MORTALITY AND COSTS FROM ACUTE CARE SURGICAL EMERGENCIES

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There are growing difficulties in caring for patients with acute surgical emergencies. In response, some trauma centers restructured their surgical services, integrating critical care and emergency surgery into their trauma programs. Few studies have examined these; however, evidence of their effectiveness is far from conclusive. This project proposed to evaluate trends of hospitalizations, deaths and costs associated with acute surgical emergencies (non-traumatic surgical emergencies and trauma) and to determine the effect of trauma centers on mortality in adult patients with non-traumatic surgical emergencies, using the Nationwide Impatient Sample databases from 2005-2010 and the American Hospital Association's Annual Survey database from 2010.

The results from this project demonstrated that despite the significant increases in non-traumatic surgical emergencies and trauma related hospitalizations over time, overall mortality and costs are decreasing significantly, perhaps related to improvement in hospital management for these acute surgical emergencies. However, there were some demographic and regional variations. Overall, patients are old and are getting more comorbidities and uninsured over time. Among NTSEm, mortality is not decreasing significantly over time for all surgical conditions. For the injured patients, falls is becoming the leading mechanism of injury and penetrating trauma related mortality is increasing over time in the United States. Penetrating injuries in the

South demonstrated a significant increase in related hospitalization. Finally, the results from these secondary data analyses do not support the hypothesis that the presence of a structured trauma centers account for differences in mortality for patients with non-traumatic surgical emergencies.

The variations observed may be related to geographical differences in acute care surgical coverage for these traumatic and non-traumatic conditions. In the past, the needs of the injured patient drove the development of the field of trauma surgery; therefore, there is a need to develop systematic approaches to fulfill the needs of patients with non-traumatic surgical emergencies. Regionalization of care, registries and severity scores will need to be created for these acute care surgical conditions, to study more in depth the quality of care and outcomes research, as acute care surgical models continue to expand across the United States.

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PREFACE

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1.0 INTRODUCTION

Treating patients with surgical emergencies has challenged the healthcare system in the United States. Emergency departments are overcrowded and patients' waiting times at emergency departments are excessive. Lifestyle considerations and the perception of poor reimbursement of emergency services have driven shortages of general surgeons and increases of surgical super sub-specialists that lack the experience and motivation to provide emergency surgical coverage. These conditions have limited access to high-quality emergency surgical care for the growing, older, and more co-morbid population of the United States.[1-9] This has raised questions about variations over time of hospitalizations, mortality, and costs associated with acute surgical emergencies.

The development of trauma systems in the United States has placed the care of injured patients into the hands of specialist that provide coordinated, seamless, and expertise-driven trauma care throughout the entire care spectrum (prevention, pre-hospital care, acute management, and rehabilitation). These have demonstrated improvements in quality of care and patients' outcomes.[10] A critical factor for delivering optimal trauma care involves the immediate participation of in-house attending trauma surgeons, as part of a multidisciplinary team that provides dedicated, in-hospital, around the clock care.[11]

Unfortunately, there are no similar systems for patients with non-traumatic surgical emergencies. Hospitals that are not designated as trauma centers rely on a roster of general surgeons and surgical subspecialists to provide emergency care coverage for the majority of critically ill patients with surgical emergencies.[7] These surgeons may not be immediately available during nights, weekends, or busy schedules of elective procedures. As a result, surgical consultations and operative interventions are delayed and subsequently, mortality and complication rates are higher.[7,12] As the needs of the injured patient drove the development of the field of trauma surgery, the needs of the emergency general surgery patient must drive the development of systematic approaches to care for these patients.[13]

Recognizing the need for emergency and critical care surgical coverage, hospitals started to influence the organization of surgical services. During the last decade, trauma centers expanded their trauma programs combining the resources available for trauma with those for critical care and emergency surgery under a single system. According with the Effective Practice and Organization of Care Cochrane group (EPOC) taxonomy of interventions aimed at achieving practice change of healthcare professionals, these can be classified as organizational interventions in which there is a formal integration of services with multi-disciplinary teams that expand their surgical coverage not only for trauma but for all surgical emergencies and separated from elective surgery. In addition, the American Association for the Surgery of Trauma Committee on Acute Care Surgery has created a new specialty of surgical training and practice that requires broad training in elective and emergency general surgery, trauma surgery, and surgical critical care.[3,6]

Few studies have examined the impact of trauma centers on outcomes for patients with non-traumatic surgical emergencies. Some studies have compared surgical outcomes in single trauma centers, before and after the integration of services for all acute care surgical emergencies;[14-16] others have examined these outcomes over time just after integration of services.[17] In these studies, trauma centers have been reported to improve patient access and outcomes, bringing shorter wait times and length of stay in emergency departments, expediting surgical consultations and surgical operations when required, and reducing complications and mortality rates. However, these studies have limited designs and have failed to control for the multilevel factors that influence these outcomes in patients with non-traumatic surgical emergencies. Some are single center studies that are not representative of the US population. Some have focused on single diseases that might not be representative of all surgical emergencies. Trends and seasonal variations that could impact outcomes in before-and-after intervention evaluations were not taken into account. Finally, some studies have failed to control for the multilevel factors that influence patient, hospital, or system-levels.[2,14-18] Therefore, the evidence of the impact of trauma centers on patients with non-traumatic surgical emergencies remains inconclusive.

The **aim** of this project was to evaluate mortality and costs in patients with non-traumatic surgical emergencies in the United States. These comprised abdominal aortic aneurysm and dissection, abdominal sepsis, acute appendicitis, acute mesenteric ischemia, bowel obstruction, bowel perforation, and necrotizing fasciitis. Acute appendicitis was selected because appendectomy for acute appendicitis is the most common performed operation worldwide and because it could be performed in hospitals with at least basic surgical resources.[19,20] The other non-traumatic surgical emergencies were selected because of their increasing prevalence in the US, because of their higher associated etiological co-morbidities as a consequence of the aging of the population of the United States, because these conditions have been recognized as a possible cause of catastrophic events, and because patients with these conditions require promptly identification by a surgical team and, if required, expedited operative intervention.[12,21-26]

For the development of this project, secondary data analyses were performed using the Nationwide Impatient Sample database from the Healthcare Cost and Utilization Projects and the American Hospital Association's Annual Survey database. **The first specific aim** of this project evaluated trends of yearly estimates of hospitalizations, deaths, and costs associated with non-traumatic surgical emergencies in the United States, during 2005-2010. Societal and economic conditions could affect trend estimates in the entire population of the United States. Therefore, trends of a control group were also evaluated; **the second specific aim** evaluated trends of yearly estimates of hospitalizations, deaths, and costs associated with trauma patients in the United States, during 2005-2010. Since trauma centers in structured trauma systems have developed the infrastructure necessary for immediate operative interventions in trauma patients that can also benefit patients with other (non-traumatic) emergency surgical conditions, **the third specific aim** of this project determined the effect of trauma centers on mortality in adult patients with non-traumatic surgical emergencies in the United States for the year 2010.

2.0 TRENDS IN HOSPITALIZATIONS, DEATHS, AND COSTS FROM HOSPITALIZED ACUTE CARE SURGICAL EMERGENCIES IN THE UNITED STATES, 2005-2010

2.1 INTRODUCTION

According to the National Center of Health Statistics (NCHS), during 2001-2006, the estimated number of emergency department (ED) visits ranged from 107 to 119 million and the numbers of hours spent in ambulance diversions increased from 276 (standard deviation [SD], 42) to 473 hours (SD, 73).[4] Previous reports indicated that between 1993 and 2003, the United States (US) experienced a net loss of 703 hospitals and 198,000 hospital beds mainly in response to cost cutting measures, lower reimbursement by payers, and uninsured patients.[27] This has resulted in overcrowding and excessive patients' ED waiting times.

The US population is projected to increase 42% during 2010-2050. The population is expected to become much older, with nearly 20% of US residents aging to 65 years and older in 2030. The aging of the population will have a wide-ranging of implication for policy makers and social security and Medicare programs.[28] This growing population with more co-morbid conditions will demand highly complex interventions, including emergency surgical procedures in critical care environments.

In contrast to the current population growth, there is a nationwide shortage of general surgeons, a trend exacerbated by lifestyle considerations, perceptions of poor reimbursement of emergency services, and by surgical sub-specialization.[6,7] Surgeons are aging in parallel with the current population and older surgeons are often allowed to "opt out" night and weekend calls. Since emergency services are often uncompensated, surgeons have been forced to minimize disruptions to their elective practices and to sub-specialize in narrow fields dominated by elective services. This pool of super subspecialist lacks often the motivation and the necessary experience to care for critically ill patients with acute care surgical emergencies.[7,9]

This focuses its importance as a public health problem raising questions about variations over time of mortality and costs associated with non-traumatic surgical emergencies (NTSEm). The aim of this study was to evaluate trends of yearly estimates of hospitalizations, deaths, and costs associated with NTSEm in the US during 2005-2010. This aim hypothesized that yearly estimates of hospitalizations, deaths, and costs for these NTSEm are increasing over time in all regions of the US.

2.2 METHODS

A secondary analysis of six years of the Nationwide Impatient Sample (NIS) databases was performed. The NIS is maintained by the Healthcare Cost and Utilization Project (HCUP) of the Agency for Healthcare Research and Quality (AHRQ). It is a database of hospital inpatient stays and the largest all-payer inpatient care database that is publicly available in the US, containing each year about 8 million hospitals stays from about 1,000 hospitals sampled from a 20% stratified sample of US community hospitals. The NIS is drawn from States participating in

HCUP; these comprised 96% of the US population in 2010. Sampling weights included in the database allow for stratified calculations of total population estimates. Inpatient stay records include clinical and resource information typically available from discharge abstracts. In addition, the NIS contains charge information on all patients, regardless of payer, including persons covered by Medicare, Medicaid, private insurance, and the uninsured.[29]

2.2.1 Non traumatic surgical emergencies

Patients with discharge diagnoses of NTSEm were identified from NIS using the International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM) codes.[30] NTSEm included abdominal aortic aneurysm and dissection, abdominal sepsis, acute appendicitis, acute mesenteric ischemia, bowel obstruction, bowel perforation, and necrotizing fasciitis. Acute appendicitis was selected because treatment with appendectomy is the most common performed operation worldwide and because it could be performed in hospitals with at least basic surgical resources.[19,20] The others NTSEm were selected because of their increasing prevalence in the US, because of their higher associated etiological co-morbidities as a consequence of the aging of the US population, because these conditions have been recognized as a possible cause of complications and deaths, and because patients with these conditions require promptly identification by a surgical team and, if required, expedited operative intervention.[12,21-26] Patients were excluded if they had diagnoses of trauma at hospital discharge.

2.2.2 Study measures

De-identified patients' information including demographics, comorbidity measures and clinical information related to diagnostic codes, and hospital characteristics were abstracted from NIS. Adjustment for comorbidity is of interest in all types of health care studies and it is essential in observational studies because baseline differences in health status may modulate differences in study outcomes.[31,32] AHRQ comorbidity measures were developed by Elixhauser for large administrative databases to predict mortality, hospital charges, and hospital length of stay, and have been adapted for risk adjustment purposes. Using Diagnosis-Related Groups (DRG) and secondary ICD-9-CM diagnosis codes, 30 unweight comorbidity indicators are most likely to reflect individuals' chronic illness burden and are practical with large administrative databases.[31] These AHRQ comorbidity measures from NIS were summarized and included in the analyses.

Outcome measures were rate of hospitalization, mortality at hospital discharge, and hospital costs for each patient. The NIS database contains information on total charges for each hospital in the database. This charge information represents the amount that hospitals billed for services, but does not reflect how much hospital services actually cost or the specific amounts that hospitals received in payment. HCUP cost-to-charge ratio files were used to enable the translation of hospital charges to actual costs in United States dollars.

2.2.3 Analysis

Demographic, clinical information related to the diagnostic codes, and hospital characteristics were analyzed descriptively by year. Comparisons of continuous variables were performed using non-parametric tests, given their non-normal distributions. Comparisons among categorical variables were performed using Chi-squared tests.

The proportions of NTSEm hospitalizations were calculated using as denominator the total number NIS admissions. Mortality was calculated using the total number of NTSEm as the denominator. The odds of hospitalizations and deaths were fitted in multilevel logistic regressions adjusted for age, sex, race, insurance status, AHRQ comorbidity index, hospital length of stay, hospitals characteristics (bed-size, location, teaching status, and volume), and a random effect to account for the correlation among patients within hospitals. Trend analyses of the odds of hospitalizations and deaths by year were performed to assess changes over time. Findings were presented as odds ratios (OR) with 95% confidence intervals (CI) and P values.

To make costs from different years comparable, hospital costs were adjusted for inflation over time using the Consumer Price Index and standardized to year 2010.[33] For regression analyses, values below the 1st percentile and above the 99th percentile were removed. Log-transformed costs were fitted in multilevel linear regressions adjusted for age, sex, race, insurance status, AHRQ comorbidity index, hospital length of stay, hospitals characteristics (bed-size, location, teaching status, and volume), and a random effect for hospitals. Trend analyses of averages of log-transformed costs by year were performed to assess changes over time. Findings were presented as β coefficients with 95% CI and P values. The coefficient indicated the proportional change in the average cost per year over the study period.

Regional variation is important to consider when assessing disease occurrence and health outcomes.[7] Therefore, trend analyses of the odds of hospitalizations and deaths and trend analyses of the log-transformed costs during 2005-2010 were repeated for each NTSEm separately by US census regions. All the analyses were performed in Stata (Version 12) software.

2.3 RESULTS

During the six-year period (2005-2010), there were 1,926,581 patients with discharge diagnoses of NTSEm in NIS database. There were 62,386 excluded because of diagnoses of trauma. The 1,864,195 NTSEm patients accounted for 3.9% of total NIS discharges.

Table 1 shows the descriptive trends of characteristics in NTSEm patients during the study period. The median age of NTSEm patients (62 years, inter quartile range [IQR] 43-76) remained similar over the study period. The proportion of females decreased over time from 50.3 in 2005 to 48.9% in 2010 ($p<0.001$). Most of the patients were whites (58.2%) followed by African Americans (8.2%) and Hispanics (8.1%). In 21.1% of NTSEm patients race/ethnicity information was not provided; nonetheless, the proportion of race/ethnicity missing data decreased over time from 26.5% in 2005 to 11.0% in 2010 ($p<0.001$).

Among insurance status, Medicare was the most frequent expected payer (47.7%) followed by private insurances (34.0%). Medicare status was decreased over the study period (from 47.6% in 2005 to 47.4% in 2010, $p<0.001$). The proportion of patients with private insurances decreased from 34.8% in 2005 to 32.2% in 2010 ($p<0.001$), whereas the proportion of Medicaid and self-payment increased during 2005-2010 from 9.8% to 11.5% ($p<0.001$) and from 4.6% to 5.0% ($p<0.001$), respectively.

A great majority of patients had two or more comorbidities (58.3%) while patients with no comorbidities accounted only 23.0%. The proportion of patients with two or more comorbidities increased from 53.0% in 2005 to 62.2% in 2010 ($p<0.001$); meanwhile the proportion of patients with no comorbidities decreased from 26.4% in 2005 to 20.7% in 2010 ($p<0.001$).

Median hospital length of stay was five days (IQR 2-9) and remained similar over the study period. The majority of the patients were admitted to large sized hospitals (62.0%) located in urban areas (86.6%). Over the study period, the proportion of patients admitted to teaching facilities increased from 38.7% in 2005 to 45.0% in 2010 ($p<0.001$).

2.3.1 Trends of NTSEm hospitalizations

There were 294,903 NTSEm hospitalizations in 2005, accounting for 3.7% of NIS discharges; this proportion increased to 4.1% (319,732 patients) by 2010. Descriptive trends of NTSEm hospitalizations are depicted in Table 1. The adjusted trend analysis showed a significant increase of 2.9% per year in the odds of hospitalizations between 2005 and 2010 (OR 1.029, 95%CI 1.023-1.035, $p<0.001$) (Table 3). The increase in the odds of hospitalizations occurred after 2008 (OR 1.085, 95%CI 1.053-1.118, $p<0.001$) and this increase in the odds remained constant until 2010 (OR 1.135, 95%CI 1.101-1.171, $p<0.001$). Figure 1 illustrates the adjusted odds of hospitalizations by year in each NTSEm.

The greatest increase in the proportion of hospitalizations was observed in patients with abdominal sepsis, from 8.4% in 2005 to 10.1% in 2010 ($p<0.001$) (Table 1); the adjusted trend analysis showed a significant increase of 3.1% per year in the odds of hospitalizations (OR

1.031, 95%CI 1.026-1.035, p<0.001) (Table 3). Again, the increase in the odds of hospitalization for abdominal sepsis occurred after 2008 (OR 1.066, 95%CI 1.038-1.096, p<0.001) and this increase remained constant until 2010 (OR 1.139, 95%CI 1.108-1.170, p<0.001) (Figure 1).

Conversely, the proportion of hospitalization decreased significantly over time in patients with acute mesenteric ischemia, from 3.4% in 2005 to 3.1% in 2010 (p<0.001) (Table 1); the adjusted trend analysis showed a significant decrease of 2.7% per year in the odds of hospitalization during the study period (OR 0.973, 95%CI 0.968-978, p<0.001) (Table 3). This reduction in the odds of hospitalization for acute mesenteric ischemia occurred after 2007 (OR 0.931, 95%CI 0.893-0.970, p=0.001) and remained constant until 2010 (OR 0.896, 95%CI 0.859-0.934, p<0.001) (Figure 1). The trends of the odds of hospitalization did not reach statistical significance for acute appendicitis (OR 0.997, 95%CI 0.993-1.002, p=0.316), bowel obstruction (OR 1.002, 95%CI 0.999-1.005, p=0.117), and necrotizing fasciitis (OR 1.008, 95%CI 0.994-1.022, p=0.240) (Table 3).

2.3.2 Trends of NTSEm mortality

Overall NTEm mortality was 4.9%. During the study period, mortality decreased from 5.2% in 2005 to 4.5% in 2010 (p<0.001) (Table 2). The adjusted trend analysis showed a significant decrease of 3.8% per year in the odds of deaths between 2005 and 2010 (OR 0.962, 95%CI 0.856-0.968, p<0.001) (Table 4). The decrease in the odds of deaths remained constant over the study period. Figure 2 illustrates the adjusted odds of deaths by year in each NTSEm.

The greatest decrease in the proportion of deaths was observed in patients with acute appendicitis, from 0.3% in 2005 to 0.2% in 2010 (p<0.001) (Table 2); the adjusted trend analysis showed a significant decrease of 11.2% per year in the odds of deaths (OR 0.888, 95%CI 0.850-0.929, p<0.001) (Table 4). The decrease in the odds of deaths for acute appendicitis occurred after 2007 (OR 0.712, 95%CI 0.551-0.920, p=0.010); however, the greatest decrease was observed from 2008 (OR 0.720, 95%CI 0.563-0.921, P=0.009) to 2010 (OR 0.522, 95%CI 0.402-0.678, p<0.001) (Figure 2). The trends of the odds of deaths did not reach statistical significance for necrotizing fasciitis (OR 0.977, 95%CI 0.939-1.016, p=0.253) (Table 4).

2.3.3 Trends of hospital costs associated with NTSEm

Median costs of NTSEm hospitalization per patient was $11,457 [IQR 6,671-21,858]. The median costs decreased from $11,994 [IQR 6,939-23,084] in 2005 to $10,296 [IQR 5,968-19,702] in 2010 (p<0.001) (Table 2). The adjusted analysis showed a significant proportional decrease of 2.8% per year in the average costs of NTSEm hospitalizations between 2005 and 2010 (β -0.028, 95%CI -0.029 -0.027, p<0.001) (Table 5); however, the decreased trend was not constant over the study period. The trend analysis showed an initial proportional increase of 0.5% in the average costs between 2005 and 2006 (β 0.005, 95%CI 0.000 0.010, p=0.018), thereafter, the trend demonstrated a significant proportional decrease in 2007 (β -0.021, 95%CI -0.026 -0.016, P<0.001) and remained constant until 2010 (β -0.151, 95%CI -0.156 -0.146, p<0.001). Figure 3 illustrates the adjusted average costs variation by year in each NTSEm. There were significant proportional decreased trends in all conditions. The greatest proportional decrease was observed in patients with acute mesenteric ischemia (β -0.036, 95%CI -0.040 -0.031, P<0.001), bowel perforation (β -0.036, 95%CI -0.041 -0.031, P<0.001), and necrotizing fasciitis (β -0.036, 95%CI -0.044 -0.027, P<0.001). The lowest proportional decrease was observed in patients with abdominal aortic aneurysm and dissection (β -0.026, 95%CI -0.029 -

0.024, P<0.001) and in patients with bowel obstruction (β -0.026, 95%CI -0.027 -0.025, P<0.001) (Table 5).

2.3.4 Analysis by US regions

2.3.4.1 Trends of NTSEm hospitalizations by US regions. There were 335,217 NTSEm discharges in the Northeast region, 426,290 in the Midwest, 707,839 in the South, and 394,849 in the West; accounting for 3.7%, 4.0%, 3.8%, and 4.2% of total NIS discharges in each region, respectively. The regression analyses showed trends of significant increased odds of NTSEm hospitalizations in all regions (Table 3). The greatest increase was observed in the West, with a significant increase of 4.1% per year between 2005 and 2010 (OR 1.041, 95%CI 1.030-1.052, p<0.001); the increase occurred after 2007 (OR 1.060, 95%CI 1.001-1.122, p=0.043) and remained constant until 2010 (OR 1.227, 95%CI 1.150-1.308, p<0.001). The lowest increase was observed in the Midwest, about 1.5% per year during the study period (OR 1.015, 95%CI 1.002-1.029, p=0.021); this increase turned significantly only after 2009 (OR 1.078, 95%CI 1.011-1.149, p=0.020) and remained in 2010 (OR 1.082, 95%CI 1.011-1.158, p=0.022).

For the Northeast region, the regression analysis showed a significant increase of 2.5% per year in the odds of hospitalizations between 2005 and 2010 (OR 1.025, 95%CI 1.013-1.037, p<0.001) (Table 4). This increase in the Northeast occurred after 2008 (OR 1.077, 95%CI 1.017-1.141, p=0.011) and remained constant until 2010 (OR 1.122, 95%CI 1.057-1.191, p<0.001). The trends of the odds of hospitalization increased significantly in patients with abdominal sepsis (peritonitis) (OR 1.041, 95%CI 1.030-1.052, p<0.001) and bowel obstruction (OR 1.012, 95%CI 1.005-1.018, p<0.001). Conversely, the trends demonstrated a significant decrease in patients with abdominal aorta aneurysm and dissection (OR 0.976, 95%CI 0.966-0.985, p<0.001), acute appendicitis (OR 0.981, 95%CI 0.971-0.991, p<0.001), and acute mesenteric ischemia (OR 0.977, 95%CI 0.963-0.992, p=0.002). The trends of the odds of hospitalization did not reach statistical significance for, bowel perforation (OR 1.011, 95%CI 0.994-1.028, p=0.196), and necrotizing fasciitis (OR 1.023, 95%CI 0.991-1.056, p=0.159) (Table 3).

For the Midwest region, the trends of the odds of hospitalization increased significantly in patients with abdominal sepsis (peritonitis) (OR 1.027, 95%CI 1.014-1.040, p<0.001) and bowel obstruction (OR 1.018, 95%CI 1.010-1.027, p<0.001). However, the trends demonstrated a significant decrease in patients with abdominal aorta aneurysm and dissection (OR 0.983, 95%CI 0.972-0.994, p=0.004), acute appendicitis (OR 0.982, 95%CI 0.970-0.995, p=0.009), and acute mesenteric ischemia (OR 0.968, 95%CI 0.950-0.986, p=0.001). Again, the trends did not reach statistical significance for, bowel perforation (OR 0.988, 95%CI 0.968-1.009, p=0.286), and necrotizing fasciitis (OR 1.012, 95%CI 0.975-1.051, p=0.497) (Table 3).

For the South region, the adjusted analysis showed a significant increase of 2.8% per year in the odds of hospitalizations between 2005 and 2010 (OR 1.028, 95%CI 1.019-1.037, p<0.001) (Table 3). The increase occurred after 2008 (OR 1.078, 95%CI 1.023-1.137, p=0.005) and remained constant until 2010 (OR 1.116, 95%CI 1.060-1.174, p<0.001). Patients with abdominal sepsis demonstrated the greatest trend towards increased odds of hospitalization (OR 1.038, 95%CI 1.030-1.045, p<0.001), followed by patients with bowel perforation (OR 1.014, 95%CI 1.000-1.027, p=0.038). Conversely, patients with acute mesenteric ischemia (OR 0.980, 95%CI 0.968-0.991, p=0.001) and bowel obstruction (OR 0.987, 95%CI 0.983-0.992, p<0.001) demonstrated trends towards decreased odds of hospitalizations. The trends did not reach statistical significance for, abdominal aortic aneurysm and dissection (OR 1.000, 95%CI 0.992-

1.007, p=0.929), acute appendicitis (OR 1.005, 95%CI 0.998-1.012, p=0.143), and necrotizing fasciitis (OR 1.016, 95%CI 0.995-1.037, p=0.129) (Table 3).

For the West region, the trends of the odds of hospitalization increased significantly in patients with abdominal sepsis (peritonitis) (OR 1.012, 95%CI 1.003-1.022, p=0.010), acute appendicitis (OR 1.009, 95%CI 1.000-1.019, p=0.049), and bowel obstruction (OR 1.006, 95%CI 1.000-1.013, p=0.050); however, patients with abdominal aortic aneurysm and dissection (OR 0.989, 95%CI 0.982-0.996, p=0.004), acute mesenteric ischemia (OR 0.980, 95%CI 0.965-0.995, p=0.012) demonstrated trends of decreased odds. The trend did not reach statistical significance for bowel perforation (OR 1.009, 95%CI 0.992-1.027, p=0.270) (Table 3).

2.3.4.2 Trends of NTSEm mortality by US regions. There were 18,551 NTSEm related deaths (5.5%) in the Northeast region, 19,347 (4.5%) in the Midwest, 34,821 (4.9%) in the South, and 18,738 (4.8%) in the West. Regression analyses showed trends of significant decreased odds of NTSEm related deaths in all regions (Table 4). The greatest decrease was observed in the Midwest, with a significant decrease of 4.7% per year during 2005-2010 (OR 0.953, 95%CI 0.938-0.967, p<0.001); the decreased trend was constant over the study period. The lowest decrease was observed in the South, with 3.1% per year during 2005-2010 (OR 0.969, 95%CI 0.959-0.978, p<0.001); the decrease in the odds of deaths for the South region occurred since 2007 (OR 0.879, 95%CI 0.832-0.930, p<0.001) and remained constant until 2010 (OR 0.840, 95%CI 0.795-0.889, p<0.001).

For the Northeast region, the trend analysis showed a significant decrease in the odds of death of 4.1% per year during 2005-2010 (OR 0.959, 95%CI 0.947-0.971, p<0.001); this decreased trend was constant over the study period. The greatest reduction in the odds of deaths was observed in patients with acute appendicitis (OR 0.882, 95%CI 0.806-0.966, p=0.007).

Trends for bowel perforation (OR 0.977, 95%CI 0.940-1.016, p=0.262) and necrotizing fasciitis (OR 0.986, 95%CI 0.908-1.070, p=0.743) did not reach statistical significance (Table 4).

For the Midwest, the greatest reduction in the odds of deaths was observed in patients with bowel perforation (OR 0.925, 95%CI 0.880-0.973, p=0.003), the lowest trend of decreased odds of death was observed in patients with bowel obstruction (OR 0.965, 95%CI 0.947-0.984, p<0.001). Trends for acute appendicitis (OR 0.918, 95%CI 0.820-1.027, p=0.136) and necrotizing fasciitis (OR 0.934, 95%CI 0.835-1.045, p=0.238) did not reach statistical significance (Table 4).

For the South, the greatest reduction in the odds of deaths was observed in patients with acute appendicitis (OR 0.891, 95%CI 0.829-0.958, p<0.001), the lowest significant reduction in the odds of death was observed in patients with abdominal sepsis (peritonitis) (OR 0.979, 95%CI 0.960-0.998, p=0.039). Trends did not reach statistical significance for bowel perforation (OR 1.009, 95%CI 0.978-1.041, p=0.538) and necrotizing fasciitis (OR 1.027, 95%CI 0.966-1.091, p=0.389) (Table 4).

For the West region, the adjusted trend analysis showed a significant decrease of 4.0% per year in the odds of deaths during 2005-2010 (OR 0.960, 95%CI 0.948-0.973, p<0.001); the decrease in the odds occurred in 2007 (OR 0.918, 95%CI 0.853-0.987, p<0.001) and remained until 2010 (OR 0.776, 95%CI 0.720-0.837, p<0.001). The greatest decrease in the odds of deaths was observed in patients with acute appendicitis (OR 0.876, 95%CI 0.797-0.962, p=0.006) and the lowest significant decrease in the odds of death was observed in patients with bowel obstruction (OR 0.958, 95%CI 0.942-0.974, p=0.021). The trend did not reach statistical significance for patients with abdominal aortic aneurysm and dissection (OR 0.996, 95%CI 0.966-1.027, p=0.808) (Table 4).

2.3.4.3 Trends of hospital costs by US regions. Median cost of NTSEm hospitalization per patient was $11,568 [IQR 6,770-22,260] in the Northeast region, $11,593 [IQR 6,728-22,097] in the Midwest, $10,551 [IQR 6,170-20,109] in the South, and $13,074 [IQR 7,648-24,654] in the West. There were trends of significant proportional decrease in the costs among all regions (Table 5).

The greatest proportional decrease in the costs was observed in the West region, about 3.4% per year during 2005-2010 (β -0.034, 95%CI -0.036 -0.032, $p<0.001$) (Table 5). The decreased trend was not constant over the study period, the trend analysis showed an initial proportional increase of 1.4% in the average costs between 2005 and 2006 (β 0.014, 95%CI 0.004 0.024, $p=0.005$), then, the trend demonstrated a significant proportional decrease in 2007 (β -0.031, 95%CI -0.040 -0.021, $P<0.001$) and remained constant until 2010 (β -0.202, 95%CI -0.211 -0.192, $p<0.001$).

The lowest proportional decrease in the costs was observed in the Midwest, about 1.7% per year during the study period (β -0.017, 95%CI -0.019 -0.015, $p<0.001$) (Table 6). This proportional decrease in the average costs occurred in 2008 (β -0.020, 95%CI -0.032 -0.008, $p=0.001$) and remained constant until 2010 (β -0.098, 95%CI -0.111 -0.086, $p<0.001$).

2.4 DISCUSSION

Over the study period, the number of non-traumatic surgical emergencies related hospitalizations increase significantly in all US regions. The greater proportion of patients with NTSEm were on Medicare insurance, however, this was decreased over the study period as well as patients with private insurances. In the other hand, patients with NTSEm on Medicaid and self-payment increased over time. In addition, patients with NTSEm had two or more comorbidities and the proportion increased during 2005-2010. There were variations of trends of hospitalizations among NTSEm conditions and by US regions.

Mortality decreased significantly over time in all US regions. However, differences in mortality trends among NTSEm conditions in US regions were observed. For example, mortality trends for necrotizing fasciitis decreased significantly only in the West region. In the South region, bowel perforation and necrotizing fasciitis demonstrated trends toward increased mortality over time; nonetheless, these trends did not reach statistical significance. This study also documented that trends of cost associated with NTSEm were decreasing over time.

The increased trends in NTSEm and abdominal sepsis hospitalizations in all US regions observed in this study are consistent with results from a recent study describing increased trends of hospitalizations for some emergency general surgery conditions and increased trends of sepsis rates. [34] It is also consistent with increased nationwide trends of emergency department utilization across the US.[4,9,35] Gale et al. reported that the actual number of US admissions related to emergency general surgical conditions increased from 2,380,535 in 2001 to 3,034,878 in 2010; in addition, the proportion of patients with sepsis rates increased from 1.9% to 2.2% during the same period of time.[34] The increased trends of hospitalizations from acute care surgical conditions, observed from this and previous studies are suggested to occur by the increased and more comorbid population in the US that requires more healthcare utilization resources.[6]

In this study, there were some surgical conditions demonstrating regional differences in trends of hospitalization. For example, patients with acute appendicitis demonstrated decreased trends in the Northeast and Midwest, but increased trends in the West. Previous studies reported decreased trends of hospitalization for acute appendicitis in Europe and Cananda.[36-38] However, Buckius et al. in a recent study described an increase in annual rate of acute appendicitis from 7.62 (per 10,000) population) in 1993 to 9.38 (per 10,000 population) in 2008 in the US.[39] In addition, the trend of hospitalizations from bowel obstruction demonstrated no significant variation over time in the US, but when looked by US region, there were increased trends in the Northeast, Midwest, and West regions, but a decreased trend in the South. In a previous study, Scott et al. demonstrated no significant variations in hospitalization rates over time for bowel obstruction during a 20-year period.[40]

NIS database is only index hospitalization data, it does not account for patients discharged from the emergency department and treated as outpatients. This may underestimate the true burden of hospitalizations for these conditions in differential manner by US regions. A previous report from the American Surgical Association highlighted societal and economic determinants for variations of regional health and access of care; the same report highlighted higher rupture rates from acute appendicitis in areas of the US that do not have good access to surgeons.[7] Therefore, regional differences observed in trends of hospitalizations could be related with regional differences in acute care surgical coverage and diagnostic resource utilization across the US, reported previously.[7]

Despite the significant increase in NTSEm hospitalizations with more comorbid conditions, mortality for NTSEm decreased significantly over time in all US regions. This study also demonstrated that mortality decreased over time for all US regions in patients with abdominal sepsis. Abdominal sepsis is the most common source of sepsis among all surgical patients, when septic shock follow sepsis, there is an increased mortality rate among all emergent surgical patients, up to 39%.[41] This significant reduction in mortality over time may have multiple explanations. However, previous studies have demonstrated similar reductions in mortality rates related to sepsis, attributable to the implementation of guidelines for the treatment of sepsis after 2004.[42] Therefore, the similar findings from this study suggest that these decreased trends in mortality could be related with the concurrent implementation of guidelines for the treatment of sepsis and from the increased capabilities and workforce of intensive care resources in the US.[6,42]

The increased trends of hospitalizations of NTSEm patients with more comorbidities, observed in this study, hypothesized more acute care resource utilization and more health care spending for the treatment of these conditions. Previous reports have highlighted increasing demands over time of critical care resources in the US.[6] In addition, reports on health care cost and utilization have demonstrated that healthcare spending in the US accounts for a large share of the gross domestic product, represented about 16.5% of the gross domestic product in 2008, and it is projected to grow to about 19.6% by 2016.[43] Between 2010 and 2011 in the US, the estimated total healthcare spending per capita increased both by inpatient and outpatient services; the highest per capita expenditure and average prices paid to inpatient care were for surgical admissions.[44] However, the results from this study documented that trends of cost associated with NTSEm were decreasing over time. In addition to the increased proportion of Medicaid insurance and self-payment, these decreased trends indicated that reimbursement for this care may be declining. One possible explanation could be that healthcare spending and average prices paid were shifted to outpatient care as previously reported with elective surgical procedures for cancer related conditions, [45] but this seems less likely for these NTSEm because length of hospital stay did not change over the study period. Another explanation could be that acute surgical care for NTSEm is getting more cost-effective since trends of mortality and costs are decreasing for this more comorbid and uninsured population in the US. Nonetheless, these findings may have an impact into the already apparent public health crisis of nationwide shortage of general surgeons and into future acute care surgical service coverage and regionalization across the US.[6,7]

2.4.1 Limitations

The study strengths are the use of an established administrative database with continuous data collection over the study period and a large sample size in relation to the number of confounding variables examined. Nonetheless, limitations must be acknowledged. NIS database is only index hospitalization data, it does not account for patients discharged from the emergency department and treated as outpatients. Administrative databases are never complete or detailed enough to provide clinical information. However, six-years of consistent data that allowed comprehensive estimations of the magnitude and direction of the trends of hospitalizations, deaths, and costs associated with these NTSEm conditions. It also allowed the generalization of the trend estimates to all regions of the US. In addition, the generalized random mixed effect models used in this study are more robust to deal when missing data problems arise in secondary data analyses and account for the correlation encountered in multilevel data.[46,47]

The AHRQ comorbidity software uses the ICD-9-CM codes to build the index, but still it is an approximation of comorbidities encountered in clinical scenarios. Nonetheless, it is a comorbidity measure developed and validated for this type of administrative databases and adapted for risk adjustment purposes.[31] Diagnoses in administrative databases are usually arbitrarily coded, based on nonclinical decisions, and biased by resources and reimbursement.[32]

This may bias the estimations in an unknown direction. I attempted to overcome this by using all diagnosis codes to identify this patient population. Finally, the observational approach used for trend analyses can be biased by surgical care differences among hospitals. The inclusion of the random effect in the regression analysis could help to reduce this bias.

2.4.2 Conclusion

There is an increase in NTSEm related hospitalizations over time, probably related to the aging and increase in comorbidities of the US population. This will continue to limit the access to high-quality emergency surgical care and will continue to challenge the healthcare system in the US. Despite that increase in NTSEm related hospitalizations with more comorbid and uninsured patients, mortality and costs are decreasing significantly over time. This could be related to improvements in hospital management and to the integration and penetration of surgical services with multidisciplinary teams that expand their surgical coverage for all surgical emergencies and separate it from elective surgery. However, variations among US regions were observed. These may be related to geographical differences over time in acute care surgical coverage in the US.

Table 1. Descriptive trends of characteristics in NTSEm

Characteristics	2005-2010 (N=1,864,195)	2005 (n=294,903)	2010 (n=319,732)	P value
Age (years)				
Median [IQR]	62 [43-76]	62 [41-77]	62 [44-76]	<0.001
Female	49.3	50.3	48.9	<0.001
Race/ethnicity				
White	58.2	55.9	64.0	<0.001
Black	8.2	6.6	10.6	<0.001
Hispanic	8.0	7.2	9.4	<0.001
Other	4.4	3.5	4.8	<0.001
No data	21.0	26.5	11.0	<0.001
Insurance				
Medicare	47.7	47.6	47.4	<0.001
Medicaid	9.9	9.8	11.5	<0.001
Private	34.0	34.8	32.2	<0.001
Self-pay	4.7	4.6	5.0	<0.001
Other	3.3	2.9	3.4	<0.001
AHRQ comorbidity index				
0	23.0	26.4	20.7	<0.001
1	18.7	20.6	17.2	<0.001
2+	58.3	53.0	62.2	<0.001
Hospital length of stay (days)				
Median [IQR]	5 [2-9]	5 [2-9]	5 [2-9]	0.307
Hospital bed-size				
Small	13.4	12.5	13.5	<0.001
Medium	24.1	24.7	23.7	<0.001
Large	62.0	62.7	61.7	<0.001
Hospital location				
Urban	86.6	86.8	86.0	<0.001
Hospital teaching status				
Teaching	43.6	38.7	45	<0.001
NTSEm				
Abdominal aortic aneurysm and dissection	13.9	12.8	13.9	<0.001
Abdominal sepsis	9.2	8.4	10.1	<0.001
Acute appendicitis	20.1	21.5	18.7	<0.001
Acute mesenteric ischemia	3.2	3.4	3.1	<0.001
Bowel obstruction	57.2	57.3	57.8	<0.001
Bowel perforation	2.2	2.2	2.2	0.151
Necrotizing fasciitis	0.9	0.8	1.0	<0.001

NTSEm, non-traumatic surgical emergencies; IQR, inter-quartile range, AHRQ, Agency for Healthcare Research and Quality.
Data are percentages unless otherwise indicated.

Table 2. Descriptive trends of mortality and costs by NTSEm

	2005-2010	2005	2010	P value
Mortality				
NTSEm	4.9	5.2	4.5	<0.001
Abdominal aortic aneurysm and dissection	4.8	5.3	4.5	<0.001
Abdominal sepsis	10.7	11.7	10.1	<0.001
Acute appendicitis	0.3	0.3	0.2	<0.001
Acute mesenteric ischemia	20.6	21.9	19.1	<0.001
Bowel obstruction	5.0	5.3	4.4	<0.001
Bowel perforation	19.8	19.5	20.1	0.369
Necrotizing fasciitis	10.1	9.9	9.5	0.947
Costs in US dollars				
NTSEm				
Median [IQR]	11,457 [6,671-21,858]	11,994 [6,939-23,084]	10,296 [5,968-19,702]	<0.001
Abdominal aortic aneurysm and dissection				
Median [IQR]	11,276 [5,968-21,809]	13,723 [7,142-27,024]	12,301 [6,505-23,835]	<0.001
Abdominal sepsis				
Median [IQR]	18,922 [9,943-35,219]	20,912 [10,987-38,397]	16,685 [8,780-31,591]	<0.001
Acute appendicitis				
Median [IQR]	9,354 [6,860-13,175]	9,713 [7,054-13,803]	8,375 [6,064-11,696]	<0.001
Acute mesenteric ischemia				
Median [IQR]	16,459 [8,643-32,726]	17,108 [9,057-34,058]	15,003 [7,969-29,799]	<0.001
Bowel obstruction				
Median [IQR]	12,318 [6,357-24,012]	12,913 [6,616-25,358]	11,067 [5,733-21,637]	<0.001
Bowel perforation				
Median [IQR]	24,935 [13,861-42,908]	26,843 [15,722-47,010]	22,250 [12,307-38,102]	<0.001
Necrotizing fasciitis				
Median [IQR]	23,565 [12,536-41,923]	24,270 [12,879-45,143]	21,411 [11,478-37,375]	<0.001

NTSEm, non-traumatic surgical emergencies; IQR, inter-quartile range.
Mortality data are percentages.

Table 3. Trend analyses of hospitalizations in NTSEm by US regions

Trends of hospitalizations	OR	95% CI	P value
NTSEm	1.029	1.023-1.035	<0.001
Abdominal aortic aneurysm and dissection	0.987	0.984-0.991	<0.001
Abdominal sepsis	1.031	1.026-1.035	<0.001
Acute appendicitis	0.997	0.993-1.002	0.316
Acute mesenteric ischemia	0.973	0.968-0.978	<0.001
Bowel obstruction	1.002	0.999-1.005	0.117
Bowel perforation	1.008	1.000-1.017	0.037
Necrotizing fasciitis	1.008	0.994-1.022	0.240
Northeast			
NTSEm	1.025	1.013-1.037	<0.001
Abdominal aortic aneurysm and dissection	0.976	0.966-0.985	<0.001
Abdominal sepsis	1.041	1.030-1.052	<0.001
Acute appendicitis	0.981	0.971-0.991	<0.001
Acute mesenteric ischemia	0.977	0.963-0.992	0.002
Bowel obstruction	1.012	1.005-1.018	<0.001
Bowel perforation	1.011	0.994-1.028	0.196
Necrotizing fasciitis	1.023	0.991-1.056	0.159
Midwest			
NTSEm	1.015	1.002-1.029	0.021
Abdominal aortic aneurysm and dissection	0.983	0.972-0.994	0.004
Abdominal sepsis	1.027	1.014-1.040	<0.001
Acute appendicitis	0.982	0.970-0.995	0.009
Acute mesenteric ischemia	0.968	0.950-0.986	0.001
Bowel obstruction	1.018	1.010-1.027	<0.001
Bowel perforation	0.988	0.968-1.009	0.286
Necrotizing fasciitis	1.012	0.975-1.051	0.497
South			
NTSEm	1.028	1.019-1.037	<0.001
Abdominal aortic aneurysm and dissection	1.000	0.992-1.007	0.929
Abdominal sepsis	1.038	1.030-1.045	<0.001
Acute appendicitis	1.005	0.998-1.012	0.143
Acute mesenteric ischemia	0.980	0.968-0.991	0.001
Bowel obstruction	0.987	0.983-0.992	<0.001
Bowel perforation	1.014	1.000-1.027	0.038
Necrotizing fasciitis	1.016	0.995-1.037	0.129
West			
NTSEm	1.041	1.030-1.052	<0.001
Abdominal aortic aneurysm and dissection	0.989	0.982-0.996	0.004
Abdominal sepsis	1.012	1.003-1.022	0.010
Acute appendicitis	1.009	1.000-1.019	0.049
Acute mesenteric ischemia	0.980	0.965-0.995	0.012
Bowel obstruction	1.006	1.000-1.013	0.050
Bowel perforation	1.009	0.992-1.027	0.270

Necrotizing fasciitis	0.975	0.948-1.004	0.093

NTSEm, non-traumatic surgical emergencies; OR, odds ratio; CI, confidence interval.
Odds ratios were calculated using multilevel logistic regressions adjusted for age, sex, race, insurance status, AHRQ comorbidity index, hospital length of stay, hospitals characteristics (bed-size, location, teaching status, and volume), and a random effect for hospitals.
Multilevel logistic regressions were performed separately for each NTSEm by US region.

Table 4. Trend analyses of deaths in NTSEm by US regions

Mortality trends	OR	95% CI	P value
NTSEm	0.962	0.956-0.968	<0.001
Abdominal aortic aneurysm and dissection	0.968	0.955-0.981	<0.001
Abdominal sepsis	0.957	0.946-0.969	<0.001
Acute appendicitis	0.888	0.850-0.929	<0.001
Acute mesenteric ischemia	0.942	0.927-0.957	<0.001
Bowel obstruction	0.961	0.954-0.969	<0.001
Bowel perforation	0.976	0.957-0.995	0.016
Necrotizing fasciitis	0.977	0.939-1.016	0.253
Northeast			
NTSEm	0.959	0.947-0.971	<0.001
Abdominal aortic aneurysm and dissection	0.940	0.915-0.966	<0.001
Abdominal sepsis	0.948	0.925-0.972	<0.001
Acute appendicitis	0.882	0.806-0.966	0.007
Acute mesenteric ischemia	0.934	0.904-0.964	<0.001
Bowel obstruction	0.952	0.937-0.968	<0.001
Bowel perforation	0.977	0.940-1.016	0.262
Necrotizing fasciitis	0.986	0.908-1.070	0.743
Midwest			
NTSEm	0.953	0.938-0.967	<0.001
Abdominal aortic aneurysm and dissection	0.948	0.919-0.978	0.001
Abdominal sepsis	0.931	0.903-0.959	<0.001
Acute appendicitis	0.918	0.820-1.027	0.136
Acute mesenteric ischemia	0.926	0.890-0.965	<0.001
Bowel obstruction	0.965	0.947-0.984	<0.001
Bowel perforation	0.925	0.880-0.973	0.003
Necrotizing fasciitis	0.934	0.835-1.045	0.238
South			
NTSEm	0.969	0.959-0.978	<0.001
Abdominal aortic aneurysm and dissection	0.977	0.955-0.999	0.047
Abdominal sepsis	0.979	0.960-0.998	0.039
Acute appendicitis	0.891	0.829-0.958	0.002
Acute mesenteric ischemia	0.944	0.919-0.969	<0.001
Bowel obstruction	0.967	0.956-0.979	<0.001
Bowel perforation	1.009	0.978-1.041	0.538
Necrotizing fasciitis	1.027	0.966-1.091	0.389
West			
NTSEm	0.960	0.948-0.973	<0.001
Abdominal aortic aneurysm and dissection	0.996	0.966-1.027	0.808
Abdominal sepsis	0.951	0.928-0.975	<0.001
Acute appendicitis	0.876	0.797-0.962	0.006
Acute mesenteric ischemia	0.954	0.922-0.988	0.009
Bowel obstruction	0.958	0.942-0.974	<0.001
Bowel perforation	0.952	0.914-0.992	0.021

Necrotizing fasciitis	0.895	0.824-0.972	0.008

NTSEm, non-traumatic surgical emergencies; OR, odds ratio; CI, confidence interval.
Odds ratios were calculated using multilevel logistic regressions adjusted for age, sex, race, insurance status, AHRQ comorbidity index, hospital length of stay, hospitals characteristics (bed-size, location, teaching status, and volume), and a random effect for hospitals.
Multilevel logistic regressions were performed separately for each NTSEm by US region.

Table 5. Trend analyses of log-transformed costs in NTSEm by US regions

Trends of log-transformed costs	β	95% CI	P value
NTSEm	-0.028	-0.029 -0.027	<0.001
Abdominal aortic aneurysm and dissection	-0.026	-0.029 -0.024	<0.001
Abdominal sepsis	-0.032	-0.035 -0.030	<0.001
Acute appendicitis	-0.028	-0.029 -0.027	<0.001
Acute mesenteric ischemia	-0.036	-0.040 -0.031	<0.001
Bowel obstruction	-0.026	-0.027 -0.025	<0.001
Bowel perforation	-0.036	-0.041 -0.031	<0.001
Necrotizing fasciitis	-0.036	-0.044 -0.027	<0.001
Northeast			
NTSEm	-0.031	-0.033 -0.029	<0.001
Abdominal aortic aneurysm and dissection	-0.039	-0.044 -0.034	<0.001
Abdominal sepsis	-0.039	-0.044 -0.034	<0.001
Acute appendicitis	-0.020	-0.022 -0.019	<0.001
Acute mesenteric ischemia	-0.038	-0.047 -0.030	<0.001
Bowel obstruction	-0.032	-0.034 -0.030	<0.001
Bowel perforation	-0.044	-0.054 -0.033	<0.001
Necrotizing fasciitis	-0.041	-0.060 -0.022	<0.001
Midwest			
NTSEm	-0.017	-0.019 -0.015	<0.001
Abdominal aortic aneurysm and dissection	-0.010	-0.016 -0.004	0.001
Abdominal sepsis	-0.024	-0.030 -0.017	<0.001
Acute appendicitis	-0.013	-0.016 -0.010	<0.001
Acute mesenteric ischemia	-0.039	-0.049 -0.028	<0.001
Bowel obstruction	-0.014	-0.017 -0.012	<0.001
Bowel perforation	-0.023	-0.036 -0.011	<0.001
Necrotizing fasciitis	-0.038	-0.061 -0.015	0.001
South			
NTSEm	-0.027	-0.028 -0.025	<0.001
Abdominal aortic aneurysm and dissection	-0.023	-0.027 -0.019	<0.001
Abdominal sepsis	-0.025	-0.029 -0.021	<0.001
Acute appendicitis	-0.027	-0.029 -0.026	<0.001
Acute mesenteric ischemia	-0.030	-0.037 -0.022	<0.001
Bowel obstruction	-0.026	-0.028 -0.024	<0.001
Bowel perforation	-0.030	-0.038 -0.022	<0.001
Necrotizing fasciitis	-0.022	-0.034 -0.010	<0.001
West			
NTSEm	-0.034	-0.036 -0.032	<0.001
Abdominal aortic aneurysm and dissection	-0.034	-0.040 -0.028	<0.001
Abdominal sepsis	-0.044	-0.050 -0.039	<0.001
Acute appendicitis	-0.043	-0.045 -0.041	<0.001
Acute mesenteric ischemia	-0.041	-0.050 -0.031	<0.001
Bowel obstruction	-0.029	-0.031 -0.026	<0.001
Bowel perforation	-0.053	-0.064 -0.041	<0.001

Necrotizing fasciitis	-0.059	-0.077 -0.042	<0.001

NTSEm, non-traumatic surgical emergencies; β, regression coefficient,; CI, confidence interval. Coefficients indicated the proportional change in the average cost per year over the study period. Coefficients were calculated using multilevel linear regressions adjusted for age, sex, race, insurance status, AHRQ comorbidity index, hospital length of stay, hospitals characteristics (bed-size, location, teaching status, and volume), and a random effect for hospitals. Multilevel linear regressions were performed separately for each NTSEm by US region.

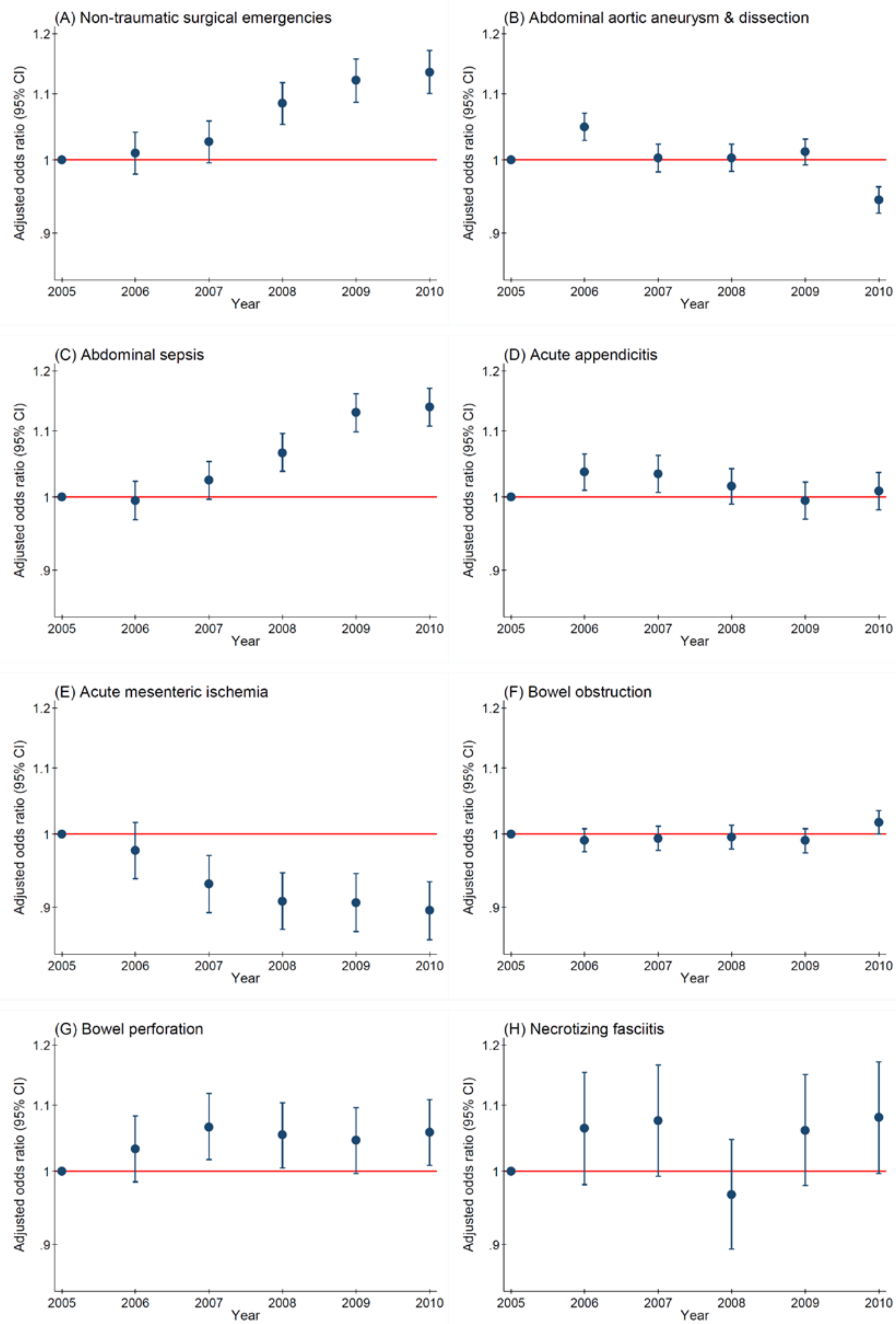


Figure 1. Yearly odds of NTSEm hospitalizations compared with 2005. Adjusted odds ratios were calculated using multilevel logistic regressions adjusting for age, sex, race, insurance status, AHRQ comorbidity index, hospital length of stay, hospitals characteristics (bed-size, location, teaching status, and volume), and a random effect for hospitals.

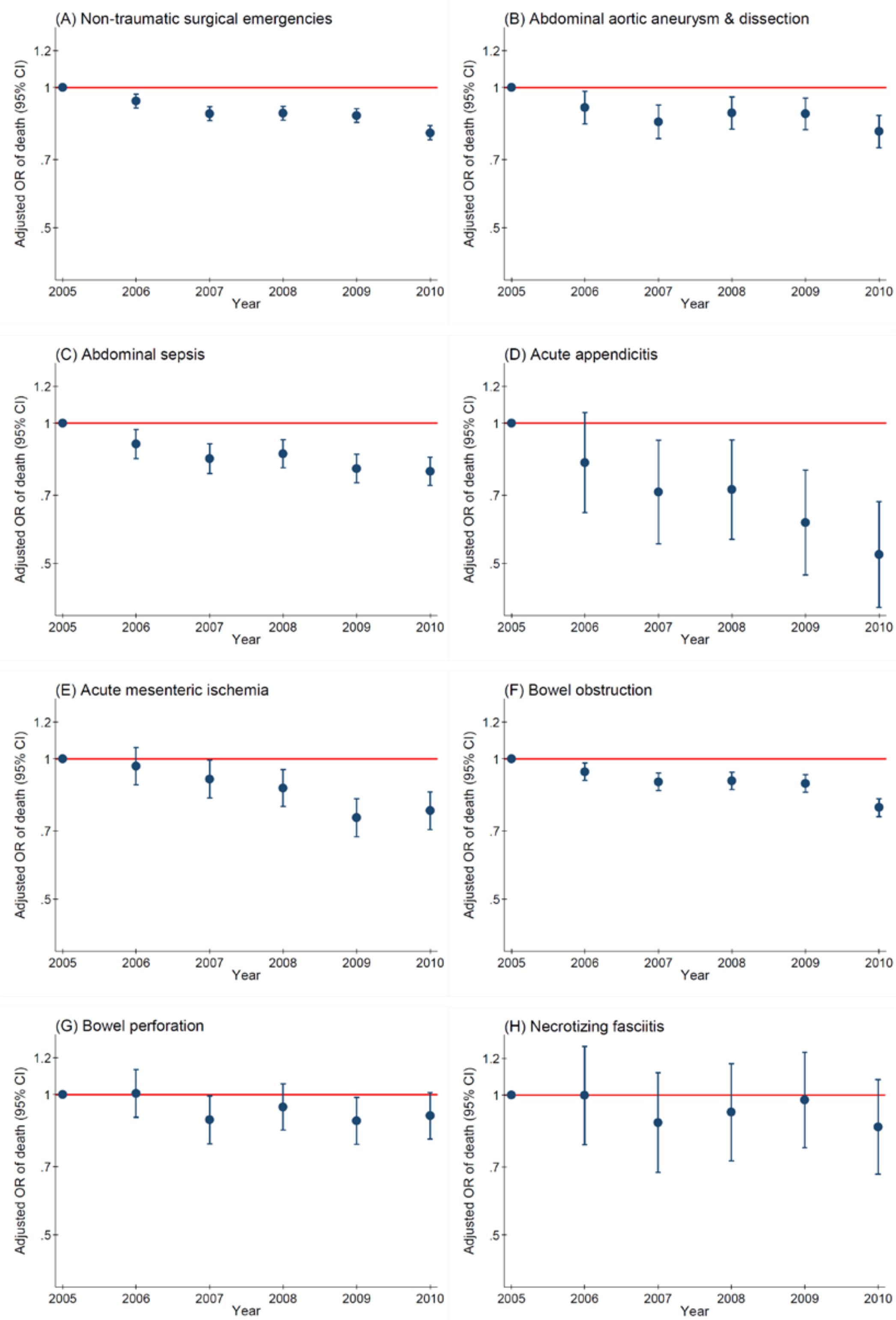


Figure 2. Yearly odds of NTSEm deaths compared with 2005. Adjusted odds ratios were calculated using multilevel logistic regressions adjusting for age, sex, race, insurance status, AHRQ comorbidity index, hospital length of stay, hospitals characteristics (bed-size, location, teaching status, and volume), and a random effect for hospitals.

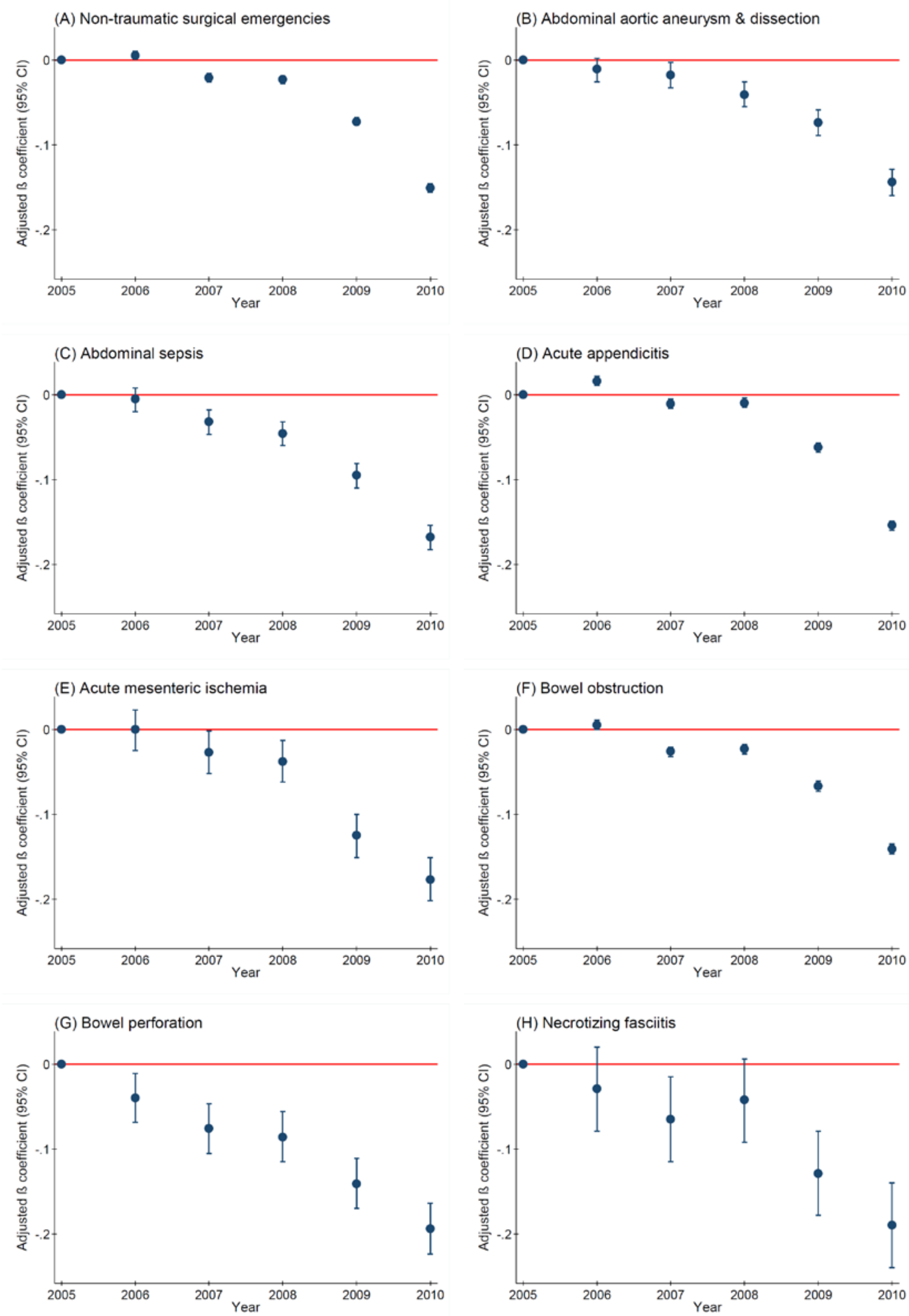


Figure 3. Yearly averages of log-transformed costs for NTSEm compared with 2005. Adjusted coefficients were calculated using multilevel linear regressions adjusting for age, sex, race, insurance status, AHRQ comorbidity index, hospital length of stay, hospitals characteristics (bed-size, location, teaching status, and volume), and a random effect for hospitals. Coefficients indicated the proportional change in the average cost per year.

3.0 TRENDS IN HOSPITALIZATIONS, DEATHS, AND COSTS FROM HOSPITALIZED TRAUMATIC INJURIES IN THE UNITED STATES, 2005-2010

3.1 INTRODUCTION

Injuries resulting from unintentional events and violence related or acts of war, are an important public health problem around the world, killing more than five million people worldwide annually and causing harm and disability to millions more.[48] In the United States (US), injuries rank fourth as a cause of death for all age group, and it is the leading cause of death among children, adolescents, and young adults ages 1-34. There have been studies reporting declines in specific trends for injuries over the past several decades. Nonetheless, injuries account for over 30% of total years of potential life lost for all deaths occurring before age 65.[49]

The development of trauma systems in the US has placed the care of injured patients into the hands of specialist that provide them coordinated, seamless, and expertise-driven care throughout the entire care spectrum (prevention, pre-hospital care, acute management, and rehabilitation). These have demonstrated dramatic improvements in quality of care delivered and patients' outcomes.[10] A critical factor for delivering optimal trauma care involves the immediate participation of in-house attending trauma surgeons in the resuscitative phase of the severely injured patients, as part of a multidisciplinary team that provides dedicated, in-hospital, around the clock care.[11] However, there are no similar systems for patients with no n-traumatic surgical emergencies and currently the literature has described difficulties in providing emergency surgical coverage for the growing, older, and more comorbid US population.[2-7,9,27] In response to this growing difficultly in caring for these patients some trauma centers have restructured their surgical services, integrating critical care and emergency surgery into their trauma programs in new models of Acute Care Surgery.[3,6]

Previously, I described national trends of hospitalizations, deaths, and costs associated with non-traumatic surgical emergencies. There were increased trends of hospitalizations in patients with NTSEm and decreased trends of mortality and costs in addition to some regional variations over time. However, these trends may be affected by societal and economic conditions in the US. Therefore, a control group of patients needed to be evaluated. This additional analysis on epidemiologic trends associated with trauma patients will allow allocating resources appropriately within the new models of acute care surgery. The aim of this study was to evaluate trends of yearly estimates of hospitalizations, deaths, and costs associated with hospitalized traumatic injured patients in the US during 2005-2010. This aim hypothesized that yearly estimates of trauma related hospitalizations, deaths, and costs decreased over time in all regions of the US.

3.2 METHODS

A secondary analysis of six years of the Nationwide Impatient Sample (NIS) databases was performed. The NIS is maintained by the Healthcare Cost and Utilization Project (HCUP) of the Agency for Healthcare Research and Quality (AHRQ). It is a database of hospital inpatient stays and the largest all-payer inpatient care database that is publicly available in the US, containing each year about 8 million hospitals stays from about 1,000 hospitals sampled from a 20% stratified sample of US community hospitals. The NIS is drawn from US States participating in HCUP; these comprised 96% of the US population in 2010. Sampling weights included in the database allow for stratified calculations of total population estimates. Inpatient stay records include clinical and resource information typically available from discharge abstracts. In addition, the NIS contains charge information on all patients, regardless of payer, including persons covered by Medicare, Medicaid, private insurance, and the uninsured.[29]

3.2.1 Case selection

Patients with trauma were identified using the Barell injury diagnostic matrix,[50] a framework for standardizing injury diagnosis that allows comparisons across time and place. It uses the International Classification of Disease, Ninth, Revision, Clinical Modification (ICD-9-CM) codes.[30] The matrix excluded patients with ICD-9-CM codes of adverse effects and complications of medical care, events that are not considered pertinent to injury prevention.[50,51]

Severity of the trauma was classified using anatomic scoring systems. The Abbreviated Injury Scale (AIS) groups injuries into 6 body regions (head and neck, face, chest, abdomen, extremity, and external) and classifies each injury according to its relative importance on a 6-level scale. AIS scores of 1 are minor injuries, and scores of 6 are maximum injury-virtually un-survivable.[52-54] The Injury Severity Score (ISS) is a multi-injury score attempting to assess the combined effect of multiple injuries sustained by a given person. With ranges from 1 (least severe) to 75 (un-survivable), is it the sum of the squares of the highest AIS scores from the three most severely injured body regions. Higher scores reflect higher likelihoods of mortality.[53-55]

AIS and ISS were derived by using the computerized algorithm of the International Classification of Disease programs for injury categorization (ICDPIC), an inexpensive method for translating ICD-9-CM codes into standard injury categories and/or scores. The programing code and associated tables are completely open for Stata (statistical software) users. It has been validated against other coding programs using the NIS.[56,57] ICDPIC does not calculate scores for late effects of injuries, effects of foreign body, burns, certain early complications of trauma, and poisoning by drugs, toxic and other effects.[57] Therefore, patients were not included if they had ICD-9-CM codes of adverse effects or complications of medical care, late effects or complications of an injury event, foreign body, burns, or poisoning.

3.2.2 Study measures

De-identified patients' information including demographics, comorbidity measures and clinical information related to diagnostic codes, injury information related to diagnostic codes, and hospital characteristics were abstracted from NIS. Adjustment for comorbidity is of interest in all types of health care studies and it is essential in observational studies because baseline differences in health status may modulate differences in study outcomes.[31,32] AHRQ comorbidity measures were developed by Elixhauser for large administrative databases to predict mortality, hospital charges, and hospital length of stay, and have been adapted for risk adjustment purposes. Using Diagnosis-Related Groups (DRG) and secondary ICD-9-CM diagnosis codes, 30 unweight comorbidity indicators are most likely to reflect individuals' chronic illness burden and are practical with large administrative databases.[31] These AHRQ comorbidity measures from NIS were summarized and included in the analyses.

Using the external causes of injury codes classified by the ICD-9-CM and based on the recommendations for presenting injury mortality data by de Centers for Disease Control and Prevention,[51] mechanism of injury was grouped into the following categories: falls, motor vehicles, stab/knife, firearms, and others. Type of injury categorized as blunt or penetrating and the AIS and ISS derived from the ICDPIC were used in the statistical analysis for risk adjustment. In each body region, AIS greater or equal to 4 classified the anatomic injury as severe. Overall, ISS equal or greater than 16 classified the trauma as severe.

Outcome measures were rate of hospitalization, mortality at hospital discharge, and hospital costs for each patient. The NIS database contains information on total charges for each hospital in the database. This charge information represents the amount that hospitals billed for services, but does not reflect how much hospital services actually cost or the specific amounts that hospitals received in payment. HCUP cost-to-charge ratio files were used to enable the translation of hospital charges to actual costs in US dollars.

3.2.3 Analysis

Demographic, clinical information, injury information, and hospital characteristics were analyzed descriptively by year. Comparisons of continuous variables were performed using non-parametric tests, given their non-normal distributions. Comparisons among categorical variables were performed using Chi-squared tests.

The proportions trauma hospitalizations were calculated using as denominator the total number NIS discharges. The odds of hospitalizations were fitted in multilevel logistic regressions adjusted for age, sex, race, insurance status, AHRQ comorbidity index, hospital length of stay, hospitals characteristics (bed-size, location, teaching status, and volume), and a random effect to account for the correlation among patients within hospitals.

Mortality was calculated using the total number of trauma patients as the denominator. The odds of deaths were fitted in multilevel logistic regressions adjusted for age, sex, race, insurance status, AHRQ comorbidity index, ISS, type of injury, hospital length of stay, hospitals characteristics (bed-size, location, teaching status, and volume), and a random effect to account for the correlation among patients within hospitals. Trend analyses of the odds of hospitalizations and deaths by year were performed to assess changes over time. Findings were presented as odds ratios (OR) with 95% confidence intervals (CI) and P values.

Hospital costs were adjusted for inflation over time using the Consumer Price Index and standardized to year 2010.[33] For regression analyses, values below the 1st percentile and above the 99th percentile were removed. Log-transformed costs were fitted in multilevel linear regressions adjusted for age, sex, race, insurance status, AHRQ comorbidity index, ISS, type of injury, hospital length of stay, hospitals characteristics (bed-size, location, teaching status, and volume), and a random effect for hospitals. Trend analyses of averages of log-transformed costs by year were performed to assess changes over time. Findings were presented as β coefficients with 95% CI and P values. The coefficient indicated the proportional change in the average cost per year over the study period.

Analyses were performed separately in patients with penetrating injuries and in patients with severe trauma (ISS≥16). Regional variations are important to consider when assessing disease occurrence and health outcomes.[7] Therefore, trend analyses of the odds of hospitalizations and deaths and trend analyses of the log-transformed costs during 2005-2010 were repeated for all trauma patients, severe trauma, and penetrating trauma patients separately by US census regions. All the analyses were performed in Stata (Version 12) software.

3.3 RESULTS

During the six-year period (2005-2006), there were 2,752,514 discharges diagnoses of trauma in NIS database, accounting for 5.7% of total NIS discharges. The median age of trauma patients was 64 years (inter quartile range [IQR] 40-81). The proportion of females decreased from 51.7% in 2005 to 50.0% in 2010 ($p<0.001$). Most of the patients were whites (59.9%), followed by Hispanics (7.5%) and African Americans (7.3%). In 21.1% of the trauma patients, race/ethnicity information was not provided or missing; this proportion decreased over time from 26.8% in 2005 to 12.2% in 2010 ($p<0.001$) (Table 6).

Medicare was the most frequent expected payer (48.6%), followed by private insurances (26.6%). Medicare status increased from 48.3% in 2005 to 50.0% in 2009 ($p<0.001$), then it decreased to 48.1% in 2010 ($p<0.001$). Private insurance decreased from 27.0% in 2005 to 25.7% in 2010 ($p<0.001$). Medicaid insurance increased from 9.8% in 2005 to 11.2% in 2010 ($p<0.001$) (Table 6).

The great majority of patients had two or more comorbidities (53.7%); this proportion of patients increased from 47.5% in 2005 to 57.5% in 2010 ($p<0.001$). Patients with no comorbidities accounted for 25.3%; this proportion of patients decreased from 29.9% to 22.8% during 2005-2010 period ($p<0.001$) (Table 6).

The most frequent mechanism of injury was falls (45.2%), followed by motor vehicle crashes (14.2%). Stab/knifes accounted for 3.1% and firearms for 1.3% of the total trauma patients discharged from the NIS. During 2005-2010, the proportion of fall related injuries increased from 43.6% to 45.2% ($p<0.001$) and the proportion of traffic related injuries decreased from 15.0% in 2005 to 14.1% in 2010 ($p<0.001$). The proportion of stab/knife injuries decreased from 3.1% to 3.0% during 2005-2010, although the trend difference reached statistical significance ($p<0.001$). The proportion of firearm injuries remained similar over the study period (p=578). Penetrating injuries remained almost similar over the study period (from 4.5% in 2005 to 4.6% in 2010, $p<0.001$) although the trend difference reached statistical significance (Table 6).

Median ISS was 4 (IQR 2-9); the proportion of severe trauma patients increased from 7.1% in 2005 to 9.6% in 2010 ($p<0.001$). The proportion of patients with severe injury to the head and neck increased from 3.8% in 2005 to 5.3% in 2010 ($p<0.001$), the proportion of patients with severe injury to the thorax increased from 0.6% in 2005 to 1.1% in 2010 ($p<0.001$) and the proportion of patients with severe injury to the abdomen remained almost similar (0.6%) over the study period, although the slightly increase over time reached statistical significance ($p=0.002$) (Table 6).

Median hospital length of stay was 4 days (IQR 2-6) and remained similar over the study period. The majority of patients were admitted to large sized hospitals (64.1%) located in urban areas (86.9%). Over the study period, the proportion of patients admitted to teaching facilities increased from 42.1% in 2005 to 50.6% in 2010 ($p<0.001$) (Table 6).

3.3.1 Trends of hospitalizations

There were 439,524 injury related hospitalizations in 2005, accounting for 5.5% of NIS discharges for that year; this proportion increased to 6.3% (489,275 patients) by 2010 (Table 6). The adjusted trend analysis showed a significant increase of 2.5% per year in the odds of hospitalizations between 2005 and 2010 (OR 1.025, 95%CI 1.014-1.036, p<0.001) (Table 8). The increase in the odds of hospitalization occurred after 2009 (OR 1.080, 95%CI 1.021-1.143, p=0.007) and remained significant in 2010 (OR 1.142, 1.075-1.213, p<0.001). Figure 4 illustrates the adjusted odds of hospitalizations by year in trauma patients.

In patients with severe trauma, the adjusted trend analysis showed a significant increase of 3.9% per year in the odds of hospitalizations between 2005 and 2010 (OR 1.039, 95%CI 1.034-1.044, p<0.001) (Table 8); this increase in the odds of hospitalizations remained constant over the study period (Figure 4). In patients with penetrating trauma, the adjusted trend analysis showed a significant decrease of 0.8% per year in the odds of hospitalization during the study period (OR 0.991, 95%CI 0.985-0.997, p=0.005) (Table 8); however, the trend analysis in patients with penetrating trauma demonstrated variations over the study period (Figure 4).

3.3.2 Trends of mortality

Mortality was 2.5%. During the study period, mortality varied from 2.4% in 2005 to 2.6% in 2010 (p<0.001) (Table 7). However, the adjusted trend analysis showed a significant decrease of 2.3% per year in the odds of deaths between 2005 and 2010 (OR 0.976, 95%CI 0.970-0.983, p<0.001) (Table 9). The decrease in the odds occurred after 2007 (OR 0.904, 95%CI 0.869-

0.941, p<0.001) and remained constant until 2010 (OR 0.885, 95%CI 0.850-0.921, p<0.001). Figure 5 illustrates the adjusted odds of deaths by year in trauma patients.

In patients with severe trauma mortality was 10.0% during the study period; it decreased from 10.9% in 2005 to 9.6% in 2010 (P<0.001) (Table 7). The adjusted trend analysis showed a significant decrease of 6.5% per year in the odds of deaths (OR 0.930, 95%CI 0.918-0.942, p<0.001) (Table 9). The decrease in the odds of deaths was constant over the study period (Figure 5).

In patients with penetrating trauma mortality was 2.8% during the study period; it increased from 2.5% in 2005 to 3.5% in 2010 (P<0.001) (Table 7). The adjusted trend analysis showed a significant increase of 4.4% per year in the odds of deaths (OR 1.044, 95%CI 1.011-1.078, p=0.008) (Table 9); this increase in the odds of deaths was statistically significantly only in 2010 (OR 1.310, 95%CI 1.082-1.585, p=0.006) (Figure 5).

3.3.3 Trends of hospital costs

Median costs of hospitalizations per trauma patient were $9,951 [IQR, 5,614-17,243]. The median costs decreased from $10,236 [IQR 5,738-17,783] in 2005 to $9,299 [IQR 5,269-16,199] in 2010 (P<0.001) (Table 7). The adjusted trend analysis showed a significant proportional decrease of 2.5% per year in the average costs of hospitalizations between 2005 and 2010 (β -0.025, 95%CI -0.025 -0.024, p<0.001) (Table 10). The decreased trend was not constant over time; initially, the trend analysis showed proportional increase of 0.4% per year in the average costs between 2005 and 2006 (β 0.004, 95%CI 0.000 0.007, p=0.029), after that, costs decreased significantly in 2007 (β -0.019, 95%CI -0.023 -0.015, p<0.001) and remained constant until 2010 (β -0.140, 95%CI -0.144 -0.136, p<0.001) (Figure 6).

In patients with severe trauma, the adjusted trend analysis showed a significant proportional decrease in the costs of hospitalizations of 3.8% per year (β -0.038, 95%CI -0.041 -0.036, p<0.001) (Table 10), a decrease that was consistent over the study period. In patients with penetrating trauma, the adjusted trend analysis showed a significant proportional decrease of 3.5% per year in the costs of hospitalizations (β -0.035, 95%CI -0.038 -0.032, p<0.001), a decrease that was also consistent over time (Figure 6).

3.3.4 Analysis by US regions

3.3.4.1 Trends of hospitalizations in trauma patients by US regions. There were 509,750 discharges in the Northeast, 634,298 in the Midwest, 1,052,994 in the South, and 555,472 in the West; accounting for 5.7%, 5.9%, 5.7%, and 5.8% of total NIS discharges in each region, respectively. Trends of hospitalizations in trauma patients demonstrated an increase over time; however, some of these trends did not reach statistical significance (Table 8).

For the Northeast region, the regression analysis showed a significant increase of 3.1% per year in the odds of hospitalizations during the study period (OR 1.031, 95%CI 1.010-1.052, p=0.003). The increase in the Northeast occurred after 2008 (OR 1.138, 95%CI 1.026-1.261, p=0.014) and remained constant until 2010 (OR 1.134, 95%CI 1.004-1.282, p=0.043). In patients with severe trauma, the adjusted analysis showed a significant increase of 3.0% per year in the odds of hospitalizations during 2005-2010 (OR 1.030, 95%CI 1.020-1.040, p<0.001). In patients with penetrating trauma, there was a decreased trend of 2% per year in the odds of hospitalizations during the study period (OR 0.980, 95%CI 0.969-0.992, p=0.002).

For the Midwest region, the trend analysis for trauma-related hospitalizations did not reach statistical significance (OR 1.000, 95%CI 0.981-1.019, p=0.962). Nonetheless, there were significant trends of hospitalizations during 2005-2010 for patients with severe trauma and penetrating trauma. The adjusted trend analysis demonstrated a significant increase of 3.1% per year for severe trauma patients (OR 1.031, 95%CI 1.017-1.044, p<0.001). Conversely, the adjusted trend analysis demonstrated a significant decrease of 3.1% per year for penetrating trauma patients (OR 0.969, 95%CI 0.951-0.986, p<0.001).

For the South, adjusted trend analysis demonstrated a significant increase of 2.5% per year in the odds of hospitalizations during 2005-2010 (OR 1.025, 95%CI 1.008-1.043, p=0.004); however, this increase occurred significantly only in 2010 (OR 1.166, 95%CI 1.061-1.281, p=0.001). In patients with severe trauma, the adjusted trend analysis demonstrated a significant increase of 5.2 per year in the odds of hospitalizations during 2005-2010 (OR 1.052, 95%CI 1.045-1.060, p<0.001). In patients with penetrating trauma, the adjusted analysis showed an increase of 2.6% per year in the odds of hospitalizations (OR 1.026, 95%CI 1.017-1.036, p<0.001).

For the West region, the adjusted trend analysis demonstrated a significant increase of 3.3% per year during 2005-2010 (OR 1.033, 95%CI 1.006-1.061, p=0.016); the increase occurred significantly only in 2010 (OR 1.214, 95%CI 1.049-1.406, p=0.009). In patients with severe trauma, the trend analysis showed a significant increase of 2.5% per year (OR 1.025, 95%CI 1.015-1.035, p<0.001). Conversely, patients with penetrating trauma demonstrated a significant decrease of 4.7% per year during the study period (OR 0.953, 95%CI 0.941-0.965, p<0.001).

3.3.4.2 Trends of mortality in trauma patients by US regions. There were 12,701 (2.5%) deaths in the Northeast, 14,684 (2.3%) in the Midwest, 27,442 (2.6%) in the South, and 13,589 (2.5%) in the West. Regression analyses showed trends toward decreased odds of deaths in all regions; however, in the Midwest (OR 0.988, 95%CI 0.972-1.005, p=0.202) and in the West (OR 0.989, 95%CI 0.975-1.004, P=0.180) these trends did not reach statistical significance (Table 9).

The greatest decrease was observed in the Northeast, with a significant decrease of 4.5% per year during 2005-2010 (OR 0.955, 95%CI 0.941-0.970, p<0.001); a decrease that occurred after 2007 (OR 0.876, 95%CI 0.806-0.952, p=0.002) and remained constant until 2010 (OR 0.795, 95%CI 0.729-0.867, p<0.001). In patients with severe trauma, trends of mortality decreased significantly 5.8% per year during 2005-2010 (OR 0.942, 95%CI 0.917-0.967, p<0.001). In patients with penetrating trauma, there was a trend toward increased mortality (OR 1.048, 95%CI 0.978-1.123, p=0.178) that did not reach statistical significance.

In the Midwest, patients with severe trauma demonstrated a significant decrease of mortality of 9.1% per year during the study period (OR 0.908, 95%CI 0.880-0.937, p<0.001). In patients with penetrating trauma, the adjusted trend analysis of the odds of deaths did not reach statistical significance (OR 1.054, 95%CI 0.963-1.154, p=0.245).

In the South, the adjusted analysis demonstrated a significant decrease of 2.2% per year in the odds of deaths during 2005-2010 (OR 0.978, 95%CI 0.967-0.989, p<0.001); a decrease that occurred in 2007 (OR 0.927, 95%CI 0.871-0.987, p=0.018) and remained constant until 2010 (OR 0.904, 95%CI 0.848-0.965, p=0.002). In patients with severe trauma, the adjusted trend analysis showed a significant decrease of 7.1% per year in the odds of deaths during the study period (OR 0.929, 95%CI 0.911-0.947, p<0.001). In patients with penetrating trauma, the trend analysis did not reach statistical significance (OR 1.043, 95%CI 0.991-1.097, p=0.104).

In the West region, patients with severe trauma demonstrated a significant decrease of 5.8% per year in the odds of deaths during 2005-2010 (OR 0.942, 95%CI 0.917-0.968, p<0.001). In patients with penetrating trauma, the adjusted trend analysis of the odds of deaths did not reach statistical significance (OR 1.018, 95%CI 0.955-1.086, p=0.567).

3.3.4.3 Trends of hospital costs in trauma patients by US regions. Median cost of hospitalization per trauma patient was $ 10,018 [IQR 5,705-17,772] in the Northeast region, $9,722 [IQR 5,534-16,520] in the Midwest, $9,321 [IQR 5,245-15,948] in the South, and $11,687 [IQR 6,506-20,602] in the West. There were trends of significant proportional decrease in the costs among all regions (Table 10).

The greatest proportional decrease was observed in the West region, 3.2% per year during 2005-2010 (β -0.032, 95%CI -0.033 -0.030, p<0.001). However, the decrease was not constant over the study period, the trend analysis showed an initial proportional increase of 4.2% in the average costs during 2005-2006 (β 0.042, 95%CI 0.033 to 0.051, p<0.001), then, a significant proportional decreased in the cost occurred during 2006-2007 (β -0.027, 95%CI -0.036 -0.019, p<0.001) and remained until 2010 (β -0.194, 95%CI -0.203 -0.186, p<0.001). Adjusted trend analyses showed a proportional decreased of 4.6% per year in the average cost of severe trauma (β -0.046, 95%CI -0.052 -0.041, p<0.001) and a proportional decrease of 5.7% per year in the average costs of penetrating trauma (β -0.057, 95%CI -0.064 -0.050, p<0.001) during 2005-2010.

The lowest proportional decrease was observed in the Midwest, 1.5% per year during 2005-2010 (β -0.015, 95%CI -0.017 -0.013, p<0.001). The decrease occurred in 2008 (β -0.015, 95%CI -0.025 -0.005, p=0.004) and remained constant until 2010 (β -0.086, 95%CI -0.096 -0.075, p<0.001). Adjusted trend analyses showed a proportional decrease of 3.6% per year in the average costs of severe trauma (β -0.036, 95%CI -0.043 -0.029, p<0.001) and a proportional decrease of 2.6% per year for penetrating trauma (β -0.026, 95%CI -0.035 -0.017, p<0.001).

3.4 DISCUSSION

During 2005-2010, trauma related hospitalizations increase significantly in the US. The great proportion of patients was on Medicare insurance, however, a shift toward more Medicaid and less Medicare was observed during the study period. In addition, the proportion of patients with comorbidities increased during 2005-2010. Falls has become the leading mechanism of injury of this aged and more comorbid population. Conversely, stab/knife, firearm, and penetrating injuries are decreasing over time. There were low ISS scores on average in trauma patient; however, the proportion of severe trauma patients increased over the study period. Trends of hospitalizations of severe trauma patients increased in all regions and hospitalizations of penetrating trauma patients decreased significantly but in the South, wherein a significant increased trend was observed.

Mortality in trauma patients and in severe trauma patients decreased significantly over time; however, mortality in penetrating trauma patients demonstrated a significant increase in the overall analysis, and non-significant increased trends among US regions. Regional variations were observed in the Midwest and in the West regions. In addition, this study documented that trends of average costs associated with trauma patients were decreasing over time; however, the significant decreased occurred after 2007-2008. In patients with severe and penetrating trauma, associated trends of average costs decreased over time in all US regions.

Previous reports from developed countries have also documented the increasing trends of hospitalizations in trauma patients as well as the changing patient and injury characteristics over time.[58-61] More recently, a secondary analysis using multiple databases from the US reported increased trends in the US of fatal and nonfatal fall-related injuries from 2002-2010.[62] These studies are consistent with this study results, reporting increments in the number of hospitalizations of more comorbid and more severe trauma patients, with increased proportions of injured related falls and decrements of the proportion of patients injured in traffic events.

The population of the US is becoming older and more comorbid.[28] In this study, the average age of trauma patients did not increase significantly over time. However, the proportion of trauma patients with two or more comorbidities increased significantly from 2005-2010. This could explain more hospitalized patients severely injured after falls that were observed in this study. Falls is becoming an important public health concern within the US population and this results and other reports highlights the need for improved strategies for fall injury prevention.

Despite the significant increase in trauma related hospitalizations, mortality and costs decreased significantly over time, especially for the severe trauma patients. Previous studies from Canada reported decreased trends in the odds of death among severely injured patients in trauma centers.[60,61] A more recent publication has reported a decreased injury related mortality in the US from 2002-2010.[62] Therefore, the results from this study are consistent with the previous literature and might be considered as continuous improvements in trauma care as a hole since the implementation of trauma systems across the US, including the increased use of damage control surgery or improvements in intensive care for trauma patients.[58]

There were some variations in trends of hospitalizations and deaths in trauma patients among US regions. Trends of hospitalizations in patients with penetrating injuries were decreasing over time in the US, but in the South region, the trend demonstrated a significant increase for these penetrating injuries. The reductions in the odds of deaths over time did not reach statistical significance for the Midwest and West regions. And finally, trends of increased odds of deaths over time in patients with penetrating injuries were observed; these trends towards increasing mortality over time were also observed separately in each US region, however, they did not reach statistical significance in the regression analyses.

Previous studies have demonstrated declining trends in firearm homicides and overall gunshot deaths. Kegler et al. using mortality data from the National Vital Statistic System and population from the US Census Bureau reported that firearm homicide rates decreased nationally from 4.2 to 3.7 cases per 100,000 population and in major metropolitan areas from 5.2 to 4.3 cases per 100,000 population, from 2006-2007 to 2009-2010 year periods.[63] Jena et al. using data from the Centers for Disease Control and Prevention Web-based Injury Statistics and Reporting System (WISQARS) reported that gun-related deaths in the United States did not changed significantly during 2002-2011, from 10.4 to 10.3 cases per 100,000 population.[64] However, non-fatal gunshot injuries have increased over time in the US. Using the same WISQARS, Jena et al also reported that non-fatal gunshot injuries have been increasing over the same study period from 20.5 cases per 100,000 population in 2002 to 23.7 cases per 100,000 population in 2011; mostly of the increase was attributable to non-fatal assaults.[64]

These increased trends observed in this study for penetrating trauma hospitalizations in the South and for penetrating trauma related deaths, in concordance with the increased trends of non-fatal firearm and nonfatal injuries reported recently in the US, could be attributed to changes in economics, demographics, policing and policy across the US.[63] Previously, stakeholders and policy makers started to ignore the impact of violence on public health, given the focused attention on the decreased gun-related homicide rate trends over the last decade. However, the results from this study suggest the need for innovative approaches across the entire injury spectrum, from injury prevention and control, to the clinical assessment and management practice, and tertiary prevention and rehabilitation that will result in improved outcomes for these patients.[65]

Finally, this study demonstrated increased volumes over time of more comorbid and uninsured trauma patients, emphasizing the requirements of more specialized and expensive trauma care. However, the decreased trends of costs also observed could indicate that reimbursement for trauma care may be declining. The implementation of trauma systems in the US has proved to be cost-effective.[66] Nonetheless, these findings highlight future potential financial pressures to the system that may impact negatively the delivery of trauma care across the country.

3.4.1 Limitations

NIS database is only index hospitalization data. Trauma patients managed at emergency departments who were not hospitalized and out of hospital deaths were not part of this analysis. In addition, hospital sampling approximates a 20% of US community hospitals; indicating that some trauma centers that care in greater proportion of severe injured patients, may have not been sampled during 2005-2010. Therefore, the true incidence of trauma and injury related mortality in the US may be underestimated. However, six-years of consistent data allowed comprehensive estimations of the magnitude and direction of the trends of hospitalizations, deaths, and costs, associated with traumatic injuries. Since NIS is a population-based database, it allowed the generalization of trend estimates to all regions of the US. The generalized random mixed effect models used in this study are more robust to deal when missing data problems arise in secondary data analyses.[46,47] The observational approach used for trends evaluation can be biased by trauma care differences among hospitals. The inclusion of the random effect in this analysis may help to reduce this bias.

3.4.2 Conclusion

Trauma care is challenged by more hospitalizations of more comorbid, uninsured, and severe injured patients. Despite that increase, mortality and costs are decreasing significantly over time, may be consistent with continuous improvement in trauma care since the implementation of trauma systems across the US. However, there were regional variations observed in this study. The number of hospitalizations in patients with penetrating trauma is increasing over time in the South region. In addition, mortality in patients with penetrating trauma is increasing significantly during 2005-2010 in the US. More effective fall prevention programs may reduce the burden of trauma-related hospitalizations. Violence and injury prevention efforts and trauma resources will need to be directed to accommodate the increasing trends of penetrating trauma.

Table 6. Descriptive trends of characteristics in trauma patients

Characteristics	2005-2010 (N=2,752,514)	2005 (n=439,524)	2010 (n=489,275)	P value
Age (years)				
Median [IQR]	64 [40-81]	63 [37-81]	63 [41-81]	<0.001
Female	51.1	51.7	50.0	<0.001
Race/ethnicity				
White	59.9	56.7	65.6	<0.001
Black	7.3	6.1	9.4	<0.001
Hispanic	7.5	6.8	8.2	<0.001
Other	4.3	3.7	4.5	<0.001
No data	21.1	26.8	12.2	<0.001
Insurance				
Medicare	48.6	48.3	48.1	<0.001
Medicaid	9.8	9.8	11.2	<0.001
Private	26.6	27.0	25.7	<0.001
Self-pay	7.9	8.1	8.2	<0.001
Other	6.8	6.5	6.6	<0.001
AHRQ comorbidity index				
0	25.3	29.9	22.8	<0.001
1	21.0	22.6	19.7	<0.001
2+	53.7	47.5	57.5	<0.001
Mechanism of injury				
Falls	45.2	43.6	45.3	<0.001
Motor vehicle	14.2	15.0	14.1	<0.001
Stab/knife	3.1	3.1	3.0	<0.001
Firearms	1.3	1.4	1.5	0.578
Other	36.2	37.0	36.0	<0.001
Penetrating injury	4.5	4.5	4.6	<0.001
ISS				
Median [IQR]	4 [2-9]	4 [2-9]	4 [2-9]	<0.001
***Severe head/neck injury**	4.5	3.8	5.3	<0.001
***Severe thoracic injury**	0.8	0.6	1.1	<0.001
***Severe abdominal injury**	0.6	0.6	0.7	0.002
***Severe extremity injury**	0.1	0.1	0.2	0.205
****Severe trauma**	8.1	7.1	9.6	<0.001
Hospital length of stay (days)				
Median [IQR]	4 [2-6]	4 [2-6]	4 [2-6]	<0.001
Hospital bed-size				
Small	11.5	11.4	11.1	<0.001
Medium	23.6	24.9	21.9	<0.001
Large	64.1	63.7	65.2	<0.001
Hospital location				
Urban	86.9	86.9	86.2	<0.001
Hospital teaching status				

Teaching	48.6	42.1	50.6	<0.001

IQR, inter-quartile range, AHRQ, Agency for Healthcare Research and Quality; ISS, injury severity score.

Data are percentages unless otherwise indicated.

*In each body region, an Abbreviated Injury Scale score greater or equal to 4 classifies the anatomic injury as severe.

**ISS greater or equal than 16 classified the trauma as severe.

Table 7. Descriptive trends of mortality and costs in trauma patients

	2005-2010	2005	2010	P value
Mortality				
All traumatic injuries	2.5	2.4	2.6	<0.001
Penetrating trauma	2.8	2.5	3.5	<0.001
**Severe trauma	10.0	10.9	9.6	<0.001
Costs in US dollars				
All traumatic injuries				
Median	9,951	10,236	9,299	<0.001
[IQR]	[5,614-17,243]	[5,738-17,783]	[5,269-16,199]	
Penetrating trauma				
Median	7,511	7,954	7,188	<0.001
[IQR]	[4,110-14,388]	[4,366-15,201]	[3,914-14,101]	
Severe trauma				
Median	16,330	18,513	14,243	<0.001
[IQR]	[8,387-31,474]	[9,306-35,761]	[7,374-28,176]	

Mortality data are percentages.
IQR, inter-quartile range
**Injury severity score greater or equal than 16 classified the trauma as severe.

Table 8. Trend analyses of hospitalizations in trauma patients by US regions

Trends of hospitalizations	OR	95% CI	P value
All traumatic injuries	1.025	1.014-1.036	<0.001
Penetrating trauma	0.991	0.985-0.997	0.005
**Severe trauma	1.039	1.034-1.044	<0.001
Northeast			
All traumatic injuries	1.031	1.010-1.052	0.003
Penetrating trauma	0.980	0.969-0.992	0.002
**Severe trauma	1.030	1.020-1.040	<0.001
Midwest			
All traumatic injuries	1.000	0.981-1.019	0.962
Penetrating trauma	0.969	0.951-0.986	<0.001
**Severe trauma	1.031	1.017-1.044	<0.001
South			
All traumatic injuries	1.025	1.008-1.043	0.004
Penetrating trauma	1.026	1.017-1.036	<0.001
**Severe trauma	1.052	1.045-1.060	<0.001
West			
All traumatic injuries	1.033	1.006-1.061	0.016
Penetrating trauma	0.953	0.941-0.965	<0.001
**Severe trauma	1.025	1.015-1.035	<0.001

OR, odds ratio; CI, confidence interval.
**Injury severity score greater or equal than 16 classified the trauma as severe.
Odds ratios were calculated using multilevel logistic regressions adjusted for age, sex, race, insurance status, AHRQ comorbidity index, hospital length of stay, hospitals characteristics (bed-size, location, teaching status, and volume), and a random effect for hospitals.
Multilevel logistic regressions were performed separately for all traumatic injuries, penetrating trauma, and severe trauma and by US region.

Table 9. Trend analyses of deaths in trauma patients by US regions

Mortality trends	OR	95% CI	P value
All traumatic injuries	0.976	0.970-0.983	<0.001
Penetrating trauma	1.044	1.011-1.078	0.008
**Severe trauma	0.930	0.918-0.942	<0.001
Northeast			
All traumatic injuries	0.955	0.941-0.970	<0.001
Penetrating trauma	1.048	0.978-1.123	0.178
**Severe trauma	0.942	0.917-0.967	<0.001
Midwest			
All traumatic injuries	0.988	0.972-1.005	0.202
Penetrating trauma	1.054	0.963-1.154	0.245
**Severe trauma	0.908	0.880-0.937	<0.001
South			
All traumatic injuries	0.978	0.967-0.989	<0.001
Penetrating trauma	1.043	0.991-1.097	0.104
**Severe trauma	0.929	0.911-0.947	<0.001
West			
All traumatic injuries	0.989	0.975-1.004	0.180
Penetrating trauma	1.018	0.955-1.086	0.567
**Severe trauma	0.942	0.917-0.968	<0.001

OR, odds ratio; CI, confidence interval.
**Injury severity score greater or equal than 16 classified the trauma as severe.
Odds ratios were calculated using multilevel logistic regressions adjusted for age, sex, race, insurance status, AHRQ comorbidity index, ISS, type of injury, hospital length of stay, hospitals characteristics (bed-size, location, teaching status, and volume), and a random effect for hospitals.
Multilevel logistic regressions were performed separately for all traumatic injuries, penetrating trauma, and severe trauma and by US region.

Table 10. Trend analyses of log-transformed costs in trauma patients by US regions

Trends of log-transformed costs	β	95% CI	P value
All traumatic injuries	-0.025	-0.026 -0.024	<0.001
Penetrating trauma	-0.035	-0.038 -0.032	<0.001
**Severe trauma	-0.038	-0.041 -0.036	<0.001
Northeast			
All traumatic injuries	-0.029	-0.030 -0.028	<0.001
Penetrating trauma	-0.040	-0.045 -0.034	<0.001
**Severe trauma	-0.038	-0.043 -0.033	<0.001
Midwest			
All traumatic injuries	-0.015	-0.017 -0.013	<0.001
Penetrating trauma	-0.026	-0.035 -0.017	<0.001
**Severe trauma	-0.036	-0.043 -0.029	<0.001
South			
All traumatic injuries	-0.020	-0.022 -0.019	<0.001
Penetrating trauma	-0.023	-0.028 -0.017	<0.001
**Severe trauma	-0.035	-0.039 -0.031	<0.001
West			
All traumatic injuries	-0.032	-0.033 -0.030	<0.001
Penetrating trauma	-0.057	-0.064 -0.050	<0.001
**Severe trauma	-0.046	-0.052 -0.041	<0.001

β, regression coefficient,; CI, confidence interval.
**Injury severity score greater or equal than 16 classified the trauma as severe.
Coefficients indicated the proportional change in the average cost per year over the study period.
Coefficients were calculated using multilevel linear regressions adjusted for age, sex, race, insurance status, AHRQ comorbidity index, ISS, type of injury, hospital length of stay, hospitals characteristics (bed-size, location, teaching status, and volume), and a random effect for hospitals.
Multilevel linear regressions were performed separately for all traumatic injuries, penetrating trauma, and severe trauma and by US region.

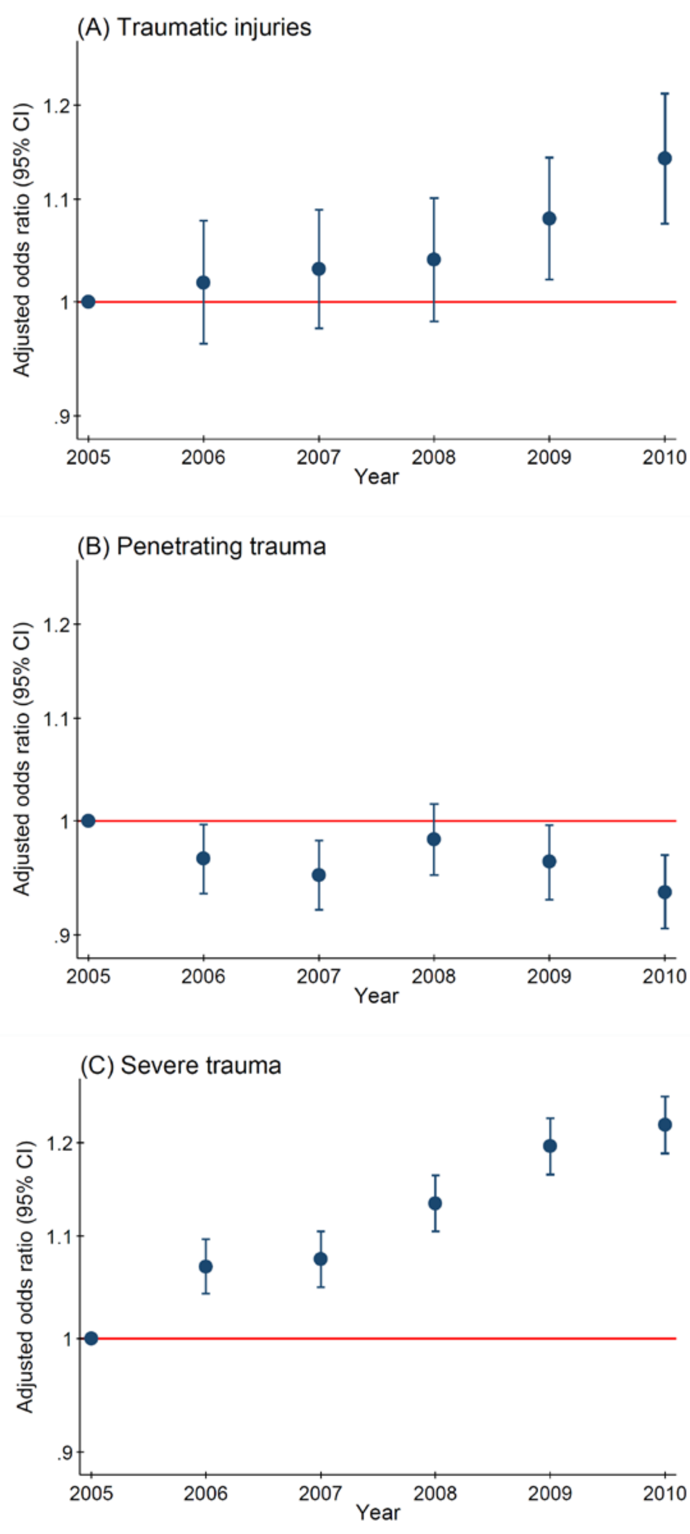
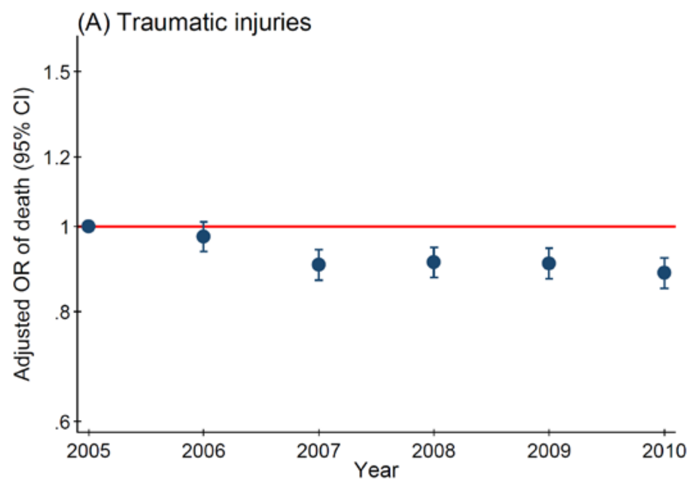
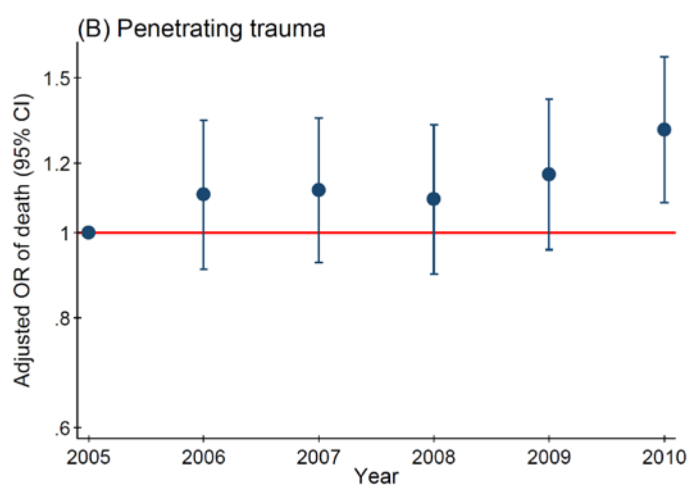


Figure 4. Yearly odds of trauma hospitalizations compared with 2005. Adjusted odds ratios were calculated using multilevel logistic regressions adjusted for age, sex, race, insurance status, AHRQ comorbidity index, hospital length of stay, hospitals characteristics (bed-size, location, teaching status, and volume), and a random effect for hospitals.





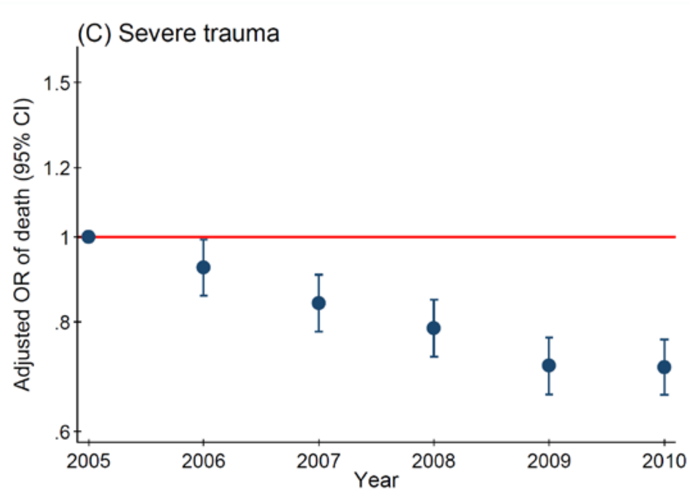


Figure 5. Yearly odds of trauma deaths compared with 2005. Adjusted odds ratios were calculated using multilevel logistic regressions adjusted for age, sex, race, insurance status, AHRQ comorbidity index, ISS, type of injury, hospital length of stay, hospitals characteristics (bed-size, location, teaching status, and volume), and a random effect for hospitals.

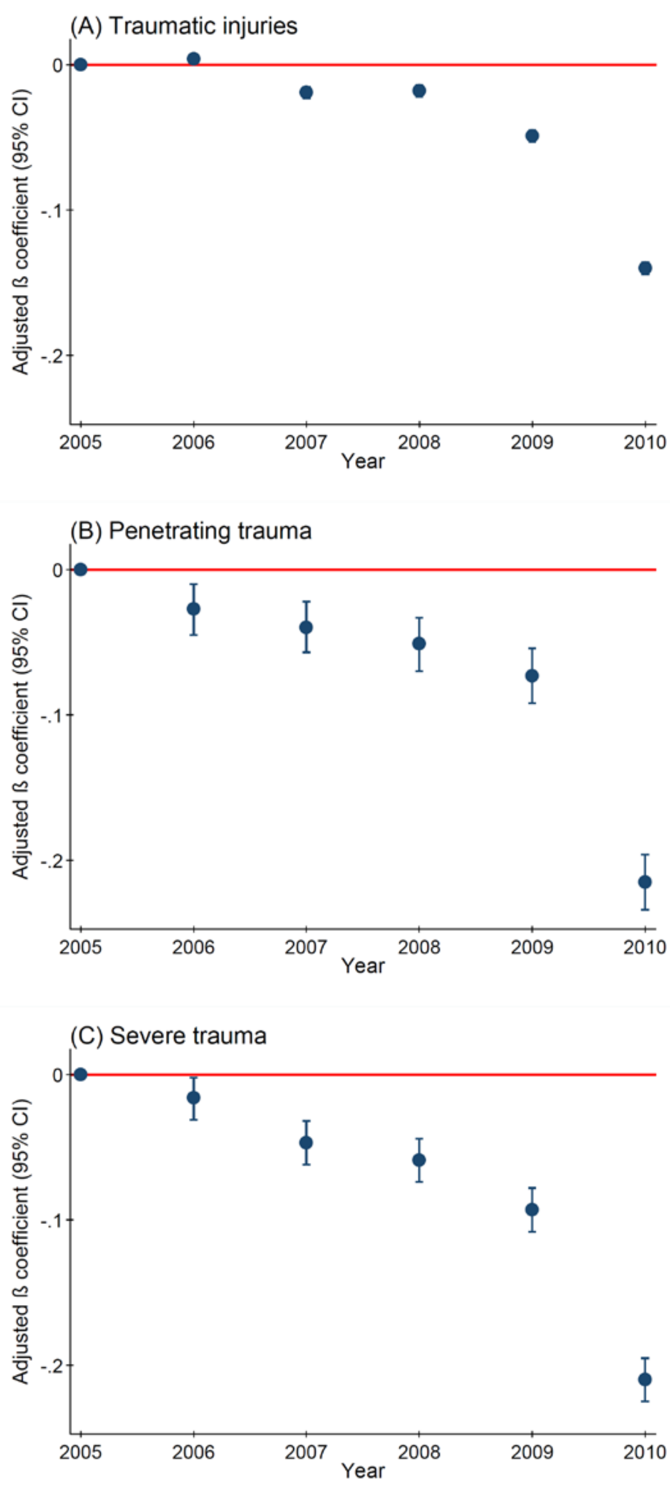


Figure 6. Yearly averages of log-transformed costs for trauma compared with 2005. Adjusted coefficients were calculated using multilevel linear regressions adjusting for age, sex, race, insurance status, AHRQ comorbidity index, ISS, type of injury, hospital length of stay, hospitals characteristics (bed-size, location, teaching status, and volume), and a random effect for hospitals. Coefficients indicated the proportional change in the average cost per year.

4.0 THE EFFECT OF TRAUMA CENTER CARE ON MORTALITY FOR ACUTE CARE SURGICAL EMERGENCIES IN THE UNITED STATES, 2010

4.1 INTRODUCTION

There are difficulties in providing emergency surgical coverage for the growing, older, and more co-morbid population of the United States (US). Emergency departments (ED) are overcrowded and patients' waiting times are excessive. Lifestyle considerations and the perception of poor reimbursement of emergency services have driven shortages of general surgeons and increases of surgical super sub-specialists that lack the experience and motivation to provide emergency surgical coverage.[1-9]

Surgeons provide emergency care for injured patients and for patients with non-traumatic surgical emergencies. Trauma systems have taken care of injured patients.[10] However, there are no similar systems for patients with non-traumatic surgical emergencies (NTSEm). These comprise great anatomic and physiologic diversity, creating difficulties for standardization, evaluation of outcome and management.[34] Therefore, patients with these are treated in hospitals that rely on rosters of on-call surgical specialists who may not be immediately available during nights, weekends, or busy schedules of elective procedures. Surgical consultation and operative interventions are delayed for surgical emergencies.[3,6,7] Compared with elective surgery, morbidity and mortality for emergency surgery are much greater.[67,68]

Recognizing the need, some hospitals were restructuring surgical services to provide coverage for patients with NTSEm. Trauma centers have developed the infrastructure necessary for immediate operative interventions in trauma patients that can also benefit patients with other (non-traumatic) emergency surgical conditions.[11] Therefore, and during the last decade, trauma centers have restructured their surgical services, integrating critical care and emergency surgery into their trauma programs.[3,6] In addition, surgical associations have developed committees to develop a comprehensive definition of these non-traumatic surgical conditions for assessment, research, and education efforts.[69]

Few studies have examined these new models. However, their limited designs have failed to control for the multilevel factors that influence patient, physician, hospital, and system-level outcomes.[2,16,18] Therefore, evidence of trauma centers' impact on patients with NTSEm remains inconclusive. The objective of this study was to determine the effect of trauma centers (TC) on mortality in adult patients with NTSEm in the US. For patients with NTSEm, this aim hypothesized that compared with patients discharged from non-trauma centers (NTC) patients discharged from TC are associated with lower mortality.

4.2 METHODS

This study comprised a secondary analysis of the Nationwide Impatient Sample (NIS) database during the years 2010. The NIS is maintained by the Healthcare and Costs Utilization Project (HCUP) of the Agency for Healthcare Research and Quality (AHRQ). It is a database of hospital inpatient stays. Researchers and policy makers use the NIS to identify, track, and analyze national trends in healthcare utilization, access, charges, quality, and outcomes. The NIS is the largest all-payer inpatient care database that is publicly available in the US, containing each year data from 5 to 8 million hospital stays from about 1,000 hospitals sampled to approximate a 20% stratified sample of US community hospitals. The NIS is drawn from those States participating in HCUP; in 2010 these 45 States comprised 96% of the US population. NIS information was linked to hospital-level data from the American Hospital Association's (AHA) Annual Survey database, except in those States that do not allow the release of hospital identifiers. In 2010, 439 hospitals (42%) out of 1,051 sampled in NIS database did not include AHA hospital identifiers and were not linked at the hospital level.[29] In addition, six were pediatric centers and were excluded. From the 606 selected hospitals, 521 (86.0%) were NTC, 29 (4.8%) were designated level I TC, 40 (6.6%) level II TC, and 16 (2.6%) level III TC.

4.2.1 Patient selection

Adult patients (aged $\geq$18 years old) with discharge diagnoses of NTSEm were identified using International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM) codes.[30] NTSEm included abdominal aortic aneurysm and dissection, abdominal sepsis, acute appendicitis, acute mesenteric ischemia, bowel obstruction, bowel perforation, and necrotizing fasciitis. Acute appendicitis was selected because appendectomy for acute appendicitis is the most common performed operation worldwide and because it could be performed in hospital with at least basic surgical resources.[19,20] The others NTSEm were selected because of their increasing prevalence in the US, because of their higher associated etiological co-morbidities as a consequence of the aging of the US population, because these conditions have been recognized as a possible cause of complications and deaths, and because patients with these conditions require promptly identification by a surgical team and, if required, expedited operative intervention.[12,21-26] The incidences of acute mesenteric ischemia, abdominal aortic aneurysm and dissection, abdominal sepsis, bowel obstruction, bowel perforation, and necrotizing fasciitis increase with the increase of age in the population.[12,21-26] Therefore, the research topic is not relevant to children. Patients under 18 years of age were excluded. In addition, patients were excluded if they had diagnoses of trauma at hospital discharge.

4.2.2 Study measures

De-identified patients' information included demographics, socioeconomics, comorbidity measures and clinical information related to diagnostic codes. Admission information and hospital characteristics were also abstracted from NIS. Additional hospitals characteristics including designation of trauma center were collected using the AHA database for the year 2010. This database has been previously used by other authors to gather hospitals characteristics.[70,71]

Adjustment for comorbidity is of interest in all types of health care studies and it is essential in observational studies because baseline differences in health status may modulate differences in study outcomes.[31,32] AHRQ comorbidity measures were developed by Elixhauser for large administrative databases to predict mortality, hospital charges, and hospital length of stay, and have been adapted for risk adjustment purposes. Using Diagnosis-Related Groups (DRG) and secondary ICD-9-CM diagnosis codes, 30 unweight comorbidity indicators are most likely to reflect individuals' chronic illness burden and are practical with large administrative databases.[31] These AHRQ comorbidity measures from NIS were included in this analyses. The main outcome measure included mortality at hospital discharge.

4.2.3 Analysis

Demographics, socioeconomics, comorbidity measures and clinical information related to diagnostic codes, admission information, and hospital characteristics were compared between patients in TC and patients in NTC. Continuous variables were compared using non-parametric tests based on their non-normal distributions. Comparisons among categorical variables were performed using Chi-square tests. Main analyses compared mortality rates between patients in TC and patients in NTC and mortality rates among trauma center levels.

A propensity score was used to adjust for potential confounding of patient demographics and hospital characteristics. The propensity score is constructed to represent the probability of a patient encountering the exposure of interest by taking into account measured covariates.[72] In this study, the propensity score attempted to approximate the conditions of random assignation of hospitals (TC vs NTC) for treatment of NTSEm in patients who have similar distribution of covariates. A non-parsimonious logistic regression was developed to predict treatment in TC using as predictors patients' demographics, socioeconomics, comorbidity measures, clinical information related to procedure codes, and hospitals characteristics. Patients were stratified into quartiles of increasing propensity score.

To test the hypothesis that compared with patients in NTC, patients in TC were associated with lower mortality; multilevel logistic regressions in a stepwise manner were fitted and adjusted for patients' demographics, socioeconomics, comorbidity measures, clinical information related to procedure codes, hospitals characteristics, quartiles of propensity score, and a random effect to account for the correlation among patients within hospitals. Variables were removed if the associated regression coefficient had a $p\text{-value} > 0.1$. Regression analyses were also performed to compare mortality between patients in NTC and patients in each trauma center levels. Subgroup analyses were performed for each NTSEm condition. Findings were presented as odds ratios (OR) with 95% confidence intervals (CI) and P values. All the analyses were performed in Stata (Version 12) software.

4.3 RESULTS

From the 606 selected hospitals in NIS 2010, there were 5,290,675 hospital discharges; adults were 4,508,849 (85.2%). Adults with discharge diagnoses of NTSEm were 212,955 (4.7%); from these we excluded 7,986 patients with discharge diagnoses of trauma and 103 patients (<0.1%) with missing data on discharge status. The study population included in the analyses was 204,871 patients; 66,241 (32.3%) were discharged from TC (28,525 from level I, 31,574 from level II, and 6,142 from level III TC) (Figure 7).

Patients discharged from NTC were older than from TC (median age of 65 years in NTC vs. 62 years in TC, p<0.001). Females were discharged in greater proportion from NTC than from TC (50.3% vs. 47.9%, p<0.001). White patients were discharged in greater proportion from NTC; conversely, African American patients and Hispanics were discharged in greater proportion from TC (p<0.001) (Table 11).

Patients with location of residence in a rural area comprised only 6.3% of the total NTSEm discharges, they were discharged in greater proportion from NTC than from TC (6.5% vs. 5.7%, p<0.001). Patients with low median household income were discharged in greater proportion from TC (20.1% in NTC vs. 24.8% in TC, respectively), whereas patients with high income were discharged in greater proportion from NTC (27.6% in NTC vs. 24.5% in TC, p<0.001). Medicare was the primary insurance (51.1%) followed by private insurance (31.0%). The proportion of patients with Medicaid insurance was greater in TC (11.3%) than in NTC (8.7%, p<0.001) (Table 11).

A great majority of patients had two or more comorbidities (65.3%), in contrast, patients without comorbidities accounted for only 17.2%. Patients discharged from NTC and TC had two or more comorbidities in almost similar proportions (66.0% in NTC vs. 64.0% in TC, p<0.001), however, this difference reached statistical significance (Table 11).

Admission information indicated that the great proportion of patients were admitted during a week-day, this proportion was almost similar in NTC and TC (78.4% vs. 79.0%, p=0.001). There were no differences in month of admission between NTC and TC (p=0.889). The proportion of patients transferred in from other healthcare facilities was greater in TC (9.6%) than in NTC (6.5%, p<0.001). In addition, the proportion of patients admitted for elective procedures were also greater in TC (19.8%) than in NTC (17.5%, p<0.001). Nonetheless, the majority of NTSEm patients were admitted through the ED (72.4% in NTC vs. 67.6% in TC, p<0.001) (Table 11).

The proportion of patients in which a major diagnostic procedure was performed was 2.9% in NTC and 3.3% in TC (p<0.001). The proportion of patients in which a major therapeutic procedure was performed was 46.6% in NTC and 51.8% in TC (p<0.001). Patients in TC had in greater proportion a major operating room procedure (47.0% in NTC and 52.2% in TC, p<0.001) than patients discharged from NTC (Table 11).

Median length of hospital stay were 4 days [IQR, 2-9] in NTC and 5 days [IQR, 2-10] in TC (p<0.001). When compared to patients in NTC, patients in TCs were admitted in greater proportion to public, large size, teaching facilities, owned by the government, and located in urban areas (Table 11).

Bowel obstruction accounted for 59.3% of the total NTSEm discharges (59.9% in NTC and 58.1% in TC, $p<0.001$), followed by acute appendicitis with 15.5% (15.9% in NTC and 14.5% in TC, $p<0.001$) and by non-traumatic abdominal aortic aneurysm and dissection with 15.2% (15.1% in NTC and 15.2% in TC, $p=0.504$). Abdominal sepsis accounted for 10.3% of total NTSEm discharges (9.4% in NTC and 12.2% in TC, $p<0.001$). Acute mesenteric ischemia accounted for 3.3% (3.2% in NTC and 3.6% in TC, $p<0.001$), bowel perforation accounted for 2.3% (2.3% in NTC and 2.4% in TC, $p=0.506$), and necrotizing fasciitis for 1.0% of total NTSEm discharges (0.8% in NTC and 1.3% in TC, $p<0.001$) (Table 11).

4.3.1 Trauma centers' effect on mortality

Overall mortality from NTSEm was 4.9%. Mortality was 4.7% in NTC and 5.4% in TC (Table 12). Mortality in level I, level II, and level III TC was 5.9%, 5.2% and 3.9%, respectively. Univariable analysis indicated that mortality in TC was higher than in NTC (OR 1.17, 95%CI 1.12-1.22, $p<0.001$). In addition, univariable analyses indicated that mortality in level I (OR 1.29, 95%CI 1.22-1.36, $p<0.001$) and level II (OR 1.13, 95%CI 1.07-1.19, $p<0.001$) TC were also higher than in NTC. Conversely, univariable analysis demonstrated that mortality in level III TC was lower than in NTC (OR 0.83, 95%CI 0.72-0.94, $p=0.006$) (Table 13).

Regression analyses to evaluate the effect of TC on mortality were controlled for age, sex, race/ethnicity, location of patients' residence, quartiles of median household income for patients' zip code of residence, insurance status, day and month of admission, transferred status, ED admission, elective procedure admission, AHRQ comorbidity measures, type of procedures performed (diagnostics, therapeutics, operative interventions), length of stay, and hospital characteristics (region, bed size, rural location, teaching status, type of ownership, number of total discharges and NTSEm discharges, and indicators of full time equivalent of registered nurses and licensed practice nurses). Using a stepwise manner, only those variables with a p-value<0.1 were retained in the regression analyses. In addition, we included a propensity score indicator and a random effect for hospitals. The final regression model demonstrated no differences in mortality between NTC and TCs (OR 1.13, 95%CI 0.97-1.31, p=0.104). When compared with NTC, the final regression analysis demonstrated that mortality from NTSEm was not statistically different in level I TC (OR 1.08, 95%CI 0.87-1.35, p=0.440), level II TC (OR 1.16, 95%CI 0.94-1.42, p=0.145), and level III TC (OR 1.16, 95%CI 0.80-1.66, p=0.417) (Table 13). Random effects accounted for 4.4% (Coefficient 0.044, 95%CI 0.034-0.057, p<0.001) of the total variance in the final regressions.

4.3.2 Subgroup analyses

Patients with bowel perforation demonstrated the highest mortality among NTSEm (20.8%), followed by acute mesenteric ischemia (19.2%), necrotizing fasciitis (10.5%) and abdominal sepsis (10.4%). Acute appendicitis demonstrated the lowest rate (0.2%) (Table 12). In final regression analyses, there were no differences in mortality between NTC and TC among NTSEm. Nonetheless, in patients with abdominal sepsis, mortality in TC demonstrated a trend toward lower mortality when compared with NTC (OR 0.93, 95%CI 0.78-1.11, p-0.446); a difference that did not reach statistical significance (Table 13). For abdominal sepsis, the random effects accounted for 3.3% (Coefficient 0.033, 95%CI 0.019-0.056, $p<0.001$) of the total variance in the final regressions.

4.4 DISCUSSION

This work represents a comprehensive assessment of NTSEm mortality from hospitalized patients in the US during the year 2010. When compared to NTC, the study results demonstrated that crude mortality was higher in TC. In addition, crude mortality showed an increased relationship by TC level complexity, since crude mortality was higher in level I TC than level II and level III. However, in the multivariable analysis and after controlling for the random effect for hospitals, mortality rates from NTSEm were not different in TC compared to NTC.

A previous report on mortality from a similar NTSEm is consistent with the results of the present study. Utter et al. evaluated the effects of trauma center care in the US on organ failure and death rates in patients with ruptured abdominal aortic aneurysms, using similar administrative databases for the year 2001.[73] Looking at in-hospital mortality their adjusted analyses demonstrated no statistically significant differences in the likelihood of death between regional trauma centers and non-designated trauma center hospitals.[73] The lack of statistical difference in mortality rates between NTC and TC observed with data from 2001 was observed also with data from 2010 in this present study and after the inclusion of the propensity score indicator and the random effects for hospitals. This could be explained by the evident between-hospitals differences in surgical care previously reported for surgical conditions in the US.[74] This suggests that, for patients with NTSEm, other factors less readily quantified might be responsible for differences in surgical care among hospitals, rather than infrastructure and resources immediately available in TC. These also highlight the needs of standardization of surgical care for these NTSEm across the US.

Hospital-based studies have reported in-hospital mortality and complication rates before and after restructuring surgical services to provide coverage for patients with non-traumatic surgical emergencies. Diaz et al. compared yearly mortality rates over a 5-year period, just after the implementation of an acute care surgery service in a single center.[17] They case types used for the study were a variety of non-traumatic acute surgical diseases. Across the time period, mortality rate decreased significantly from 4.9% to 1.6% (p value <0.001). Ekeh et al. performed a similar study and evaluated the impact of the implementation of an acute care surgical service, in a level I trauma center.[15] Perforation rates were 12% before and 7.5% after implementation; however, this difference did not reach statistical significance ($p=0.114$). Despite their limited designs, these studies concluded that trauma centers can effectively incorporate emergency surgical coverage under the new models of acute care surgery, demonstrating a decrease in mortality in patients with a variety of non-traumatic acute surgical diseases.

Structured trauma systems in trauma centers accounted for differences in mortality for injured patients.[10,66,75] In other context, cancer center designation was significantly associated with lower likelihood of death in hospitalized patients who were immunocompromised.[76] Finally, the hospital-based studies discussed previously, documented improved outcomes for patients with non-traumatic surgical emergencies after restructuring their surgical services.[15,17] However, the results of the present study have shown no differences between TC and NTC in mortality for patients with NTSEm, suggesting that infrastructure and resources available at trauma centers might not be the only factors necessary for immediate management of acute care surgical emergencies. In the past, the needs of the injured patient drove the development of the field of trauma surgery; therefore, the needs of the emergency general surgery patient must drive the development of systematic approaches to care for these patients [13]. The results from this study emphasizes the already recognized need for regionalization and implementation of acute care surgical systems that allow better allocation of multidisciplinary resources and treatments for patients with non-traumatic surgical emergencies.[3,6,7,9,13] These must be complemented with registries and with the development of severity scores for these acute surgical conditions that will allow improvements of quality of care and outcomes for patients with these non-traumatic surgical emergency conditions.

4.4.1 Limitations

This is not a randomized controlled trial, and therefore, is subject to confounding. The multivariate logistic regression analysis used in this study attempted to adjust for confounders provided in the database; in addition, propensity score adjustments were used to approximate the conditions of random assignation of hospitals for treatment of NTSEm. NIS did not provide clinical information to account for physiologic status on admission or during hospitalization and therefore, it was not possible to stratify for the physiological derangement or the severity of the illness. MacKenzie et al. demonstrated that when looking at trauma patients, those treated in NTC were less severe injured than trauma patients treated in TC.[10] Perhaps, TC were more likely to discharge sicker NTSEm patients or NTSEm patients with worse physiologic status, but I was not able to address this based on the data provided from NIS.

The AHRQ comorbidity software uses the ICD-9-CM codes to build the index, but still it is an approximation of comorbidities encountered in clinical scenarios. Nonetheless, it is a comorbidity measure developed and validated for this type of administrative databases and adapted for risk adjustment purposes.[31] Diagnoses in administrative databases are usually arbitrarily coded, based on nonclinical decisions, and biased by resources and reimbursement.[32] Although this study found almost similar distribution of the number and type of comorbidities among NTC and TC, this might not accurately represent the severity of illness from these NTSEm patients. This may bias the outcomes' estimations in an unknown direction. Finally, this observational approach can be biased by surgical care differences among hospitals and this was observed in the final regression models after the inclusion of the random effect for hospitals, providing evidence that other factors less readily quantified in this study might be responsible for difference in surgical care among hospitals.

4.4.2 Conclusion

This study demonstrated no differences in mortality in TC when compared to NTC for patients with NTSEm. This data does not support the perception that patients requiring immediate surgical care for non-traumatic surgical conditions benefit from the infrastructure and resources immediately available in certified trauma centers. In addition, this study highlights the evident between-hospitals differences in surgical care in the US for these surgical conditions. Implementation of acute care surgical systems with multidisciplinary teams, in addition of with registries and the development of severity scores for this conditions will need to be created to study more in depth the quality of care and outcomes; meanwhile, acute care surgical models need to continuously expand across the US.

Table 11. Characteristics of adult patients with NTSEm in NTC and TC

Characteristics	All patients (N=204,871)	NTC (n=138,630)	TC (n=66,241)	P value
Age in years				
Median [IQR]	64 [49-77]	65 [49-78]	62 [47-75]	<0.001
Female	49.6	50.4	47.9	<0.001
Race/ethnicity				
White	68.4	70.2	64.4	<0.001
Black	10.2	9.6	11.6	
Hispanic	8.6	8.0	9.7	
Other	4.8	5.2	3.9	
No data	8.1	7.0	10.5	
Patient's location of residency				
Rural	6.3	6.5	5.7	<0.001
Quartiles of patient's income				
$1 – $38,999	21.6	20.1	24.8	<0.001
$39,000 – $47,999	23.6	24.3	22.3	
$48,000 – $62,999	25.7	25.8	25.5	
$63,000+	26.6	27.6	24.5	
Insurance				
Medicare	51.1	52.6	47.8	<0.001
Medicaid	9.6	8.7	11.3	
Private	31.0	31.4	30.2	
Self-pay	4.8	4.5	5.5	
Other	3.4	2.6	5.1	
Admission during weekends	21.4	21.6	21.0	0.001
Month of admission				
January	7.5	7.6	7.1	0.889
February	6.7	6.9	6.5	
March	7.7	7.9	7.4	
April	7.2	7.4	6.9	
May	7.4	7.5	7.2	
June	7.3	7.4	7.0	
July	7.5	7.6	7.2	
August	7.4	7.5	7.2	
September	7.1	7.3	6.9	
October	7.1	7.2	6.7	
November	6.9	7.0	6.7	
December	7.0	7.1	6.8	
Transferred from				
Not a transfer	92.1	93.3	89.5	<0.001
Acute care hospital	4.5	3.4	6.8	
Another type of health facility	3.0	3.1	2.8	
Emergency admission	70.9	72.4	67.7	<0.001
Elective admission	18.3	17.5	19.8	<0.001

AHRQ comorbidity index				
0	17.2	17.0	17.8	<0.001
1	17.4	17.1	18.2	
2+	65.3	66.0	64.0	
Procedure information				
Major diagnostic	3.0	2.9	3.3	<0.001
Major therapeutic	48.3	46.6	51.8	<0.001
Major operating room	48.7	47.0	52.2	<0.001
Hospital length of stay (days)				
Median [IQR]	5 [2-9]	4 [2-9]	5 [2-10]	<0.001
Hospital region				
Northeast	26.4	24.9	29.4	<0.001
Midwest	13.8	16.9	7.4	
South	31.4	30.4	33.6	
West	28.4	27.8	29.7	
Hospital bed-size				
Small	13.1	17.6	3.8	<0.001
Medium	24.1	27.3	17.3	
Large	62.8	55.2	78.8	
Hospital location				
Urban	88.8	86.6	93.4	<0.001
Hospital teaching status				
Teaching	44.9	33.6	68.6	<0.001
Hospital ownership				
Government	12.3	9.4	18.3	<0.001
Trauma center designation				
Level one (I)	…	…	43.1	…
Level two (II)	…	…	47.7	
Leve three (III)	…	…	9.3	
NTSEm				
Abdominal aortic aneurysm and dissection	15.2	15.1	15.2	0.504
Abdominal sepsis	10.3	9.4	12.2	<0.001
Acute appendicitis	15.5	15.9	14.5	<0.001
Acute mesenteric ischemia	3.3	3.2	3.6	<0.001
Bowel obstruction	59.3	59.9	58.1	<0.001
Bowel perforation	2.3	2.3	2.3	0.506
Necrotizing fasciitis	1.0	0.8	1.3	<0.001

NTSEm, non-traumatic surgical emergencies; NTC, non-trauma center; TC, trauma center; IQR, inter quartile range; AHRQ, Agency for Healthcare Research and Quality.
Data are in percentages unless otherwise indicated.

Table 12. Crude mortality rates among NTSEm in NTC and TC

	All patients	NTC	TC	P value
NTSEm	4.9	4.7	5.4	
Abdominal aortic aneurysm and dissection	4.6	4.4	5.1	0.010
Abdominal sepsis	10.4	10.3	10.6	0.474
Acute appendicitis	0.2	0.2	0.3	0.287
Acute mesenteric ischemia	19.22	16.9	23.5	<0.001
Bowel obstruction	4.6	4.5	4.8	0.107
Bowel perforation	20.8	19.8	22.9	0.014
Necrotizing fasciitis	10.5	8.5	13.3	0.001

NTSEm, non-traumatic surgical emergencies; NTC, non-trauma center; TC, trauma center. Mortality data are in percentages.

Table 13. Odds of death among NTSEm associated with trauma center designation

	Crude analyses			Regression analyses		
	OR	95%CI	P	OR	95%CI	P
NTEm						
TC	1.17	1.12-1.22	<0.001	1.13	0.97-1.31	0.104
Level I	1.29	1.22-1.36	<0.001	1.08	0.87-1.35	0.440
Level II	1.13	1.07-1.19	<0.001	1.16	0.94-1.42	0.145
Level III	0.83	0.72-0.94	0.006	1.16	0.80-1.66	0.417
Abdominal aortic aneurysm and dissection						
TC	1.15	1.03-1.29	0.011	1.21	0.99-1.48	0.051
Level I	1.40	1.20-1.62	<0.001	1.27	0.97-1.67	0.080
Level II	0.98	0.85-1.14	0.863	1.11	0.86-1.43	0.398
Level III	1.14	0.85-1.54	0.366	1.60	0.90-2.83	0.105
Abdominal sepsis						
TC	1.03	0.94-1.13	0.474	0.93	0.78-1.11	0.446
Level I	1.05	0.94-1.17	0.372	0.91	0.71-1.16	0.454
Level II	1.02	0.90-1.16	0.647	0.96	0.76-1.20	0.739
Level III	0.89	0.65-1.22	0.503	0.87	0.52-1.46	0.618
Acute appendicitis						
TC	1.30	0.80-2.10	0.288	1.29	0.64-2.58	0.461
Level I	1.06	0.52-2.17	0.864	0.76	0.24-2.42	0.649
Level II	1.75	1.00-3.05	0.049	1.88	0.91-3.89	0.086
Level III	…			…		
Acute mesenteric ischemia						
TC	1.51	1.33-1.71	<0.001	1.06	0.83-1.34	0.618
Level I	1.70	1.45-1.99	<0.001	1.04	0.75-1.43	0.797
Level II	1.41	1.20-1.66	<0.001	1.08	0.81-1.45	0.581
Level III	1.09	0.75-1.59	0.626	1.01	0.51-1.99	0.962
Bowel obstruction						
TC	1.04	0.98-1.10	0.107	1.08	0.91-1.27	0.339
Level I	1.09	1.01-1.18	0.020	1.05	0.82-1.33	0.680
Level II	1.07	0.99-1.16	0.050	1.12	0.90-1.39	0.292
Level III	0.71	0.59`-0.85	<0.001	1.04	0.69-1.55	0.845
Bowel perforation						
TC	1.20	1.03-1.39	0.014	1.17	0.93-1.47	0.155
Level I	1.21	1.00-1.47	0.045	1.15	0.85-1.58	0.350
Level II	1.23	1.01-1.49	0.038	1.24	0.94-1.65	0.121
Level III	0.94	0.59-1.52	0.828	0.94	0.48-1.84	0.863
Necrotizing fasciitis						
TC	1.65	1.23-2.20	0.001	1.34	0.86-2.08	0.183
Level I	1.76	1.26-2.45	0.001	1.50	0.87-2.57	0.141
Level II	1.76	1.18-2.61	0.005	1.57	0.93-2.65	0.085
Level III	0.20	0.02-1.49	0.117	…		

NTSEm, non-traumatic surgical emergencies; NTC, non-trauma center; TC, trauma center; OR

odds ratio; CI, confidence interval.
Mortality rates in TC were compared with mortality rates in NTC.
Crude odds ratios were computed separately for each NTSEm.
Regression analyses were performed separately for each NTSEm calculating the odds ratios using multilevel logistic regressions adjusted for age, sex, race/ethnicity, location of patients' residence, quartiles of median household income for patients' zip code of residence, insurance status, day and month of admission, transferred status, ED admission, elective procedure admission, AHRQ comorbidity measures, type of procedures performed (diagnostics, therapeutics, operative interventions), length of stay, hospital characteristics (region, bed size, rural location, teaching status, type of ownership, number of total discharges and NTSEm discharges, and indicators of full time equivalent of registered nurses and licensed practice nurses), a propensity score indicator, and a random effect for hospitals.

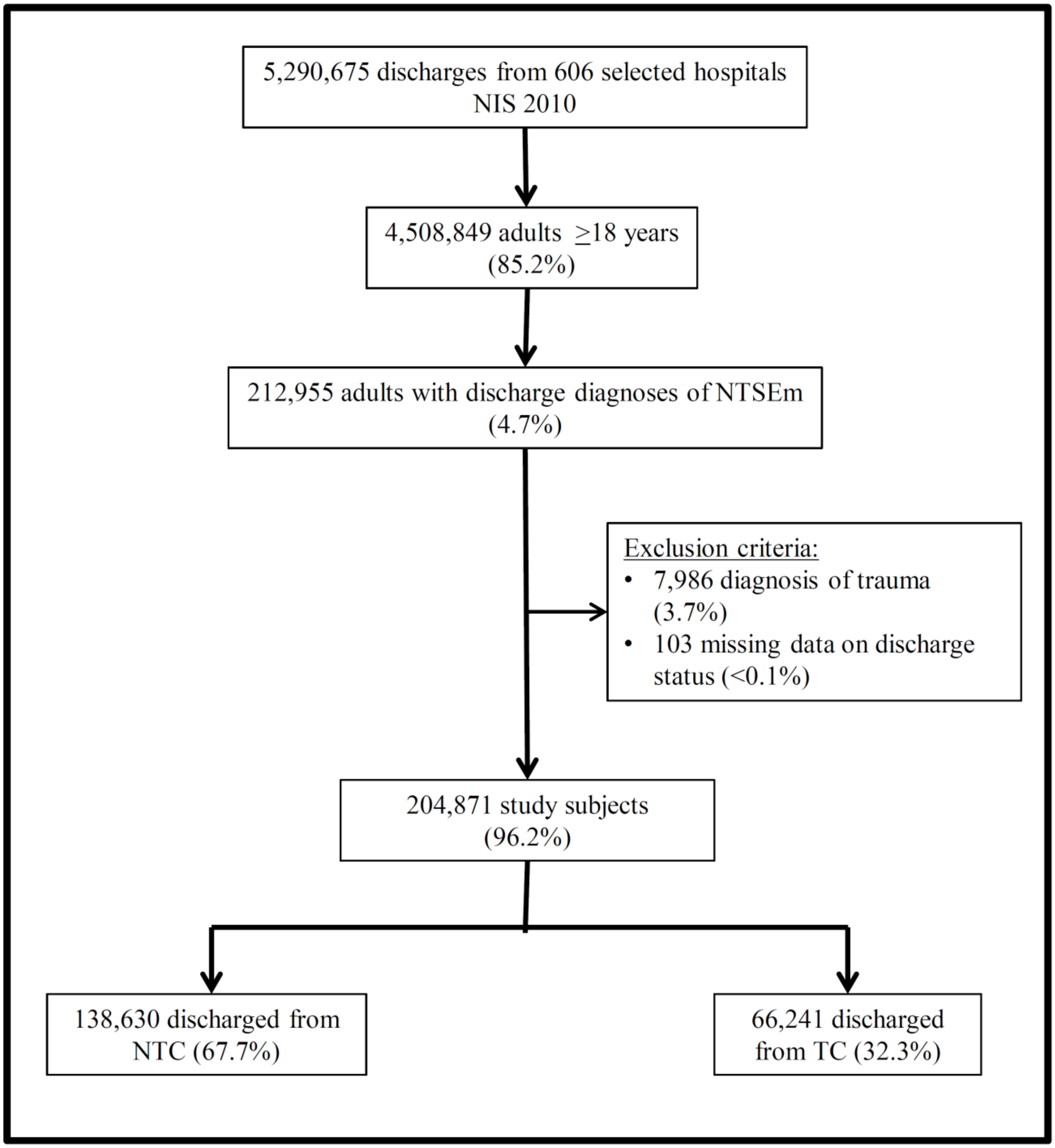


Figure 7. Selection of adult NTSEm patients. NIS, nationwide impatient sample; NTSEm, non-traumatic surgical emergencies; NTC, non-trauma centers; TC, trauma centers.

5.0 DISCUSSION

This study attempted to provide scientific knowledge of the mechanisms and factors that could impact the outcomes of patients with acute surgical emergencies. The study assessed trends of hospitalization, deaths and costs from patients with acute surgical emergencies. In addition, it evaluated the effectiveness of trauma centers for patients with non-traumatic surgical emergencies. For NTSEm, the results of this project demonstrated increases in hospitalizations over time, probably related to the aging and increase in comorbidities of the population. Despite that, mortality and costs for NTSEm decreased significantly over time, with some regional variations among NTSEm. For trauma patients there were increased trends of hospitalizations and conversely, decreased trends of deaths and costs over time. There were also regional variations; for example, penetrating trauma related hospitalizations are decreasing except in the South region. Finally, the results does not support the hypothesis that the presence of a structured trauma system/team in certified trauma centers account for differences in mortality for patients with non-traumatic surgical emergencies.

It is important to acknowledge the limitation that the databases for the selection of patients with acute surgical conditions were only index hospitalization data, it did not account for patients discharged from the emergency department and treated as outpatients. In addition, hospital sampling of NIS approximates a 20% of US community hospitals, indicating that some hospitals that care in greater proportion of acute surgical emergencies including injured patients may have not been sampled during 2005-2010. Therefore, the true incidence of hospitalizations and deaths from acute surgical conditions might be underestimated. Administrative databases are never complete or detailed enough to provide clinical information. However, I used six-years of consistent data that allowed comprehensive estimations of the magnitude and direction of the trends of hospitalizations, deaths, and costs associated with these NTSEm conditions. Since the database is population based, it also allowed the generalization of trend estimates to all regions of the US.

Another potential source of bias and confounding was the comorbidity index used for regression adjustment, since the AHRQ comorbidity software uses the ICD-9-CM codes to build the index, but still it is an approximation of comorbidities encountered in clinical scenarios. Diagnoses in administrative databases are usually arbitrarily coded, based on nonclinical decisions, and biased by resources and reimbursement.[32] This may bias the estimations in an unknown direction. Nonetheless, it is a comorbidity measure developed and validated for this type of administrative databases and adapted for risk adjustment purposes.[31]

The observational approach used can be biased by surgical care differences and other unknown factors among hospitals. By using multivariate logistic regression analyses, I have attempted to adjust for confounders provided in the database. In addition, for the evaluation of the trauma centers' effect on mortality for NTSEm, I attempted to control for a propensity score to approximate the conditions of random assignation of hospitals for treatment of NTSEm. The databases used for this project provided no means to account for physiologic status on admission or during hospitalization and therefore, it was not possible to stratify the physiological derangement or the severity of the illness for patients with acute surgical conditions. The multilevel analysis in addition with the propensity score adjustment attempted to control for confounding factors that might impact the patients' outcomes and surgical treatment among hospitals.

The increases in hospitalizations over time observed for these acute surgical emergencies (traumatic and non-traumatic) will continue to limit the access to high-quality emergency surgical care already reported in the literature.[6,7] The observed increased proportions of Medicaid insurance and self-payment in addition to the decreased trends of costs over time could indicate that reimbursement may be declining. Whether or not these will impact acute care surgical service coverage or regionalization is non-known. Nonetheless, these findings highlight future potential financial pressures to the system that may impact negatively the delivery of acute surgical care across the United States.

For trauma patients with penetrating injuries, the reasons for the increases in the trends of hospitalizations and deaths are not clear. They could be multifactorial and societal and economics reasons could be triggering the increases especially in the South region. In the past, there were reductions in violent-related deaths attributed to economics, demographics, and policy efforts.[63] However, the results from this project emphasizes the need for innovative approaches across the entire injury spectrum, from injury prevention and control, to the clinical assessment and management practice, and tertiary prevention and rehabilitation, to improve outcomes for these patients.[65]

In the evaluation of trauma centers' effect on mortality for NTSEm, the analyses showed that mortality rates were not different in TC compared to NTC. Previous hospital-based studies have reported improved outcomes after restructuring surgical services to provide coverage for patients with non-traumatic surgical emergencies.[14,15,17,73] In other contexts, structured trauma systems have accounted for differences in mortality for injury patients[10,66,75] and cancer center hospitals were significantly associated with lower likelihood of death in immunocompromised patients.[76] However the results of this project are conflicting with these previous studies. I hypothesize that trauma centers' infrastructure and resources availability are not the only factors required for immediate management of acute care surgery patients. Therefore, regionalization and better allocation of multidisciplinary resources is needed for patients with non-traumatic surgical conditions. These must be complemented with registries and with the development of severity scores to improve the quality of care and patients outcomes.

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