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The Relationship Between State Level Funding, Designated Trauma Centers, and Trauma Related Morbidity

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THE RELATIONSHIP BETWEEN STATE LEVEL FUNDING, DESIGNATED TRAUMA CENTERS, AND TRAUMA RELATED MORTALITY

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A DISSERTATION

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HEALTHCARE LEADERSHIP

ABSTRACT

This study examined the relationship of funding and the number of designated trauma centers and age-adjusted trauma mortality across the 50 states. State level funding was defined as monies that were paid to the designated trauma hospitals in aggregate by state and by year for the years 2008 to 2017. The number of designated trauma hospitals were considered in the categories of total number of state trauma hospitals and designation levels 1 through 4. Age-adjusted mortality included the ICD-10 codes for trauma from the WISQARS database. The strategic adaptation theory was used to inform the trauma hospital manager's need to attain, maintain, increase/decrease designation or close the trauma hospital program. Two hypotheses were tested to consider the positive association between state level funding and the number of trauma hospitals in a state as well as the negative association between the number of trauma hospitals in a state and trauma related mortality.

The study was completed using fixed effects panel regression analysis. Study findings showed an increase of 25.83% in Level 1 trauma hospitals in states that expanded Medicaid relative to the period prior to expansion. Each additional Level 3 trauma hospital in a state was associated with a .19 point increase in

trauma related mortality in contrast to Level 4 hospitals where an additional one in a state was associated with a .25 point decrease in trauma related mortality.

Keywords: funding, trauma, mortality, designation, Medicaid expansion, strategic adaptation

DEDICATION

I want to dedicate this work to the many nurses, physicians, and EMS providers who strive to provide the best care to patients with traumatic injuries every day. They work tirelessly in difficult settings and circumstances to provide the best outcomes for those they serve. For all the holidays and special events that these dedicated professionals miss to give their patients a chance to celebrate another holiday with their loved ones, I dedicate this research in the hopes that it will contribute to the body of learning that supports their valiant efforts.

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CHAPTER 1

INTRODUCTION

The leading cause of death in the first four decades of life in the United States is related to traumatic injury (Pigneri et al., 2017). Trauma is described as the accidental death or disability of an individual that is avoidable (Seeley, 1966). Examples of accidental trauma range from the less severe fracture of extremities to the more severe traumatic brain injuries, spine injuries and abdominal injuries from motor vehicle accidents and falls (DiMaggio et al., 2016). The number of traumatic injuries in the United States is rising annually and is responsible for more than 42 million emergency room visits, 2 million inpatient admissions, and over $406 billion of expenditures related to care of the injured patient as of 2013 (Kelly et al., 2015).

Trauma systems are defined as the prehospital services such as emergency medical services with 911 support, designated trauma center activation and resuscitation, and finally, post-acute services like rehabilitation and social services provided within a defined geographical area in a preplanned and coordinated fashion (Lin et al., 2020). Early treatment at a designated trauma center that has the level of services available to meet the patient's needs has been shown to improve outcomes for the injured patient (Ashley et al., 2015). Patients with severe trauma injuries require the highest level of trauma care available and rapid coordinated transport to the nearest Level 1 or 2 trauma center (Dakessian et al., 2007). Celso et al. (2006) found in their meta-analysis of trauma

literature a 15% reduction in mortality for trauma injured patients in the presence of a functioning trauma system.

The greatest threat to sustaining trauma systems' ability to provide regional organized care is financial insecurity (Mann et al., 2005). The financial challenges are driven by several factors inherent with the provision of trauma services (Scott et al., 2017). Designated trauma centers have high fixed-cost structures associated with readiness costs to meet the needs of severely injured trauma patients and comply with the quality standards of the American College of Surgeons Committee on Trauma (ACS-COT) that require the availability of highly trained personnel activated prior to the trauma patient arriving to the trauma center (Geehan, 2010). In the absence of federal funding, some states have closed the gap in funding needed to sustain trauma systems in their states by providing state level funding (Kelly et al., 2015).

Background

Trauma centers are divided into different types based upon their capabilities, commonly referred to as levels. Level 1 is the highest designation of a trauma center with the most resources and Level 4 is the lowest designation of a trauma center with the least number of resources needed to care for the injured patient. The ACS-COT recommends the required elements for each of the designation levels for trauma centers.

Level 1 trauma centers are typically found in academic medical centers and include a research and teaching requirement that supports the continued development of trauma services as a part of their designation. The Level 1 trauma center provides the most acute care available to trauma patients and is typically located in more populated

urban areas and serves as the hub for an inclusive trauma system (Ashley et al., 2015). These trauma centers are typically associated with the highest fixed costs of the designated trauma centers due to the research and teaching requirement and in many instances are associated with safety net hospitals that experience higher rates of uninsured injured patients that place these trauma centers at financial risk in the absence of state level funding (Knowlton et al., 2018).

Level 2 trauma centers provide nearly equivalent level of care to injured patients as Level 1 trauma centers but do not have the teaching and research requirements. As part of a regionalized trauma system they are typically located in an area that is less populated than those of a Level 1 trauma center, but still play a significant role in the trauma system by caring for severely injured trauma patients (Press, 2021). Level 1 and Level 2 trauma centers provide care to the most severely injured patients in most states regardless of the trauma system design whether it be inclusive or exclusive due to the availability of resources required to care for the trauma patients being concentrated in these hospitals.

Exclusive trauma systems are designed around higher Level 1 or Level 2 designated trauma centers with emphasis of transporting trauma patients rapidly to the larger trauma centers (Lansink & Leenen, 2007). Inclusive trauma systems are designed with all levels of designated trauma centers included and focus on prehospital triage protocols to get the patient to the most appropriate trauma center rapidly in a coordinated manner within a region that is predetermined by the lead agency (Lansink & Leenen, 2007; Pigneri et al., 2017).

Level 3 and Level 4 trauma centers are part of an inclusive trauma system that are located in more rural parts of a region or state, and their role is to help triage, stabilize,

and coordinate transfer of trauma patients to Level 1 or 2 trauma centers as needed. Studies have demonstrated that with state level funding more robust inclusive trauma systems can thrive and sustain Level 3 trauma centers that support trauma patients' entry into a coordinated system of trauma care (Kelly et al., 2015).

Financial Implications

In the absence of a national trauma system, individual states retain the authority to approve criteria for trauma center designation and the formation of regionalized trauma care. Hospitals are free to choose to participate as designated trauma centers or remain undesignated if they perceive the costs outweigh the benefits of participating in the trauma system. The costs associated with maintaining trauma center readiness are comprised of administrative costs, clinical medical staff, operating room standby costs and education and outreach costs aimed at prevention (Ashley et al., 2017). These readiness costs are not reimbursed through traditional payment models and require funding from state level sources to help offset expenses to support trauma system viability (Knowlton et al., 2018).

Twenty percent of trauma patients are uninsured on average nationally at the time of their injury and can require not only expensive emergency trauma care but also have extended stays in the intensive care unit and require rehabilitative care that takes months or years to complete (Scott et al., 2017). Many Level 1 trauma centers are found within safety-net hospitals that serve a vulnerable population who are more likely to be uninsured or underinsured putting additional financial pressure on the trauma center to cover the fixed costs associated with 24/7 readiness found at high level designated trauma

centers (Knowlton et al., 2018). Safety-net hospitals depend on additional subsidies such as disproportionate share hospital payments to help offset operational losses and continue to provide the level of care required for trauma patients in a Level 1 trauma center setting especially in the absence of state level funding dedicated to trauma system services (Knowlton et al., 2018).

The two largest expenses associated with designated trauma centers are treatment costs and readiness costs (Ashley et al., 2019). Readiness costs associated with designated trauma center operations are those costs that are incurred by the trauma center in stand-by expenses for the trauma team to be immediately available for a trauma patient's arrival yet are not directly billable to an individual patient (Ashley et al., 2017). The average readiness cost per trauma patient, according to Ashley et al. (2019) in a study of the Georgia trauma system, was $4,480. State level trauma system funding in the state of Georgia is set at $16 million annually to offset this expense that is not billable to the patient but incurred by the trauma center (Ashley et al., 2019).

In an effort to cover losses not subsidized by another revenue stream, some trauma centers have elected to charge activation fees for trauma stand-by time to the injured patient. These activation fees are an attempt to reconcile the readiness costs associated with designated trauma center compliance with high Level 1 and 2 guidelines as outlined by the ACS-COT. The challenge with activation fees is determining the amount to charge the patient as compared to the cost of the readiness stand-by time to be accurately attributed to each trauma patient. Activation fees have become controversial in some states where the rates have exceeded the billed treatment costs and have been

perceived as an attempt to drive profit while ignoring adherence to ACS-COT guidelines for volume requirements for Level 1 and 2 trauma center designations (Hancock, 2021b).

The risk of trauma center closure due to financial hardship is greatest for safety-net hospitals and rural hospitals leaving vulnerable communities without immediate access to designated trauma centers. Rural residents experience a lack of access to physician care and travel time that exceeds 30 minutes to emergency care due to rural hospital closures (Brown et al., 2016; Hsia & Shen, 2011). For the urban safety-net hospitals, closure of the trauma center is most often a result of financial hardship and a negative profit margin that leaves a vulnerable community geographically farther from definitive trauma services in the event of traumatic injury (Hsia & Shen, 2011).

Patient Outcomes

Early intervention at a Level 1 or Level 2 trauma center for the most severely injured patient has been shown to reduce mortality as compared to treatment at a non-trauma center (Härtl et al., 2006; MacKenzie et al., 2006). Multiple studies have been conducted that have shown reduction in morbidity and mortality when patients receive trauma care at Level 1 and Level 2 trauma centers in a timely manner and do not have to travel long distances to access these higher levels of care (Hsia et al., 2014). The American College of Surgeons (ACS) *Statement on Trauma Center Designation Based upon System Need* states that "regional trauma system implementation has been shown to improve mortality and reduce complications" (para. 1).

A study conducted by the Arkansas department of health to review the implementation of an inclusive statewide trauma system on the reduction of preventable

mortality found a preventable death rate reduction of 16% from 2009-2014 (Maxson et al., 2017). At the beginning of the study, none of the hospitals had designated trauma centers and by the end of the five-year period the state had designed an inclusive regionalized trauma system with highly coordinated care that included prehospital triage protocols, interhospital transfer agreements and protocols and use of air medical support. The state of Arkansas funded the trauma system in the amount of $20 million annually (Maxson et al., 2017). This example of an inclusive regionalized trauma system has been shown to be successful to reduce mortality in the civilian and military setting repeatedly (Maxson et al., 2017).

A review of the Georgia state trauma system demonstrated an increased survival rate of 8.3% to 22.0% when a trauma patient was treated at a designated trauma center from 2008 to 2012 (Ashley et al., 2015). At the time, the state of Georgia was developing their state trauma system and just beginning to fund $16 million annually to develop an inclusive regionalized trauma system. During this period, they went from an exclusive trauma system with some independent Level 1 trauma centers to a more cohesive organized statewide trauma system and improved number of designated trauma centers and saw their trauma mortality improve (Ashley et al., 2015).

National studies on trauma systems and subsequent trauma mortality demonstrate the same reduction in overall trauma mortality of 25% when patients are treated in an inclusive regionalized trauma system (Lansink & Leenen, 2007). The funding of regionalized trauma systems is not done at the federal level and is not universal or consistent across states. “A critical component of this systems approach is the designation or verification of trauma center hospitals equipped to treat more severely injured

patients" (Branas et al., 2005, p. 2626). Several rural areas of the country are still at risk for prolonged travel times and have limited access to designated trauma centers and thus, do not receive the same benefits of mortality reduction (MacKenzie et al., 2006). State funded trauma systems promote inclusive regionalized systems that reduce mortality over time (Olson et al., 2001).

Even with reduction in trauma mortality in inclusive regionalized trauma systems, overall trauma death rate is on the rise from 2000 to 2010 by 22.8% (Rhee et al., 2014). Rhee et al. (2014) conducted a study examining the increase of trauma deaths in the United States for the years 2000 to 2010 and found a trimodal pattern of growth and shift in the peak ages of trauma related mortality. The decades of 20, 40, and 80 had the highest peaks of mortality, and the age associated with trauma mortality shifted to an older average age within these decades of life by several years respectively during the course of the study (Rhee et al., 2014). DiMaggio et al. (2016) found that the average age of injured patients was increasing and attributed this increase to the overall aging of the population. Trauma remains the leading cause of death for people in the first four decades of life and is the leading cause of productive years of life lost when compared to other diseases up to the sixth decade of life (DiMaggio et al., 2016; Rhee et al., 2014).

Theory

Organizational adaptation theory focuses on the "intentional decision making undertaken by organizational members, leading to observable actions that aim to reduce the distance between an organization and its economic and institutional environments" (Sarta et al., 2021, p. 44). This theory helps to explain the behavior that trauma center

managers exhibit when faced with the decisions to attain, maintain, lower, or increase trauma center designation or ultimately close a trauma center.

Trauma center designation requires adherence to ACS-COT guidelines that require continued readiness for severely injured trauma patients. This level of readiness is costly and is not directly reimbursable by traditional payers. One out of five trauma patients are not insured (Scott et al., 2017), which requires the trauma center manager to maintain operations of the designated trauma center with limited reimbursement and high fixed cost. In the absence of federal and state funding, the trauma center manager has to respond to organizational pressures and either limit costs or improve revenues to continue to offer trauma services as a designated trauma center (Trinh & Begun, 1999). This can be done by discontinuing trauma services altogether or lowering the trauma designation level in an effort to minimize financial hardship. In the situation where state funding is present, trauma center managers are more likely to respond to environmental needs and participate in an inclusive regionalized system where fixed costs are covered (Trinh & Begun, 1999).

Problem Statement

The high cost of trauma related care of the injured patient at a Level 1 and Level 2 trauma center as part of a larger trauma system, threatens the long-term viability of trauma centers and could lead to longer travel times for injured patients to receive care if trauma centers were to close or discontinue trauma services. The reduction in services and treatment can lead to injured patients receiving care at non-trauma centers which is known to have higher mortality rates for injured patients as compared to Level 1 and

Level 2 trauma centers (Ashley et al., 2015). Inclusive regionalized trauma systems provide a coordinated approach to the care of the injured patient and increase the number of designated trauma centers by increasing the number of Level 3 and 4 trauma centers as part of the trauma system. This has been demonstrated in several states with the implementation of state level funding for a statewide trauma system (Ciesla et al., 2017; Maxson et al., 2017). Reduction in trauma related mortality has been documented because of the implementation of these statewide funded trauma systems (Ashley et al., 2015; Maxson et al., 2017).

This study examined the relationship between state trauma funding, the number of designated state trauma centers, and state level trauma related mortality. The two examples of Arkansas and Georgia statewide trauma systems demonstrate the possibility of a positive relationship with state funding and number of designated trauma centers and improvement in trauma related mortality. Previous studies related to trauma centers have researched the relationships of the current study independently, but none have researched these relationships collectively. The study examined these relationships between the years of 2008 and 2017 for all 50 states.

CHAPTER 2

LITERATURE REVIEW

The following chapter provides an overview of the literature related to the topics of state level funding, trauma center designation and costs, and trauma related mortality. Despite the advances in medicine, trauma related injury continues to be an expensive public health crisis (Ashley et. al., 2019). In the absence of a federal trauma program, the delivery of care and organization of trauma systems becomes a responsibility of local trauma centers, regions and states. This responsibility for trauma care and absence of federal funding provides a challenging environment for the trauma center manager to operate within successfully. This chapter provides a conceptual framework to motivate the study hypotheses.

Trauma Center Designation

Trauma centers are designated by levels according to the provision of services that they provide to the injured patient. The ACS-COT provides a classification system for these levels. Level 1 trauma centers provide the highest level of care to the injured patient and also fulfill a research and teaching mission. They are typically associated with a University that supports research and residency teaching as well as outreach in the community for injury prevention and system planning with an annual volume of injured patients that exceed 1,200 admissions per year or 240 major trauma patients per year and

are typically located in an urban area (ACS-COT, 2014; Bazzoli & MacKenzie, 1995; MacKenzie et al., 2003).

Level 2 trauma centers are part of a larger trauma system and provide nearly identical care to a Level 1 trauma center with the exception of highly specialized care in subspecialty areas and don't have the volume requirements of a Level 1 trauma center. Level 2 trauma centers are typically located in less populated but urban areas and serve as the primary trauma center that coordinate with a Level 1 center for the most severely injured patient that needs to be transferred and provide leadership in their local geographic area for system planning (MacKenzie et al., 2003; Surgeons, 2014).

Level 3 trauma centers provide important care as a part of a larger trauma system. Injured patients that present to a 2Level 3 trauma center require stabilization and/or emergent surgery as a part of their care and approximately two-thirds of them are located in rural areas (Bazzoli & MacKenzie, 1995). Subsequently, patients may be transferred to a level 1 or 2 trauma center if the severity of injury dictates the need for transfer to a higher level of care. Level 3 trauma centers provide an entry point into the trauma system and stabilizing care with coordination of additional support from higher level trauma centers when needed (MacKenzie et al., 2003; Surgeons, 2014).

Level 4 trauma centers are most likely located in rural areas and serve communities that do not have access to Level 1 or 2 trauma centers. Their role in the trauma system is to assess, stabilize the patient to the best of their ability, and transfer the patient to the closest, most appropriate facility that can manage their trauma needs ((ACS-COT, 2014; MacKenzie et al., 2003).

Trauma Systems

The regionalization of a trauma system is outlined in the 1992 model trauma system plan written by the Health Resources and Services Administration (HRSA) that includes "injury prevention, prehospital phase, the hospital phase, rehabilitation, and returning back to work, and importantly, a method for assessing the system performance and identifying and fixing problem areas" (Jurkovich, 2012, p. 8). The ACS-COT and the American College of Emergency Physicians produced a joint consensus statement in 1998 on the eight key elements of a trauma system necessary for the care of an injured patient. These elements act as a guide for states in the absence of a national trauma system and are closely aligned with HRSA recommendations. The guidelines require (1) a lead agency with regulatory authority such as the state health department that can provide ultimate oversight of the system, (2) ensure the system addresses the care of the patient from the prehospital setting until the post hospital rehabilitation environment with a focus on prevention outreach, (3) a formal survey process for trauma center level designation, (4) established treatment/triage protocols for routing of injured patients to the correct trauma center based on need, (5) ensure access for the most severely injured to higher level trauma center care, (6) needs based location of trauma centers across the state optimized to provide access for the injured patient, (7) lead agency monitors costs associated with care of the injured patient to ensure continued access to high level trauma centers, and (8) continuous monitoring of quality of care to facilitate improved outcomes in morbidity and mortality for the injured patient (Bazzoli et al., 1998; Blackwell et al., 2003; NASEMSO, 2016). The differentiation of an inclusive versus exclusive trauma system is defined by how patients in an inclusive system are cared for in a geographical

region with the coordination of all the hospital facilities participating in the trauma system rather than in an exclusive system in which care is centered around a singular level 1 trauma center (Ashley et al., 2015; Lansink & Leenen, 2007). For example, patients treated in an exclusive trauma system are more likely to be triaged incorrectly and not transported to the closest most appropriate trauma center at initial time of injury (Ciesla et al., 2017). The inclusive trauma system includes the eight key elements of a trauma system and is therefore more comprehensive and collaborative to improve the appropriate distribution of injured patients within the trauma system.

As briefly mentioned in Chapter 1, Arkansas invested $20 million dollars in their statewide trauma system and realized an improvement in the care of trauma patients and the number of lives saved (Maxson et al., 2017). They started by increasing the number of patients transported directly from the scene of the accident to a Level 1 trauma center when possible and increasing the number of patients resuscitated in a Level 3 or 4 trauma center as part of a regionalized trauma system and then transferred as needed to a higher level trauma center (Maxson et al., 2017; Sewalt et al., 2021). They were able to achieve a 47% reduction in preventable mortality of trauma patients in under five years since the inception of their trauma system due to the coordination in care (Maxson et al., 2017). Southern Illinois Healthcare Memorial Hospital opened as the only trauma center in southern Illinois in 2019 and achieved Level 2 trauma center designation and is decreasing the time from injury to treatment by reduction in drive time and coordinating transfer to Level 1 trauma centers for the most severely injured patients (Press, 2021). In the first year of operation, the trauma center doubled the projected volume of trauma related cases demonstrating the need for the trauma center and ultimately the

improvement to mortality (Associated Press, 2021). The new trauma center provided earlier access to care for patients in the region and coordination with the Illinois trauma system for transfer of patients to higher level of care as needed (Associated Press, 2021). Both states are examples of an inclusive trauma system that provides regionalized care across a large geographic area. This type of coordination supported by state level funding to provide the resources of higher-level designated trauma centers improves outcomes and reduces trauma related mortality (Olson et al., 2001).

The regionalization of a trauma system that produces an inclusive system has a positive impact on the urban and rural geographic areas of a state that ultimately affects access to trauma centers for injured patients. A regionalized trauma network that provides for consultation between the Level 3 or Level 4 hospital and the tertiary care Level 1 or 2 hospitals allows the triage of patients and care to be provided in the best setting while avoiding unnecessary transfers (Choi et al., 2021). A challenge in regionalizing trauma systems lies in the urban setting. The ACS-COT designed a Needs Based Assessment of Trauma Systems tool (NBATS) that considers the variables of population, the size of the region, and the number of trauma patients to determine the need for designated trauma centers within a defined region (Stey et al., 2020). The need for the number of Level 1 or Level 2 trauma centers in large cities is difficult to assess with the NBATS tool because it treats urban and rural areas the same (Stey et al., 2020). Large urban cities have higher injury rates proportionately than rural areas and as such the need in urban areas for Level 1 or Level 2 trauma centers may exceed what is identified by the NBATS tool according to a study by Stey et al. (2020) describing the density of high-level trauma centers in the 15 largest U.S. cities. In densely populated areas, over supply of Level 1 and Level 2

trauma centers can dilute trauma volume and negatively impact training and patient outcomes that are part of the mission of a larger trauma center (Stey et al., 2020). As of January 2005, “more than four fifths of Americans had access to Level I or II trauma centers within an hour” (Branas et al., 2005, p. 2630).

Small hospital closures and lack of physician presence in rural communities puts these small communities at risk for poor outcomes due to traumatic injury as a result of extended travel time to reach a trauma center (Hsia & Shen, 2011). For those injured patients in rural areas treated in Level 3 or 4 trauma centers, studies have shown that treatment in lower level trauma centers that are part of a regionalized trauma system improves patient outcomes (Olson et al., 2001). Hsia and Shen (2011) studied baseline distance to trauma centers in 2001 and found that three-fourths of the U.S. population lived within 10 miles of a trauma center. In a study by Kelly et al. (2015) the number of Level 3 trauma centers was shown to increase when the trauma system had state level funding. This increase drives improved coordination and planning across a region and ultimately access to timely trauma care in rural areas. Oregon implemented a statewide trauma system and required all trauma center providers to be certified in advanced trauma life support including the Level 3 and Level 4 medical personnel (Olson et al., 2001). Care of trauma patients improved at the Level 3 and Level 4 hospitals prior to their transfer to a higher level of care after the implementation of the trauma system statewide (Olson et al., 2001). This investment in rural trauma centers demonstrated that training and providing care according to consistent protocols improved trauma patients’ care despite the longer travel times to Level 1 or Level 2 trauma centers once the patients were transferred.

Funding and Costs

State Level Funding

Trauma centers loosely follow the ACS-COT guidelines for level designation unless they seek ACS accreditation. The United States does not have a national standard for trauma centers or trauma systems and delegates the oversight to the state level. The lack of national standards and funding has resulted in disparities in funding, lack of adherence to accreditation guidelines and gaps in regionalization of trauma centers and trauma systems (Brown et al., 2013). In a study conducted by Kelly et al. (2015), they found that only 24 states had some type of state level funding in place for trauma systems and the remaining 26 states had no state level funding in place for trauma systems which exacerbates the challenges to access coordinated care for trauma injured patients. A study of all 50 states was conducted by Mann et al. (2005) to determine the strengths, weaknesses, opportunities, and threats to their state trauma systems. Mann et al. (2005) found that finance was listed as the top weakness, threat and opportunity in the study suggesting that inadequate funding is the highest priority for improvement of trauma systems. Lin et al. (2020) conducted a survey of all 50 states to determine the different types of funding the trauma systems in each state received and were able to locate eight different types and amounts of funding for 58% of the states. One state had no funding source of any kind, and the remaining 40% of states were undetermined because the information was unable to be obtained. This study illustrates the varied sources of funding across the U.S. and highlights the financial insecurity that can be experienced by trauma centers and the lack of a national standard for regionalized trauma systems. Trauma centers that are the anchor of a trauma system require reliable funding that

supports the 24-hour availability of necessary personnel and equipment for the injured patient (Blackwell et al., 2003).

Safety Net Hospitals and Disproportionate Share Payments

Level 1 trauma centers care for 40% of the severely injured patients in the United States which are known to have a higher percentage of Medicaid and unfunded payer sources than other hospital patient types while the cost of care is rising faster than total healthcare spending (DiMaggio et al., 2016). "The marginal cost per life saved was between $32,514 and $122,750" (Durham et al., 2006, p. 782). This compares favorably to other major disease states such as coronary artery bypass graft and breast cancer treatment when you consider the number of years of productivity gained as compared to the cost in the younger population of trauma patients (Durham et al., 2006). The Institute of Medicine recommends greater regionalization of trauma services to not only improve services provided to injured patients but also to deliver a coordinated and accountable system that supports funding to safety-net hospitals with trauma centers that provide disproportionate levels of unfunded care (IOM, 2006; Kim et al., 2009).

Level 1 trauma centers are frequently found in safety-net hospitals (SNH) which are defined as hospitals "that organize and deliver a significant level of health care to the uninsured, Medicaid, and other vulnerable populations, or who by mission, offer access to care regardless of a patient's ability to pay" (Knowlton et al., 2018, p. 172). Many SNH rely on disproportionate share hospital (DSH) payments to offset losses associated with the care of high numbers of uninsured or underinsured patients (Knowlton et al., 2018; Scott et al., 2017). The expansion of Medicaid under the Patient Protection and

Affordable Care Act (ACA) in some states increased the number of trauma patients with insurance but threatens to reduce the DSH payments to SNH. While Medicaid reimbursement has a significant impact on the financial solvency for SNH and trauma centers, additional subsidies are needed in order to maintain the high level of standards required to comply with ACS level designation (Knowlton et al., 2018; Scott et al., 2017). The hazard rate of closing a trauma center is higher with a negative profit margin, high HMO market penetration and hospitals in regions with higher numbers of minorities (Shen et al., 2009). Safety net hospitals (SNH) are at greatest risk of closing trauma centers without additional funding due to increasing numbers of patients with penetrating trauma, Medicaid and self-pay (Hsia et al., 2011).

Fakhry and colleagues (2010) conducted a study to examine the profitability of a trauma center considering the length of stay (LOS) of trauma patients as a driver of profit or loss. Fakhry et al. found that LOS was important to the trauma center and could be managed to minimize cost, but in a SNH overall profitability was determined by the overall payer mix and not solely by the extended stay of trauma patients. Twenty percent of trauma patients are uninsured on average so the expansion of insurance coverage under the ACA can lead to an increase in reimbursement for trauma centers and in some geographic areas could lead to an increase in trauma centers that are not needs based resulting in dilution of volume and erosion of quality of care (Scott et al., 2017). In other geographic areas that are less profitable, loss of DSH funds for SNH could exacerbate lack of access to trauma care for vulnerable populations if SNH have to close trauma centers in non-profitable areas (Scott et al., 2017; Shen et al., 2009).

Forrester et al. (2017) conducted a study of Level 1 trauma centers to understand the financial payer mix and population served and determine if they could be described by definable clusters. They found three distinct clusters of Level 1 trauma centers. The first cluster was more likely to admit older, white trauma patients after a fall with private insurance or Medicare. The second cluster were more likely to admit younger, minority males with penetrating trauma that were unfunded or had Medicaid insurance. The third cluster resembled the first cluster in demographics and insurance status but shared the second cluster characteristics in types of injuries encountered. A larger percentage of the first cluster were discharged to a skilled nursing facility than the other two clusters and the mortality rate for the three clusters was not found to have a statistically significant difference. This clustering methodology could help direct limited trauma funding resources towards Level 1 trauma centers in SNH that are most vulnerable to closure due to financial pressures and serve minority populations such as those found in the second cluster (Forrester et al., 2017). “Trauma center closures over the last 20 years have disproportionately occurred in low-income areas” (Stey et al., 2020, p. 3). Low income communities and rural areas experience disparities in health outcomes related to traumatic injuries due to difficulty with access to emergency care (Hsia & Shen, 2011). Rural communities have a greater challenge with access to a trauma center exacerbated by closures than urban areas due to distance from the nearest trauma center (Hsia & Shen, 2011).

Hsia et al. (2011) found that SNH were more likely to close their emergency departments which would displace the vulnerable population that depends on the SNH for healthcare and put pressure on surrounding hospitals leading to more emergency

department overcrowding. In the absence of adequate, reliable state and federal funding for SNH that serve trauma patients, these trauma centers are at risk of closure which could impact the insured and uninsured with higher morbidity and mortality (Bazzoli et al., 1996; Hsia et al., 2011). Hsia et al. (2014) completed a study in California of trauma centers to determine the impact on patients who had an increase in drive time due to closures of trauma centers and found that 21% were more likely to die of trauma than those that did not have an increase in drive time. Those who faced an increase in drive time were more likely to be younger, insured with Medicaid, a minority, and low income and subsequently more likely to experience 29% higher odds of inpatient mortality due to trauma centers within two years of closure (Forrester et al., 2017; Hsia & Shen, 2011; Hsia et al., 2014; Stey et al., 2020). "The future of trauma systems seems to depend on finding fiscal solutions to providing the intensive level of care that trauma systems demand" (Mullins, 1999, p. 9).

Readiness Costs

Level 1 and Level 2 trauma centers provide similar levels of trauma care and must have medical personnel on standby for the immediate care of a severely injured patient (Kaji et al., 2017). The time spent by medical personnel in the trauma center waiting for an injured patient is known as readiness costs and is outlined in the *Resources for Optimal Care of the Injured Patient* by the ACS (Ashley et al., 2019; Geehan, 2010). Readiness costs are only part of the fixed cost of a trauma center; the other variable cost associated with a trauma center include treatment costs for the injured patient. In a 2016 study of Georgia trauma centers, the average annual readiness costs for Level 1 trauma

centers was $10,078,506 and $4,925,103 for Level 2 trauma centers (Ashley et al., 2019). Of note, the greatest difference between Level 1 and Level 2 trauma center readiness costs is due to the medical personnel costs for on-call coverage to maintain compliance with the ACS guidelines for Level 1 designation (Trauma, 2017). The volume requirement for Level 1 trauma center in combination with the surgical specialties on-call and resident teaching support, enumerates the additional cost associated with a Level 1 trauma center in comparison to a Level 2 trauma center's fixed readiness cost structure (Ashley et al., 2019). In order to offset some of the cost associated with readiness costs, some hospitals charge trauma activation fees using revenue code 68x made available in 2002 (Geehan, 2010). The spectrum of use of the revenue code 68x varies from not being used at all by some trauma centers due to its high rate of denial by payers, to over usage by a few trauma centers with elevated charges that exceed other charges for treatment, supplies, x-rays and medications as a source of revenue growth (Geehan, 2010; Hancock, 2021a).

The activation fees and revenue code 68x sparked a growth in trauma centers in Florida in the last decade that has included controversy over adherence to the ACS guidelines with respect to treatment of injured patients at an appropriate level designation hospital aligned with the severity of their injury due to the over saturation of Level 1 and 2 trauma centers (Hancock, 2021b). Charges at the new trauma centers were substantially higher than at the existing trauma centers and the addition of the new trauma centers did not improve the triage performance measures of the trauma system (Ciesla et al., 2017). Ciesla et al. (2017) noted:

> A recent statement by the American College of Surgeons Committee on Trauma noted that uncontrolled growth of trauma centers has the potential to undermine the quality of regional trauma care by creating areas of oversupply and adverse competition while ignoring underserved areas entirely. (p. 1014)

Trauma Related Mortality

During the period of 2000 to 2010 trauma deaths increased by 22.8% while the overall growth in the population was only 9.7% (Choi et al., 2021; Rhee et al., 2014). Trauma as the leading cause of death has increased in age from those under 44 years of age to those under 46 years of age while the largest single increase per age group in mortality was seen in those aged 45-64 years, attributable to unintentional injury and suicide for the same time period (Rhee et al., 2014). The group aged 84 years and older experienced a 56% increase in mortality from injuries as simple as falls from standing due to comorbidities that complicate their care and recovery for the period of 2000 to 2010 (Choi et al., 2021).

The three phases of trauma mortality as defined by Jurkovich (2012) are: (1) deaths that occur at the trauma scene that can only be stopped with injury prevention, (2) early deaths that can be mitigated by impacting improvements in coordination of prehospital and emergency department/trauma center care, and (3) late deaths that are related to the intensive care unit and reduction or avoidance of complications. Improvement efforts to guide interventions at reducing trauma related mortality start by stratifying deaths into categories of non-preventable, potentially preventable and preventable (Koh et al., 2019). This stratification allows for better understanding of the

mechanism of injury and mortality rate associated with performance of the trauma center and helps direct improvement efforts and potential funding opportunities (Koh et al., 2019). The method to rank trauma centers on mortality uses the observed-to-expected mortality ratio with the expected mortality calculated as risk adjusted by multiple patient demographics and injury severity scores (Gruen et al., 2012; Hashmi et al., 2014). The leading cause of potentially preventable death continues to be from hemorrhage which supports the need for continued efforts to improve early intervention for injured patients in a regionalized trauma system (Koh et al., 2019; Rainer & de Villiers Smit, 2003). Organized trauma system care reduces mortality and morbidity and is cost-effective due to the reduction in economic burden for the trauma patient and the community, but the sustainability of trauma centers requires injury control and trauma care to be a priority for state and national government agencies (Stewart et al., 2019).

A study by MacKenzie et al. (2006) of Level 1 trauma centers as compared to non-trauma centers across 14 states revealed that Level 1 trauma centers treat more patients that are younger and severely injured as compared to non-trauma centers that treat more patients that are elderly with comorbidities. The results of the study demonstrated that the risk of death is lower in a Level 1 trauma center as compared to a non-trauma center which supports the continued need for funding of regionalization of trauma systems (Celso et al., 2006; MacKenzie et al., 2006). In the overall performance of trauma centers versus non-trauma centers "there was a 15% - 20% reduction in mortality risk where trauma systems outperformed non-trauma hospitals" (Celso et al., 2006, p. 375). Important to note from their study is the unique complexities in the care of the elderly trauma patient and associated mortality risk and the inability to extrapolate the

results of the study to rural areas where increased distance to a trauma center can increase risk of death (MacKenzie et al., 2006).

Severely injured patients have a lower mortality risk when treated in an inclusive trauma system as compared to an exclusive trauma system due to the coordinated care (Lansink & Leenen, 2007). Trauma centers also have an inpatient mortality rate for injured patients on average of 7.6% as compared to 9.5% for non-trauma centers demonstrating continued advantages of trauma centers for patient outcomes related to mortality (Lansink & Leenen, 2007). Some of the most severely injured trauma patients are those presenting to the trauma center with no signs of life and in a study by Dakessian et al. (2020) found that with these patients with the highest risk of mortality had a survival rate as high as 27.9% at designated trauma centers. These findings support directing care of the most severely injured patients to Level 1 or Level 2 trauma centers (Glance et al., 2012). Ashley et al. (2015) conducted a review of the Georgia state trauma system and found that when patients with a mortality risk of 15% or greater were treated at a trauma center they had a significantly higher survival rate ranging from 8.3% to 22% and concluded that their investment of state funds was impacting patient survival positively.

Theory

Hospital managers today are faced with increasing pace of change and the need to transition their organization from a fee-for-service organization to a value-based provider of care (Meyer, 2011). This change is occurring while other requirements such as the implementation of costly electronic health information technology, emerging technology,

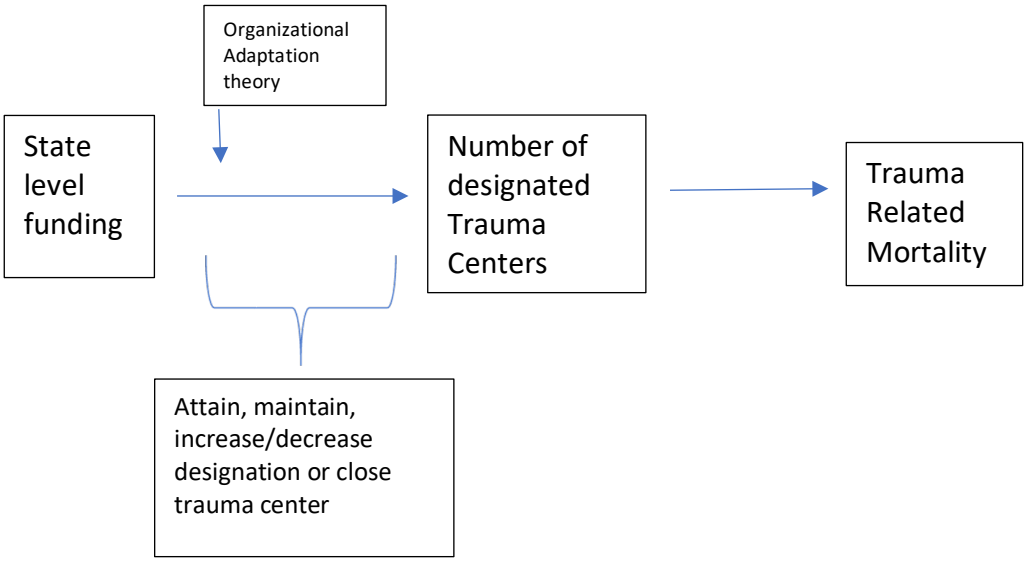
bundled payments, skilled labor shortages and rising demand for more outpatient services increases. The ability to adapt is a foundational competency of today's hospital manager so that they may acquire necessary resources, respond to community needs, provide quality care and do so in a fiscally efficient manner (Sicotte et al., 1998). Organizational adaptation theory helps explain why trauma center managers make the decision to either attain, maintain, increase/decrease their trauma center's designation level or possibly close the trauma center program. Sarta et al. (2021) defined organizational adaptation as the "intentional decision making undertaken by organizational members, leading to observable actions that aim to reduce the distance between an organization and its economic and institutional environments" (p. 44).

In order to meet the ACS-COT guidelines for trauma center designation, the organization must adhere to a certain level of training and provision of physician manpower and equipment depending on the level of designation. Trauma center costs consist mainly of treatment costs and readiness costs (ACS-COT, 2017). The higher-level trauma designation expenses to meet readiness requirements continue to be underfunded (ACS-COT, 2017). Readiness costs are not attributable on a per patient basis and are therefore not reimbursable in the current payer system. One out of every five trauma patients is not insured which makes reimbursement for treatment costs difficult to cover without state level funding (Scott et al., 2017). This leaves the trauma center manager with the challenging task of deciding the right level of trauma center designation for the organization given the financial impact of the program within the funding available to the organization through reimbursement and/or additional state level funding.

An additional consideration for the trauma center manager to consider is the impact to patient outcomes. Trauma injured patients treated at designated trauma centers versus patients treated at non-designated trauma centers have been shown to have lower mortality rates (Celso et al., 2006; MacKenzie et al., 2006). While the expenses are higher as the trauma designation Level 1ncreases, the mortality rate improves with treatment at one of the higher-level trauma designated centers. This leaves the trauma center manager with the challenging task of considering the value-based care provided by the trauma program when making the decision whether to attain, increase or decrease trauma level designation or discontinue the trauma program.

Figure 1

Conceptual Framework



Research Question

The aim of this study was to answer the question: Is there a relationship between state level funding, the number of trauma centers within a state, and trauma related mortalities? The study examined the years 2008 to 2017.

Hypothesis 1: There is a significant positive association between state level funding and the number of trauma centers in a state.

Hypothesis 2: There is a significant negative association between the number of trauma centers and trauma related mortality.

CHAPTER 3

METHODOLOGY

Study Design

The study used a quasi-experimental, fixed effects panel regression analysis ranging from 2008 to 2017 for all 50 states.

Data Sources

Since a national database that captures state-level trauma does not exist, each lead agency responsible for the provision of trauma services at the state level was contacted by phone or email to inquire about the amount of monies paid to hospitals within their state, in aggregate, and by year for the years 2008 to 2017 for the care of trauma patients. Funding amounts for the year of 2008 for the state of Illinois and 2011 for the state of West Virginia were unobtainable. Thirty-two states had no funding from the state provided to designated trauma hospitals for readiness costs or uncompensated trauma care costs while 18 states provided such funding. In instances where the lead agency could not provide the information, a request for the information was made under the Freedom of Information Act from the appropriate state agency. State level funding information was obtained for all 50 states for the study period.

The number of designated trauma centers per state per year was obtained from the American Hospital Association Database. Every year, more than 6,200 hospitals in the United States complete the AHA survey. Question 45d on the AHA survey, asks the

hospital to indicate whether it is a certified trauma center and at what level the hospital is certified.

Trauma related mortality data were collected from the Centers for Disease Control and Prevention (CDC) web-based injury statistics query and reporting system (WISQARS) database. The data were available as all injury deaths and rates per 100,000 for all races, both sexes, and all ages for the ICD-10 trauma codes Y01-Y36,Y85-Y87,Y89,U01-U03 that include falls, gunshot wounds, motor vehicle accidents, homicide, and suicide, respectively. The data are reported as number of deaths, population number, crude rate, and age-adjusted rate. The Kaiser Family Foundation website provided data related to Medicaid expansion by state for the study period. Population by state per year was collected from the WISQARS database.

Independent Variable

The independent variable in the study for Hypothesis 1 was state level funding. This variable was operationalized as dollars per year paid (in million-dollar units) at the state level to hospitals for the care of trauma patients. For Hypothesis 2, the independent variable was the total number of designated trauma centers. This variable was log transformed and operationalized as the number of hospitals in a state reporting they were a designated trauma center on the AHA survey and the total number of level 1-5 trauma centers per state. Level 5 trauma centers were determined to be too small in number to be considered meaningful in the analysis.

Dependent Variables

The dependent variable for Hypothesis 1 was the number of log transformed designated trauma centers in a state. The dependent variable for Hypothesis 2 was the number of age-adjusted trauma related deaths. All variables were constructed separately for each year of the study.

Control Variables

One control variable for this study was whether a state had expanded Medicaid (1=Medicaid expansion state, 0=non-Medicaid expansion state). For states that expanded Medicaid during the study period, the year of Medicaid expansion was coded as 1 as well as all following years. All years prior to expansion were coded 0. Temporal trends were also accounted for with year dummy variables (referent year = 2008).

Table 1

Variable Types, Definitions, and Sources

	Variable Name	**Variable Type**	**Source**	**Variable Operationalization**
Hypothesis 1	State level funding	Independent	State health depts	Continuous Variable Millions of dollars/yr/state to trauma hospitals in aggregate
	Designated trauma centers	Dependent	AHA survey	Continuous Variable Number of hospitals/yr/state that answer yes to question 45d
Hypothesis 2	Designated trauma centers	Independent	AHA survey	Continuous variable Number of hospitals/yr/state that

				answer yes to question 45d
	Trauma related mortality	Dependent	WISQARS	Continuous variable Age-adjusted rate of mortality per 100000 population/state
	Medicaid expansion states	Control	Kaiser Family Foundation website	Categorical Variable to identify expansion (0)-no expansion (1)-expansion
	Year	Control		Categorical variable (2008 was reference year)

Test of Hypothesis 1

To test Hypothesis 1, five fixed effect panel regression models were estimated. First, a fixed effects panel regression model was estimated using the dependent variable reflecting the total number of trauma hospitals. The independent variable was the amount of state level funding. As a supplementary analysis, the total number of designated trauma hospitals as a dependent variable was further broken down into the number of hospitals within each of the four trauma level designations and then regressed against state level funding to determine the relationship between different trauma level designations and state level funding. Medicaid expansion, time dummy variables, and state-fixed effects were also included as control variables.

Model for Hypothesis 1

$$Y_{it} = \beta_0 + \beta_1 * (\text{State-level funding}_{it}) + \beta_2 * (\text{Medicaid Expansion}_{it}) + \beta_3 * (\text{Year}) + \mu_{it}$$

Y_{it} is the dependent variables in each of the regression analysis total trauma hospitals and level 1-4 trauma hospitals, respectively. The intercept is represented by β_0. The independent variables are state level funding, and Medicaid expansion, and year dummy variables. The error term is represented by $\mu_{it.}$

Test of Hypothesis 2

To test Hypothesis 2, another five fixed effects panel regression models were estimated using age-adjusted mortality as the dependent variable in each of the models. First, a fixed effects panel regression model was estimated with the dependent variable of age-adjusted mortality rate and the independent variables of total trauma hospitals. The intensity of services and provision of specialty care was defined by the trauma level designation of a hospital, so the relationship of the different trauma level designations as well as the broader category of total number of trauma hospitals to age-adjusted mortality was determined to be important to understanding how the independent variables impacted trauma mortality. Therefore, a supplementary analysis also used the number of hospitals in each of the four trauma level designations as independent variables.

Model for Hypothesis 2

$Y_{it} = \beta_0 + \beta_1 * (\text{number of hospitals}_{it)} + \beta_{2*} (\text{Year}) + \mu_{it}$

Y_{it} is the dependent variable age-adjusted mortality rate. The intercept is represented by $\beta_{0.}$ The independent variables are the number of trauma hospitals in a state and level 1-4 trauma hospitals respectively represented by number of hospitals. Year is the year dummy variables. The error term is represented by $\mu_{it.}$

CHAPTER 4

RESULTS

Results of the analysis are divided into three tables. Table 2 provides the descriptive statistics. Table 3 provides the results related to Hypothesis 1. Table 4 provides the results related to Hypothesis 2. The results are reported at the start of the study period and the end of the study period to better understand the changes over the 10-year period.

The total number of trauma hospitals in 2008 ranged from 2 to 221 hospitals with an average of 30.64 trauma hospitals per state. In 2017, the number of trauma hospitals ranged from 1 to 239, with the average increasing to 33.44 per state. The number of level 1 trauma hospitals in a state in 2008 ranged from 0 to 28, with an average of 5.52 per state. In 2017, the range in the number of Level 1 trauma hospitals was 0 to 24 with an average of 5.28 per state. Level 2 trauma hospitals followed the same pattern showing a range of 0 to 42 hospitals in 2008 and an average of 8.64 hospitals per state; in 2017, the range was 0 to 37 with an average of 7.56 hospitals per state. Level 3 trauma hospitals followed the same pattern across the study period. In 2008, the range for Level 3 trauma hospitals was 0 to 127 with an average of 13.84 per state. In 2017, the range was 0 to 81 and an average of 11.48 Level 3 trauma hospitals per state. Level 4 trauma hospitals in contrast increased over the time period studied. In 2008, the range was 0 to 61 with an average of 2.26 per state. In 2017, the range was 0 to 117 and a significant increase in the average, to 8.40 Level 4 trauma hospitals per state. No Level 5 trauma hospitals were

designated in 2008. In 2017, one Level 5 trauma hospital was designated across the 50 states.

State populations in 2008 ranged from 546,043 to 36,600,000 with an average state population of 6,070,375. In 2017, the state populations ranged from 578,931 to 39,400,000 with an average of 6,485,813. The age-adjusted mortality rates in 2008 ranged from 37.76 to 101.01 per 100,000 with an average rate of 64.18 per 100,000. The range increased over the 10-year period to 48.66 to 130.80 per 100,000 in 2017, with an average of 78.82 per 100,000. State funding of trauma hospitals increased over the study period. The range in 2008 was $0 to $25,700,000 with an average of $3,145,677, compared to a range of $0 to $54,600,000 in 2017 with an average of $4,234,581.

Table 2

Descriptive Statistics

	Observations	Mean	SD	Min	Max
Trauma Hospitals Total					
2008	50	30.64	34.97	2	221
2017	50	33.44	38.09	1	239
Level 1 Trauma hospitals					
2008	50	5.52	6.01	0	28
2017	50	5.28	5.70	0	24
Level 2 Trauma hospitals					
2008	50	8.64	8.27	0	42
2017	50	7.56	7.86	0	37
Level 3 Trauma hospitals					
2008	50	13.84	21.92	0	127
2017	50	11.48	14.50	0	81
Level 4 Trauma hospitals					
2008	50	2.26	8.71	0	61

2017	50	8.40	18.30	0	117
Level 5 Trauma hospitals					
2008	50	0	0	0	0
2017	50	0.20	0.14	0	1
State Population					
2008	50	6,070,375	6,724,927	546,043	36,600,000
2017	50	6,485,813	7,316,961	578,931	39,400,000
Age-adjusted mortality rate					
2008	50	64.18	14.21	37.76	101.01
2017	50	78.82	15.41	48.66	130.80
State Funding of Trauma hospitals					
2008	49	$3,145,677	$6,827,646	$0	$25,700,000
2017	50	$4,234,581	$9,467,518	$0	$54,600,000

Multivariable Regression Results: Hypothesis 1

Figure 2 depicts the amount of state level funding and the change in total number of trauma hospitals. Table 3 provides the results of the fixed effects panel regression analyses used to test Hypothesis 1. On average, an increase of $100,000 in state level funding for trauma care was associated with a (nonsignificant) .02% increase in the number of trauma hospitals (b=.00017, p=0.21). Relative to the period prior to expanding Medicaid, states that did expand Medicaid were associated with 1.86% (nonsignificant) decrease in the number of trauma hospitals (b=-.01878, p=0.78) following expansion. Time was not a significant factor predicting the number of trauma hospitals. For example, relative to 2008, there was a .05% (nonsignificant) decrease in the number of trauma hospitals in 2009 (b=-.00053, p=0.98). Relative to 2008, there was a 5.44% (nonsignificant) increase in the number of trauma hospitals in 2017 (b=.05293, p=0.49).

On average, an increase of $100,000 in state level funding for trauma care was associated with a (nonsignificant) .04% increase in the number of Level 1 trauma

hospitals (b= .00036, p=0.28). Relative to the period prior to expanding Medicaid, states that did expand Medicaid were associated with 25.83% (significant) increase in Level 1 trauma hospitals (b=.22976, p=0.01). Relative to 2008, there was a 5.09% (nonsignificant) decline in the number of Level 1 trauma hospitals in 2009 (b=-.05220, p=0.19). Relative to 2008, there was a 17.64% (significant) decline in the number of Level 1 trauma hospitals in 2017 (b=-.19406, p=0.03).

On average, an increase of $100,000 in state level funding for trauma care was associated with a (nonsignificant) .02% increase in the number of Level 2 trauma hospitals (b=.00022, p=0.33). Relative to the period prior to expanding Medicaid, states that did expand Medicaid were associated with 4.23% (nonsignificant) decrease in the number of Level 2 trauma hospitals (b=-.04324, p=0.57). Relative to 2008, there was a 5.52% (nonsignificant) decline in the number of Level 2 trauma hospitals in 2009 (b=-.05673, p=0.07). Relative to 2008, there was a 13.54% (nonsignificant) decline in the number of Level 2 trauma hospitals in 2017 (b=-.14544, p=0.09).

On average, an increase of $100,000 in state level funding for trauma care was associated with a (nonsignificant) .09% increase in the number of Level 3 trauma hospitals (b=.00087, p=0.24). Relative to the period prior to expanding Medicaid, states that did expand Medicaid were associated with an 8.02% (nonsignificant) increase in the number of Level 3 trauma hospitals (b=.07712, p=0.47). Relative to 2008, there was a 0.38% (nonsignificant) decline in the number of trauma hospitals in 2009 (b=-.00382, p=0.95). Relative to 2008, there was a 9.87% (nonsignificant) decline in the number of Level 3 trauma hospitals in 2017 (b=-.10392, p=0.31).

On average, an increase of $100,000 in state level funding for trauma care was associated with a (nonsignificant) .03% decline in the number of Level 4 trauma hospitals (b=-.00031, p=0.62). Relative to the period prior to expanding Medicaid, states that did expand Medicaid were associated with a 7.9% (nonsignificant) decline in the number of Level 4 hospitals (b= -.08225, p=0.61). Relative to 2008, there was a 73.56% (significant) increase in the number of Level 4 trauma hospitals in 2009 (b=.55138, p<0.001). Relative to 2008, there was a 356.22% (significant) increase in the number of Level 4 trauma hospitals in 2017 (b=1.5178, p<0.001).

Figure 2

Average Number of Trauma Hospitals in State and Funding Amounts

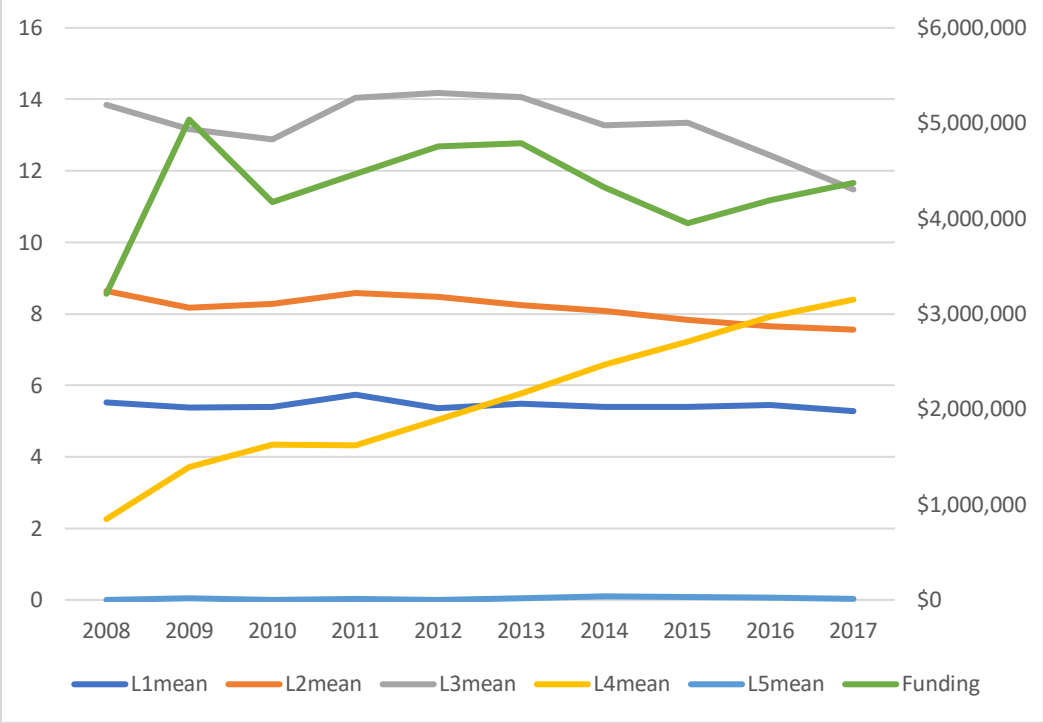


Table 3

Year Fixed Effects Regression Analysis Results for the Relationship between the Number of Trauma-designated Hospitals and Funding

	Number of Trauma designated hospitals	Number of Level 1 designated hospitals	Number of Level 2 designated hospitals	Number of Level 3 designated hospitals	Number of Level 4 designated hospitals
	β (p-value)	β (p-value)	β (p-value)	β (p-value)	β (p-value)
State-Level Funding	.00017 (0.21)	.00036 (0.28)	.00022 (0.33)	.00087 (0.24)	-.00031 (0.62)
Control Variables					
Medicaid Expansion	-.018781 (0.78)	.22976 (0.01)**	-.04324 (0.57)	.07712 (0.47)	-08225 (0.61)
Year					
2008 (referent)	n/a	n/a	n/a	n/a	n/a
2009	-.00053 (0.98)	-.05220 (0.19)	-.05673 (0.07)	-.00382 (0.95)	.55138 (<0.001)***
2010	-.02302 (0.59)	-.07239 (0.12)	-.07859 (0.12)	-.01281 (0.85)	.71078 (<0.001)***
2011	.03091 (0.47)	.00989 (0.83)	-.04298 (0.48)	.08259 (0.28)	.65908 (<0.001)***
2012	.04008 (0.42)	-.06348 (0.27)	-.03426 (0.58)	.05661 (0.46)	.70673 (<0.001)***
2013	.08360 (0.09)	-.04688 (0.42)	-.06069 (0.34)	.08125 (0.29)	.88868 (<0.001)***
2014	.11225 (0.09)	-.18528 (0.05)*	-.06243 (0.45)	-.01002 (0.93)	1.05084 (<0.001)***
2015	.12018 (0.09)	-.17237 (0.05)*	-.09864 (0.25)	.03679 (0.74)	1.25749 (<0.001)***
2016	.10171 (0.17)	-.15008 (0.13)	-.14225 (0.10)	-.00178 (0.99)	1.36492 (<0.001)***
2017	.05293 (0.49)	-.19406 (0.03)*	-.14544 (0.09)	-.10392 (0.31)	1.5180 (<0.001)***
Within subjects R-squared	0.05	0.07	0.06	0.03	0.46
Cons	2.98436 (<0.001)*	1.39587 (<0.001)*	1.9007 (<0.001)*	1.94203 (<0.001)*	.90822 (<0.001)***
***p ≤ .001, **p ≤ .01, *p ≤ .05					

Multivariable Regression Results: Hypothesis 2

Figure 3 depicts the hospital trauma level designations and age-adjusted mortality over the study period. Table 4 provides the data from the fixed effects panel regression analyses used to test Hypothesis 2. On average, each additional trauma hospital in a state was associated with a (nonsignificant) .11 point decrease in the age-adjusted mortality rate in a state (b=-.108, p=0.13). Relative to 2008, there was a 2.43-point (significant) decrease in the age-adjusted mortality rate in 2009 (b=-2.43421, p<0.001). Relative to 2008, there was a 14.94 point (significant) increase in the age-adjusted mortality rate in 2017 (b=14.9446, p<0.001).

On average, each additional Level 1 trauma hospital in a state was associated with a (nonsignificant) .24 point decrease in the age-adjusted mortality rate in a state (b=-.23570, p=0.47). Relative to 2008, there was a 2.49 point (significant) decrease in the age-adjusted mortality rate in 2009 (b=-2.491, p<0.001). Relative to 2008, there was a 14.59 point (significant) increase in the age-adjusted mortality rate in 2017.

On average, each additional Level 2 trauma hospital in a state was associated with a (nonsignificant) .09 point decrease in the age-adjusted mortality rate in a state (b=-.08537, p=0.52). Relative to 2008, there was a 2.5 point (significant) decrease in age-adjusted mortality rate in 2009 (b=-2.49727, p<0.001). Relative to 2008, there was a 14.55 point (significant) increase in age-adjusted mortality rate in 2017 (b=14.5496, p<0.001).

On average, each additional Level 3 trauma hospital in a state was associated with a (significant) .19 point increase in the age-adjusted mortality rate in a state (b= .19042, p=0.03). Relative to 2008, there was a 2.33 point (significant) decrease in age-adjusted

mortality rate in 2009 (b=-2.32852, p<0.001). Relative to 2008, there was a 15.09 point (significant) increase in age-adjusted mortality rate in 2017 (b=15.09118, p<0.001).

On average, each additional Level 4 trauma hospital in a state was associated with a (significant) .25 point decrease in the age-adjusted mortality rate in a state (b=-.24564, p<0.001). Relative to 2008, there was a 2.1 point (significant) decrease in age-adjusted mortality rate in 2009 (b=-2.09937, p<0.001). Relative to 2008, there was a 16.15 point (significant) increase in age-adjusted mortality rate in 2017 (b=16.15003, p<0.001).

Figure 3

Hospital Trauma Level Types and Age-adjusted Mortality

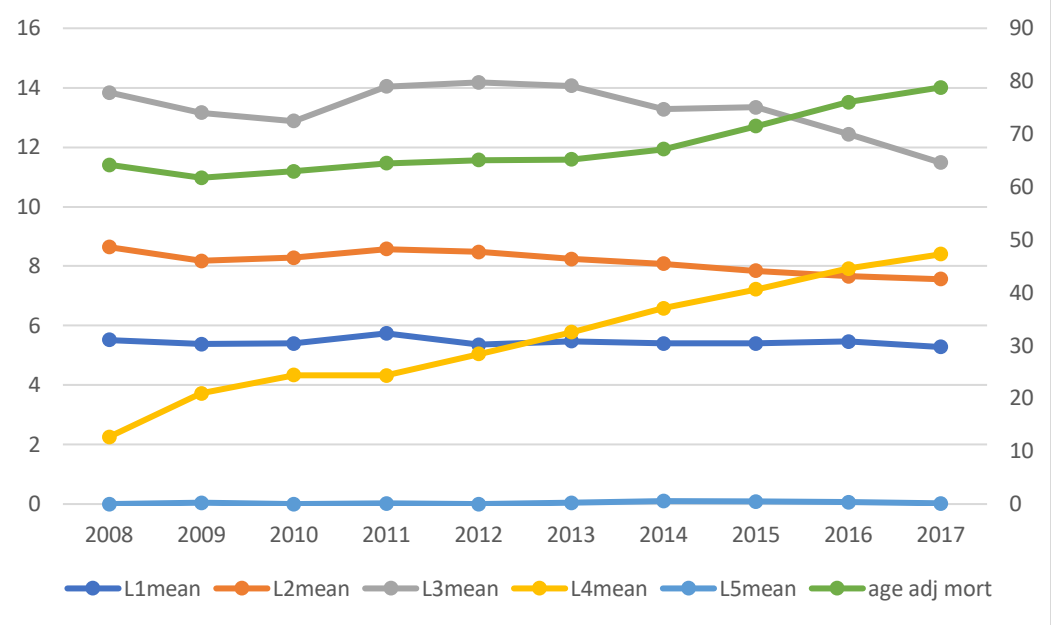


Table 4

Year Fixed Effects Regression Analysis Results for the Relationship between Age-adjusted Mortality and the Number of Trauma-designated Hospitals

Dependent Variable	Age-adjusted mortality	Age-adjusted mortality	Age-adjusted mortality	Age-adjusted mortality	Age-adjusted mortality
Independent Variables	Number of designated Trauma hospitals	Number of Level 1 hospitals	Number of Level 2 hospitals	Number of Level 3 hospitals	Number of Level 4 hospitals
β or p	-.10813 (0.13)	-.23570 (0.47)	-.08537 (0.52)	.19042 (0.03)*	-.24564 ((<0.001)***
Control Variables					
Year					
2008 (referent)	n/a				
2009	-2.43421 (<0.001)***	-2.4910 (<0.001)***	-2.49727 (<0.001)***	-2.32852 (<0.001)***	-2.09937 (<0.001)***
2010	-1.16947 (0.03)*	-1.27128 (0.02)*	-1.27373 (0.02)*	-1.06020 (0.06)	-.732070 (0.20)
2011	.523418 (0.45)	.32226 (0.60)	.26528 (0.66)	.23232 (0.72)	.776418 (0.25)
2012	1.19851 (0.10)	.86669 (0.16)	.89074 (0.16)	.83966 (0.21)	1.58728 (0.03)*
2013	1.33585 (0.11)	.98257 (0.19)	.95785 (0.20)	.95011 (0.22)	1.85665 (0.03)*
2014	3.29931 (<0.001)***	2.90772 (<0.001)***	2.88819 (<0.001)***	3.04263 (<0.001)***	3.99716 (<0.001)***
2015	7.73396 (<0.001)***	7.29912 (<0.001)***	7.25911 (<0.001)***	7.42261 ((<0.001)***	8.54577 (<0.001)***
2016	12.24757 (<0.001)***	11.85066 ((<0.001)***	11.78114 (<0.001)***	12.13138 (<0.001)***	13.25512 (<0.001)***
2017	14.9446 (<0.001)***	14.5852 (<0.001)***	14.5496 (<0.001)***	(<0.001)***	(<0.001)***
Within subjects R-squared	0.66	0.65	0.65	0.66	0.67
Cons	67.49182 (<0.001)***	65.47988 (<0.001)***	64.91637 (<0.001)***	61.54345 (<0.001)***	64.73395 (<0.001)***
***p ≤ .001, **p ≤ .01, *p ≤ .05					

CHAPTER 5

DISCUSSION

This study found several statistically significant findings regarding the relationships of state level funding, the number of designated trauma centers, and trauma related mortality. The first significant finding was the change in the number of Level 1 trauma hospitals in Medicaid expansion states as compared to nonexpansion states. During the time period of the study, 26 states expanded Medicaid in 2014, another three in 2015, and finally two more in 2016, for a total of 31 states. States that did expand Medicaid saw a 25.83% increase in the number of Level 1 trauma centers as compared to the pre-expansion period. Level 1 trauma centers are more likely to get a higher number of underinsured and uninsured trauma patients in transfer from lower level trauma centers. “The hospitals that stand to gain the most from insurance coverage expansion are those that are already caring for the highest proportion of uninsured and minority patients” (Scott et al., 2017, p. 9). The revenue stream from Medicaid is one of the primary drivers of positive operating margins for trauma centers that are considered SNH (Scott et al., 2017). The reimbursement levels associated with Medicaid vary from state to state, but a reduction in the number of uninsured patients due to Medicaid expansion ultimately help offset cost and encourage greater participation of trauma centers at the highest level they are capable of providing. The total number of trauma hospitals in each of the different level designations declined over the study period with the exception of Level 4 trauma hospitals. The decision to either contract or discontinue trauma services in

the higher trauma hospital designation categories is most often due to financial concerns driven by high numbers of uninsured, difficulty maintaining the needed specialists on call, or competitive market forces in densly populated urban areas.

In contrast, states experienced an increase in the number of Level 4 trauma hospitals over the study period that was not driven by state level funding or Medicaid expansion. Level 4 trauma hospitals are recognized by the ACS-COT as an integral part of a larger trauma system. They are located in rural areas and typically are the only source of acute care in the area. The designation as a Level 4 trauma hospital is encouraged by providing advanced trauma life support training to the physicians at the Level 4 trauma hospital and emergency preparedness training for hospital staff by using grants provided by the state to improve access to trauma care. Level 4 trauma hospitals play an important role in stabilization and transfer of the injured patient to the larger Level 1 or Level 2 trauma hospital. The increase in the number of Level 4 trauma hospitals helps to fill the gap in access to care for trauma patients across geopgraphically diverse parts of the United States.

The hypothesis regarding the significantly positive relationship between the number of designated trauma hospitals and state level funding was not supported by the analysis when considering the variable of total trauma hospitals but was partially supported in the subanalysis when considering the relationship to Level 1 trauma hospitals and Medicaid expansion. Additional funding for trauma care in alternate forms such as Medicaid expansion can impact the number of trauma hospitals available for the injured patient.

The relationship of the number of trauma hospitals and age-adjusted mortality rate was significant in regards to Level 3 and 4 trauma hospitals. The number of Level 3 trauma hospitals in a state was associated with a .19 point increase per 100,000 in age-adjusted mortality rate. Level 3 trauma centers' role in the trauma system is the resuscitation and transfer of patients to Level 1 or 2 trauma centers as needed (Maxson et al., 2017). The reasons for this small increase in age-adjusted mortality rate are likely multi factorial but suggest the resuscitation of trauma patients at a Level 3 trauma could be a factor. If trauma patients are undertriaged to a Level 3 trauma center and managed by the Level 3 staff, an increased age-adjusted mortality rate is a possibility due to delay in transfer to a higher level trauma center.

The number of Level 4 trauma hospitals in a state was associated with a .25 point per 100,000 population reduction in overall age-adjusted mortality rate. The increase in trauma services and stabilization of severely injured patients in geographically remote areas improves access to the highest level of care for trauma patients and improves stablization and transfer to higher level trauma hospitals. Time showed a consistent pattern in its relationship with age-adjusted mortality, whereby there was an initial decline in the age-adjusted mortality rate at the beginning of the study period followed by an increase in the age-adjusted mortality rate by the end of the study period.

Trauma related related deaths have been on the rise at rates that are not explained with population growth (Rhee et al., 2014). The trimodal peaks in mortality were seen with the age brackets of the 20s, 40s and 80s with possible causes including increasing violence, suicides, and comorbid conditions, respectively (Rhee et al., 2014). The hypothesis regarding the significantly negative association between the number of trauma

hospitals and trauma related mortality was not supported when considering the variable total trauma hospitals or Level 1-3 trauma hospitals. It was partially supported in the subanalysis in regards to Level 4 trauma hospitals and the reduction in mortality.

Limitations

As with all studies, this study has limitations. First, a limitation in this study was some states provide a myriad of alternative subsidies or reimbursement enhancements that were not captured in the state level funding variable that could impact the number of designated trauma centers in any one state. The second limitation relates to various mortality statistics issues, such as (1) mortality statistics are risk adjusted by age to account for the increased mortality risk associated with the elderly trauma patient, (2) mortality data do not take into consideration patients that arrive to the designated trauma center that have non-survivable injuries or that die at the scene of the accident, and (3) higher level designated trauma hospitals receive the more severely injured and receive more patients with non-survivable injuries. To control for these and other challenges would require access to data at the individual patient record level. Our data were limited to state level reported mortality rates. The study's third limitation relates to the *self-reported* designation of trauma centers' levels. Although the ACS-COT defines the criteria for Level 1 through Level 5 trauma centers, there is not a consistent approach among the states on how to approach the designation of trauma centers. Level 1 and Level 2 trauma centers are most closely aligned in states with the requirements outlined by the ACS-COT, but a great deal of variation exists in the process of achieving the designation from state to state. Some states require ACS verification of criteria in order to

achieve state designation as a trauma center, especially as a Level 1 or 2 trauma center. This type of verification process is rigorous and can be cost prohibitive for smaller hospitals in order to comply with all the criteria outlined in the ACS-COT requirements and could discourage hospitals from designation or to participate at lower levels. In contrast, the designated hospitals that meet ACS verification have more rigorous quality standards that are designed to produce better outcomes for patients.

Future Research

There are additional areas of study identified from this research for future investigation. First, examining why larger more urban and densely populated states appear to have a lower trauma related mortality as compared to other states more specifically, urban states with a strong public transportation system versus rural states with a poor public transportation system, and the relationship to motor vehicle trauma related mortality.

As previously noted, there are challenges in obtaining data regarding the amount of state level monies to trauma centers on an annual basis. As such, a second area of future study would include the multiple funding sources and the total dollar amounts associated with funding for trauma centers which would include not only state level funding but also, county level funding, Medicaid expansion, and commercial insurers' payment of activation fees and relationships to (1) the number of designated trauma hospitals in a state, or (2) the change in the total number of trauma ICU beds available for inpatient care.

Another area of interest would focus on the 18 states that currently provide state level funding and examine the relationship to age-adjusted trauma mortality pre- and post-funding. Finally, qualitative inquiries could be conducted to better understand each state's progress and challenges associated with attainment of the eight components of an inclusive trauma system.

Conclusion

State level funding as a direct source of payment was not found to have a significantly positive relationship with the number of total trauma hospitals. Currently, only 18 hospitals in the United States fund designated trauma hospitals directly. Medicaid expansion did have a signficant impact on the number of designated trauma hospitals by increasing the number of Level 1 trauma hospitals which provide the highest level of care for trauma patients by 25.83%. Medicaid expansion as an alternate source of state funding, can have a positive impact on the number of designated trauma hospitals available for the care of injured patients. The increasing trauma mortality rate over the study period and the decline in the number of higher level designated trauma centers are a concerning trend that warrants continued study of alternate funding sources to support the cost of trauma care. Medicaid expansion and other forms of funding that can stop the decline in the number of designated trauma hospitals in the United States, can help ultimately reduce trauma related mortality.

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APPENDIX

INSTITUTIONAL REVIEW BOARD LETTER OR APPROVAL

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM
Office of the Institutional Review Board for Human Use

470 Administration Building
701 20th Street South
Birmingham, AL 35294-0104
205.934.3789 | Fax 205.934.1301 |
irb@uab.edu

NHSR DETERMINATION

TO: Henry, Ginger

FROM: University of Alabama at Birmingham Institutional Review Board
Federalwide Assurance # FWA00005960
IORG Registration # IRB00000196 (IRB 01)
IORG Registration # IRB00000726 (IRB 02)
IORG Registration # IRB00012550 (IRB 03)

DATE: 29-Dec-2021

RE: IRB-300008618
the RELATIONSHIP BETWEEN STATE LEVEL FUNDING,DESIGNATED TRAUMA CENTERS, AND TRAUMA RELATED MORTALITY

The Office of the IRB has reviewed your Application for Not Human Subjects Research Designation for the above referenced project.

The reviewer has determined this project is not subject to FDA regulations and is not Human Subjects Research. Note that any changes to the project should be resubmitted to the Office of the IRB for determination.

if you have questions or concerns, please contact the Office of the IRB at 205-934-3789.

Additional Comments:

Data from AHA, ACS-COT, and State Public Health Departments looking at Trauma Center funding, number of designated Trauma Centers and trauma-related mortality.