, gender, ethnicity, as well as any cause of injury.

of traumatic injury has been reduced since the introduction of trauma systems in many developed regions worldwide, including North America,^{6 7} Europe,^{8 9} Asia,^{10 11} and Oceania.^{6 12}

Trauma care systems represent a structured, multidisciplinary response to the injury and its prevention through the continuum of care that seeks to return those affected to their preinjury status. The trauma system is defined as network cooperation in a geographical area to plan, provide and manage injuries across all aspects of trauma care services from injury prevention to rehabilitation services.¹³ This network comprises trauma service providers, typically including prehospital, in-hospital and rehabilitation services, as well as injury prevention and quality assurance programmes.¹³ In this protocol and proposed review, a designated trauma centre/major trauma centre is defined as a multispecialty hospital that provides different levels of care for trauma patients. Establishing trauma centres is often the first stage of development of a trauma system. Once a trauma system has been established, it is generally acknowledged that it takes years for a system to be



mature and an established aspect of the overall health-care system,¹⁴ although there is no agreed definition of a mature trauma system.¹⁵ Thus, it is suggested that there are broadly three levels of trauma system development; establishment of a trauma centre, establishment of a trauma system maturation of the trauma system.

Trauma care systems have been introduced in many developed countries. In the USA, development of a trauma system was initiated in the early 1970s by the American College of Surgeons' Committee on Trauma (ASC-COT). The ASC-COT criteria for classification of trauma care facilities denotes a level I trauma centre as providing the highest level of trauma care and level IV trauma facilities providing less trauma care for injured people.¹⁶ The Canadian trauma system was first established in early 1990 in Quebec province.¹⁷ Similar to the US system, hospital trauma care in Canada consists of different levels of trauma centres ranging from level I to level IV. Australia is comprised of states and territories with each operating its own trauma system; the New South Wales' trauma system was first established in 1991¹⁸ followed by the South Australian Trauma System in 1997.¹⁹ In Europe, specifically in Utrecht, Netherlands, the trauma system was implemented in 1999²⁰ and in England, UK the regionalisation trauma system was introduced in 2012.²¹ The term 'major trauma centre' is commonly used in the UK and Australian health systems to refer to the highest level of trauma care facility that can manage all types of injuries.

The majority of trauma systems in developed countries provide features including prehospital and retrieval services, prehospital triage and protocols for transfer, acute care services (designated trauma services) and integration of rehabilitation services. Furthermore, the systems also comprise social components including injury prevention programmes, ongoing education and training, research, quality management, planning, legislation, technology development, and funding.

Evidence suggests that the implementation of trauma systems has improved functional and quality-of-life outcomes for major trauma patients, and mortality and morbidity has reduced.^{11 22 23} The literature has highlighted noteworthy differences in the characteristics of trauma care systems,^{14 24} but there has not been any consideration of the clinical outcomes associated with the different stages in the development of trauma systems. The result of this study that it is anticipated will highlight the effectiveness of continual adaptation and development of trauma care system on patient mortality. These results may encourage governments, non-government agencies and healthcare providers involved in developing trauma system to continually refine the systems and support ongoing government investment in system development

A preliminary search was conducted to identify any existing or ongoing systematic reviews on the topic through MEDLINE, EMBASE, CINAHL and PROSPERO. One systemic review was found that was published in 2006

and was limited to review studies from North America countries only.²⁴ A second study was published in 2018 included evidence of the impact of individual components of the trauma system structure such as prehospital care and definitive care on injury outcomes including mortality, healthcare utilisation and disability.¹⁴ Overall, the study found that the mortality rate of injured patients has reduced following the establishment of the trauma systems.¹⁴

A revised systematic review is proposed that it will have inclusion criteria that are broader than the previous systematic review.¹⁴ For example, the proposed systematic review will include studies that compare outcomes of trauma centres and non-trauma centres to statistically assess mortality rates for the two groups. Furthermore, this review will enable the inclusion of more recent evidence and will also review studies from all countries, unlike the 2006 systematic review²⁴ that was limited to studies from the USA and Canada. No other existing or ongoing systematic reviews similar to our approach were found.

Furthermore, unlike the previous study,¹⁴ this literature review of trauma related mortality will contrast three stages of development of a trauma system. The first stage is when a country establishes a trauma centre. This review will group studies that compare mortality rates in trauma centres and non-trauma centres. The second stage is when a country creates the network cooperation essential to establish a trauma system. This review will also describe a third stage; the period following initial establishment and when the system is operating in a stable way. Noting that there is no agreed definition in the literature for system maturation,¹⁵ the operational definition of system maturation for the purpose of this review is any further timepoint (without restriction) beyond the initial system formation. Therefore, studies that report data from any post system implementation period to evaluate progressive improvements over time will be considered as mature trauma system studies. In the analysis, duration of time will be extracted and considered. This review will consider whether there is evidence that trauma systems continue to improve outcomes as they mature.

OBJECTIVE

This systematic review will aid understanding of the effectiveness of trauma care systems at different stages of development in reducing mortality by addressing the question: Does trauma-related mortality rates vary according to the different stages of trauma system development and maturation? The objective of this review is to systematically review recent research about trauma-related mortality rates and the stages of system development from trauma centres, to formative and then mature trauma systems. This protocol outlines the method for the planned systematic review and meta-analysis.

METHODS AND ANALYSIS

Protocol and registration

This review has been registered in the International Prospective Register of Systematic Reviews (PROSPERO). Although the systematic review has been registered in PROSPERO under title 'The effectiveness of trauma care systems to reduce mortality: a systematic review and meta-analysis' we have submitted an update request (November 2020) to the systematic review record with minor amendments to match with this protocol.

We report this protocol following the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) 2015 statement²⁵ (see online supplemental appendix 1, PRISMA-P checklist). The proposed study will also be reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) checklist for systematic reviews.²⁶

Eligibility criteria

This review will include primary studies involving trauma patients and people of all ages, gender, ethnicity, as well as any cause of injury such as road trauma, falls, struck by or collision with object or person and cutting or piercing, where the latter is defined as 'injury caused by a cutting and piercing instrument or object'.²⁷ This systematic review will include only quantitative study designs, for example, controlled and non-controlled before and after studies, and prospective and retrospective cohort studies.

The planned review will only include studies with sufficient data to perform analyses and to calculate ORs and effect sizes; therefore, studies with insufficient data will be excluded. All severity of injuries from relatively minor to severe as well as stable and unstable injured patients will be included. Studies focused on single types of injuries, such as pelvic injury or whiplash injury, will be excluded from this study to generalise the result. Studies which deal with 'trauma' as a whole will be included as well as studies that focus on three or more injury types. Furthermore, in terms of system maturation, we will exclude any study that focuses on any specific modification of system or adaptation within the system rather than focusing on the whole system comparison. Articles without available full text will be excluded, as well as studies that do not report on original research, such as opinion pieces. Furthermore, studies will be excluded if they report on research conducted in the same period and the same location with the same data.

This review will include (i) studies comparing mortality rates for patients who were treated at trauma centres versus non-trauma centres; (ii) studies comparing mortality rates for patients who were treated in trauma-based systems (after trauma system establishment) versus non-trauma-based systems (before trauma system establishment) and (iii) studies which evaluate the progress of system improvement from the first year after establishment compared to the last year of reported data (early to late phases of trauma system improvement).

Information sources and search strategy

The databases to be searched include MEDLINE (Ovid), EMBASE (Ovid) and CINAHL (EBSCOhost). Example of search strategy and results for MEDLINE (Ovid) is shown in online supplemental appendix 2. Additional articles will be identified from other sources, such as references of articles through database searching and author lists, this source will be classified as additional records identified from references of articles through database searching. In this review, only peer-reviewed articles written in English, human-related studies, and published between January 2000 and December 2020 will be included. The first trauma systems started in the 1970s in the USA, while the Canadian, UK and Australian trauma systems started in the early 1990s. We have chosen not to review literature published before 2000 because clinical healthcare and systems have changed rapidly in the last three decades²⁸ and including outcomes for trauma centres before 2000 could introduce influences of out-of-date systems and clinical practice. Grey literature will not be included in the proposed study.

Study selection

To identify eligible studies, three different searching and screening processes will be used, including title/abstract screening and full-text reading using the Covidence systematic review software. Following the search, all identified articles will be uploaded to Covidence software, which will remove all duplicate studies. Then, two independent authors (RJA and SS) will assess the eligible studies to be included or excluded from the systematic review. Any disagreement that arises during the process of title screening, abstract screening or full-text screening will be solved by the third reviewer (either CM or VL). After this process is finalised, Covidence software will generate a flow diagram for PRISMA. The PRISMA flow diagram will provide complete information about the number of studies included from the title screening to the full-text screening and reasons for any full text excluded studies.

Data extraction

The PRISMA data extraction guide will be performed by the primary author of the study (RJA) and one coauthor (SS) will independently extract the data to minimise errors and bias during the process of data extraction. Disagreements between the two reviewers will be resolved through discussion, or with a third reviewer through discussion (either CM or VL). The data extracted will include the author names, year of study, country of data origin, type of study, characteristics of the study population, data collection period, stage of trauma system development (centre; system; mature system) and years of operation, data source, type of study, sample size, cause of trauma, type of trauma, level of injury severity and mortality rate (see online supplemental appendix 3). The authors of primary studies will not be contacted to clarify or obtain missing data or information.



Risk of bias in individual studies

Two independent authors will critically appraise and assess the method quality for all the included studies. The Cochrane Risk of Bias for Non-randomised Studies of Interventions (ROBINS-I) tool will be used by the two authors.²⁹ Two authors of this review will discuss and agree on quality levels for each assessment tool. Any study judged of low methodological quality (does not meet the required quality level) will be excluded from the review and a reason provided for exclusion. Any disagreement that arises between the two authors will be resolved in consultation with a coauthor. All included studies will undergo data extraction and synthesis. The results of the critical appraisal will be reported in a narrative form and in a table.

Data synthesis and meta-analysis

Included studies will be pooled in a statistical meta-analysis (where possible) statistical software—Review Manager (RevMan) V.5.4. (The Cochrane Collaboration, 2020). For analysis calculation, effect sizes will be expressed as risk ratios or ORs for dichotomous data or weighted (or standardised) mean differences and 95% CIs for continuous data in this systematic review. If heterogeneity appears across the selected studies after a visual inspection of the forest plot or statistically using the standard χ^2 and I^2 tests, the choice of the model (random or fixed effects) and method for meta-analysis will be established according to Tufanaru, Munn.³⁰

Three different subgroups in meta-analysis will be conducted as following:

- ▶ The first stage: studies that compare mortality rates in trauma centres and non-trauma centres.^{31 32}
- ▶ The second stage: studies compare mortality rate before and after the implementation of trauma system.^{21 33}
- ▶ The third stage: studies that evaluate change over time since the implementing the trauma system (early to late phases of trauma system).^{23 34}

Assessment of publication bias

Data will be reported narratively in the form of tables and figures if statistical pooling is not possible because of limitations, such as substantial heterogeneity among the included studies. The authors will assess publication bias by generating a funnel plot if over 10 studies are included in a meta-analysis using RevMan V.5.4. In assessing funnel plot asymmetry (where appropriate), statistical tests (Egger test, Begg test Harbord test) will be performed.³⁵

Assessment of certainty of evidence

The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) approach for assessing the quality of evidence will be followed and a Summary of Findings (SoF) will be created using GRADEpro software (McMaster University, ON, Canada). The SoF will present the following information, where appropriate: ranking of the quality of the evidence based on study limitations

(risk of bias), indirectness, inconsistency, imprecision and risk of publication bias of the review results. The mortality rate of all included studies will be included in the SoF table.

Patient and public involvement

Patients are not directly involved in the design and conception of this study.

Ethics and dissemination

This systematic review will use secondary data only, therefore, research ethics approval is not required. The results from this study will be submitted to a peer-review journal for publication and we will present our findings at national and international conferences.

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Contributors All authors included in the article contributed to the conception, design and drafting of the article. RJA prepared the first draft of this protocol paper and revised comments from CM and VL. RJA and SS developed the search strategy that was reviewed by CM and VL. All authors approved the final version of the manuscript.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

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REFERENCES

- 1 Peden M. *World report on child injury prevention: World Health organization*, 2008.
- 2 Alharbi R, Mosley I, Miller C, *et al*. Factors associated with physical, psychological and functional outcomes in adult trauma patients following road traffic crash: a scoping literature review. *Transp Res Interdiscip Perspect* 2019;3:100061–e.
- 3 WHO. *Injuries and violence: the facts 2014, world Health organization*, 2014.
- 4 Hofman K, Primack A, Keusch G, *et al*. Addressing the growing burden of trauma and injury in low- and middle-income countries. *Am J Public Health* 2005;95:13–17.
- 5 Ameratunga S, Hijar M, Norton R. Road-Traffic injuries: confronting disparities to address a global-health problem. *The Lancet* 2006;367:1533–40.
- 6 Demetriades D, Martin M, Salim A, *et al*. The effect of trauma center designation and trauma volume on outcome in specific severe injuries. *Ann Surg* 2005;242:512–9.

- 7 Moore L, Turgeon AF, Lauzier F, *et al.* Evolution of patient outcomes over 14 years in a mature, inclusive Canadian trauma system. *World J Surg* 2015;39:1397–405.
- 8 MacKenzie EJ, Rivara FP, Jurkovich GJ, *et al.* A national evaluation of the effect of trauma-center care on mortality. *N Engl J Med* 2006;354:366–78.
- 9 Chiara O, Mazzali C, Lelli S, *et al.* A population based study of hospitalised seriously injured in a region of northern Italy. *World Journal of Emergency Surgery* 2013;8:32.
- 10 Leung K, Ho W, Tong K, *et al.* Outcome of severely injured trauma patients at a designated trauma centre in the Hong Kong special administrative region. *Chin Med J* 2010;123:1251–4.
- 11 Siman-Tov M, Radomislensky I, Peleg K. Reduction in trauma mortality in Israel during the last decade (2000–2010): the impact of changes in the trauma system. *Injury* 2013;44:1448–52.
- 12 Curtis K, Chong S, Mitchell R, *et al.* Outcomes of severely injured adult trauma patients in an Australian health service: does trauma center level make a difference? *World J Surg* 2011;35:2332–40.
- 13 Trauma RNfM. Nhs clinical Advisory groups report 2010.
- 14 Moore L, Champion H, Tardif P-A, *et al.* Impact of trauma system structure on injury outcomes: a systematic review and meta-analysis. *World J Surg* 2018;42:1327–39.
- 15 Peitzman AB, Courcoulas AP, Stinson C, *et al.* Trauma center maturation: quantification of process and outcome. *Ann Surg* 1999;230:87.
- 16 Rotondo M, Cribari C, Smith R, Trauma ACoSCo. *Resources for optimal care of the injured patient*. 6. Chicago: American College of Surgeons, 2014.
- 17 Liberman M, Mulder DS, Jurkovich GJ, *et al.* The association between trauma system and trauma center components and outcome in a mature regionalized trauma system. *Surgery* 2005;137:647–58.
- 18 Mitchell RJ, Curtis K, Chong S, *et al.* Comparative analysis of trends in paediatric trauma outcomes in New South Wales, Australia. *Injury* 2013;44:97–103.
- 19 Brennan PW, Everest ER, Griggs WM, *et al.* Risk of death among cases attending South Australian major trauma services after severe trauma: the first 4 years of operation of a state trauma system. *J Trauma* 2002;53:333–9.
- 20 Twijnstra MJ, Moons KGM, Simmermacher RKJ, *et al.* Regional trauma system reduces mortality and changes admission rates: a before and after study. *Ann Surg* 2010;251:339–43.
- 21 Metcalfe D, Perry DC, Bouamra O, *et al.* Regionalisation of trauma care in England. *Bone Joint J* 2016;98-B:1253–61.
- 22 Gabbe BJ, Biostat GD, Simpson PM, *et al.* Improved functional outcomes for major trauma patients in a regionalized, inclusive trauma system. *Ann Surg* 2012;255:1009–15.
- 23 Gabbe BJ, Lyons RA, Fitzgerald MC, *et al.* Reduced population burden of road transport-related major trauma after introduction of an inclusive trauma system. *Ann Surg* 2015;261:565–72.
- 24 Celso B, Tepas J, Languard-Orban B, *et al.* A systematic review and meta-analysis comparing outcome of severely injured patients treated in trauma centers following the establishment of trauma systems. *J Trauma* 2006;60:371–8.
- 25 Moher D, Shamseer L, Clarke M, *et al.* Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst Rev* 2015;4:1.
- 26 Moher D, Liberati A, Tetzlaff J, *et al.* Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med* 2009;6:e1000097.
- 27 Quinlan KP, Thompson MP, Annest JL, *et al.* Expanding the National electronic injury surveillance system to monitor all nonfatal injuries treated in US hospital emergency departments. *Ann Emerg Med* 1999;34:637–45.
- 28 Mokdad AH, Ballestros K, Echko M, *et al.* The state of US health, 1990–2016: burden of diseases, injuries, and risk factors among US states. *Jama* 2018;319:1444–72.
- 29 Sterne JAC, Hernán MA, Reeves BC, *et al.* ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. *BMJ* 2016;355:i4919.
- 30 Tufanaru C, Munn Z, Stephenson M, *et al.* Fixed or random effects meta-analysis? common methodological issues in systematic reviews of effectiveness. *Int J Evid Based Healthc* 2015;13:196–207.
- 31 Rogers FB, Osler TM, Shackford SR, *et al.* Population-Based study of hospital trauma care in a rural state without a formal trauma system. *J Trauma* 2001;50:409–14.
- 32 Di Bartolomeo S, Marino M, Ventura C, *et al.* Evaluation of the survival benefit of Trauma-Centre care in the Italian setting. *Injury* 2014;45:299–303.
- 33 JC H, Schechtman D, Allen DL, *et al.* Despite trauma center closures, trauma system regionalization reduces mortality and time to definitive care in severely injured patients. *The American Surgeon* 2017;83:591–7.
- 34 Moore L, Stelfox HT, Evans D, *et al.* Trends in injury outcomes across Canadian trauma systems. *JAMA Surg* 2017;152:168–74.
- 35 Egger M, Smith GD, Schneider M, *et al.* Bias in meta-analysis detected by a simple, graphical test. *BMJ* 1997;315:629–34.