

Trauma center proliferation in the United States: concerns and potential solutions

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Abstract There has been an increase in the number of Level I and II trauma centers across the United States in the past few decades. However, data suggest that access to trauma care remains poor in rural areas of the country, while in many urban areas, trauma center density may be too high. Excessive trauma center proliferation in urban areas has the potential for negative effects on patient care and increased trauma system costs. The efficiency and competency of each trauma center may be decreased by having less access to patients, with research, surgeon experience, and training programs for residents, fellows, medical students, and other allied health providers all affected. Because of these concerns, the Orthopaedic Trauma Association (OTA) Health Policy Committee reviewed trauma center trends and trauma system needs and considered the potential effect of the increase in the number of centers on patient care as well as surgeon experience and training. This article reviews the different types of trauma centers and their designation process, as well as the growth in trauma centers during the past few decades. The committee identified and explored each of these issues and provides suggestions for improvement. Potential solutions identified include developing and applying strict criteria for determining the number of trauma centers needed within a given region, considering the needs of the local population, cost containment, and impact on adjacent trauma centers and their educational and research missions. There is opportunity for the OTA to work even more collaboratively with the American College of Surgeons to develop such criteria and to be involved with the orthopaedic accreditation and orthopaedic requirements. Collaboration between professional medical societies such as the OTA and American College of Surgeons and state and federal agencies is needed to help optimize the distribution of trauma centers.

Key Words: Trauma center, ACS, health care, trauma, Level I

1. Background

Trauma center designations were established by the American College of Surgeons Committee on Trauma (ACS-COT) in 1976, categorizing trauma centers into 5 levels. Hospitals apply for designation, and their assigned level depends solely on each institution's own capabilities and anticipated volume. Since 1976, there have been numerous publications regarding trauma centers^{1–30,31–55,56–69} considering topics such as bioterrorism preparedness,^{18,25} effectiveness,^{3,4,26} volume,^{9,11,12,24,28,31} closures,²¹ public perception,²⁵ specialization,²⁷ designation changes,^{16,17,30,32} competition,³⁵ and outcomes.^{5,9,12,15,16,19,20,22–24,26,29,30,33,68,69}

It has been 20 years since a comprehensive inventory of trauma centers in the United States has been published.¹ The authors and the Orthopaedic Trauma Association (OTA) Health Policy Committee have noted that the number of trauma centers has been increasing in the past few years and that the new trauma centers are largely in urban areas already served by existing

trauma centers while access to trauma care in rural areas remains poor. Because of this, the committee reviewed trauma center trends, needs, and deficits and considered the consequences of the increase in the number of trauma centers. The following specific questions were developed:

1. In the past 2 decades, has there been a rapid increase in the number of trauma centers, especially Levels I and II?
2. Has the increase in the number of trauma centers increased health care costs?
3. Has the increase in the number of trauma centers had consequences on volume of patients, with potential reduced efficiency of care, surgeon competency, and patient outcomes of each trauma center from the dilution effect?
4. What is the effect of trauma center proliferation on research and education?

This article reports the committee's findings as related to each of the questions above and provides suggestions for improvement.

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2. What Are the Different Types of Trauma Centers, and How Do They Receive Their Designation?

A trauma center is a hospital equipped to provide care for patients sustaining major traumatic injuries. In the United States, trauma centers undergo a designation process and a verification process.

Trauma center designation is a complicated geopolitical process performed by individual state/local governments according to their specific state laws or regulations and can vary between states. Trauma center verification is a separate process performed by the ACS to ascertain continuing competency related to specific standards.³⁸ There are 5 levels of designation for trauma centers, Level I to Level V, and a trauma center may have different designations for pediatric and adult trauma. The levels refer to the resources available at the center and the number of patients admitted yearly. A Level I center provides the highest levels of trauma care, has access to medical and surgical specialists, and has a wide variety of surgical and diagnostic equipment available. The lower the trauma designation, the lower the acuity of injuries that can be treated and the less resources available. Lower level trauma centers may only be able to provide initial emergent care and stabilization and arrange transfer to a higher level trauma center for further management.^{1,3,38–40}

Trauma center categories vary from state to state. The following are common criteria for trauma centers verified by the ACS and also designated by states and municipalities:^{1,3,38–40}

- A Level I trauma center is a comprehensive tertiary care facility central to the trauma system. They must provide total care for every aspect of injury. They require 24-hour in-house coverage by general surgeons and prompt availability of specialties such as orthopaedics, neurosurgery, anesthesiology, emergency medicine, radiology, internal medicine, plastic surgery, oral and maxillofacial, pediatric, and critical care. Level I centers are also responsible for leadership in education (such as residency programs, postgraduate training for physicians and nurses, and prehospital workers), research, and system planning. As such, they are usually academic teaching hospitals and have affiliations with a medical school or university.
- A Level II trauma center is able to initiate definitive care for all injured patients; however, tertiary care needs may be referred to a Level I center (such as replants or other subspecialized procedures). They require 24-hour immediate coverage by general surgeons and coverage by orthopaedic surgery, neurosurgery, anesthesiology, emergency medicine, radiology, and critical care. They work in collaboration with a Level I center if one is available and may take off some of the responsibilities of a Level I center (such as education) if there is no Level I center available in the community. Some Level II trauma centers are able to provide a higher level of care than the Level II requirements but lack the research and educational components for a Level I center, and hence, these are also designated Level II centers.
- A Level III trauma center has the ability to provide prompt assessment, resuscitation, emergency surgery, intensive care, and stabilization of injured patients. They have 24-hour immediate coverage by emergency medicine physicians and prompt availability of general surgeons and anesthesiologists. They have transfer agreements for patients requiring more comprehensive care to be transferred to a Level I or Level II trauma center.
- A Level IV trauma center is able to provide advanced trauma life support before transfer of patients to a higher level

trauma center. It provides evaluation, stabilization, and diagnostic capabilities for injured patients. They have basic emergency department facilities and 24-hour laboratory, and a well-trained physician or midlevel provider must be available on patient arrival. They may provide surgery and critical care services if available.

- A Level V trauma center provides initial evaluation, stabilization, and diagnostic capabilities and prepares patients for transfer to higher levels of care. They have basic emergency department facilities, with a physician or midlevel provider available on patient arrival. They have an after-hours activation protocol if the facility is not open 24 hours a day.

A trauma care system is a network of facilities that provide a spectrum of care for all injured patients in a geographic area. Ideally, the number and level of trauma centers in a given area would be determined by the volume of trauma, the population, and the available resources. However, these factors may be or may not be considered when the designating authority is the state, depending on their specific laws or regulations. The ACS verification process only considers the resources and capabilities of the center in question and whether that center meets established verification criteria. In most trauma systems, a combination of different levels of designated trauma centers will coexist as they each serve a different role within the community. In an optimal trauma system, there is a lead hospital: typically, a Level I; or Level II in less dense areas; or Level III in rural settings.^{38–40}

Trauma center verification is performed by the ACS based on standards that the ACS Committee on Trauma updates regularly³⁸ and are recognized nationally. ACS verification standards are determined by the level of designation (I–III) and are most strict for Level I centers; ACS verification is not performed for Level IV and V trauma centers. During site verification, the ACS does not consider how many centers are needed in a city or region; instead, the intent is to verify resources available and competencies demonstrated against criteria listed in the ACS “Resources for Optimal Care of the Injured Patient.”³⁸ This document is used as a guide for the development of trauma centers throughout the United States and serves as the basis by which trauma centers are reviewed by ACS-approved site surveyors every 3 years. The ACS updates the published version of the “Optimal Resources” book every 7–8 years; however, the guidelines are updated annually and are available on the ACS website.³⁸

3. What Has Been Happening in the Past Two Decades, and Why?

In the past 2 decades, there has been a rapid increase in the number of designated trauma centers.^{1,8,9,63,65} The reason for this is multifactorial. Media and public attention regarding the capacity for trauma care following natural disasters or mass casualty events has contributed to greater government funding and support for trauma centers.^{18,25,26,36} Increased reimbursement for trauma care may have contributed to enthusiasm for nontrauma hospitals to acquire a trauma center designation.^{20,64} Furthermore, increases in the number of trauma-trained physicians among the various surgical subspecialties have created a larger surgeon workforce.⁶⁴ With the increased funding available for trauma care and greater availability of orthopaedic trauma-trained surgeons, there has been a hospital-initiated proliferation of trauma centers, especially among nonacademically affiliated hospitals in urban locations.^{44,64}

Regarding sheer numbers, in the United States, there are over 6000 hospitals. In 2003, there were 1154 trauma centers in the United States: 190 Level I, 263 Level II, 251 Level III, and 450 Level IV/V. Of the 1154 trauma centers, only 184 were ACS verified (89 Level I, 80 Level II, and 15 Level III; Table 1).¹ The number of ACS-verified trauma centers increased from 184 in 2003 to 315 in 2013 and then to 457 in 2019.^{1,67} In 2023, there were over 2076 adult trauma centers across the country (an 80% increase from 20 years before): 220 Level I, 325 Level II, 465 Level III, and 1065 Level IV/V, with additional 153 pediatric trauma centers.² Many of the initial and recently added trauma centers are not ACS-verified.¹ Lack of verification may lead one to question the effectiveness of a trauma center, in particular the newest trauma centers. Much has been written regarding trauma system effectiveness.^{3,4,26} The metrics typically used to study effectiveness include comparing observed with expected mortality between centers and trauma center economics.^{5,13,16,21,32}

Compared with current practice, orthopaedic trauma was in its nascent stages in the latter half of the 20th century. There were only a few orthopaedic trauma fellowships, and the Orthopaedic Trauma Association (OTA/A) had significantly fewer members. Nearly 50 years later, fracture care has evolved into an increasingly complex and highly specialized part of orthopaedics, with a heavy overlap with both general surgery and electively based orthopaedic subspecialty colleagues.²⁸ Over this period, the expected work of an orthopaedic traumatologist significantly changed as the effect of advocacy led to greater surgeon support and resources. Initially, fracture care was demanding, laborious, and stressful. Hospitals typically did not provide dedicated orthopaedic trauma rooms, and compensation models were less likely to value noninsured patients whose care was not reimbursed. Most orthopaedic traumatologists worked at Level I centers, the majority of which were academic centers.²⁸

Improvements in prehospital transport, transportation safety measures (eg, greater focus on collision safety in the automotive industry), and advances in initial resuscitative measures have allowed many more patients to survive a trauma long enough to be evaluated at a trauma center and require treatment for complex orthopaedic injuries.^{68,69} Further adding to the burden of orthopaedic cases seen at trauma centers are other system issues, including increased litigation burden in trauma patients and the fact that such care is sometimes uncompensated work. As a result of these and other considerations such as concerns about work-life balance, many communities have a shortfall in the availability of general orthopaedic surgeons willing to take orthopaedic trauma call.^{47,54}

Fortunately, other positive changes in our health care systems have mitigated some of these burdens. It is now common practice to base surgeon compensation on work performed as measured by worked relative value unit models, rather than collected billings.⁶³ Furthermore, the importance of an available orthopaedic trauma room for effective patient care was recognized and is now incorporated into trauma guidelines.³⁸ This, coupled with

increasing research demonstrating that treatment of many orthopaedic injuries can be safely deferred to the next day without adverse consequences, has made a career in orthopaedic traumatology more desirable. In conjunction with an increase in orthopaedic trauma fellowship programs, pursuit of a career in orthopaedic traumatology became more common.⁵⁴

4. Why Does It Matter If There Are More Trauma Centers?

4.1. How Does the Increased Number of Trauma Centers Affect Patients and Surgeons?

One potential driver of growth in the number of trauma centers overall is the need to increase patient access.^{41–43} However, geographic distribution of new trauma centers has not necessarily addressed access disparities, as newer centers are predominantly found in urban/suburban communities near existing trauma centers.^{47,55,65} The addition of new trauma centers near an existing trauma center has been demonstrated to lead to decreased patient volume and changes in payer mix at the existing trauma center without a commensurate improvement in patient triage.^{45,63–66} Geospatial modeling studies based on systems developed by the ACS-COT have demonstrated that the addition of a new trauma center in a particular area can result in a 25%–40% reduction in the trauma volume at an existing trauma center while access to a trauma center increased between 1% and 62% depending on the location of the proposed new center.⁴³

The effect of Hospital Corporation of America (HCA) expansion can be used as an example for the effect of trauma center expansion on patients and surgeons.⁴⁴ HCA was one of the first hospital companies in America. They expanded rapidly by building hospitals in underserved areas, taking over existing facilities, and entering into graduate medical education and trauma centers.⁴⁴ HCA hospital growth has been especially notable in the state of Florida. Tepas et al⁴⁵ evaluated the impact of the opening of an HCA-affiliated Level II trauma center in the city of Jacksonville, Florida. Jacksonville was already home to University of Florida-Shands Hospital, an ACS-accredited Level I trauma center. The authors found that in the year after the Level II center became active, the overall volume at the Level I trauma center decreased by 9.4% and admissions related to blunt injury mechanisms decreased by 14%.⁴⁵ At the time, Jacksonville's regional trauma system was mature, and the incidence of trauma was actually decreasing. Yet, the addition of a Level II trauma center to the regional system increased trauma center access by 25% and increased the expense of necessary core personnel by 217%.⁴⁵ The economic benefits of adding a Level II center in proximity to an established Level I center are questionable.⁴⁵ Ideally, decisions on adding trauma centers to a region should be based on access needs and consider the survivability of the all trauma centers in the region.^{3,5,8–10,16,17,23,31,35,42,55}

In 2015, the ACS-COT developed the Needs Based Assessment of Trauma Systems (NBATS) to help optimize the distribution and type of trauma centers in a region. Winchell et al reported on the NBATS for California, which represents a geographically large state with numerous urban and large rural regions. The results demonstrated that there were 62 state-designated trauma centers: 13 Level I, 36 Level II, and 13 Level III.⁴⁶ Overall, NBATS estimates regarding the optimum number of trauma centers for the state were 27%–47% lower than the number of trauma centers in existence.⁴⁶ However, there were marked differences comparing urban with rural areas, with estimated need for trauma centers being lower than actual in 70% of urban areas but

Table 1
Number of trauma centers in the United States in 2002 and 2023.

Trauma Designation	2002	2023
Level I	190	220
Level II	263	326
Level III	251	465
Levels IV, V	450	1065
Total	1154	2076

higher than actual in 90% of rural areas.⁴⁶ Nicholas et al used NBATS to evaluate the state of Georgia, which has 19 designated Level I-III centers. In this case, the NBATS methodology suggested that 21 trauma centers were needed. However, similar to California, evaluation of location of the existing trauma centers demonstrated imbalances between need and capacity. Overall, among 10 distinct regions in the state, demand and capacity were matched in 2, capacity exceeded demand in 3, and distribution of trauma centers was deficient in 5.⁴⁷ In Georgia, densely populated/urban areas tended to have a higher number of trauma centers compared with estimated need, whereas geographically vast rural areas had a single urban core with a designated trauma center within that served the entire area.⁴⁷

The studies on NBATS across the country indicate a need for inclusion of additional information, such as improved modeling of population and injury distribution and consideration of transport time to the closest trauma center. Ideally, trauma center distribution would be based on ensuring that everyone would be within a 45-minute drive from a trauma center. Fischer et al evaluated the effect of using additional data points (NBATS-2 methodology) in planning a trauma system in an area with a legacy trauma center.⁴² In the area evaluated, 48% of the population and 58% of the injuries were within a 45-minute drive to a trauma center. Interestingly, modeling showed that adding another urban trauma center to the region increased access using the 45-minute drive criteria by only 1% while decreasing the trauma volume at the existing center by 40%.⁴² By contrast, if 2 rural trauma centers were added instead, the potential coverage increased to 62% of the total population and 71% of the injured. The volume at the legacy center would decrease by 25% and also be accompanied by an increase in the self-pay rate of 16%, highlighting the complex interaction between trauma center access and economics of trauma care.⁴² Although orthopaedic trauma care has been shown to be a valuable resource to the hospital ledger^{49,50} and hospital systems view trauma care as an opportunity to expand services, the effects on the entire trauma system should have some oversight.

With more hospitals designated as trauma centers, there is a need for more orthopaedic trauma surgeons in the workforce. Concern has been raised regarding the resulting volume and skill set of the surgeons at the existing trauma centers when more trauma centers are added. Several studies have projected trauma volume decreases at each site with expansion in overall trauma center numbers.⁴⁷ The addition of new trauma centers dilutes the number of complex trauma cases seen at each individual center and decreases the number of cases per surgeon. The effect of overall saturation of an urban area with multiple trauma hospitals is a major issue, as studies have demonstrated that lower hospital and surgeon case volume is a risk factor of poor outcomes in orthopaedic trauma surgery.^{51–53}

The impact of decisions about what constitutes the ideal number of trauma centers on the next generations of orthopaedic surgeons is an important consideration. Young surgeons need adequate case volume to maintain their skills and provide the optimum outcome for their patients. Gire et al demonstrated that early-career orthopaedic trauma surgeons have been performing less complex orthopaedic trauma procedures over the period between 2003 and 2015.⁵⁴ Academic centers may also see a decrease in the number of complex cases and not be able to as effectively train residents and fellows. The oversaturation of markets with trauma centers can lead to aggressive local competition for even simple cases, and referrals to the regional trauma centers may be compromised.

4.2. What Is the Impact of Trauma Center Propagation on Research, Education, and Trauma Fellowships?

The impact of a new Level I or II trauma center may be beneficial if there are no nearby trauma centers, or if nearby centers are overwhelmed by their existing volume of trauma cases. Conversely, the impact of a new center may be harmful if the already existing volume of trauma cases is barely adequate to maintain provider skills and resident teaching; in that circumstance, any reduction in trauma case volume may reduce staff and resident experience.⁵⁵ Although there is conflicting evidence on what role trauma center volume plays in patient outcomes,^{56–59} there is a concern among academic trauma institutions that a decrease in volume may have a similar negative effect on their research and educational missions. If the trauma center proliferation rate exceeds the increased regional incidence of orthopaedic trauma cases, then, on average, each existing center will see lower case volume for its resident and fellow trainees. In addition to education, the ability to conduct research is affected by a decrease in trauma volume. With reduced patient volume, it becomes more difficult to amass data and experiences worth publishing as an individual center and thereby studying and improving outcomes for trauma patients.⁵⁵ Several studies have demonstrated both decreasing and variable resident trauma case volume among surgical trainees including orthopaedic residents.^{60–62} While many factors can contribute to this finding, the underlying volume of surgical patients is certainly an important factor. The addition of a Level II center that competes directly with a local Level I center is widely believed to affect the financial, educational, and research capabilities of that Level I center.^{63,64}

Several studies have evaluated the impact of the designation of new trauma centers near Level I centers, which are responsible for training future trauma specialists and performing trauma-related research.^{46,55,63,65} In their retrospective study evaluating trauma admissions at an academic New York hospital before and after the designation of a nearby trauma center, Simon et al⁵⁵ demonstrated a 22%–29% reduction in the number of patients with severe head injury, laparotomies, and thoracotomies. They noted that if the American Board of Surgery had not recently reduced the operative requirements for graduation, the ability of the graduating resident to accumulate minimum case requirements would have been jeopardized.⁵⁵ In their study focusing on orthopaedic trauma at a Level I trauma center, Martin et al⁶⁵ demonstrated a decrease in orthopaedic trauma volume by 11% per month that persisted even after the Level II center lost its trauma designation. While many studies have evaluated change in trauma volume when a nearby hospital acquires a trauma designation, Carpenter et al⁶⁶ demonstrated that orthopaedic resident case volume increased when their institution changed from a Level II designation to a Level I. There is concern that orthopaedic trauma training is not immune to such effects as well.

5. Proposed Solutions Regarding the Impact of Trauma Center Proliferation

The authors and members of the OTA Health Policy Committee believe that there are several solutions to help address the concerns mentioned above, as outlined further.

First, planning, designation, and verification of new trauma centers should consider the following items in addition to the candidate hospital's capacity:

- The needs of the local population (whether urban or rural) and existing capacity to treat trauma patients and any gaps in access or capacity for trauma care.

- Weighing the impact of expected trauma volume on adjacent trauma centers including influence on patient care due to the dilution effect.
- Weighing the impact on the educational and research mission of Level I or academically affiliated Level II centers.
- There should be a continued focus on cost containment and a cost-benefit analysis to the health care system when considering adding more trauma centers (as opposed to just the for-profit hospital itself).

Second, there is opportunity for the OTA to work collaboratively with the ACS regarding orthopaedic accreditation and related requirements:

- Create more strict orthopaedic requirements for becoming a Level I center.
- Establish methods to distinguish between the various Level I centers, such as (1) creation of a specific designation for high-performing trauma centers; for example, creating a “Center of Excellence” for orthopaedic trauma, with specific requirements as outlined by the OTA and ACS; or (2) creation of a new level of ACS accreditation (ie, Level 0), with more strict requirements for all subspecialties. This would help decrease the number of the highest designated centers and help separate the academic centers (eg, academic high-volume centers with in-house orthopaedic residents) from other centers that do not have the same capabilities.

Noncompliance with reporting trauma data, such as National Trauma Data Bank or National Surgical Quality Improvement Program, may also be an opportunity to reduce the number of trauma centers.

6. Conclusions

There has been an increase in the number of Level I and II trauma centers across the United States in the past 2 decades, and this has occurred primarily in urban areas where trauma center access was already adequate while not addressing poor access to trauma centers in rural areas. Undisciplined distribution of trauma centers increases costs and negatively affects patient outcomes. It also lowers the efficiency and competency of each trauma center and surgeons from the dilution effect and negatively affects research, education, and experience for surgeons, trainees, and other allied health professionals. Trauma center designations should take into account the needs of the local population and the dilution effects on patient care, efficiency, and education. There is opportunity for the OTA to continue to work collaboratively with the ACS to consider and improve orthopaedic accreditation and requirements for trauma centers to improve patient care currently and in the future.

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