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Impact of Access on Trauma Mortality

Jarrett AL[1*] and Devers JJ[1]

Eleanor Mann School of Nursing, University of Arkansas, USA

[*]**Corresponding Author:** Jarrett AL, Eleanor Mann School of Nursing, University of Arkansas, USA, Tel: 1-479-856-9700; Email: ajarret@uark.edu

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Abstract

This purpose of this literature review was to identify relevant literature related to the impact of access to care on traumatically injured victims' mortality rates. The authors independently read and screened the literature to identify national and international research studies between 2011-2019. All relevant studies were divided into those supporting the premise that time to treatment negatively impacts patient outcomes measured by mortality rate as convergent studies, and studies that support the premise that time to treatment does not negatively impact patient mortality as divergent studies. The literature review resulted in 29 convergent and seven divergent studies. Findings indicated multiple factors impact overall trauma mortality There was more evidence supporting rapid treatment and transport to the required level of care to provide best outcomes for most traumatically injured patients. Increased use of sophisticated predictive analytic methods to measure variables across populations allow trauma mortality to be more accurately reported. Important recommendations indicated a need for standardization and consistency of databases so findings can be generalized; concurrent reporting would be more useful than retrospective reviews, and efficacious time to treatment and transfer to the required level of care are indicated for best outcomes in patients sustaining traumatic injuries.

Keywords: Access to care; Geographic disparity; Rural; Systematic review; Trauma mortality

Introduction

Using a familiar trauma colloquialism, medical and nursing trauma literature continues the controversy of "scoop and run" or "stay and play" for best outcomes of victims of major trauma. This translates to rapid transport to a fixed facility, whether it is a trauma center or the nearest facility versus stabilize and provide advanced support at the scene prior to transport independent of distance. This has been studied since the 1980s, but more recently, studies of specific populations have occurred, and increased international studies have been published.

In earlier studies, overall mortality rates were measured but not necessarily with heterogeneous samples, or control of extraneous, confounding variables. Since 2011, more sophisticated multivariate statistical methods with predictive analytic models have produced results using distance and/or time to treatment as an independent variable while controlling for confounding variables to eliminate study bias. This has provided more precise, non-biased results.In previous years, there was an assumption that distance mattered on trauma patient outcomes. Because of renewed interest and more sophisticated methods of analysis, it is time to review the literature to confirm or refute this previous assumption.

This purpose of this literature review was to identify relevant literature related to the impact of access to care on traumatically injured victims' mortality rates. The Problem, Issue, Comparison, Outcome, Time (PICOT) question is: In studies done between 2011- 2019 about patients sustaining traumatic injuries, did time or distance to nearest facility impact mortality rates?

Materials and Methods

The overall goal of this literature review was to identify relevant literature related to the impact of access to care on traumatically injured victims' mortality rates. For purposes of this literature review, access to care has been described and defined by the authors as, "the availability and barriers to needed services to maximize optimal outcomes in trauma care". For the most part, studies measuring access to care use time or distance from location of emergency medical services (EMS) to the location of a traumatic incident.Specific measures include EMS response time, pre-hospital stabilization, and time or distance to the nearest facility or a trauma center to measure patient outcomes as mortality rate. For this literature review, EMS response time, pre-hospital stabilization, total time to treatment, and all studies comparing urban and rural times-to-treatment were selected.

The team consisted of a trauma researcher with 20 years' experience practicing and analyzing trauma data. The lead author created and holds a patent for the rib fracture score and protocol (Easter, 2004) and has published the methods used to create and patent the protocol (Easter, 2001). The second author is a registered nurse working toward a Doctor of Nursing practice as a family nurse practitioner.He works as a research assistant for the lead author.He is an accomplished writer and a beginning researcher. Both authors participated in developing relevant terms in this search.

Information Sources: To query databases, an electronic search of PubMed, Elton B. Stephens CO (EBSCO), ProQuest©, OpenAthens™, and Medline Complete© was conducted January 2020 using the following terms: mortality, trauma, distance, access to care, urban vs. rural mortality, mortality rates of trauma victims in rural American, mortality rates of rural trauma victims, disparity in rural trauma, rurality trauma outcomes, and geographic disparities in mortality rates. The secondary review retrieved studies from web browser searches and from the University of Arkansas' online catalogue and interlibrary loan services.

Eligibility Criteria: The search for relevant literature was limited to studies published between 2011 and 2019 and those studies published or translated to English.It included state, regional, national, and international studies, including systematic reviews, observational studies, retrospective studies, and experimental studies. The initial search found a total of 23,325 studies; this was composed of 534 articles identified in PubMED; 451 in ProQues©t; 20,974 in OpenAthens™, and 12 in Medline Complete©.

Study Selection: The authors independently read and screened the literature to identify relevant research studies.The screening was performed in stages, using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist and flowchart [1-3].After removing duplicates and non-research studies, number of articles initially selected was 36.The second author paraphrased summary findings and conclusions of selected studies.The lead author re-read the summaries and compared to each study's discussions and findings. There was 95% inter-rater agreement between the second author and lead author in the conclusions of the findings.

In the second stage the lead author reviewed and extracted all references in the 36 selected manuscripts as further means to verify important studies had not been omitted.The number of additional references from the original studies was 684, which made a total of 24,009 records screened. Duplicates and extraneous studies were eliminated. Studies previously retrieved, reports or opinions, all non-study manuscripts, duplicates among individual manuscripts, and extraneous studies, i.e., studies about advantages of helicopter transport, measuring outcomes in differing levels of trauma centers, and those studies not translated into English were eliminated from the 684 secondary review studies. This gleaned an additional 16 research studies published between 2011-2019.They were retrieved and added to the final count for a total of 52 studies. Of those 52 studies, after careful thorough reading and analysis, 16 studies from both the initial and secondary reviews were eliminated. One study had contradictory findings not supported in the discussion section, 12 studies' main research questions focused on cost of trauma, population density, treatment options, and EMS performance measures.Three studies were found to be subset of previously published studies, so they were eliminated.Both authors agreed the final 36 selected studies were quality research studies.

Analysis Process: The process used for this literature review was todivide all relevant studies into those supporting the premise that time to treatment negatively impacts patient outcomes measured by mortality rate as convergent studies, and studies that support the premise that time to treatment does not negatively impact patient mortality as divergent studies; then summarize findings of both sets of studies, and conclude with an analysis of access to care as a variable and whether it impacts trauma victims' mortality rates. PRISMA flowsheet was used to depict the selection process [3] see **Figure 1**.

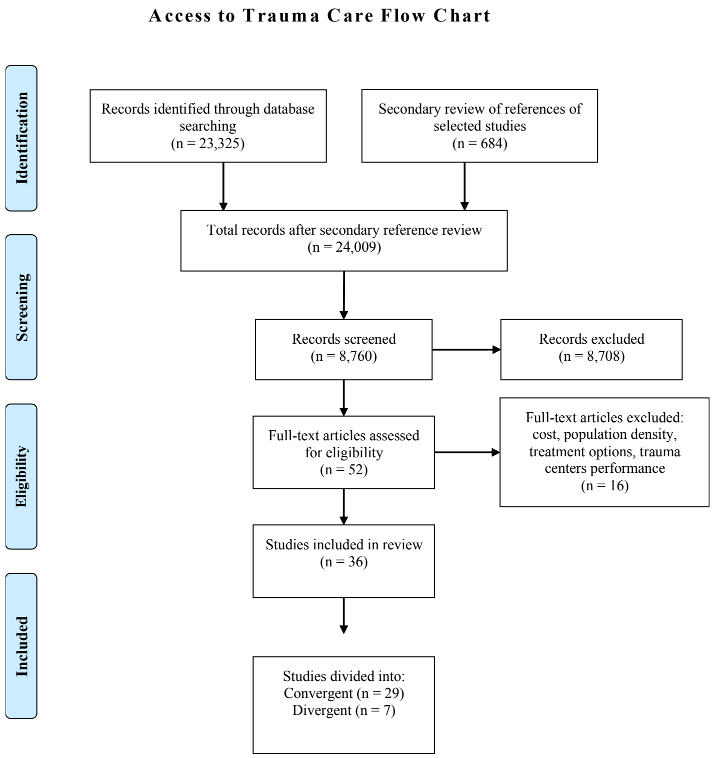

Figure 1: Access to Care for Trauma Victim Studies 2011-2019.

Results

A review of the literature found two systematic reviews [4] and 34 research articles. Three of the studies in the systematic review were also found for this study.The selected studies were further examined. Of all 36 studies, 29 studies supported a causal or predicted relationship between time to treatment and mortality rate, supporting the premise that time to treatment negatively impacts patient outcomes measured by mortality rate were categorized as convergent studies. An additional seven studies did not directly support a relationship between time to treatment and increased mortality of patients sustaining severe traumatic injuries. These studies supported the premise that that time to treatment does not

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negatively impact patient mortality and were categorized as divergent studies. **Table 1** summarizes all studies.

Authors	Design/Source	Population	n	Controlled	Findings
Brorsson et al., 2011	Prospective observational Study	2002-2005	48	N/A	Early adverse events and time of arrival were not significantly reflected in the outcome
Fatovich et al., 2011a	Royal Doctor Service Trauma Registries	ISS>15	3,333	Age, ISS, Time	Significantly reduced mortality in those treated or transferred to larger hospitals
Fatovich et al., 2011b	Trauma Registry1997 - 2006	urban and rural	3,083	ISS, regions death	There was an equivalent risk of death in trauma and non-trauma systems. In the metropolitan area, there was no demonstrated mortality benefit associated with time.
Gomes et al., 2011	Emergency Department (ED) Patients 2001- 2007	All trauma patients	1,150	None	Despite lack of medical pre-hospital care and higher previous admission in other hospital in rural patients, mortality between groups didn't differ in our trauma center
Tien et al., 2011	Retrospective Review	Thoracic injuries; ISS >35	12,105	Injury, ISS, age, On scene thoracotomy	Rapid transport of patients with traumatic subdural hematomas is associated with decreased mortality
Kidher, et al., 2012	Retrospective Cohort Study	Acute Subdural without torso injury	12,105	None	In thoracic trauma victims with high ISS and total transport time <65 minutes may be associated with Lower mortality
Travis et al.,2012	National Automatic Sampling System	Motorists	888,473	Person, event, county level factors	Motorists with severe injuries are more likely to die in rural areas, after controlling for person-and event -specific factors
Swaroop et al., 2013	Retrospective Cohort Study	Thoracic trauma	908	Crude & Adjust Ed mortality rate	In victims of penetrating thoracic trauma, mortality is strongly predicted by injury severity with shorter pre-hospital time associate with improved survival
McCoy et al., 2013	Prospective Cohort Registry	Trauma patients	19,167	None	Times on scene > 20 minutes associated with increased mortality in penetrating wounds but not blunt force trauma; transport time itself wasn't associated with increased mortality in either category
Crandall et al., 2013	Retrospective Illinois State Trauma Registry	Urban GSW	11,744	Age, gender, race, Insurance status ISS>16, SBP<90	Mean transport time and unadjusted mortality were higher for these patients

Wang et al., 2013	Retrospective California Registry Database	Children 0-18	445,236	Hosp. case mix; Demographic, Clinical variables	Decreased mortality for seriously injured California children treated in trauma centers
Kristiansen et al., 2014	Retrospective Trauma deaths Norway 98-07 Data 2010-2012	Trauma victims Ages 16-66	8,466	Centrality Geographic data Settlement data	Rural areas are at a higher risk of deaths following traumatic injuries and have higher proportions of pre-hospital deaths and deaths following transport-related injuries
Nakamura et al., 2014	Retrospective Japanese Municipalities	>65 adult Trauma Patients	1,742 Regions	Age adjusted Mortality	The geographical disparities for emergency care accessibility were related to the rate of death by Unintentional injury in Japan
Harmsen et al., 2015	Systematic Review	MEDLINE Embase©; Cochrane©	20 Level III trauma centers	Not applicable (N/A)	Swift transport is beneficial for patients suffering neurotrauma and the hemodynamically unstable penetratingly injured patient
Cassidy et al., 2015	Retrospective Descriptive Study	Inhalation injuries	1,508	None	With inhalation injury, 5.7x increased mortality rate in those cases which took longer than 16 hours for admission to burn center
Dinh et al., 2016	Retrospective Analysis of New South Wales (NSW) Trauma Registry	ISS>15 2009-2014	11,423	Adjusted mortality	Increased mortality in metropolitan trauma cases with significant improvement noted in recent rural trauma cases as well in NSW
Gale et al., 2016	Trauma Registry	Blunt TBI; > 18; Admitted < 24 Hours	1,845	None	Neither transfer distance nor time independently contributed to mortality for patients suffering traumatic brain injury (TBI)
Jarman et al., 2016	National E.D. Sample	All injuries	8,949,530	Age, sex, ISS, comorbidities trauma designation and census region	Rural residents are more likely to die in a trauma case vs urban; indicators are trauma center designation, distance, and time to treatment
Shaw, Psoinos, & Santry, 2016	Retrospective Institutional Trauma Registry	>15 years Transported to Level 1	4,522	Time and distance	Helicopter transport predicted lower mortality when injury severity was added to the model
Gunning et al., 2016	Retrospective Trauma registry Netherlands, Australia, United States (USA)	ISS>15; all direct admits from ED	4,049	Confounders to calculate odds ratio	Substantial differences across centers in patient characteristics and mortality, mainly of neurological cause

Raatiniemi et al., 2016	5-year retrospective Study Finland Medical Records Death Certificate Autopsy Reports	Fatal injuries	1,959	None	The crude mortality rate for fatal injuries was elevated in rural areas where pre-hospital deaths were more common
Bagher et al., 2017	Retrospective EMS, hospital forensic record analysis	New Injury Severity Score (NISS) >15 2011-2013	378	None	Pre-hospital rescue times had less impact on mortality than injury severity, age, and penetrating trauma in Scandinavian urban setting
Brown et al., 2016	Retrospective American Trauma Society (ATS) database	Level I/II Trauma centers	48 states 2010	Age-adjusted fatality rates	Geographic distribution of trauma centers correlates with injury mortality, with more clustered state trauma centers associated with lower fatality rates.
Brown et al., 2017	Retrospective Fatality Analysis Report System Database (FARS)	Fatal MVC 2013-2014	886	MVC; county characteristics	Rural residents are significantly more likely to die in a trauma case vs urban, the most likely indicators are trauma center designation, distance, and time to treatment
Hu, Dong, & Huan, 2018	Retrospective Kentucky Collisions' Analysis Public (KCAP)	Patients who survived collisions	8,436	None	Mortality odds of survival decreased at a rate of 1.011 per mile travelled and 0.993 per minute of travel time
Roislien, Loosiu, Kristiansen 2015	Retrospective Norwegian Cause of Death Registry 1998-2007	Death ages 16-66	8466	None; used various statistic Methods	Transport time was statistically significant in models with piecewise linear or categorized predictors, not for standard linear regression, but population density was an independent predictor of trauma Mortality rates
Newgard et al., 2017	Secondary Analysis of a Prospective Cohort in 2011	All trauma victims	17,633	Common predictors; confounders	Most high-risk trauma patients injured in rural areas were cared for outside of major trauma centers; most rural trauma death occurred early, but overall mortality did not differ between regions
Karrison et al., 2018	Retrospective Trauma incidents Chicago	Ages >16 Level I or II Injury to Level I trauma center	24,834	Injury severity	Analysis indicated a corresponding increase in mortality with increasing transport time
Kaufman et al., 2018	Secondary analysis State ED databases 2011-2012~ 6 states	Adults with isolated head injuries	62,198	None	Patients with isolated, severe head injury have better outcomes if initially treated in designated trauma centers

Taylor et al., 2018	Secondary Analysis Trauma Quality Improvement (QI) Program Database	Blunt traumatic injuries 2010-2015	400/ 606	None	Scene –to-ED time is paramount. A Moderate distance from trauma centers improves survival
Byrne et al., 2018	Retrospective Ecologic Study Thesis – Chapter 2	ACS TQIP 2012 - 2014	19,740	None	Access to trauma resources, state traffic safety laws, and rurality, longer EMS response times were strongly associated with greater rates of MVC-related death
Bryne et al., 2018	Retrospective Study Thesis-Chapter 5	National EMS Information Systems 2013 – 2015	2,214,480	Rurality, age, sex	A meaningful proportion of crash fatalities are attributable to prolonged response times in both rural/wilderness and urban/suburban counties.EMS response times should be evaluated in trauma system quality improvement efforts
Circo, G. 2019	Retrospective Study in Detroit, 2011-2017	GSW, non-self inflicted; fatal and non-fatal	9,205	None	Distance to the nearest trauma center was associated with a 22% increase in fatal outcomes, per-mile (OR 1.22, 95% CI, 1.06 to 1.40) after adjusting for block-group level covariates
Tansley et al., 2019	Observational Geo-Spatial Analysis From Nova Scotia Trauma Registry	ISS >11 related to MCV, or by penetrating mechanism 2005-2013	1,535	None	Predicted travel time of greater than 30 minutes were associated with increased mortality in motor vehicle crashes and penetrating injuries
Alanazy et al., 2019	Systematic Review	Critical Appraisal Skills Program (CASP) Checklist	31	N/A	EMS systems in urban areas are more likely to have shorter pre-hospital times, response times, on-scene time, and transport times when compared to EMS in rural areas
Windorski et al., 2019	5-year Retrospective Review	Patient records	1,428	ISS, age, Glascow Coma Scale (GCS), Shock	No significant differences in the outcome when adjusted for differences in initial severity, age, GCS, and shock

Table 1: Access to Care Studies.

Convergent Studies: Patients with severe head and inhalation injuries, severity injured children, and geriatric patients suffering trauma have better outcomes when receiving the highest level of care with rapid transport time[5-10].

Distance to trauma centers among victims suffering gunshot wounds (GSW) was associated with increased patient fatality[11-15].Assuming that being from a rural environment indicates prolonged distance from the highest level of care, several researchers indicated rural residents were more likely to die after traumatic injury, and with a conclusion that rural trauma victim deaths tend to occur early after injury in the populations they studied[16-20]. In addition, [21]found rural areas have higher proportions of pre-hospital death following transport-related injuries. Geographic disparities for emergency care accessibility were related to the rate of death by unintentional injury in Japan [22,23]calculated the crude morality rate for fatal injuries in rural areas and noted that pre-hospital deaths were common [24] conceded that helicopter transport predicted lower mortality when injury severity was added to their model.

These 29 studies indicate there was an association between rurality, time to treatment, distance, and trauma center designation for patients with GSWs motor vehicle collisions (MVC), penetrating, thoracic, and inhalation injuries; seriously injured pediatric patients in California, and geriatric patients in Florida. Going forward, studies with case mix stratification for injury severity, mechanism, and type of injury would elucidate findings[25]. Consequently, efficacious time to treatment and transfer to the required level of care are indicated for best outcomes for traumatically injured patients.

These studies provided support that distance matters. However, *time-to-treatment* may be a better end-point measure than simply distance from trauma care. Time-to-treatment should include EMS, Paramedic treatment, emergency physician virtual treatment as well as time to reach the victim.

Additionally, one study suggested it was comparing apples to oranges to attempt to measure outcomes using current methods. They concluded that first there must be a valid method to compare systems[25]. What seems to be a simple logical argument is somewhat muddled by confounding variables.

Synthesis of Convergent Studies: Emergency medical response systems in urban areas have shorter prehospital times, response times, on-scene time, and transport times than EMS in rural areas. There is an increase in mortality with increasing transport time. Rural residents are significantly more likely than non-rural residents to die after traumatic injury. Access to trauma resources, state traffic safety laws, rurality, and longer EMS response times are associated with greater trauma related deaths. Twenty-nine studies supported access to trauma care as an important predictor of mortality rates for patients suffering traumatic injuries in rural areas globally. Sixteen (60%) convergent studies were published between 2016-2019.Some studies supported the need for additional trauma resources in rural communities as well.

Divergent Studies: Found transfer distance or time neither independently contributed to mortality for patients suffering traumatic brain injury (TBI).Conversely, they concluded that an established regional trauma system with initial local stabilization using ATLS principles may reduce negative outcomes for injured patients in rural settings. Two studies determined early adverse events and time of arrival were not significantly reflected in the outcome[26]. Outcomes between patients with major trauma transported to trauma centers vs. non-trauma centers in metropolitan Perth and in rural Kansas were not found to have significant differences in outcomes [27-32] found hospital rescue times had less impact on mortality than injury severity, age, and penetrating trauma in Scandinavian urban setting [33]tracked mortality in metropolitan vs rural trauma victims in New South Wales Australia. They found increased mortality in metropolitan trauma cases with significant improvement noted in recent rural trauma cases as well.

Although the studies found contrary support for rapid treatment and transport, they are far less in number than the studies supporting efficacious time to treatment and transfer to the required level of care, it is noted that there was an increase in case-mix adjustment and an improved control of confounding variables to provide homogeneity to samples under study from 2016-2019. Although mechanism and type of injury, homogeneous populations, and similar trauma systems are important to provide consistency and accuracy in measurement, severity of injury remains an important stratification needed for patients suffering trauma [34-40]reported an important finding.For patients who are hemodynamically unstable, and for victims of neurotrauma and penetrating injuries, swift transport reduces mortality.But, for"stable undifferentiated trauma victims, focus should be on prehospital care and not on rapid transport of these trauma victims" (p.602).

Synthesis of Divergent Studies: Results of the divergent studies indicates that for undifferentiated trauma patients, increased on-scene-time and total prehospital time did not increase odds of mortality.Early adverse events, transfer distance, nor time of arrival on scene independently contributed to mortality for patients suffering traumatic brain injury (TBI). There were no significant differences in outcomes of victims with traumatic injury immediately transferred to a level I trauma facility versus resuscitation at a critical access hospital (CAH) when adjusted for injury severity score known as ISS. According to the trauma registry in New South Wales (NSW) 2009-2014, there was increased mortality in metropolitan trauma cases, but a significant improvement in rural trauma cases.

Seven studies supported the premise that outcomes are not dependent on access to care. Although fewer studies, these studies occurred between 2011 and 2019 as did the proponent studies. Four (60%) of the divergent studies were published between 2016-2019.These studies found no significant relationship between distance or time-to-treatment and mortality rate, reported by some as urban vs. rural locations.

Discussion

When referring to access to trauma care, multiple factors may determine best outcomes. A frequent comparison is made between urban vs. rural trauma care. With the assumption that rural care is a system of transferring patients to urban care to receive the highest level of care, an underlying assumption may be that urban care is superior to rural care.With that said, urban care has technological, personnel, and skill levels more precisely paired to meet the needs of critically injured trauma patients. Conversely, rural care has highly skilled generalists who encounter a great variety of illnesses and traumatic injuries. So, "is it possible for rural centers to take as good or superior care for less acutely ill patient sustaining traumatic injuries?"[35]reported the severity of injury and the level of care competency must be evaluated to determine appropriate care to achieve best outcomes.

Another question arises, "do level 1 trauma centers ONLY treat the most severely injured patients?" In level 1 trauma centers, a large sample size with a mix of critically injured and seriously injured patients can reflect better outcomes than if only critically injured patients were included in the sample. This dilution could skew results. To eliminate this, extremely homogenous Injury Severity Scores (ISS) should be used to glean true outcomes.

"Is it possible that this mismatch of level of care to severity of injury needs to be adjusted before accurate comparisons can be made?"Not all patients require the highest level of care. However, does on-scene assessment or remote visual imagery provide a comprehensive conclusion for the true level of care required for traumatic injuries? These questions must be answered, and care standardized with clear criteria to measure differences in urban vs. rural outcomes of care for trauma patients**.**

It continues to be important to study subtypes of populations considering mechanism of injury, type of injury, age and baseline health of patients, time-to-treatment, and rapid transfer to an appropriate level of care.This heterogeneous stratification is necessary to insure sound research conclusions.

Conclusion

After careful review and analysis of all studies, there is more evidence supporting rapid treatment and transport to the required level of care to provide best outcomes for most traumatically injured patients. This implies distance is a determinant of time-to-treatment. With sophisticated predictive statistically methods to measure multiple variables across multiple populations, it appears multiple factors impact overall mortality. The literature review concludes that efficacious time to treatment and transfer to the required level of care are indicated for best outcomes for these patients examined six trauma databases determine the extent of common data collection.

They concluded after examining thirty data elements in all six databases there were inconsistencies in the data values across the databases. They further recognized these discrepancies were a barrier to maximizing the use of these databases. A collaborative effort is required to develop a standardized set of elements for trauma research before significant findings can be generalized and used to decrease mortality caused by a lack of access to care.

Perhaps the most important recommendation from all studies was who reported the need for a valid method to compare systems. The confounding variables must be controlled to eliminate bias. In 2019, the studies located were of higher statistical methods and controlled for confounding variables better than many earlier studies.

The lead author found no studies, expert opinions, case reports, conference proceedings, or educational materials that did not support the need for expanded trauma systems in the United States. Perhaps trauma researchers need to use the present model of data collection and reporting being used for the Corona Novel Virus Disease-2019 (CoVID-19).This would require concurrent reports in preference to retrospective reviews.It would require a massive expansion of current trauma methodologies and support personnel. With the onset of the CoVID-19 pandemic, it has been broadcast to every person in the world that there is a need for more advanced life support during this viral contagion.By expanding, increasing, and fairly distributing trauma centers, the need for space, equipment, and personnel skills for all emergencies could be ameliorated.

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