

Appendix 1. Supplemental material

Search strategy

EMBASE

1. exp emergency health service/
2. (trauma adj (system* or care or network* or health care or model* or center* or centre* or service*)).tw,kf
3. (injury adj (system* or care or network* or health care or model* or center* or centre* or service*)).tw,kf.
4. 1 or 2 or 3
5. quality assuran*/ or quality improv*/ or benchmark*/ or clinical audit*.tw,kf. or medical audit*.tw,kf.
6. licensing/ or professional standard/ or certification/ or recertification/
7. "american college of surgeon".tw,kf.
8. "trauma association of canada".tw,kf.
9. accreditation canada.tw,kf.
10. INESSS.tw,kf.
11. "Institut national d'excellence en santé et en services sociaux".tw,kf.
12. (designated or designation or designate).tw,kf.
13. (accredited or accreditation).tw,kf.
14. (verified or verification or reverification).tw,kf.
15. 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14
16. 4 and 15
17. remove duplicates from 16

MEDLINE

1. exp Trauma Centers/
2. (trauma adj (system* or network* or care or health care or model* or center* or centre* or service*)).tw,kf.
3. (injury adj (system* or care or network* or health care or model* or center* or centre* or service*)).tw,kf.
4. 1 or 2 or 3
5. exp Benchmarking/
6. clinical audit/ or exp medical audit/
7. quality assuran*/ or quality improv*/ or benchmark*/ or clinical audit*.tw,kf. or medical audit*.tw,kf.

8. (accredited or accreditation).tw,kf.
9. (verified or verification or reverification).tw,kf.
10. "american college of surgeon*".tw,kf.
11. "trauma association of canada".tw,kf.
12. accreditation canada.tw,kf.
13. INESSS.tw,kf.
14. "Institut national d'excellence en santé et en services sociaux".tw,kf.
15. (designated or designation or designate).tw,kf.
16. 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15
17. 4 and 16
18. remove duplicates from 17

HEALTHSTAR

1. Trauma Centers/
2. (trauma adj (system* or care or network* or health care or model* or center* or centre* or service*)).tw,kf.
3. (injury adj (system* or care or network* or health care or model* or center* or centre* or service*)).tw,kf.
4. 1 or 2 or 3
5. Benchmarking/
6. clinical audit/ or exp medical audit/
7. quality assuran*/ or quality improv*/ or benchmark*/ or clinical audit*.tw,kf. or medical audit*.tw,kf.
8. accreditation/ or certification/ or licensure/
9. (accredited or accreditation).tw,kf.
10. (verified or verification or reverification).tw,kf.
11. "american college of surgeon*".tw,kf.
12. "trauma association of canada".tw,kf.
13. accreditation canada.tw,kf.
14. INESSS.tw,kf.
15. "Institut national d'excellence en santé et en services sociaux".tw,kf.
16. (designated or designation or designate).tw,kf.
17. 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16
18. 4 and 17
19. remove duplicates from 18

CINAHL

S1	TI (trauma N1 (system* or network* or care or "health care" or model* or center* or centre* or service*)) OR AB (trauma N1 (system* or network* or care or "health care" or model* or center* or centre* or service*))
S2	TI (injury N1 (system* or network* or care or "health care" or model* or center* or centre* or service*)) OR AB (injury N1 (system* or network* or care or "health care" or model* or center* or centre* or service*))
S3	S1 OR S2
S4	(MH "Accreditation+") OR (MH "American Accreditation Healthcare Commission")
S5	""accredited" OR "accreditation""
S6	(MH "Quality Assurance") OR ""clinical audit" or "quality assurance"
S7	(MH "Benchmarking") OR "benchmarking" OR (MH "Process Assessment (Health Care)+")
S8	""designation""
S9	""American College of Surgeons""
S10	""Trauma Association of Canada""
S11	""Accreditation Canada""
S12	""INESSS""
S13	""Institut national d'excellence en santé et en services sociaux""
S14	S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13
S15	S3 AND S14

ProQuest Dissertations & Theses Global

((ti(accredited OR accreditation) OR ab(accredited OR accreditation)) OR (ti(verified OR verification OR reverification) OR ab(verified OR verification OR reverification)) OR (ti("clinical audit" OR benchmarking) OR ab("clinical audit" OR benchmarking)) OR (ti(designation OR designated) OR ab(designation OR designated)) OR (ti("American College of Surgeons") OR ab("American College of Surgeons")) OR (ti("Trauma Association of Canada") OR ab("Trauma Association of Canada")) OR (ti("Accreditation Canada") OR ab("Accreditation Canada")) OR (ti("Institut national d'excellence en santé et en services sociaux") OR ab("Institut national d'excellence en santé et en services sociaux")) OR (ti("INESSS") OR ab("INESSS"))) AND ((ti(trauma NEAR/1 (system* OR network* OR care OR "health care" OR model* OR center* OR centre* OR service*)) OR ab(trauma NEAR/1 (system* OR network* OR care OR "health care" OR model* OR center* OR centre* OR service*))) OR (ti(Injur* NEAR/1 (system* OR network* OR care OR "health care" OR model* OR center* OR centre* OR service*)) OR ab(Injur* NEAR/1 (system* OR network* OR care OR "health care" OR model* OR center* OR centre* OR service*))))

Appendix 1 to Batomen B, Moore L, Carabali M, et al. Effectiveness of trauma centre verification: a systematic review and meta-analysis. *Can J Surg* 2021.

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List of key injury organisations

The American College of Surgeons, Trauma Association of Canada, International Association for Trauma Surgery and Intensive Care, Australasian Trauma Society, Trauma Audit Research Network, American Association for the Surgery of Trauma, Eastern Association for the Surgery of Trauma, American Trauma Society, British Trauma Society, Orthopaedic Trauma Association, Western Trauma Association, Trauma.org, The Society of Trauma Nurses, International Trauma Anaesthesia and Critical Care Society, BrainTrauma Foundation.

Supplemental Table S1: Reason for the exclusion of full-text reviewed studies

Author, Year	Title	Reason for exclusion
Anonymous, 1988(1)	Pediatric trauma standards: Pennsylvania Trauma Systems Foundation standards for trauma center accreditation	Narrative studies, they listed the standard requirements for pediatrics verification.
Berk, 1994(2)	Infection control for health care workers caring for critically injured patients: A national survey	Exposure Irrelevant.
Howell, 1996(3)	Level I trauma certification and emergency medicine resident major trauma experience	Exposure Irrelevant, compared verified Level 1 to all other centers.
Buechler, 1998(4)	Variation among trauma centers' calculation of Glasgow Coma Scale score: results of a national survey	Exposure Irrelevant.
Nichols, 1997(5)	Magnetic resonance imaging: utilization in the management of central nervous system trauma	Exposure Irrelevant.
Gagneux, 1998(6)	Trauma emergency unit: long term evaluation of a quality assurance programme	Exposure irrelevant, assessed the effect of a self-established quality assurance program in an emergency department.
DiRusso, 2001(7)	Preparation and achievement of American College of Surgeons Level I trauma verification raises hospital performance and improves patient outcome	Exposure Irrelevant, assessed preparation to verification.
Nathens, 2001(8)	The relationship between trauma center volume and outcome	Exposure irrelevant.
Pasquale, 2001(9)	Outcome analysis of Pennsylvania trauma centers: Factors predictive of nonsurvival in seriously injured patients	Exposure Irrelevant
Rogers, 2001(10)	Population-based study of hospital trauma care in a rural state without a formal trauma system	Exposure Irrelevant, compared verified Level 1 to non-designated centers.
Abernathy, 2002(11)	Impact of a voluntary trauma system on mortality, length of stay, and cost at a Level I trauma center	Exposure Irrelevant.
Ehrlich, 2002(12)	American College of Surgeons, Committee on Trauma verification review: Does it really make a difference?	Exposure irrelevant, assessed preparation to verification.
Ehrlich, 2002(13)	The need for a statewide pediatric trauma program	Exposure irrelevant.
Meldom, 2002(14)	Trauma in the very elderly: A community-based study of outcomes at trauma and nontrauma centers	Exposure Irrelevant, compared verified centers to non-designated hospitals.

Simons, 2002(15)	Relative importance of designation and accreditation of trauma centers during evolution of a regional trauma system	Exposure irrelevant, accreditation occurred after the end of the study.
Ciraulo, 2004(16)	A survey assessment of the level of preparedness for domestic terrorism and mass casualty incidents among Eastern Association for the Surgery of Trauma Members	Exposure Irrelevant.
Simons, 2004(17)	Optimising trauma care: Role of trauma systems and trauma centres	Narrative studies.
Biffi, 2005(18)	The evolution of trauma care at a Level I trauma center	Exposure irrelevant, unable to attribute the change to verification which occurred in 1995 while the post period started in 1999.
Demetriades, 2005(19)	The effect of trauma center designation and trauma volume on outcome in specific severe injuries	Exposure irrelevant, compared level II verified centers to other verified III or IV and non-verified centers.
Bowman, 2006(20)	Hospital characteristics associated with trauma outcomes	Exposure irrelevant.
DeBritz, 2006(21)	The impact of trauma centre accreditation on patient outcome	Narrative studies.
Eldich, 2006(22)	Level I trauma certification and emergency medicine resident major trauma experience	Narrative studies.
Nathens, 2006(23)	The delivery of critical care services in US trauma centers: is the standard being met?	Exposure irrelevant, described Intensive Unit Care standards.
Udekwa, 2006(24)	Trauma Center Designation and Outcomes	Narrative studies, letter to editor.
Shackford, 2007(25)	The increasing use of vena cava filters in adult trauma victims: data from the American College of Surgeons National Trauma Data Bank	Exposure Irrelevant, all included centers were verified.
DuBose, 2008(26)	Effect of trauma center designation on outcome in patients with severe traumatic brain injury	Exposure Irrelevant, compared Level I versus Level II verified centers.
Fang, 2008(27)	Critical care at Landstuhl Regional Medical Center	Narrative studies
Shafi, 2008(28)	Trauma quality improvement using risk-adjusted outcomes	Exposure irrelevant, compared outcomes among verified ACS centers.
Terrell, 2008(29)	Nationwide Survey of Alcohol Screening and Brief Intervention Practices at US Level I Trauma Centers	Narrative studies, the part comparing verified to non-verified centers was narrative.

DuBose, 2009(30)	American College of Surgeons trauma centre designation and mechanical ventilation outcomes	Exposure irrelevant, compared Level I versus Level II verified centers.
Mikhail, 2009(31)	Midlevel practitioner role evolution in an American College of Surgeons-verified trauma surgery service: the 23-year experience at Hurley Medical Center	Narrative studies.
Milham, 2009(32)	Are there racial disparities in trauma care?	Exposure irrelevant, look at outcomes difference due to race irrespective of verification status.
Nance, 2009(33)	Access to pediatric trauma care in the United States	Exposure irrelevant, assessed access to care.
Recinos, 2009(34)	ACS trauma centre designation and outcomes of post-traumatic ARDS: NTDB analysis and implications for trauma quality improvement	Exposure Irrelevant, compared Level I versus Level II verified centers.
Ropele, 2009(35)	Cervical spine clearance in the non-alert, non-communicative, or unreliable pediatric blunt trauma patient	Exposure Irrelevant, just described current practices for clearing the cervical spine in a special pediatric population.
Salottolo, 2009(36)	Effects of a nonsurgical hospitalist service on trauma patient outcomes	Exposure irrelevant.
Bennett, 2010(37)	The volume-outcomes relationship for United States level one trauma centers	Duplicate.
Brown, 2010(38)	Trauma center designation correlates with functional independence after severe but not moderate traumatic brain injury	Exposure Irrelevant, compared Level I versus Level II.
Cudnik, 2010(39)	Are all trauma centers created equally? A statewide analysis	Exposure irrelevant, all included centers were verified.
Hemmilia, 2010(40)	The trauma quality improvement program: pilot study and initial demonstration of feasibility	Exposure Irrelevant.
Nyberg, 2010(41)	A national survey: acceptance of physician assistants and nurse practitioners in trauma centers	Outcome irrelevant, no patient outcomes.
DuBose, 2011(42)	The relationship between post-traumatic ventilator-associated pneumonia outcomes and American College of Surgeons trauma centre designation	Exposure Irrelevant, compared Level I versus Level II verified centers.
Bennett, 2011(43)	The volume-outcomes relationship for United States level I trauma centers	Narrative studies, comparison between verified and non-verified centers was a secondary analysis and described narratively.
Kesler, 2011(44)	Demographic factors and outcomes in patients with epidural hematoma	Narrative studies.

Plurard, 2011(45)	Trauma center designation and the decreasing incidence of post-traumatic acute respiratory distress syndrome: A potential guidepost for quality improvement	Exposure Irrelevant.
Testerman, 2011(46)	Full-time orthopedic traumatologists enhance rural trauma center pelvic fracture outcomes and financials	Exposure irrelevant, assessed preparation to preparation.
Bailey, 2012(47)	Verification and Regionalization of Trauma Systems. The Impact of These Efforts on Trauma Care in the United States	Narrative studies.
Bukur, 2012(48)	The impact of American College of Surgeons trauma center designation and outcomes after early thoracotomy: A national trauma databank analysis	Exposure Irrelevant, assessed differences between levels of verified centers.
Moore, 2013(49)	Evaluating trauma center structural performance: The experience of a Canadian provincial trauma system	Exposure irrelevant.
Anonymous, 2014(50)	Hasbro designated Level 1 Pediatric Trauma Center by ACS	Narrative studies
Badjie, 2014(51)	Metamorphosis of a massive blood transfusion protocol at a level I trauma center	Exposure Irrelevant, no comparison of outcomes before and after verification.
Balogh, 2014(52)	Trauma verification: for the trauma centre or for the trauma system?	Narrative studies which described Australia verification process.
Carr, 2014(53)	Impact of adding Level II and III trauma centers on volume and disease severity at a nearby Level I trauma center	Exposure Irrelevant, assessed the impact of the designation of new centers on patient volume of an existing center.
Clark, 2014(54)	The effect of hospital care on early survival after penetrating trauma	Exposure irrelevant, they compared verified level I to all other hospitals which may include verified level II.
Guess, 2014(55)	Do level I trauma centers address the psychological responses associated with trauma?	Narrative studies.
Kim, 2014(56)	Relationship of trauma centre characteristics and patient outcomes: a systematic review	Narrative studies.
Shafi, 2014(57)	Compliance with recommended care at trauma centers: Association with patient outcomes	Exposure Irrelevant, did not assess verification.

Nikolis, 2015(58)	Establishing a massive transfusion protocol (MTP): A collaborative effort	Exposure irrelevant, described an aspect of preparation to verification.
Santy, 2015(59)	Variations in the implementation of acute care surgery: Results from a national survey of university-affiliated hospitals	Exposure Irrelevant.
Drefyus, 2016(60)	Comparison of pediatric motor vehicle collision injury outcomes at Level I trauma centers	Exposure irrelevant, only verified Level I was included.
Falcone, 2016(61)	A paradigm for achieving successful pediatric trauma verification in the absence of pediatric surgical specialists while ensuring quality of care	Exposure Irrelevant, they evaluated the impact of the collaborative partnership on improving regional pediatric trauma care
Grossman, 2016(62)	Effect of American college of surgeons trauma center designation on outcomes: Measurable benefit at the extremes of age	Duplicate. Was an abstract and the full paper was published the next year and included.
Myers, 2016(63)	A National Analysis of Pediatric Trauma Care Utilization and Outcomes in the United States	Exposure Irrelevant, compared centers regardless of verification status.
Brown, 2017(64)	Impact of Volume Change over Time on Trauma Mortality in the United States	Exposure Irrelevant, assessed the volume outcome relationship
Joseph, 2017(65)	American College of Surgeons Level I trauma centers outcomes do not correlate with patients' perception of hospital experience	Exposure Irrelevant, only included verified centers.
Kaufman, 2017(66)	Triage of injured patients in New York state prior to implementation of the American college of surgeons committee on trauma verification system	Exposure Irrelevant, described triage prior verification.
Bank, 2018(67)	Collaborative implementation of a massive transfusion protocol at a level one trauma center	Exposure irrelevant, they summarized the necessary blood bank resources implemented to ensure successful ACS verification/re-verification.
Bjurlin, 2018(68)	Impact of Trauma Center Designation and Interfacility Transfer on Renal Trauma Outcomes: Evidence for Universal Management	Exposure irrelevant, only included verified centers.
Polites, 2018(69)	Undertriage after severe injury among United States trauma centers and the impact on mortality	Exposure irrelevant, the purpose of this study was to determine the undertriage rate between trauma centers. No stratification between ACS and State centers.

Hamidi, 2019(70)	Outcomes After Massive Transfusion in Trauma Patients: Variability Among Trauma Centers	Exposure irrelevant.
Spaulding, 2019(71)	Hospital Value-Based Purchasing and Trauma-Certified Hospital Performance	Exposure irrelevant, compared trauma centers to non-trauma centers.
Swartz, 2019(72)	Geriatric trauma collaboration: Feasibility, sustainability and improved outcomes	Exposure irrelevant.
Ukwuoma, 2019(73)	Does an Emergency Department Trauma Status Upgrade Impact the Timeliness of Nontrauma Computed Tomography Scans	Irrelevant, non-trauma patients.

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Supplemental Table S2: GRADE evidence profile: Effectiveness of trauma center verification

Quality assessment						Summary of findings				
						Number of patients			Absolute risk	
No of Studies	Limitations	Inconsistency	Indirectness	Imprecision	Publication bias	Controls	Verified	OR (95% CI)	WMD † (95% CI)	Quality
Hospital Mortality (number of studies)										
All patients (1)	Serious	N.A	N.A	N.A	N.A	No details	No details	0.91 (0.83 – 0.99)	-	N.A
Pediatrics (2)	Serious	Serious	No Serious*	Serious	Unlikely	No details	No details	0.94 (0.62 – 1.42)	-	Very Low
Severe Injuries (1)	Serious	N.A	N.A	N.A	N.A	No details	No details	1.17 (1.05 – 1.30)	-	N.A
Level I (3)	Serious	Serious	No Serious*	No Serious	Unlikely	No details	No details	0.95 (0.91 – 1.00)	-	Very Low
Level II (1)	No Serious	N.A	N.A	N.A	N.A	No details	No details		-	N.A
Other (2)	Serious	N.A	Serious	N.A	Unlikely	No details	No details	-	-	N.A
Length of Stay (number of studies)										
Overall (1)	Serious	N.A	N.A	N.A	N.A	118	113	-	-0.06 (-0.22, 0.09)	N.A
Overall Level I (4)	Serious	Serious	No Serious	Serious	Unlikely	2,828	2,715	-	-0.04 (-0.21, 0.14)	Very Low
Overall Level II (1)	No Serious	N.A	N.A	N.A	N.A	3,973	3,835	-	-0.14 (-0.19, -0.10)	N.A
Overall Sub-population (4)	Serious	Serious	No Serious	Serious	Likely	572	774	-	0.20 (-0.8, 0.68)	Very Low
ICU Level I (2)	Serious	No Serious	No Serious	No Serious	Likely	777	447	-	0.29 (0.13, 0.46)	Very Low
ICU Sub-population (2)	Serious	No Serious	No Serious	No Serious	Likely	297	186	-	0.28 (0.00, 0.57)	Very Low

*There is minor indirectness of the interventions due to comparison groups

†Exponentiate of weighted mean differences can be interpreted as geometric mean ratio

N.A: Not Applicable; OR: Odds Ratio; WMD: Weighted mean difference