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Healthcare Costs of Injured Youth: The Need for Prevention, Policy, and Proper Triage

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by

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Dedication

To my parents, Joe and Jana, and brother, Jared, for your encouragement, help, and unwavering support. To my Davie, Ryan, and Gemma for keeping life happy, full of love, and in perspective.

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Abstract

Objective

The goal of this dissertation was to identify evidence regarding potential means to reduce healthcare spending on youth injury while protecting and promoting the health of our youth. The first analysis estimated and analyzed both the financial costs and time lost from sports injuries among inpatient and ED youth patients to aid in identifying key populations, raising awareness to policy makers, and emphasizing the need of prevention programs for sports injury. The second analysis analyzed the effect of volume and trauma center (TC) ownership type on trauma alert response charges, which are billed to injured patients for a trauma team activation. The objectives of the third analysis were to evaluate associations of mechanism of injury in youth who have been misclassified as trauma alerts, and to analyze the effect of misclassified youth on healthcare costs.

Methods

The first study was a retrospective analysis of sports injuries identified in Florida's Agency for Healthcare Administration (AHCA) 2010-2014 all-inclusive inpatient and ED datasets. The study population included all hospital patients, aged 5 to 18 years, with a recorded injury from sport. Fixed effects linear and negative binomial regression were used. In the second analysis, every inpatient who visited a TC in Florida and was billed a trauma response charge from 2012 to 2014 was included for a total of 45,993 observations. Multiple linear regression, controlling for patient and hospital factors, was used to find associations between volume and trauma response charges and hospital ownership type and charges. Severity

elasticity of trauma response charges was calculated by ownership type. AHCA's 2012-2014 inpatient and financial data were used in the third analysis. The study population included patients, aged 5 to 18 years with no surgery, an ICISS score ≥ .90, a hospital stay less than 24 hours, discharged to home, with recorded mechanism and defined injury. Misclassified patients were those designated as a trauma alert in the field. Logistic and multivariable linear regression were used.

Results

Over the five year period, sports injuries in Florida youth cost $24,555,547 for inpatient care and $87,083,482 for ED care. Youth spent 10,397 days in the hospital and a total of 536,893 hours in the ED. Youth averaged $6,039 and 2.5 days for an inpatient visit and $439 and 2.3 hours for an ED visit in costs from sports injuries. Volume had a significant, inverse relationship with trauma response charges. For-profit TCs had statistically higher trauma response charges and government owned TCs had statistically lower trauma response charges than not-for-profits. For-profit TCs had an inelastic response to severity for trauma response charges. The mechanisms of injury of firearm, motor vehicle traffic, and transport were significantly, positively associated with misclassification as a trauma alert. Inpatient costs were associated with an 87% increase for patients who were misclassified as a trauma alert.

Conclusion

Older athletes and males consistently have high healthcare costs from sports. Baseball, basketball, bike riding, football, rollerskating/skateboarding, and soccer are sports with high costs for both ED patients and inpatients and would benefit from prevention programs. Injuries from noncontact sport participants are few but can have high costs. These athletes could benefit from prevention programs as well. Trauma response charges are higher when patient volume is reduced and at for-profit TCs. If injured youth had visited government or not-for-profit TCs, an estimated annual $6.5 to $8.3 million reduction in trauma response charges would have occurred. Reducing these charges are a potential way to reduce excessive healthcare spending without decreasing quality. Mechanism of injury is not a reliable predictor of trauma and was associated with misclassification of pediatric patients with minor injuries as trauma alerts. Costs were higher for mildly injured patients who were trauma alerted, in part due to the trauma alert charge.

Chapter 1: Introduction

Dissertation Purpose

In the United States, injury is the leading cause of death and disability for people aged 1 to 44 and a significant economic burden (Centers for Disease Control and Prevention [CDC], 2016). The goal of this dissertation is to identify evidence regarding potential means to reduce healthcare spending on youth injury while protecting and promoting the health of our youth. The dissertation uses a three article format. Each article focuses on a specific issue of youth injury, analyzes the related cost data, and identifies areas of potential unnecessary health care spending. Injury prevention commonly uses the three "E's" of education, enforcement, and engineering. The cost focus of injury has led the dissertation to discuss three "P's" instead: prevention, policy, and proper triage.

The first article explores youth injuries from sports and the cost of these injuries that might have been avoided with prevention. One of the objectives of the injury and violence prevention (IVP) goal of Healthy People 2020 is #26 to reduce sports and recreation injuries (Office of Disease Prevention and Health Promotion [ODPHP], 2017). Although the injuries may appear minor, sports injuries represent a significant cost to society (Knowles et al., 2007). More research is needed on the cost of sports injuries as well as assessment of sports injury in different populations in order to design injury prevention programs (Finch, 2012; Knowles et al., 2007). The research aims for this analysis are to identify patient factors associated with cost and length of stay (LOS) for both youth inpatient and ED visits. Older youth, males, and contact sports participants are expected to have a positive association with hospital costs and LOS (Timpka, Lindqvist, Ekstrand, & Karlsson, 2005; Yang et al., 2007).

The second article, Chapter 3, of the dissertation analyzes the effect of volume and trauma center ownership on trauma response charges. When an injured person receives a trauma alert from paramedics, they are taken to the nearest trauma center (TC) which bills a trauma alert response charge for the trauma team activation. Trauma alerts activate certain procedures and notify the trauma team of the incoming patient, but this also has a price. Volume of patients is hypothesized to be inversely related to trauma response charges since charges cover the fixed costs of staffing a trauma team. Zayas and Stein (2014) found that for-profit TCs average a higher trauma response charge than other TC ownership types. TC ownership type is hypothesized to be associated with amount and severity elasticity of trauma response charges.

The third manuscript focuses on classification of youth by paramedics when they are injured. When a youth is severely injured and the responders issue a trauma alert, they transport the patient to the nearest trauma center. A potential area of excess healthcare spending is when mild to moderate youth are trauma alerted and triaged to a trauma center, which is termed "overtriage" in the literature. Another objective of Healthy People 2020's goal of injury and violence prevention is to reduce hospitalizations (IVP-1.2) and ED visits (IVP-1.3) for nonfatal injuries (ODPHP, 2017). There are separate objectives to prevent the injuries, these objectives appear to focus on reducing unnecessary hospital visits. When youth are overtriaged, the trauma alert triggers trauma center procedures that are unnecessary for mild to moderate injury. Little research has been done on the cost effects of treating low to moderately injured patients at trauma centers; however, it has been reported that adhering to triage guidelines and properly triaging patients could save up to $136.7 million annually (Newgard et al., 2013). Research demonstrates conflicting evidence regarding whether mechanism of injury is acceptable to use in triaging or associated with overtriage. This third study analyzes costs of misclassified youth and models misclassification to assess associations with injury mechanisms. Costs are expected to be higher for youth who are misclassified. Injury mechanisms are expected to be acceptable for triage purposes.

Literature Review

Healthcare Costs

Healthcare costs and spending in the United States is currently high. In 2014, healthcare spending climbed to $3.2 trillion in the U.S., which equals 17.8% of the nation's gross domestic product (GDP) and per capita spending averaged $9,990 (Centers for Medicare and Medicaid Services [CMS], 2016). The federal government accounts for 29 percent of the healthcare spending, households for 28 percent, private businesses for 20 percent, and state/local governments for 17 percent (CMS, 2016). Hospital care comprises 32 percent of the $3.2 trillion spending, followed by physician and clinical services (20 percent); prescription drugs (10 percent); other health, residential, and personal care services such as ambulances and mental health facilities (5 percent); nursing care facilities and retirement communities (5 percent); dental services (4 percent); home health care (3 percent); other professional services such as physical therapy, optometry, and chiropractic medicine (3 percent); durable medical equipment (2 percent); and other non-durable medical products such as over-the-counter medicines and surgical dressings (2 percent) (CMS, 2016). The top five costliest medical conditions are heart disease, trauma-related disorders, cancer, mental disorders, and COPD/asthma (Cohen, 2014). In 2010, fatal injuries cost the United States $189.5 billion in medical and work loss costs (CDC, 2016). Annual healthcare costs of injured youth total nearly $20 billion in the ED and over $7 billion in hospitalizations (CDC, 2016). Trauma-related costs totaled $92.1 billion in 2012 with an average of $2,609 per patient (Cohen, 2014).

When the US is compared to other Organisation for Economic Co-operation and Development (OECD) countries, healthcare spending in other nations is lower. The average percentage of GDP spent on healthcare among OECD countries is 9.3% while their average life expectancy is higher than in the US (OECD, 2014). The US ranked first among 34 countries in health expenditures as a percent of GDP, health expenditure per capita, and pharmaceutical expenditure per capita (OECD, 2014).

The OECD (2017) found that a considerable amount of health spending does not improve health systems or health outcomes and can be cut. The IOM (2013) estimated over $750 billion is wasted in healthcare costs annually on areas such as unnecessary services, inefficiently delivered services, excess administrative costs, prices that are too high, missed prevention opportunities, and fraud. A third or more of annual healthcare spending in the U.S. could be considered wasteful (Lallemand, 2012). The goal of policy makers has increasingly become to cut healthcare costs that are not needed without reducing quality (Lallemand, 2012).

Injury

Each year worldwide injuries cause more than 5 million fatalities, millions more hospitalizations and emergency department (ED) visits, and billions of doctors' appointments (World Health Organization [WHO], 2017). Injuries have generally been classified by intent: intentional includes injuries from assault, neglect, and suicide, anything done with the intent to harm; and unintentional injuries, such as falls, poisonings, burns, actions that occurred without intent to harm. Unintentional injury is the leading cause of death for Americans aged 1 to 44.

The leading fatal unintentional injury is drowning for ages 1 to 4, motor vehicle traffic injuries for ages 5 to 24, and poisoning for ages 25 to 44 years old (CDC, 2016).

One of the goals of Healthy People 2020 is to prevent unintentional injuries and violence, and reduce their consequences (ODPHP, 2017). The last part of the goal is important as most injuries are not fatal but may still have a lifetime impact on a person's physical and mental health and ability. In 2014, there were nearly 31 million nonfatal injuries in the United States, which is an injury rate of 9.76% (CDC, 2016). Falls are the number one cause of nonfatal injury for youth (Borse et al., 2008). For the 10 to 24 year old age group, it is unintentional struck by/against (CDC, 2016). Struck by/against is when a person collides into another person or object.

Injuries disproportionately affect youth and are the leading cause of death and disability for their age group. More than 2,000 children die a day worldwide from a preventable injury (Peden et al., 2008). Annually, 12,175 youth die from unintentional injury in the United States (CDC, 2016). Nearly 12 million injured youth are seen in the emergency department (ED) annually with the most frequent payer types being Medicaid/Children's Health Insurance Program (CHIP) (41.7%) and private insurance (40.7%) (Albert & McCaig, 2014).

Injury mechanisms of youth are different than adults. Children's physical and mental abilities are not yet mature and they judge risk differently. Their size alone makes them more susceptible to certain injuries and the consequences of injuries greater. Annually 2.6 million children are treated in EDs for sports and recreation related injuries. More research is needed on the cost of sports injuries (CDC, 2013). Lawrence, Spicer, and Miller (2015) found sports and recreation injuries account for 30% of all youth ED visits and are a leading source of costs for youth ages 5 to 24.

In addition to injury mechanisms, children are notably different from adults in their response to trauma; therefore, the management of trauma and injury should be different as well (Holton & Kelley, 2015). McCarthy, Curtis, and Holland (2016) found that prehospital triage guidelines for severely injured youth were not consistent and led to both missed injuries and a waste of limited resources. This waste of limited resources is important because, by 2000, trauma care was the second costliest medical condition in the U.S. and had the largest increase (169 percent) per treated patient from 1987 to 2000 (Thorpe, Florence, & Joski, 2004).

Summary

The Institute of Medicine (IOM) (2013) has identified several ways in which healthcare spending is wasted, including missed prevention opportunities and unnecessary services. By analyzing sports injury costs of youth for prevention programs, volume and trauma center ownership on trauma alert response charges, mechanism of injury on misclassification of youth patients as trauma alerts, and the effects of misclassification on cost, this dissertation aims to identify areas for improvement in healthcare spending on injured youth.

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Chapter 2: The Need for Prevention: Financial Costs and Time Lost from Sports Injuries Among Youth

Abstract

Objective. To estimate and analyze both the financial costs and time lost from sports injuries among inpatient and ED youth patients to aid in identifying key populations, raising awareness to policy makers, and emphasizing the need of prevention programs for sports injury.

Methods. A retrospective analysis of sports injuries identified in Florida's Agency for Healthcare Administration (AHCA) 2010-2014 all-inclusive inpatient and ED datasets. The study population included all hospital patients, aged 5 to 18 years, with a recorded injury from sport. Fixed effects linear and negative binomial regression were used in the analysis.

Results. Over the five year period, sports injuries in Florida youth cost $24,555,547 for inpatient care and $87,083,482 for ED care. Youth spent 10,397 days in the hospital and a total of 536,893 hours in the ED. Youth averaged $6,039 and 2.5 days for an inpatient visit and $439 and 2.3 hours for an ED visit in costs from sports injuries.

Conclusion. Older athletes and males consistently have high healthcare costs from sports. Baseball, basketball, bike riding, football, rollerskating/skateboarding, and soccer are sports with high costs for both ED patients and inpatients and would benefit from prevention programs. Injuries from noncontact sport participants are few but can have high costs. These athletes could benefit from prevention programs as well.

Introduction

Population-level injury prevention strategies have not been applied to sport activities, resulting in a critical need to prioritize sports injury prevention in children under 15 years of age (Finch, Wong Shee, & Clapperton, 2014; Frisch, Croisier, Urhausen, Seil, & Theisen, 2009; Leadbeater, Babul, Jansson, Scime, & Pike, 2009; Schwebel & Brezausek, 2014). An estimated 30 to 45 million youths in the United States play recreational and competitive sports (Brenner, 2007). Sports are encouraged for youth to promote physical activity and instill values such as teamwork and good sportsmanship. Many youth enjoy sports while gaining satisfaction and confidence from participating. However, a percentage of these youth will be injured while participating in sports. A sports injury is defined as loss of bodily functioning resulting from an isolated exposure to physical energy during sports training or competition that can be diagnosed by a medical professional as a recognized injury (Timpka et al., 2014).

Approximately 3.5 million youth annually receive medical treatment for a sports injury (Safe Kids Worldwide, 2016) and sports injuries account for 30% of youth emergency department (ED) visits (Lawrence, Spicer, & Miller, 2015). Previous research has found that males have a higher risk of injury in team sports and females have a higher injury risk in individual sports (Timpka, Lindqvist, Ekstrand, & Karlsson, 2005). In addition, white youth are at higher risk of sports injury (Ni et al., 2002). Almost half (49%) of pediatric hospitalizations from sports injury were in 15 to 18 year olds, 85% were for males, and 54% were due to fractures (Yang et al., 2007). Sports injuries typically have mild injury severity scores and low mortality rates; however, they can still lead to high hospital admission rates, disability, long term health impact, and high healthcare costs (Dekker, Kingma, Groothoff, Eisma, & Ten Duis, 2000; Frisch et al., 2009; Miller, Romano, & Spicer, 2000). In addition, injuries acquired as youth may have a lifelong impact on a person's physical activity level and health (Mitchell, 2004; Webborn, 2012).

The cost of sports injuries in youth has been described as substantial (Frisch et al., 2009; Khan et al., 2012; Knowles et al., 2007; Lawrence, et al., 2015; Leadbeater et al., 2009; Mitchell, 2004). Hospitalizations from youth sports injuries annually costs between $113 and $133 million (Yang et al., 2007). Research gaps have been identified in the costs of sports injury to include the scope of costs and costs in different populations, (Centers for Disease Control and Prevention [CDC], 2013; Cumps, Verhagen, Annemans, & Meeusen, 2008; Knowles et al., 2007; Yang et al., 2007).

Further, there is an indirect cost of sports injury in the form of time lost from school for youth and from work for their parents (Cumps et al., 2008). When calculating societal cost of unintentional childhood injury, most of the cost (over 80%) comes from productivity loss of the children for future work and productivity loss of the parents from current work in order to care for the child and 17% of the cost is attributed to medical care (Miller et al., 2000). Yang et al. (2007) found the average length of stay (LOS) for youth inpatients injured from sport was 2.4 days and nearly 80% of these patients were covered by commercial health insurance.

The purpose of this research was twofold. The first objective was to estimate both the financial costs and time lost from sports injuries among inpatient and ED youth patients. In 2012, Finch argued that one of the key reasons public health prevention programs have not been implemented at a policy level is lack of data about the size and scope of the problem – specifically information on which groups are at-risk, effective and cost-effective prevention programs, medical treatments, cost measurements, and policy implications. Finch listed three questions to determine if an issue needs to be put on a government public health agenda: (i) Is the problem large enough? (ii) Which of the community members are most vulnerable? and (iii) Why should the government be concerned? The second objective was to analyze patient factors with cost and time data to aid in answering the second and third questions above, raise awareness to policy makers, and help focus the need of prevention programs for sports injury.

Research Questions

1. What patient factors were associated with cost of youth inpatients injured from sport?

   Hypothesis: Patients with fractures, who are older, and are male are all expected to have a positive association with cost as these groups tend to have injuries that are more severe and are hospitalized more often from sports injuries. Patients with a more severe injury score are also expected to have a positive association with cost.

2. What patient factors were associated with time hospitalized of youth inpatients injured from sport?

   Hypothesis: Patients with fractures, who are older, and are male are all expected to have a positive association with time as these groups tend to have injuries that are more severe and are hospitalized more often from sports injuries. Patients with a more severe injury score are also expected to have a positive association with time.

3. What patient factors were associated with cost of youth ED patients injured from sport?

   Hypothesis: Patients with fractures, who are older, and are male are all expected to have a positive association with cost as these groups tend to have injuries that are more severe.

4. What patient factors were associated with time in ED of youth patients injured from sport?

   Hypothesis: Patients with fractures, who are older, and are male are all expected to have a positive association with time as these groups tend to have injuries that are more severe.

Methods

The Florida Agency for Healthcare Administration (AHCA) 2010 to 2014 ED and inpatient dataset was used in this analysis; these datasets are mutually exclusive meaning patients are only included in the inpatient dataset if they visited the ED and were admitted into the hospital. The dataset includes demographic variables, up to 30 diagnoses, and external cause of injury code [E-code] information for patients who visited a licensed ED and acute care hospital in the state; ambulatory care patients are not included in the analyses. AHCA also releases annual hospital financial data which includes information such as ownership status, location, and teaching status of each hospital. Hospitals excluded from AHCA reporting are closed facilities, psychiatric facilities, VA and military facilities, inpatient residential treatment facilities, and inpatient rehabilitation hospitals. The hospital factors were merged with the patient data for each year so the model could control for differences in the 123 hospitals. Every inpatient and ED patient between the ages of 5 and 18 who had a sports related E-code was included in the analysis. Patients were categorized into age groups: elementary school included ages 5 to 10, middle school included ages 11 to 13, and high school included ages 14 to 18. The ICD-9 Injury Severity Score (ICISS) severity score was used to measure injury severity. ICISS uses a range from 0 to 1 with 1 being 100% survival and 0 being 100% death. The lower the ICISS score, the more severe the injury or combination of injuries. The severity variable used was ICISS multiplied by 100 in order for the model estimates to be more easily interpreted.

Patients who had an injury from a sport were identified using the following E-code fields: E006.x (individual sports), E007.x (team sports), E008.x (other sports), E886.0 (fall from sports), E917.0 (struck in sports), and E917.5 (struck and fall in sports). These are all of the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9) codes that included "sports" in the description of the code. The inpatient data included 4,658 observations and the ED data included 234,754 observations used in the descriptive statistics. Observations were omitted from the model analyses if they did not include an E-code for a specific sport; e.g. patients who were injured with an E-code of "struck in sports" or "other activity involving other sports" without an additional E-code identifying which sport were dropped. Observations were also omitted from the model analyses if the patient did not seek treatment of one of the injuries defined in the Barell Injury Diagnosis Matrix. The Barell Injury Diagnosis Matrix is a commonly used tool in injury epidemiology that uses ICD-9 codes to classify injury by body region and nature of injury. Examples from those omitted observations included youth patients who were principally diagnosed with an unspecified episodic mood disorder or other cellulitis or abscess. An observation that was an outlier was omitted from the model. The observation had a cost twelve times higher than the average cost for the other observations in that sport due to abnormal reaction/complication. For the final analysis, the inpatient models used 2,303 observations and the ED data for the model analysis used 162,169 observations.

The sports E-codes were categorized according to the American Academy of Pediatrics Committee on Sports Medicine and Fitness (2001). The categories were full contact or collision sports, limited contact sports, and noncontact sports. The full contact sports group included observations with E-codes of E007.0 (football), E007.2 (rugby), E007.4 (lacrosse/field hockey), E007.5 (soccer), E007.6 (basketball), E008.0 (boxing), E008.1 (wrestling), and E008.4 (martial arts). The limited contact group included E006.0 (roller skating/skateboarding), E006.1 (horseback riding), E006.4 (bike riding), E007.1 (flag football), E007.3 (baseball), E007.7 (volleyball), E008.2 (racquet/hand sports), and E008.3 (frisbee). The noncontact sports group included observations with E-codes of E006.2 (golf), E006.3 (bowling), E006.5 (jump roping), and E006.6 (non-running track and field).

The principal diagnosis code of the patients was used to create nature of injury categories according to the Barell Injury Diagnosis Matrix. Injuries were categorized using the matrix into fractures of the skull, neck, and trunk; other fractures; sprains and strains; internal; open wound; amputations; blood vessels; contusion/superficial; crush; burns; nerves; and unspecified according to the principle diagnosis code of the patient (Barell et al., 2002). The control group included sprains and strains and contusion/superficial injuries. Burns, blood vessels, nerves, amputation, and crush each had well under 1% of the observations. Therefore, these were added to the unspecified injury observations and this variable was called other injuries.

The inpatient cost model was analyzed using fixed effects regression based on Florida county. The model was linear multivariable controlling for cost differences between counties. The dependent variable was cost of the hospital visit. This was calculated from the total charges of the visit as reported in AHCA. The total charges were multiplied by each hospital's annual weighted cost-to-charge ratio to estimate the actual cost. Cost-to-charge ratios are the reported total costs divided by the total revenue of each cost center. Cost-to-charge ratios were calculated for each hospital for each year. The cost center ratios are then combined for an annual weighted overall hospital cost-to-charge ratio. The costs found were then adjusted for inflation to 2014 dollars using the producer price indexes for hospital inpatient care and hospital outpatient care accordingly. The distribution of the costs was highly skewed, therefore, the cost dependent variable was log transformed.

The inpatient time model was analyzed using fixed effects regression as well. Negative binomial regression was used as this is commonly used with count data, which typically has a dispersion significantly different than zero meaning the variance is much larger than the mean. The dependent variable was LOS of the hospitalization which had a mean of 2.22 and a variance of 10.56. The hospital was controlled for to account for any differences in internal policies and procedures. Twenty-nine of the 123 hospitals only had one observation. When these hospitals were included in the model, the results were not stable and could not be interpreted with any confidence. The hospitals with only one observation were omitted from the time model and the model then converged to produce reliable results. The county where these hospitals are located is listed in Appendix A.

The data did not fit either youth ED model well. Only 11% of the cost of an ED visit was explained by the independent variables. The time of an ED visit did not vary enough to accurately explain it; the average length of an ED visit for a youth injured by sport was 2.29 hours with a range of 2.15 – 2.80. It was such a large dataset that most of the variables were significant when all of the observations were included. Samples of the study population were taken to find the variables still significant at a smaller dataset size. However, taking multiple samples of different sample sizes did not produce consistent results. The estimates of the regression models were not stable enough to be reported and discussed.

Microsoft Excel 2016, Microsoft Access 2016, and SAS software version 9.4 were used in this analysis.

Models

First Model: Cost of Inpatient Youth Injured in Sport

$\text{Log (Cost)} = \beta_0 + \beta_1\text{elementary} + \beta_2\text{ middle} + \beta_3\text{female} + \beta_4\text{black} + \beta_5\text{other} + \beta 6\text{hispanic} + \beta_7\text{uninsured} + \beta_8\text{Medicaid} + \beta_9\text{full contact} + \beta_{10}\text{noncontact} + \beta_{11}\text{elective} + \beta_{12}\text{urgent} + \beta_{13}\text{trauma} + \beta_{14}\text{SNT} + \beta_{15}\text{other fracture} + \beta_{16}\text{internal} + \beta_{17}\text{dislocation} + \beta_{18}\text{open wound} +$

β_{19}other injury + β_{20}ICISS + β_{21}rural + β_{22}teaching + β_{23}FP + β_{24}government +

$\sum \text{county}_i + \varepsilon$

Second Model: Time of Inpatient Youth Injured in Sport

LOS = β_0 + $\beta_1$elementary + β_2 middle + $\beta_3$female + $\beta_4$black + $\beta_5$other + β6hispanic +

$\beta_7$uninsured + β_8Medicaid + $\beta_9$full contact + β_{10}noncontact + β_{11}elective + β_{12}urgent +

β_{13}trauma + β_{14}SNT + β_{15}other fracture + β_{16}internal + β_{17}dislocation + β_{18}open wound +

β_{19}other injury + β_{20}ICISS + β_{21}rural + β_{22}teaching + β_{23}FP + β_{24}government +

$\sum \text{hospital}_i + \varepsilon$

List of Variables

Cost = Cost in 2014 dollars

LOS = Time spent hospitalized in days

Age group:

Elementary = 1 if $5 \leq$ age ≤ 10, 0 if not

Middle = 1 if $11 \leq$ age ≤ 13, 0 if not

control group = High school, $14 \leq$ age ≤ 18)

Female = Gender = 1 if female, 0 if male

Race:

Black = 1 if Black or African American, 0 if not

Other = 1 if American Indian, Alaskan Native, Asian, Native Hawaiian, Other Pacific Islander, other, or unknown, 0 if not

control group = White

Hispanic = Ethnicity = 1 if Hispanic, 0 if not

Principal payer:

Uninsured = 1 if uninsured, 0 if not

Medicaid = 1 if Medicaid, Medicaid Managed Care, or Kidcare, 0 if not

control group = Commercial insurance

Sports group:

Full contact = 1 if full contact, 0 if not

Noncontact = 1 if noncontact, 0 if not

control group = Limited contact

Priority of Admission:

Elective = 1 if elective, 0 if not

Urgent = 1 if urgent, 0 if not

Trauma = 1 if trauma, 0 if not

control group = Emergency

ICISS = ICD-9 Injury Severity Score (ICISS)

Nature of injury:

SNT = 1 if fractures of the skull, neck, and trunk, 0 if not

Other fracture = 1 if other fractures, 0 if not

Internal = 1 if internal, 0 if not

Dislocation = 1 if dislocation, 0 if not

Open wound = 1 if open wound, 0 if not

Other injury = 1 if other injury, 0 if not

control group = Sprains and strains and contusion/superficial

Rural = Hospital location = 1 if rural, 0 if not

Teaching = Hospital teaching status = 1 if teaching, 0 if not

Hospital ownership:

FP = 1 if for-profit, 0 if not

Government = 1 if government, 0 if not

control group = Not-for-profit

$\sum \text{county}_i$ = County fixed effects = 1 if county, 0 if not

$\sum \text{hospital}_i$ = Hospital fixed effects = 1 if facility, 0 if not

ε = Error term

Results

In Florida from 2010 – 2014, sports injuries in youth ages 5 to 18 cost $24,555,547 for inpatient care and $87,083,482 for ED care. Youth spent 10,397 days in the hospital and a total of 536,893 hours in the ED. The cost of these sports injuries is broken down by demographics in Table 2.1 for inpatient visits and Table 2.2 for ED visits.

The average cost of an inpatient visit was $6,039. Sports injuries for Medicaid insured youth cost $10,821,525 for inpatient visits. The average LOS for youth patients was 2.5 days. The minimum average LOS was 1.93 days for elementary school ages. The maximum average LOS was 2.87 days, which was for Medicaid youth.

The average cost of an ED visit for an injured youth from sport was $439. Sports injuries for Medicaid insured youth cost $44,236,556 for ED visits. The average time spent in the ED for a youth sports injury was 2.30 hours. The maximum wait time was 2.44 hours for Hispanic youth. The minimum average was 2.17 hours for other race youth.

The financial and time costs of youth from sports injury in Florida from 2010 – 2014 were categorized by sport E-code in Table 2.3 for inpatient visits. The average cost per sport per visit ranged from $3,231 (jump roping) to $28,366 (frisbee). However, the frisbee average was impacted by the outlier observation. The next highest average cost was golf ($14,693) followed by volleyball ($12,370). Football had the highest total costs with a sum of $4,892,582. Frisbee (28.67 days), volleyball (14.5 days) and golf (5.06 days) had the longest average LOS. LOS ranged from an average of 1 day to 28.67 days.

In Table 2.4, the financial and time costs of youth from sports injury in Florida from 2010 – 2014 was categorized by sport E-code for ED visits. The average ED cost per sport ranged from $189 to $655. Youth patients who had an E-code of struck in sports had the highest average cost with $655 per injury followed by golf ($628), fall from sports ($599), and horseback riding ($444). Correspondingly, struck in sports also had the highest total cost of injury with $55,315,947 over five years. Football had the second highest total ED costs with a sum of $11,517,088 followed by basketball with a sum of $8,089,247. There was very little variation in time spent in the ED. The overall average length of time youth patients spent in the ED was 2.28 hours.

The cost regression model of inpatient youth injured by sport, reported in Table 2.5, had an overall model F-value of 29 with a p-value of <.0001 meaning at least one of the predictor variables was significantly associated with cost. The R-square for the model was 0.24. Nested models of each group of predictor variables were tested (demographics, sport, admission, injury, severity, and hospital factors) and all were found to be statistically significant. Younger age groups were associated with lower cost; elementary school had a 32% decrease while middle school youth were associated with a 21.8% decrease compared to high school aged youth. Females were found to have 10.5% lower costs than males. Elective and trauma admission were associated with 26.1% and 34.7% increases respectively compared with emergency admissions to the hospital. ICISS was associated with a 3.8% decrease in cost per ICISS unit increase towards milder injury. Fractures were predicted to be positively associated with cost; however, only other fractures were (30.9%) not fractures of the skull, neck, and trunk. Internal injuries were associated with lower cost (-52.6%). The unexpected association was with noncontact sports. Noncontact sports were found to have a 45.7% increase in costs compared to contact sports.

The negative binomial regression model, shown in Table 2.6, for time of inpatient youth injured from sport had a deviance and Pearson Chi Square lower than their degrees of freedom, meaning the data were not overdispersed. Fewer variables were significant when predicting the time of sports related injured youth inpatients compared to cost. Elementary age was statistically significant with a 17% shorter LOS. Neither middle school aged youth, females, nor any injury type had a statistically significant association. Youth who were admitted by elective priority were associated with a 21.6% shorter LOS. Milder ICISS was associated with a 3.8% decrease in LOS. Again, noncontact sports was unexpectedly associated with an 88.9% longer LOS compared to limited contact sports.

Discussion

Sports injuries of Florida youth, aged 5 to 18, proved to create significant expense with a total cost of $111,639,019 and 32,767.5 days lost during the years 2010 to 2014. Annually, this equates to $22,327,804 in healthcare costs and 6,553.5 days missed due to sports per year. High school aged youth and males were two key groups that consistently had higher cost sports injuries. Sports to target for prevention programs include baseball, basketball, bike riding, football, rollerskating/skateboarding, and soccer as each of these had the highest inpatient and ED costs for the five-year time period. Youth with Medicaid insurance had $10,821,525 in inpatient costs and $44,236,556 in ED costs. Medicaid youth also had the highest average cost ($6,252) and LOS (2.87 days) for inpatient visits among payer types.

There was very little variation in inpatient or ED time lost when categorized by demographics. There was also little variation in ED time when stratified by sport; however, certain sports had a much longer LOS than others. The average LOS for a youth hospitalization from a sports injury was 2.5 days. Bike riding, frisbee, racquet/hand sports, volleyball, wrestling, and golf all had an average LOS of three days or longer for youth patients. The LOS in this study was a proxy for how many days of school each youth missed as a minimum. In many cases, it is likely the youth missed additional days once released from the hospital. In addition, it is probable that a parent(s) missed work for the corresponding days the youth is hospitalized and recovering. The sports listed above could benefit from further research into how these injuries occurred and if prevention programs could be practical for them in terms of costs and benefits.

An unexpected result from this analysis was the impact of noncontact sports, such as bowling, golf, jumping rope, and non-running track and field events, injuries on youth. Contact sports such as football and soccer receive much more attention in the media as well as in scientific studies. After the literature review, the noncontact sports group was not expected to have severe injuries let alone statistically significant higher cost and longer LOS from their injuries when compared to a contact sports group. After reviewing the noncontact sports group observations, there were only 27 observations but they included severe and serious injuries. It is possible noncontact sports athletes are more selective in seeking care for their mild injuries. Further research needs include quantitative and qualitative research to determine how these injuries happened as well as explore the possibility that noncontact sport participants seek healthcare less often. In addition, further research should analyze the need of prevention programs for athletes in noncontact sports.

Preventive policies and programs for sports injury have usually been focused on a particular sport or at a local level. For instance, US Soccer recently banned heading for youth in U-11 programs and younger. Football rules have changed over the last several years to prevent injury (for example, spearing was banned in 1976). These are great examples of steps sports can take to reduce injury counts and healthcare costs. Policies have been put into place in all 50 states to educate youth athletes, parents, and coaches on the signs and symptoms of concussion. These policies appear to be effective and ED concussion diagnoses have increased (Gibson, Herring, Kutcher, & Broglio, 2015; Mackenzie et al., 2015). However, these policies are not preventive but instead aim to diagnose. If policies could be put into place for sports injury prevention on a nationwide scale, significant healthcare costs could be saved.

There are limitations to this study. The data used throughout the dissertation was from AHCA's ED, inpatient, and financial datasets, which are publicly available and deidentified. These administrative datasets come with three inherent limitations: (i) the data reflects the number of hospital visits and not the number of patients, (ii) data for sports injury and injury mechanism may be underreported, and (iii) clinical findings are not reported (Florida Department of Health, 2017). The datasets do not allow tracking of a patient over time. Any hospital transfer, readmission, or follow-up visit would be entered as a new patient record, which is why the dataset reflects counts of injury visits and not counts of injuries. E-codes have been estimated to be missing 30% of the time (Finch & Boufous, 2008), which is why sports injury and injury mechanism may be underreported. After adjusting for underreporting, sports injuries rose from 13.9% to 20% of hospitalizations. Their analysis estimated an additional 6 – 22.9% of hospital injuries may be sports related but not reported as such. Consequently, healthcare costs associated from youth sports injuries in the present analysis may be underreported. The absence of clinical information means it is difficult to know if all sports injuries were recorded as such; and the details of the injuries are omitted. Clinical records could potentially explain some of the variation in the models.

In addition, AHCA is data collected from hospitals in Florida. Youth are able to play many sports, such as soccer, year round due to Florida's warm climate that may not be played all year in other places. This extra exposure may increase the sports injury rate as well as the count of sports injuries compared with other states, which in turn will increase healthcare spending on sports injuries.

The AHCA ED data did not fit the financial cost and time model well. It is possible that additional data on the patient and their sports injury could build a more reliable model such as height, weight, arrival by ambulance, and acute versus chronic injury.

Conclusion

Sports are a meaningful way to exercise, maintain health, release stress, and build confidence and friendships. This analysis identified youth athletes and sports to prioritize groups that would benefit from prevention programs. The goal is for youth to continue playing sports while lowering the risk of injury, especially as Frisch et al. (2009) found the most consistent risk factor for injury is having a previous injury. Lowering the risk of sports injury would not only save the health of youth athletes but significant healthcare costs annually. Marshall, Lopatina, Lacny, and Emery (2016) found that one prevention program aimed solely at youth soccer could save millions of dollars in healthcare costs annually.

Future research is needed to identify and assess which prevention programs are effective among sports and athlete groups in creating cost and time savings. Translational research is needed to find prevention programs and policies that can be instituted at a broad level for athletes in full contact, limited contact, and noncontact sports.

Table 2.1: Demographics of Financial and Time Costs for Inpatient Youth, 2010-2014

	Count	**Inpatient: 2014 dollars**		**Inpatient: LOS days**	
Age		*Average*	*Sum*	*Average*	*Sum*
Elementary school	639	$4,634	$2,845,546	1.93	1234
Middle school	1,043	$5,457	$5,598,898	2.62	2727
High school	2,479	$6,641	$16,111,103	2.60	6436
Gender					
Female	612	$5,738	$3,402,635	2.80	1,712
Male	4,046	$6,091	$21,152,913	2.45	8,685
Race					
Black	1,142	$6,571	$7,418,243	2.77	3161
Other	471	$5,855	$2,687,512	2.26	1066
White	3,045	$5,831	$14,449,792	2.42	6170
Ethnicity					
Hispanic	747	$5,733	$4,167,879	2.68	2005
Non-Hispanic	3,911	$6,106	$20,387,668	2.46	8392
Principal payer					
Medicaid	1,767	$6,252	$10,821,525	2.87	5065
Uninsured	242	$5,433	$1,282,299	2.07	501
Commercial	2,649	$5,932	$12,451,724	2.25	4831
All inpatients	4,658	$6,039	$24,555,547	2.50	10397

Table 2.2: Demographics of Financial and Time Costs for ED Youth, 2010-2014

	Count	**ED: 2014 dollars**		**ED: hours spent**	
Age		*Average*	*Sum*	*Average*	*Sum*
Elementary school	43,586	$342	$12,724,455	2.29	99,461
Middle school	68,059	$483	$27,959,448	2.28	154,391
High school	122,747	$449	$46,399,569	2.32	283,041
Gender					
Female	51,786	$327	$14,076,603	2.25	116,032
Male	182,968	$470	$73,006,869	2.31	420,861
Race					
Black	64,849	$582	$33,270,537	2.31	149629
Other	25,540	$312	$6,707,468	2.17	55408
White	144,365	$394	$47,105,467	2.32	331856
Ethnicity					
Hispanic	48,195	$253	$10,420,486	2.44	116663
Non-Hispanic	186,559	$488	$76,662,986	2.26	420230
Principal payer					
Medicaid	121,379	$422	$44,236,556	2.27	274714
Uninsured	22,251	$671	$12,406,006	2.32	51400
Commercial	91,124	$406	$30,440,910	2.33	210779
All ED patients	234,754	$439	$87,083,472	2.30	536893

Table 2.3: Financial and Time Costs for Inpatient Youth by Sport E-code, 2010-2014

	Count	**Inpatient: 2014 dollars**		**Inpatient: LOS days**	
Full contact sports		*Average*	*Sum*	*Average*	*Sum*
Basketball	364	$5,931	$2,093,583	2.80	1019
Boxing	7	$4,678	$32,746	2.00	14
Football	852	$5,859	$4,892,582	2.21	1880
Lacrosse/Field hockey	22	$5,784	$115,685	2.41	53
Martial arts	23	$5,423	$124,737	2.17	50
Rugby	6	$4,017	$24,106	1.00	6
Soccer	314	$5,502	$1,639,706	2.05	645
Wrestling	95	$7,938	$738,274	3.15	299
Limited contact sports					
Baseball	230	$5,063	$1,139,159	2.07	475
Bike riding	249	$7,908	$1,921,557	3.41	848
Flag football	46	$5,957	$268,087	2.45	113
Frisbee	3	$28,366	$85,099	28.67	86
Horseback riding	63	$6,227	$386,081	2.87	181
Racquet/Hand sports	4	$6,203	$24,812	3.00	12
Roller skating/skateboarding	258	$5,592	$1,425,874	2.10	541
School games	37	$4,745	$166,081	1.78	66
Volleyball	20	$12,370	$321,621	14.50	406
Noncontact sports					
Bowling	3	$4,788	$14,363	2.33	7
Golf	16	$14,693	$235,090	5.06	81
Jumping rope	2	$3,231	$6,462	2.00	4
Non-running track & field events	6	$6,633	$33,165	2.50	15
Other					
Other sports played individually	245	$6,843	$1,608,155	2.85	697
Other sports played as a team	64	$5,028	$321,792	1.94	124
Other sports	108	$8,844	$928,664	2.47	267
Mechanism					
Fall from sports	353	$6,470	$2,245,043	2.27	800
Struck in sports	1383	$5,431	$7,365,263	2.42	3352
Struck in sports with fall	516	$6,177	$3,131,919	2.51	1297

Table 2.4: Financial and Time Costs for ED Youth by Sport E-code, 2010-2014

	Count	**ED: 2014 dollars**		**ED: hours spent**	
Full contact sports		*Average*	*Sum*	*Average*	*Sum*
Basketball	42,682	$223	$8,089,247	2.20	93736
Boxing	533	$247	$111,090	2.25	1201
Football	53,035	$255	$11,517,088	2.30	121411
Lacrosse/Field hockey	1,839	$283	$377,553	2.36	4321
Martial arts	2,253	$242	$466,115	2.30	5173
Rugby	252	$318	$64,611	2.50	625
Soccer	19,458	$248	$3,994,243	2.33	45158
Wrestling	5,078	$273	$1,137,725	2.40	12119
Limited contact sports					
Baseball	16,421	$246	$3,340,503	2.25	36690
Bike riding	9,806	$337	$2,814,189	2.47	24073
Flag football	2,310	$269	$524,042	2.49	5737
Frisbee	182	$201	$31,705	2.33	421
Horseback riding	1,088	$444	$403,776	2.73	2946
Racquet/Hand sports	539	$244	$108,044	2.31	1239
Roller skating/Skateboarding	11,518	$319	$3,027,545	2.40	27493
School games	2,398	$237	$479,858	2.21	5271
Volleyball	3,894	$224	$690,352	2.15	8319
Noncontact sports					
Bowling	281	$189	$44,228	2.08	582
Golf	346	$628	$160,109	2.41	835
Jumping rope	252	$193	$42,413	2.19	553
Non-running track & field events	136	$218	$25,947	2.27	308
Other					
Other sports played individually	2,746	$283	$707,440	2.80	7676
Other sports played as a team	2,557	$238	$529,666	2.20	5601
Other sports	1,539	$303	$424,139	2.40	3674
Mechanism					
Fall from sports	7,479	$599	$3,497,997	2.49	18630
Struck in sports	100,846	$655	$55,315,947	2.24	225523
Struck in sports with fall	13,967	$315	$3,785,643	2.53	35261

Table 2.5: Regression Model of Cost of Inpatient Youth Injured in Sport

		Parameter Estimate	P-value	Percentage Change to Cost
Patient Factors	**Elementary school***	**-0.320**	**<.0001**	**-32%**
	Middle school*	**-0.218**	**<.0001**	**-21.8%**
	Female*	**-0.105**	**<.0001**	**-10.5%**
	Black	0.046	0.2644	
	Other race	-0.000	0.9945	
	Hispanic	0.030	0.4760	
	Uninsured	0.025	0.7049	
	Medicaid	0.047	0.1605	
	Full contact sports	0.003	0.9352	
	Noncontact sports*	**0.457**	**0.0030**	**45.7%**
	Elective admission*	**0.261**	**<.0001**	**26.1%**
	Urgent admission	-0.113	0.0850	
	Trauma admission*	**0.347**	**<.0001**	**34.7%**
	ICISS*	**-0.038**	**<.0001**	**-3.8%**
Nature of Injury	Fractures of the skull, neck, or trunk	-0.048	0.6197	
	Other fractures*	**0.309**	**0.0004**	**30.9%**
	Internal injury*	**-0.526**	**<.0001**	**-52.6%**
	Dislocation	-0.086	0.5254	
	Open wound	0.105	0.4708	
	Other injury	-0.203	0.1435	
Hospital Factors	Rural hospital	0.338	0.2551	
	Teaching hospital*	0.067	0.0685	
	For profit hospital	-0.026	0.5343	
	Government hospital*	**0.122**	**0.0221**	**12.2%**

* Statistically significant at the $\alpha = 0.05$ level

Table 2.6: Regression Model of Time of Inpatient Youth Injured in Sport

		Estimate	P-value	Exp (Estimate) for Change in Time
Patient Factors	**Elementary school***	**-0.186**	**0.0005**	**-17%**
	Middle school	-0.081	0.0525	
	Female	-0.062	0.2368	
	Black	0.059	0.1938	
	Other race	0.079	0.1692	
	Hispanic	0.019	0.7094	
	Uninsured	-0.030	0.6918	
	Medicaid	0.033	0.3760	
	Full contact sports	-0.041	0.3188	
	Noncontact sports*	**0.636**	**<.0001**	**88.9%**
	Elective admission*	**-0.243**	**0.0009**	**-21.6%**
	Urgent admission	0.077	0.2977	
	Trauma admission	0.004	0.9509	
	ICISS*	**-0.039**	**<.0001**	**-3.8%**
Nature of Injury	Fractures of the skull, neck, or trunk	0.135	0.2462	
	Other fractures	0.116	0.2808	
	Internal injury	0.095	0.4016	
	Dislocation	-0.148	0.3921	
	Open wound	0.241	0.1427	
	Other injury	0.233	0.1339	
Hospital Factors	Rural hospital	0.199	0.6913	
	Teaching hospital	0.698	0.2285	
	For profit hospital	-0.149	0.4239	
	Government hospital	-0.227	0.6071	

* Statistically significant at the $\alpha = 0.05$ level

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Chapter 3: The Need for Policy: Associations of Trauma Alert Response Charges with Volume and Hospital Ownership Type

Abstract

Objective. The purpose of this research was to analyze the effect of volume and trauma center (TC) ownership type on trauma alert response charges, which are billed to injured patients for a trauma team activation.

Methods. Every inpatient who visited a TC in Florida and was billed a trauma response charge from 2012 to 2014 was included in the analysis for a total of 45,993 observations. Multiple linear regression, controlling for patient and hospital factors, was used to find associations between volume and trauma response charges and hospital ownership type and charges. Severity elasticity of trauma response charges was calculated by ownership type.

Results. Volume had a significant, inverse relationship with trauma response charges. For-profit TCs had statistically higher trauma response charges and government owned TCs had statistically lower trauma response charges than not-for-profits. For-profit TCs had an inelastic response to severity for trauma response charges.

Conclusion. Trauma response charges are higher when patient volume is reduced and at for-profit TCs. If injured youth had visited government or not-for-profit TCs, an estimated annual $6.5 to $8.3 million reduction in trauma response charges would have occurred. Reducing these charges are a potential way to reduce excessive healthcare spending without decreasing quality.

Introduction

When a person is injured, decisions on how to treat the injury are quickly made. The first decisions are made by the injured person or persons within close proximity to include: (i) whether the injury is severe enough to need medical treatment, (ii) whether a physician's office, urgent care, or emergency department (ED) is the best place to seek treatment, and (iii) if ED care is necessary, whether emergency medical services (EMS) should be called. Once EMS responders are notified, they also have key decisions to make that include whether the patient meets trauma alert criteria. A trauma alert requires that the patient is taken to the closest designated trauma center hospital (TC), where a trauma team is notified by EMS and waiting for the patient upon arrival. Designating an injured person as a trauma alert has both medical and cost implications. In Florida in 2014, 2,348 injured youth were trauma alerted, 10,322 injured youth were hospitalized, and 514,334 injured youth visited the ED (Florida Department of Health, 2014).

In Florida, designated TCs have been verified by the state as meeting specific standards in professional staffing, services, equipment, facilities, training, care capabilities, and programs in order to provide the best possible care to severely injured patients (Florida Department of Health, 2010; Tracy, 2004). Florida's Roy E. Campbell Trauma Act of 1990 established these requirements, as well as the necessary components of Florida's trauma system (Florida Department of Health, 2010; Lundine, 1996). There are different levels of trauma centers with Level 1 being the most comprehensive. Level 1 TCs include 24 hour in-house coverage of surgeons and prompt availability of specialists, leadership in prevention to the community, education for the trauma team, quality assessment, trauma research, programs for patients, and a minimum volume of severly injured patients (American Trauma Society [ATS], 2017). Level 2

TCs include 24 hour immediate coverage of surgeons and specialists, trauma prevention and education programs, and a quality assessment program (ATS, 2017). The Florida Department of Health approves new TCs and has recently allowed a large expansion of for-profit TCs (Zayas & Stein, 2014). Currently, Florida has 33 TCs with additional applications pending. The state allows for up to 44 designed TCs; however, there have been legal and political battles over opening more TCs due to the potential effects, both clinical outcome and financial, for current TCs (Hiers, 2014; Lundine, 1996; Saunders, 2017). The optimal number and distribution of TCs requires balancing issues of access, volume, quality, and cost. Too few TCs can prohibit access whereas too many TCs in a region may result in trauma volume that is less than optimal relative to quality and costs to patients.

Patient volume can impact patient outcomes, including mortality, as hospitals and surgeons with more experience are better at identifying problems and managing patients (Bell, Boustany, Jenkins, & Zarzaur, 2015). Several studies have found that high-risk patients, including those with traumatic injury, have better outcomes with high volume providers (Bell et al., 2015; Caputo, Salottolo, Slone, Mains, & Bar-Or, 2014; Konvolinka, Copes, & Sacco, 1995; Marcin & Romano, 2004; Marx et al., 2011; Nathens et al., 2001; Pasquale, Peitzman, Bednarski, & Wasser, 2001). Miyata, Cho, Park, Matsushima, and Bliss (2017) found injured pediatric patients had better mortality rates in higher volume hospitals. However, the link between volume and outcomes remains controversial in the literature as several studies have found no link or benefit to higher volume (Caputo et al., 2014).

A literature review of the relationships between TC volume and cost and volume and charges only yielded two applicable research articles. Koo, Wang, Thompson, Merbs, and Grant (2013) found that higher volume was associated with lower costs at regional eye TCs.

Monuteaux, Bourgeois, Mannix, Samnaliev, and Stack (2015) found that higher volume was associated with decreased charges for patients with fractures and infectious mouth disorders, but not for patients with lacerations.

When EMS notifies a TC that a patient is being transported to them, the trauma team is activated. This activation leads to a trauma alert response charge that is added to a patient's hospital bill. The purpose of the trauma response charge is to help cover the TC's fixed cost of keeping physicians and staff on-call at all times, which has been estimated at $2.7 million annually and does not vary based on volume (Taheri, Butz, Lottenberg, Clawson, & Flint, 2004; Tracy, 2004). There are additional costs of TCs to include continuing education, injury prevention programs, specialized equipment, and specialty surgeons who perform on an as-needed basis (Tracy, 2004).

Under the American Hospital Association's National Uniform Billing Committee, TCs bill trauma response charges based on three levels of trauma team activations (Tracy, 2004). The trauma team consists of a trauma surgeon, an ED physician, a trauma nurse, a nurse recorder, a respiratory therapist, and three technicians at a minimum (Tracy, 2004). The first and most expensive activation level is for the full trauma team including a trauma surgeon; the second level is the trauma team without a trauma surgeon, and the third level is a trauma consult without activating the trauma team (Tracy, 2004). The more severe injuries should be charged the highest trauma response charge. The amount of the trauma response charge varies widely between TCs (Fakhry, Potter, Crain, & Maier, 2009). *The Tampa Bay Times* published a news article that reported trauma response charges vary by hospital ownership type with Hospital Corporation of America (HCA), a for-profit hospital chain, charging as much as $33,000 while other Florida TCs averaged a trauma response charge of $6,754 (Zayas & Stein, 2014).

Not-for-profit and for-profit hospitals behave differently as for-profit status influences the objectives of the hospital (Bayindir, 2012; Woolhandler & Himmelstein, 2004). Not-for-profit hospitals are driven by providing health care for the community while for-profit hospitals are focused on cost, efficiency, and profits (Rotarius, Trujillo, Liberman, & Ramirez, 2005). The difference in such objectives stems from the difference in the way they treat profit. Not-for-profits invest extra revenue into the organization or community as charitable care, health education, health campaigns, research, and teaching. In contrast, for-profits distribute profits to their shareholders, which motivates them to produce larger profits as seen in their pricing strategies (Rotarius et al., 2005). For-profits are thought to be more efficient than not-for-profits in reducing costs and increasing profits (Rotarius et al., 2005; Woolhandler & Himmelstein, 2004). One part of the debate to allow for-profit hospitals in healthcare is that they are more efficient and will pass on cost savings to their patients and the patients' insurance companies ultimately decreasing total healthcare spending. However, research has found conflicting evidence if costs are lower in for-profit hospitals (Rotarius, Trujillo, Liberman, & Ramirez, 2006; Shen, Eggleston, Lau, & Schmid, 2005). Even if costs are lower, for-profits do not seem to pass on the cost savings as evidence points to for-profits having higher prices and revenues than not-for-profits (Rotarius et al., 2006). While many have argued that hospital pricing has little to do with actual costs and payments received, high hospital charges harm patients such as the uninsured, patients with high deductibles, out-of-network patients, and patients with worker's compensation or automobile insurance (Bai & Anderson, 2015; Brown, 2014; Hsia & Antwi, 2014). Furthermore, charges are the starting point of negotiations between insurers and hospitals. High charges ultimately drive up healthcare spending for everyone (Brown, 2014).

The purpose of this research was to analyze the associations of volume and TC ownership type on trauma alert response charges. The Florida Department of Health's practice to allow additional for-profit TCs in areas already served by a TC has volume implications for current TCs as well as ownership type implications on current healthcare spending. Trauma response charges have been billed as high as $66,000 in Florida. Reducing such extreme trauma response charges is a potential way to reduce healthcare spending on youth injuries. As of 2014, neither the Department of Health nor the Agency for Healthcare Administration (AHCA) had examined trauma charges (Zayas & Stein, 2014).

The first objective of this study was to analyze the association of trauma volume and trauma alert response charges to determine if fewer trauma patients are associated with higher trauma response charges. The second objective was to analyze the association of hospital ownership type and trauma response charges by modeling the charges, as well as calculating severity elasticity of the charges by hospital ownership type. Elasticity was used to measure the effect of a change in severity on charges. The higher the elasticity, the more the charge will change in response to a change in severity. If elasticity is below 1, the demand is inelastic meaning the trauma response charges are unaffected by changes in severity.

Research Questions

1. Is volume of trauma patients related to trauma charges?

   Hypothesis: Trauma team and facility readiness are fixed costs. The costs when divided among more patients will be less per patient than when costs are divided among fewer patients. Therefore, trauma charges will have an inverse relationship with trauma volume.

2. Is there a relationship between hospital ownership type and trauma charges when controlling for patient and hospital factors?

   Hypothesis: For-profit hospitals will have higher trauma charges than not-for-profits and government hospitals, after controlling for severity, as they seek to maximize profit.

3. Does the elasticity of trauma response charges from severity differ among hospital ownership type?

   Hypothesis: Elasticity will not be different among hospital ownership types.

Methods

AHCA's 2012 to 2014 inpatient and financial datasets were used in this retrospective analysis. The datasets were described in Chapter 2 and are publicly available and de-identified. The study population consisted of every inpatient who visited a licensed, acute care hospital in Florida and was billed a trauma response charge. Since trauma volume includes all patients, this analysis did not restrict the study population age to youth. The observations included 46,020 patients from 31 hospitals. Three hospitals that were not TCs charged trauma response fees to 27 patients. These observations were removed from the model analysis, which made the final count of observations 45,993.

Multiple linear regression was used to model trauma response charges. The specific costs related to trauma teams were not reported in AHCA, so a trauma cost to charge ratios could not be used in this analysis. Trauma charges were transformed due to the distribution being skewed towards higher charges. The log of trauma charges was the dependent variable in the model. Independent variables included patient demographics such as age, gender, race, ethnicity, payer, and an injury severity score. The injury severity score used was the ICD-9 Injury Severity Score (ICISS) inverted and multiplied by 100. ICISS, which ranges from 0 to 1, is the product of survival risk ratios of a patient's traumatic injury ICD-9 codes (Osler, Rutledge, Deis, & Bedrick, 1996). An ICISS score of 1 means that 100% of patients with the particular injury survived. Similarly, an ICISS score of 0 means that no previous patients with the injury or combination of injuries survived. This makes it less intuitive to interpret the severity coefficient in the model as a unit increase in severity score is associated with a milder injury. In addition, it is difficult to interpret the coefficient of a one unit change in score since ICISS scores are in the tenths and hundredths of decimal points. Therefore, ICISS was inverted so a higher score meant more severe injury and multiplied by 100 for ease in interpreting the parameter estimate of the model.

The Barell Injury Diagnosis Matrix, described in Chapter 2, was used to identify nature of injury variables. Patients without a principal diagnosis that fell into a defined nature of injury categories were combined with the unspecified injury patients.

Mechanism of injury was categorized according to the recommended framework of E-code groupings for presenting injury mortality and morbidity data from the CDC National Center for Health Statistics (2017). The categories in the framework include cut/pierce, drowning/submersion, fall, fire/burn/hot object, firearm, machinery, motor vehicle traffic, transport, natural/environmental, overexertion, poisoning, struck by/against, suffocation, other, and unspecified. The 'other' categories included recognized injuries that were not classified elsewhere such as injuries from explosions, electric current, radiation, animal and scratches (CDC WISQARS, 2014). Patients without an E-code that identified their mechanism of injury were combined with the other mechanism of injury patients. Drowning, overexertion, poisoning, and suffocation are not injuries that typically require a trauma surgeon. However, EMS assesses a patient for consciousness, airway, and circulation in deciding trauma alert status; a trauma team focuses on resuscitation if needed upon a patient's arrival; and these injury mechanisms caused patients to be trauma alerted. Therefore, patients with injuries from drowning (75 observations), overexertion (35), poisoning (203), and suffocation (214) were included in the analysis.

Hospital independent variables included volume, TC level (1 or 2), teaching status, and hospital ownership type. Volume of trauma patients was the number of trauma alert patients each TC had. Bed size was an independent variable in the model; however, it was too highly correlated with volume (a Pearson correlation coefficient of 0.789) and teaching status (0.712) and was removed. There are no level one or two TCs located in a rural area in Florida, therefore, location of the TC was not included in the model. Appendix B has a table with each hospital's TC level and teaching status.

The severity elasticity of trauma response charge was calculated by ownership. The formula used was the percentage change in trauma response charge divided by the percentage change in severity.

Microsoft Excel 2016, Microsoft Access 2016, and SAS software version 9.4 were used in this analysis.

Model

Trauma Charges of Florida Inpatients, 2012 – 2014

$$\text{Log (Charge)} = \beta_0 + \beta_1\text{age} + \beta_2\text{female} + \beta_3\text{black} + \beta_4\text{other} + \beta_5\text{Hispanic} + \beta_6\text{uninsured} + \beta_7\text{Medicaid} + \beta_8\text{Medicare} + \beta_9\text{Other insurance} + \beta_{10}\text{ICISS} + \beta_{11}\text{SNT} + \beta_{12}\text{internal} + \beta_{13}\text{open wound} + \beta_{14}\text{burns} + \beta_{15}\text{blood vessels} + \beta_{16}\text{nerves} + \beta_{17}\text{dislocation} + \beta_{18}\text{sprains} + \beta_{19}\text{contusion} + \beta_{20}\text{amputation} + \beta_{21}\text{crush} + \beta_{22}\text{unspecified injury} + \beta_{23}\text{cut} + \beta_{24}\text{drown} + \beta_{25}\text{fall} + \beta_{26}\text{fire} + \beta_{27}\text{firearm} + \beta_{28}\text{machinery} + \beta_{29}\text{MVT} + \beta_{30}\text{transport} + \beta_{31}\text{natural} + \beta_{32}\text{overexertion} + \beta_{33}\text{poison} + \beta_{34}\text{struck} + \beta_{35}\text{suffocation} + \beta_{36}\text{other mechanism} + \beta_{37}\text{volume} + \beta_{38}\text{level} + \beta_{39}\text{teaching} + \beta_{40}\text{FP} + \beta_{41}\text{government} + \varepsilon$$

List of Variables

Charge = Trauma response charge ($)

Age = Age in years

Female = Gender = 1 if female, 0 if male

Race:

Black = 1 if Black or African American, 0 if not

Other = 1 if American Indian, Alaskan Native, Asian, Native Hawaiian, Other Pacific Islander, other, or unknown, 0 if not

control group = White

Hispanic = Ethnicity = 1 if Hispanic, 0 if not

Principal payer:

Uninsured = 1 if uninsured, 0 if not

Medicaid = 1 if Medicaid, Medicaid Managed Care, or Kidcare, 0 if not

Medicare = 1 if Medicare or Medicare Managed Care, 0 if not

Other insurance = 1 if Worker's compensation, Tricare, VA, other state/local government, other, or commercial liability coverage

control group = Commercial insurance

ICISS = inverted ICD-9 Injury Severity Score (ICISS) multiplied by 100

Nature of injury:

SNT = 1 if fractures of the skull, neck, and trunk, 0 if not

Internal = 1 if internal, 0 if not

Open wound = 1 if open wound, 0 if not

Burns = 1 if burns, 0 if not

Blood vessels = 1 if blood vessels, 0 if not

Nerves = 1 if nerves, 0 if not

Dislocations = 1 if dislocations, 0 if not

Sprains = 1 if sprains and strains, 0 if not

Contusion = 1 if contusion or superficial, 0 if not

Amputation = 1 if amputations, 0 if not

Crush = 1 if crush, 0 if not

Unspecified injury = 1 if unspecified injury, 0 if not

control group = Other fractures

Mechanism of injury:

Cut = 1 if cut/pierce, 0 if not

Drown = 1 if drowning or submersion, 0 if not

Fall = 1 if fall from another level, 0 if not

Fire = 1 if fire/burn/hot object, 0 if not

Firearm = 1 if firearm, 0 if not

Machinery = 1 if machinery, 0 if not

MVT = 1 if motor vehicle traffic, 0 if not

Transport = 1 if transport, 0 if not

Natural = 1 if natural/environmental, 0 if not

Overexertion = 1 if overexertion, 0 if not

Poison = 1 if poisoning, 0 if not

Struck = 1 if struck by/against, 0 if not

Suffocation = 1 if suffocation, 0 if not

Other mechanism = 1 if other mechanisms, 0 if not

control group = Fall from same level

Volume = number of trauma alerted patients

Level = TC level = 1 if TC level 1, 0 if not

Teaching = Hospital teaching status = 1 if teaching, 0 if not

Hospital ownership:

FP = 1 if for-profit, 0 if not

Government = 1 if government, 0 if not

control group = Not-for-profit

ε = Error term

Results

Table 3.1 provides volume and trauma response charges reported by demographic information. For the 45,993 patients in Florida who received a trauma response charge between 2012 and 2014, the average charge was $11,121 and the total of the charges was $511,501,665. Youth patients averaged a trauma response fee of $9,280 for a total of $40,385,059 in charges. Of the 4,352 youth patients, 1,389 went to for-profit TCs, 1,074 went to government owned, and 1,889 went to not-for-profits. Patients whose race was black averaged the lowest trauma response charge ($8,418) while patients who were other race averaged the highest ($16,688). Commercially insured patients averaged the highest average trauma response charge ($14,640) among the payer types for a total of $173,685,689.

Trauma response charges were categorized according to ownership type in Table 3.2. For-profit hospitals averaged a trauma response charge of $20,518, more than eight times higher than government owned hospitals ($2,480) and over three times more than not-for-profit hospitals ($6,306). The average total fees a hospital assessed during the 3-year time period was $9,487,417 for not-for-profits, $5,100,586 for government owned, and $36,266,231 for for-profits. Most hospitals varied their trauma response charges, consistent with level of response. However, two hospitals had static charges: Nicklaus Children's Hospital ($1,817) and Bay Medical Center Sacred Heart Health ($8,479). The smallest trauma response charge was $197 at Orange Park Medical Center and the largest was $66,000 charged at Regional Medical Center Bayonet Point.

Table 3.3 provides the results of the trauma response charge regression model. The overall F-value, 3346.97, was highly significant and the model had an adjusted R-squared of 0749. Volume was statistically significant and inversely related to trauma charges as hypothesized. For each additional trauma patient, the trauma response charge decreases by .01%. The second independent variables of interest were the TC ownership variables. Both were significantly associated with trauma charges and have high coefficients. For-profits TCs had trauma response charges 105.36% higher than not-for-profits. Government owned TCs had trauma response charges 102.41% lower than not-for-profits. The other hospital factors were significant as well; teaching hospitals were associated with a 5.03% decrease while level one TCs were associated with a 5.30% increase. Several patient factors had statistically significant associations with trauma response charges: age (.03%); black race (1.86%), other race (18.15%), inverted ICISS (.11%) and all payer types. Patients without insurance or who had other insurance had trauma response charges 8.44% and 7.39% higher respectively. Patients with Medicaid (3.11%) and Medicare (3.05%) had higher trauma response charges than commercially insured patients as well. Only four nature of injury types were significantly associated with trauma charges: fractures of the skull, neck, and trunk (-5.56%), internal injury (-4.70%), open wound (6.52%), and contusion or superficial (5.85%). Several mechanism of injuries were associated with trauma response charges, all of them increased the charge compared with falls from the same level. The statistically significant mechanism of injury variables were cut (11.56%), fall (8.81%), fire (12.34%), firearm (9.48%), machinery (9.42%), motor vehicle traffic (12.92%), transport (9.74%), natural or environmental (8.79%), struck by/against (7.70%), suffocation (10.63%), and other mechanism (4.90%).

The severity elasticity of trauma response charges was calculated by ownership type. The severity elasticity for not-for-profit TCs was 3.45 and for government owned TCs was 4.63. For every one unit increase in severity, the trauma charges increase by 3.45% at not-for-profit TCs and 4.63% at government owned TCs. The severity elasticity of trauma response charges at for-profit TCs was inelastic at 0.82; the severity level does not change the trauma charges at for-profit TCs. Table 3.4 provides the related elasticity information.

Three hospitals, all not-for-profit, charged trauma response fees yet were not TCs. All three hospitals were part of a network of hospitals that included a TC yet only two of the 27 patients were transferred from those hospitals to a different one. The rest were discharged to home or rehabilitation and one patient was sent to hospice. Dr. P Phillips Hospital, part of the Orlando Regional Medical Center network, charged one patient a trauma response charge of $6,370. However, South Seminole Hospital, also part of Orlando Regional Medical Center network, had total trauma response charges of $94,716. Healthpark Medical Center, affiliated with Lee Memorial, charged a total of $69,954 in three years. It is unclear why the three non-TC hospitals charged trauma response fees.

Discussion

TCs have fixed costs to keep a trauma team on-call and at the hospital 24 hours a day, 365 days a year. These costs are partially, if not fully, recovered by the trauma response charge billed to patients following a trauma alert. The hypothesis of the first research question was that volume would be inversely related to trauma charges due to fixed costs being divided among the patient volume. After controlling for patient and hospital variables, a one patient decrease in trauma volume was associated with a .01% increase in trauma response charges. This may seem small; however, Carr, Geiger, McWilliams, Reilly, & Wiebe (2014) found that accrediting additional lower level TCs within 50 miles of a Level I TC equated to a 1,903 patient reduction over 51 months. The loss of 1,903 patients is estimated to increase a TC's trauma response charges by 19%. For not-for-profit hospitals, a 19% increase is estimated to increase an average trauma response charge from $6,306 to $7,504. The estimate for government hospitals is an increase from $2,480 to $2,951, and at for-profits the estimated increase is from $20,518 to $24,416.

Hospital ownership types were statistically significant when estimating trauma response charges. Government owned hospitals had the lowest trauma response charges and for-profits the highest. Even after controlling for patient and hospital factors, if a TC was for-profit, the trauma response charges were more than twice the charges of a not-for-profit. Furthermore, for-profit TCs are severity inelastic relative to trauma response charges, meaning the severity of a patient's injury was not associated with an effect on the trauma charge amount despite the 3-level billing codes for trauma team activations. Not-for-profit and government owned TCs both had severity elasticity of trauma charges. The change in severity of a patient's injuries was associated with a change in trauma response charges.

The largest TC provider in the state, HCA, is for-profit and treats one in five trauma patients in Florida (Zayas & Stein, 2014). In a news report, HCA officials released a statement defending their trauma response charges and noting that the charges are misleading as no one pays the full amount (Zayas & Stein, 2014). Charges are often viewed as arbitrary in the hospital industry. However, charges impact many patients to include those without insurance, patients who visit an out-of-network hospital or have worker's compensation or automobile insurance, and patients with high deductibles (Bai & Anderson, 2015; Brown, 2014; Hsia & Antwi, 2014). When charges increase, payments and costs tend to follow. In the five years since HCA opened its first TC, statewide costs increased by $1 billon (Zayas & Stein, 2014).

Trauma response charges are increasing the healthcare costs of injured patients and are another potential way to save on excessive costs without decreasing quality. If the 1,389 injured youth who went to for-profit TCs had been treated in not-for-profits, total trauma response fees potentially could have decreased from $28,499,502 to $8,759,034 for the 3-year time period of this analysis; which equates to a $19,740,468 total difference and an annual difference of $6,580,156. If those same youth had went to a government owned TC, charges would have totaled $3,444,720 for a $25,054,782 total difference and $8,351,594 difference annually.

Reducing high trauma charges is important not just for injured youth who are uninsured but for those who have commercial insurance as well. The charges are a starting point of negotiation between TCs and insurance companies. Insurers have less leverage in negotiating trauma response charges since the patients must be transported to the closest TC, meaning insurers do not have the ability to negotiate a lower rate with another TC. Higher payments eventually lead to higher premiums and more healthcare spending.

There are limitations to this study. AHCA was used which comes with inherent limitations as mentioned in Chapter 2. The study population is restricted to Florida, which has a mature trauma system and high level of for-profit TCs. Caution should be applied if extrapolated to other states. Trauma response charges were used in this analysis. AHCA does not identify expenses of trauma teams meaning a cost-to-charge ratio could not be applied to trauma response charges to find differences in costs between TC ownership type. The trauma response charge differences between TC ownership types are estimates and therefore, not exact. AHCA is an administrative dataset and does not include clinical findings, which may help explain why the patients from non-TCs had a trauma response charge. AHCA also does not report on the level of trauma team activation that a patient required.

Conclusion

Trauma response charges were implemented in 2002 to help recoup the costs of staffing a trauma team at all times. In the 15 years since, trauma response charges have risen dramatically (Zayas & Stein, 2014), and they are significantly higher in for-profit TCs. Some portion of these fees are necessary to cover costs. However, in Florida, for-profits trauma response charges were nearly three times the average of not-for-profits. There is potential for healthcare spending of injured patients to be reduced if trauma response charges were lowered in for-profit TCs to the levels of not-for-profit TCs, if more patients went to not-for-profit or government owned TCs, or if there were fewer TCs in Florida.

Florida state statutes expect Level I TCs to see 1,000 patients annually and Level II TCs to see 500 patients annually. The volume of trauma alerted patients by TC level can be viewed in Appendix B. Not every TC was designated for the full three years, which makes the annual average lower, but only seven TCs in the state met this expectation and a few more came close.

Adequate trauma patient volume is important for current TCs in terms of quality and cost and should be balanced with issues of access when verifying new TCs.

In addition, there are policy implications from this analysis. The Florida Department of Health has allowed several new for-profit TCs to be certified in the last few years. Some new TCs have reduced the patient volume at existing TCs, which necessitates higher trauma response charges at both the new and the existing centers as existing TCs spread their fixed costs over fewer trauma alerted patients. Increasing trauma response charges increases a patient's total bill which raises healthcare spending.

Further research should include analyzing the trauma alert team activation levels that patients are billed for to assess how they are used relative to injury severity and by TC ownership. Cost of trauma teams by TC ownership would be beneficial in determining a possible explanation for the differences in trauma response charges. In addition, a trend analysis is indicated for potential influences of new for-profit TC's trauma response charges on surrounding not-for-profit and government TC's trauma response charges controlling for changes in volume.

Table 3.1: Volume and Trauma Response Charges by Demographics, 2012-2014

			Trauma Charges	
		Volume	**Average**	**Total**
Age	**0-18 years**	4,352	$9,280	$40,385,058
	19-64 years	31,629	$11,106	$351,284,965
	65+ years	10,012	$11,969	$119,831,642
Gender	**Female**	13,684	$11,541	$157,930,837
	Male	32,309	$10,943	$353,570,828
Race	**Black**	8,478	$8,418	$71,366,744
	Other	5,438	$16,688	$90,750,378
	White	32,077	$10,892	$349,384,543
Ethnicity	**Hispanic**	9,333	$10,801	$100,801,398
	Non-Hispanic	36,660	$11,203	$410,700,267
Insurance	**Uninsured**	8,456	$10,733	$90,754,567
	Medicaid	5,787	$9,951	$57,587,493
	Medicare	8,417	$11,809	$99,393,515
	Other	11,469	$7,854	$90,080,401
	Commercial	11,864	$14,640	$173,685,689
TOTAL		**45,993**	**$11,121**	**$511,501,665**

Table 3.2: Trauma Response Charges by Ownership, 2012-2014

		Trauma Response Charges			
Name	**Volume**	**Minimum**	**Average**	**Maximum**	**Total**
Not-for-profits					
UF Health Jacksonville	2119	$7,000	$7,700	$21,000	$16,316,198
Orlando Regional Medical Center	2970	$5,953	$6,247	$12,740	$18,554,255
Lee Memorial Hospital	2237	$2,888	$7,611	$20,132	$17,026,538
Holmes Regional Medical Center	2051	$1,173	$4,498	$10,000	$9,225,204
Sacred Heart Hospital	1194	$6,831	$7,904	$16,958	$9,437,405
St Joseph’s Hospital	521	$1,087	$1,244	$2,489	$648,326
UF Health Shands Hospital	1616	$4,000	$8,243	$21,930	$13,320,850
Tampa General Hospital	1822	$10,273	$11,534	$26,990	$21,014,628
Tallahassee Memorial Hospital	703	$6,500	$6,518	$13,000	$4,582,500
Lakeland Regional Medical Center	1302	$5,000	$8,921	$10,816	$11,614,544
All Children's Hospital	15	$1,022	$3,492	$7,198	$52,386
Nicklaus Children’s Hospital	38	$1,817	$1,817	$1,817	$69,046
Arnold Palmer Medical Center	236	$5,953	$6,248	$6,370	$1,474,547
Total Average		**$4,577**	**$6,306**	**$13,188**	**$9,487,417**
Government owned					
Halifax Health Medical Center	1171	$1,205	$2,902	$9,670	$3,398,740
Jackson Memorial Hospital	6535	$1,363	$1,480	$5,452	$9,671,848
Memorial Regional Hospital	447	$2,422	$2,536	$5,612	$1,133,373
Broward Health Medical Center	2292	$3,250	$4,310	$13,500	$9,877,932
Broward Health North	1211	$860	$1,173	$2,704	$1,421,038
Total Average		**$1,820**	**$2,480**	**$7,388**	**$5,100,586**
For-profits					
St Mary's Medical Center	2961	$2,069	$11,854	$42,500	$35,099,933
Bay Medical Center Sacred Heart Health	169	$8,479	$8,479	$8,479	$1,432,951
Bayfront Medical Center - St Petersburg	1312	$2,830	$8,189	$29,700	$10,744,340
Kendall Regional Medical Center	3158	$1,000	$23,930	$46,890	$75,572,320
Ocala Regional Medical Center	1223	$19,500	$23,903	$49,000	$29,232,860
Blake Medical Center	1344	$29,000	$29,261	$58,000	$39,326,900
Orange Park Medical Center	397	$197	$22,072	$48,871	$8,762,446
Lawnwood Regional Medical Center	2034	$26,244	$31,309	$65,534	$63,682,986
Regional Medical Center Bayonet Point	1658	$29,000	$32,281	$66,000	$53,521,920
Delray Medical Center	3257	$6,330	$13,904	$42,500	$45,285,651
Total Average		**$12,465**	**$20,518**	**$45,747**	**$36,266,231**

Table 3.3: Regression Model of Trauma Response Charges, 2012 – 2014

		Parameter Estimate	P-value	Percentage Change to Cost
Patient Factors	**Age***	**0.0003**	**0.0251**	**0.03%**
	Female	-0.0039	0.4842	
	Black*	**0.0186**	**0.0088**	**1.86%**
	Other race*	**0.1815**	**<.0001**	**18.15%**
	Hispanic	0.0085	0.2397	
	Uninsured*	**0.0844**	**<.0001**	**8.44%**
	Medicaid*	**0.0311**	**0.0005**	**3.11%**
	Medicare*	**0.0305**	**0.0012**	**3.05%**
	Other Insurance*	**0.0739**	**<.0001**	**7.39%**
	ICISS*	**0.0011**	**<.0001**	**0.11%**
Nature of Injury	**Fractures of the skull, neck, or trunk***	**-0.0556**	**<.0001**	**-5.56%**
	Internal injury*	**-0.0470**	**<.0001**	**-4.70%**
	Open wound*	**0.0652**	**<.0001**	**6.52%**
	Burns	0.0315	0.2912	
	Blood vessels	0.0012	0.9572	
	Nerves	0.0250	0.6014	
	Dislocation	0.0126	0.6901	
	Sprains and strains	-0.0115	0.8183	
	Contusion or superficial*	**0.0585**	**0.0053**	**5.85%**
	Amputations	0.0703	0.0604	
	Crush	-0.0377	0.2909	
	Unspecified injury	0.0120	0.2561	
Mechanism of Injury	**Cut***	**0.1156**	**<.0001**	**11.56%**
	Drowning	-0.0121	0.8421	
	Fall*	**0.0881**	**<.0001**	**8.81%**
	Fire*	**0.1234**	**0.0001**	**12.34%**
	Firearm*	**0.0948**	**<.0001**	**9.48%**
	Machinery*	**0.0942**	**0.0057**	**9.42%**
	Motor Vehicle Traffic*	**0.1292**	**<.0001**	**12.92%**
	Transport*	**0.0974**	**<.0001**	**9.74%**
	Natural or environmental	**0.0879**	**0.0092**	**8.79%**
	Overexertion	0.1097	0.2141	
	Poisoning	0.0513	0.1681	
	Struck by or against*	**0.0770**	**<.0001**	**7.70%**
	Suffocation*	**0.1063**	**0.0035**	**10.63%**
	Other mechanism*	**0.0490**	**<.0001**	**4.90%**
Hospital Factors	**Volume***	**-0.0001**	**<.0001**	**-.01%**
	Level I TC*	**0.0530**	**<.0001**	**5.30%**
	Teaching hospital*	**-0.0503**	**<.0001**	**-5.03%**
	For profit hospital*	**1.0536**	**<.0001**	**105.36%**
	Government hospital*	**-1.0241**	**<.0001**	**-102.41%**

* Statistically significant at the $\alpha = 0.05$ level

Table 3.4: Severity Elasticity of Trauma Response Charges by Ownership

	Coefficient Charge	Average Charge	Coefficient Severity	Average Severity	Elasticity
Not-For-Profit	1	$6,306	0.00114	24.776	3.4465
Government	-0.99184	$2,480	-0.00163	18.863	4.6282
For-profit	1.03717	$20,518	0.00105	17.069	0.8217

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Chapter 4: The Need for Proper Triage: Mechanism of Injury and Cost Associations with Misclassification of Youth Patients as Trauma Alerts

Abstract

Objectives. The objectives were to evaluate associations of mechanism of injury in youth who have been misclassified as trauma alerts, and to analyze the effect of misclassified youth on healthcare costs.

Methods. Florida's Agency for Healthcare Administration (AHCA) 2012-2014 inpatient and financial data were used. The study population included patients, aged 5 to 18 years with no surgery, an ICISS score $\geq .90$, a hospital stay less than 24 hours, discharged to home, with recorded mechanism and defined injury. Misclassified patients were those designated as a trauma alert in the field. Logistic and multivariable linear regression were used in the analysis.

Results. The mechanisms of injury of firearm, motor vehicle traffic, and transport were significantly, positively associated with misclassification as a trauma alert. Inpatient costs were associated with an 87% increase for patients who were misclassified as a trauma alert.

Conclusion. Mechanism of injury is not a reliable predictor of trauma and was associated with misclassification of pediatric patients with minor injuries as trauma alerts. Costs were higher for mildly injured patients who were trauma alerted, in part due to the trauma alert charge.

Introduction

Emergency medical services (EMS) have three major responsibilities upon arrival at the scene of an injured person: to assess injury severity; to stabilize the patient to the extent possible; and to decide if the patient meets trauma alert criteria, which determines the appropriate receiving hospital based on the patient's injuries. The last task is done through a process known as triage (Centers for Disease Control and Prevention [CDC], 2012; Ciesla et al., 2015). Minor and moderately injured patients are typically triaged to the closest community hospital, including non-trauma center hospitals, whereas severely injured patients are transported to a trauma center hospital (Ciesla et al., 2015; Newgard et al., 2013). Patients identified as a trauma alert automatically are transported to the nearest trauma center; with pediatric patients transported to the nearest pediatric trauma center. Patients who are trauma alerted are charged a trauma alert response charge, which is a fee for the activation of the trauma team at the trauma center. Trauma response charges vary greatly between and across trauma center levels and regions (Fakhry, Potter, Crain, & Maier, 2009).

There has been a lack of valid, reliable triage guidelines specifically designed for children (McCarthy, Curtis, & Holland, 2016). In Florida, paramedics use the Pediatric Trauma Scorecard Methodology, as required in the Florida Administrative Code Section 64J-2.005, to assess whether a patient meets trauma alert criteria (Florida Trauma, 2017). The Pediatric Trauma Scorecard Methodology uses the following conditions in the assessment: airway, consciousness, circulation, fracture, cutaneous, and pediatric size (Florida Trauma, 2017). However, if patients do not meet any of the trauma conditions, EMS responders are allowed to use their judgment in issuing a trauma alert, and document it in the patient care record (Florida Trauma, 2017).

Qualitative analysis with EMS responders suggest triage decisions are guided heavily by their own judgement of visual cues of the trauma scene and injury mechanism as opposed to triage guidelines (Newgard et al., 2011). Engum et al. (2000) found that paramedics cannot evaluate youth as well as adults when field triaging patients. Lin, Becker, and Lynn (2012) found that paramedic judgment was one of the most common causes of overtriage. Overtriage is when there is a false assumption made from prehospital criteria that a patient is severely injured (Lin et al., 2012). These overtriaged patients are often trauma alerted and then taken to a trauma center. Undertriage is the assumption that a patient is not critically injured when they actually are (Lin et al., 2012).

Research shows conflicting evidence of mechanism of injury as a reliable factor of trauma care. McSwain et al. (2011) did not find mechanism of injury to be a reliable predictor while Engum et al. (2000) and Santaniello et al. (2003) found it to be a good indicator of trauma and reasonable to use in triaging. Newgard et al. (2005) found motor vehicle crashes are a reliable mechanism of injury for use in triage guidelines of youth. Ciesla et al. (2015) found high energy transfer transportation-related injury mechanisms to be associated with overtriage. Lerner et al. (2011) found mechanism of injury reduced undertriage rates while significantly raising overtriage rates, and that some mechanisms of injury from the Field Triage Decision Scheme were found to be more appropriate for use in triage than others.

Undertriage leads to patients not getting appropriate and potentially life-saving care and raises healthcare quality concerns. In contrast, overtriage is an economic issue that can create a myriad of problems, such as longer distance transports that are inconvenient for the patient and family, unnecessary use of land and air EMS vehicles, greater demands of EMS personnel, loss of revenue for the bypassed community hospitals, potential overburdening of urban trauma centers, and a waste of valuable resources if the trauma team is unnecessarily activated (Ciesla et al., 2015; McSwain, Rotondo, Meade, & Duchesne, 2011). It is important to correctly identify trauma patients to ensure the balance of suitable over- and undertriage rates. Research has estimated the overtriage rate of youth is as high as 71% (Engum et al., 2000). Acceptable rates of overtriage are as high as 50% in order to keep undertriage below 5% (American College of Surgeons, 2006). Newgard et al. (2011) argued that this high overtriage rate has been accepted and perpetuated by current trauma system culture. There is an acceptable overtriage rate as the trauma system errs on the side of patient safety and caution; however, it is possible to keep patient risk low while reducing overtriage rates and consequently costs (DiDomenico, Pietzsch, & Pate-Cornell, 2008).

Developing effective trauma systems is important because of the high occurrence of injury, limited trauma center resources, and the ever increasing costs of healthcare (Newgard et al., 2013). Thorpe, Florence, and Joski (2004) found trauma to be the second largest contributor to health care spending in the U.S. among the five most expensive conditions. Healthcare costs are higher at trauma centers, meaning resources are wasted when patients are overtriaged (Newgard et al., 2013). Newgard et al. (2013) found taking low-risk patients to a Level I trauma center led to an overtriage rate of 34.3% accounting for up to 40% of acute injury costs.

EMS triage decisions have large cost implications (Lin et al., 2012; Newgard et al., 2013). In 2014, trauma charges for inpatient youth patients in Florida ranged from $923 to $35,000. There has been little research in evaluating factors associated with acute injury costs and trauma systems and the direct and indirect costs of overtriage to identify potential ways to reduce healthcare spending (DiDomenico et al., 2008; Newgard et al., 2013; Osen, Bass, Abdullah, & Chang, 2010).

Factors associated with overtriage and undertriage are an important research need (Gaines, 2005; Poltavski & Muus, 2005). Florida has a mature statewide trauma system with almost universal access, which makes it a reliable state to study trauma center performance (Ciesla et al., 2015). This research article focuses on youth with mild to moderate injuries who were trauma alerted. These patients are referred to as misclassified throughout the rest of this analysis. The first objective of this study is to evaluate the associations of mechanism of injury on youth that have been misclassified to add to the existing literature on reliability of this indicator in use of triage. The second objective is to analyze the effect of misclassified youth on healthcare costs to determine the significance and size of the relationship. Reducing overtriaged youth may potentially be a means of lowering excessive healthcare costs.

Research Questions

1. Which mechanisms of injury are associated with misclassification of injured youth as trauma alerts?

   Hypothesis: Motor vehicle traffic and transport, which have been shown to be unreliable for triage, will be associated with patients who are misclassified. Cut/pierce, fall, fire/burn/hot object, firearm, natural/environmental, and struck by/against will not be associated with misclassification.

2. Do misclassified patients have higher costs than non-trauma alert patients?

   Hypothesis: Misclassified patients will have a positive association with cost as they will have trauma charges.

Methods

The 2012 – 2014 Florida Agency for Healthcare Administration (AHCA) inpatient and financial data were used in this retrospective analysis and were described in Chapter 2. The study population included youth patients ages 5 to 18 who were hospitalized; had a priority of admission of either trauma or emergency; were admitted from a non-healthcare facility source of origin, physician's clinic, emergency department, or law enforcement (i.e. not transferred); had a recorded mechanism of injury; and had mild to moderate injuries. Major trauma was defined as having an ICD-9 Injury Severity Score (ICISS) < .85 by the Florida Department of Health (Champion et al., 1990; Ciesla et al., 2015). Even though major trauma is regarded as an ICISS of below .85, this study used a threshold of .90 or higher to ensure only patients with mild to moderate injuries were included. ICISS was again inverted and multiplied as detailed in Chapter 3. The threshold ICISS of .90 equals an inverted ICISS of 10, meaning only 10% of patients died from the same injury or combination of injuries.

Youth patients with mild to moderate injuries were defined as having no surgery; an inverted ICISS of 10 or lower; a length of stay of less than 24 hours; discharged to home or self-care; and an injury identified in the Barell Injury Diagnosis Matrix. This definition was based on the commonalities in the definitions of pediatric secondary overtriage in the research of Ciesla, Sava, Street, and Jordan (2008); Goldstein et al. (2015); and Osen et al. (2010).

Patients with a trauma response charge were considered to be misclassified. A trauma response charge indicates that the patient received a trauma alert in the field. Of the 889 observations in the study population, 218 patients met the misclassification criteria. The ICISS means of each group were assessed to confirm that the misclassified and properly classified groups were comparable. The properly classified group were youth who had mild to moderate injury as described above and no trauma alert. The average inverted ICISS for the misclassified group was 1.68 and the average inverted ICISS for the properly classified group was 1.56.

The Barell Injury Diagnosis Matrix, described in Chapter 2, was used to create nature of injury categories. For this analysis, the fracture category was split into fractures of the skull, neck, and trunk and other fractures per Ciesla et al. (2015). Other fractures was used as the control group. The categories of blood vessels, dislocation, amputations, crush, and nerves each had less than one percent of the observations and were grouped with unspecified into a category called other injury. Sprains and strains and contusion/superficial did not have any observations in the study population.

Mechanism of injury was categorized according to the same framework recommended by the CDC as used in Chapter 3. Unspecified injuries was combined with other injury. Drowning, overexertion, poisoning, and suffocation did not have any trauma alerts in the study population and the categories were not included in the analysis. Machinery only had one observation and was omitted as a category. Fall was split into two categories: falls from the same level and falls from another level. Falls from the same level was used as the reference group.

Logistic regression was used for the misclassification model; the dependent variable was whether or not a patient was misclassified with a trauma alert. Multiple linear regression was used for the cost model; the dependent variable was cost of the hospital visit. There was not high correlation between any of the independent variables. Cost was calculated from total charges for the admission as reported in AHCA. The total charges were multiplied by each hospital's annual weighted cost-to-charge ratio to estimate the actual cost. These costs were then adjusted for inflation to 2014 dollars using the producer price indices for hospital inpatient care and hospital outpatient care accordingly. The distribution of the costs was skewed towards higher costs, therefore, the cost dependent variable was log transformed.

Microsoft Excel 2016, Microsoft Access 2016, and SAS software version 9.4 were used in this analysis.

Models

First Model: Misclassification of Inpatient Youth with Mild Injuries

Misclassification = $\beta_0 + \beta_1$age + $\beta_2$female+ $\beta_3$black + $\beta_4$other + β_5Hispanic + $\beta_6$uninsured + β_7Medicaid + β_8SNT + $\beta_9$internal + β_{10}open wound + β_{11}burns + β_{12}other injury + β_{13}cut + β_{14}fall + β_{15}fire + β_{16}firearm + β_{17}MVT + β_{18}transport + β_{19}natural + β_{20}struck + β_{21}other mechanism + ε

Second Model: Cost of Inpatient Youth with Mild Injuries and a Trauma or Emergency Admission

Log (Cost) = $\beta_0 + \beta_1$age + $\beta_2$female+ $\beta_3$black + $\beta_4$other + β_5Hispanic + $\beta_6$uninsured + β_7Medicaid + $\beta_8$time + β_9ICISS + β_{10}misclassification + β_{11}SNT + β_{12}internal + β_{13}open wound + β_{14}burns + β_{15}other injury + β_{16}cut + β_{17}fall + β_{18}fire + β_{19}firearm + β_{20}MVT + β_{21}transport + β_{22}natural + β_{23}struck + β_{24}other mechanism + β_{25}teaching + β_{26}FP + β_{27}government + ε

List of Variables

Misclassification = Patients who are misclassified = 1 if trauma alert, 0 if not

Cost = Cost in 2014 dollars

Age = Age in years

Female = Gender = 1 if female, 0 if male

Race:

Black = 1 if Black or African American, 0 if not

Other = 1 if American Indian, Alaskan Native, Asian, Native Hawaiian, Other Pacific

Islander, other, or unknown, 0 if not

control group = White

Hispanic = Ethnicity = 1 if Hispanic, 0 if not

Principal payer:

Uninsured = 1 if uninsured, 0 if not

Medicaid = 1 if Medicaid, Medicaid Managed Care, or Kidcare, 0 if not

control group = Commercial insurance

Time = Length of stay in hours

ICISS = inverted ICD-9 Injury Severity Score (ICISS) multiplied by 100

Misclassification = Patients who are misclassified = 1 if trauma alert, 0 if not

Nature of injury:

SNT = 1 if fractures of the skull, neck, and trunk, 0 if not

Internal = 1 if internal, 0 if not

Open wound = 1 if open wound, 0 if not

Burns = 1 if burns, 0 if not

Other injury = 1 if other injury, 0 if not

control group = Other fractures

Mechanism of injury:

Cut = 1 if cut/pierce, 0 if not

Fall = 1 if fall from another level, 0 if not

Fire = 1 if fire/burn/hot object, 0 if not

Firearm = 1 if firearm, 0 if not

MVT = 1 if motor vehicle traffic, 0 if not

Transport = 1 if transport, 0 if not

Natural = 1 if natural/environmental, 0 if not

Struck = 1 if struck by/against, 0 if not

Other mechanism = 1 if other mechanisms, 0 if not

control group = Fall from same level

Teaching = Hospital teaching status = 1 if teaching, 0 if not

Hospital ownership:

FP = 1 if for-profit, 0 if not

Government = 1 if government, 0 if not

control group = Not-for-profit

ε = Error term

Results

Misclassified counts and costs were reported by demographics in Table 4.1. The percentage of patients who were misclassified overall was 24.5%; their share of the total costs was 45.3%. The percentage of patients who were misclassified ranged from 21.2% (white) to 31.6% (black). However, the percentage of costs misclassified patients used was much higher and ranged from 41.4% (white) to 52.9% (other race). Most of the misclassified demographic groups had costs nearly twice their expected share. For example, 27.3% of patients who were coded as other race were misclassified. The healthcare costs of these misclassified patients were 52.9% of the total costs of other race patients.

The percentage of patients who were misclassified (receiving a trauma alert when they had an injury, an inverted ICISS 10 or under, less than 24 hour stay, no surgery, and discharged to home) in Florida from 2012 to 2014 are reported by mechanism of injury in Table 4.2.

Firearm had the biggest percentage of misclassified patients at 50%, followed by motor vehicle traffic (39.9%), and fire/burn/hot object and mechanism (both 29.8%). Struck by/against and firearm had the highest average trauma charges with $13,793 and $13,583 respectively. Motor vehicle traffic had the highest collective trauma charges with $909,438.

The results of the logistic regression model of misclassified youth to test for associations of mechanism of injury are reported in Table 4.3. The Likelihood Ratio and Wald test statistics were both statistically significant (p-value of <.0001) meaning that at least one of the variables in the model had a β not equal to 0. The independent variables were not highly correlated. The independent variables of interest are the mechanism of injuries. Patients with injury mechanisms of firearm, motor vehicle traffic, and transport were more likely to be associated with a trauma alert than patients with a same level fall. The rest of the mechanisms of injury were not significant in predicting misclassification. Older (1.07) youth were more likely to be misclassified than younger youth. Also, youth with fractures of the skull, neck, or trunk (5.32), internal injury (8.49), open wound (7.04), burns (59.91), and other injury (7.50) were more likely to be misclassified than youth with other fractures. All of the hospital factors were significant. Patients who went to a teaching hospital were 1.76 times more likely to be misclassified than patients who did not. Patients were more likely to be misclassified at for-profit (6.43) and government (3.92) hospitals than not-for-profit hospitals.

Costs of Florida youth with minor injuries who received trauma alerts are reported in Table 4.4. The adjusted R-square of the model is 0.5146, meaning 51.46% of the variation in cost is explained by the independent variables. The independent variable of interest was misclassification, which was positively associated with cost. If patients were misclassified, costs increased 86.9%. The misclassification variable had the largest impact on cost. Other patient factors that increased cost were age (1.4% per year), time (1.3% per hour), and inverted ICISS (2.3% per unit increase in score). Fractures of the skull, neck, or trunk (11.3%), internal injury (17.4%), and other injury (23.5%) were positively associated with cost. The mechanisms associated with increasing cost included firearm (31.2%) and motor vehicle traffic (41.5%). Teaching status of a hospital was also shown to increase costs by 20% for patients treated at a teaching hospital.

Discussion

Mechanisms of injury as a reliable tool in triage has shown conflicting evidence in the literature. This study found that some mechanisms were associated with misclassification and, therefore, overtriage as Lerner et al. (2011) found. The research found two of the mechanisms, motor vehicle traffic and transport, were highly associated with misclassification, consistent with Ciesla et al. (2015). The other mechanism found to be associated with overtriage was firearm, which was misclassified half of the time. The rest of the mechanisms were not associated with misclassification. Mechanism of injury does not make a reliable, primary guideline in triage. Paramedics often use their experience and the trauma scene to evaluate patients (Newgard et al., 2011); they should be conscious of the influence mechanism of injury may have on the triage, and overtriage, of a patient.

Youth with mild injuries who were trauma alerted have significantly higher healthcare costs than youth with mild injuries who were not trauma alerted. The trauma response charge alone contributes to total charges and may explain part of the increase in these patient’s cost. Even though misclassified youth are a small percentage of the youth inpatient population, their costs are a substantial percentage of youth inpatient healthcare costs. Triage decisions are not 100% accurate because of the limited information at the time of injury (Ciesla et al., 2015).

Most experts agree there is an acceptable level of overtriage in order to prevent undertriage from occurring (DiDomenico et al., 2008; Engum et al., 2000; Hoff, Tinkoff, Lucke, & Lehr, 1995). With the consequences of overtriage affecting patients, EMS, and trauma centers, it is important to lower overtriage rates without increasing undertriage rates. Lowered overtriage rates will save on excess healthcare costs of trauma alerts and the corresponding trauma response charges.

There are different policies for the Florida triage system that could potentially lower overtriage rates and healthcare costs. The first is to develop reliable triage guidelines designed for pediatric patients and train experienced paramedics to follow them instead of injury mechanism or their visual assessment of the trauma scene. The second is to take mildly injured patients to a trauma center without a trauma alert activation. Research suggests the experience of trauma centers may make treating mild injuries easier and faster (Lehmann et al., 2007). This approach would not only save healthcare spending on treatments but it would save the trauma response charge as well. The third option is to take patients with minor injuries to their closest hospital. If patients are sent to a hospital who cannot care for their injuries, an inter-hospital transfer can occur (McSwain et al., 2011). These policy recommendations are for pediatric patients with minor, not major, injuries.

There are limitations to this study. AHCA was used which comes with inherent limitations as described in Chapter 2. The study population is restricted to Florida and caution should be applied if extrapolated to other states. AHCA is an administrative dataset and does not include clinical findings, which may help explain why some patients with mild to moderate injuries were trauma alerted.

Conclusion

Mechanism of injury is not a reliable predictor of trauma and should not be used as the primary focus in triage of pediatric patients. It is associated with misclassification of pediatric patients with minor injuries as trauma alerts. Costs are higher for mildly injured patients that are trauma alerted, in part due to the additional trauma charge. The triage decision resides with EMS responders. They could potentially lower healthcare costs with properly triaged and trauma classified patients.

Future research needs include qualitative research with paramedics to determine the reason for trauma alerts in the misclassified youth and potential strategies for prevention.

Table 4.1: Misclassified Counts and Costs by Demographics

		Total	**Misclassified**		**Total**	**Misclassified**	
		Count	**Count**	**Percentage**	**Cost**	**Cost**	**Cost Percentage**
Gender	Female	276	69	25.0%	$568,814	$279,056	49.1%
	Male	613	149	24.3%	$1,180,572	$513,273	43.5%
Race	Black	209	66	31.6%	$407,176	$201,945	49.6%
	Other race	128	35	27.3%	$299,869	$158,739	52.9%
	White	552	117	21.2%	$1,042,341	$431,645	41.4%
Ethnicity	Hispanic	193	54	28.0%	$425,704	$212,428	49.9%
	Non-Hispanic	696	164	23.6%	$1,323,681	$579,900	43.8%
Insurance	Uninsured	81	23	28.4%	$147,980	$71,024	48.0%
	Medicaid	422	107	25.4%	$794,196	$361,927	45.6%
	Commercial	386	88	22.8%	$807,210	$359,378	44.5%
Total		889	218	24.5%	$1,749,386	$792,329	45.3%

Table 4.2: Misclassification and Trauma Response Charges by Mechanism of Injury

Mechanism of Injury	**Count**	**Misclassified Count**	**Misclassified Percentage**	**Average Trauma Response Charge**	**Total Trauma Response Charges**
Cut/pierce	22	5	22.7%	$9,379	$46,897
Fall from another level	161	21	13.0%	$8,917	$187,264
Fire/burn/hot object	57	17	29.8%	$9,167	$155,855
Firearm	40	20	50%	$13,583	$271,676
Motor vehicle traffic	178	71	39.9%	$12,809	$909,438
Transport	163	41	25.2%	$12,271	$503,095
Natural/environmental	15	1	6.7%	$1,363	$1,363
Struck by/against	218	39	17.9%	$13,793	$537,940
Other mechanism	161	48	29.8%	$11,592	$556,436
Fall from same level	12	2	16.7%	$4,733	$9,467
Total	889	218	24.5%	$12,237	$2,667,589

Table 4.3: Logistic Regression Model of Misclassification of Youth with Minor Injury

		Odds Ratio Estimate	95% Wald Confidence Limits	
Patient Factors	**Age***	**1.072**	**1.020**	**1.126**
	Female	1.001		
	Black	1.467		
	Other race	1.120		
	Hispanic	1.290		
	Uninsured	1.507		
	Medicaid	1.462		
	ICISS	0.990		
Nature of Injury	**Fractures of the skull, neck, or trunk***	**5.318**	**2.097**	**13.487**
	Internal injury*	**8.487**	**3.528**	**20.414**
	Open wound*	**7.035**	**2.600**	**19.034**
	Burns*	**59.908**	**5.863**	**612.097**
	Other injury*	**7.502**	**2.465**	**22.825**
Mechanism of Injury	Cut	2.951		
	Fall	3.132		
	Fire	0.755		
	Firearm*	**9.987**	**2.209**	**45.155**
	Motor vehicle traffic*	**7.514**	**1.373**	**41.113**
	Transport*	**6.612**	**1.257**	**34.781**
	Natural/environmental	0.744		
	Struck by/against	2.356		
	Other mechanism	1.151		
Hospital Factors	**Teaching***	**1.762**	**1.082**	**2.869**
	For-Profit*	**6.432**	**3.898**	**10.613**
	Government*	**3.924**	**2.304**	**6.683**

* Statistically significant at the $\alpha = 0.05$ level

Table 4.4: Regression Model of Cost of Youth with Minor Injury

		Parameter Estimate	P-value	Percentage Change to Cost
Patient Factors	**Age***	**0.014**	**0.0011**	**1.4%**
	Female	0.019	0.5856	
	Black	-0.028	0.5114	
	Other race	0.053	0.2676	
	Hispanic	0.073	0.0834	
	Uninsured	-0.113	0.0522	
	Medicaid	-0.033	0.3510	
	Time*	**0.013**	**0.0001**	**1.3%**
	ICISS*	**0.023**	**0.0090**	**2.3%**
	Misclassification*	**0.869**	**<.0001**	**86.9%**
Nature of Injury	**Fractures of the skull, neck, or trunk***	**0.113**	**0.0462**	**11.3%**
	Internal injury*	**0.174**	**0.0007**	**17.4%**
	Open wound	-0.015	0.8395	
	Burns	-0.276	0.1714	
	Other injury*	**0.235**	**0.0023**	**23.5%**
Mechanism of Injury	Cut	-0.138	0.3067	
	Fall	0.138	0.4447	
	Fire	0.319	0.1105	
	Firearm*	**0.312**	**0.0057**	**31.2%**
	Motor vehicle traffic*	**0.415**	**0.0206**	**41.5%**
	Transport	0.226	0.1970	
	Natural/environmental	0.094	0.6712	
	Struck by/against	0.158	0.3719	
	Other mechanism	0.116	0.5462	
Hospital Factors	**Teaching hospital***	**0.200**	**<.0001**	**20%**
	For-profit hospital	0.058	0.1797	
	Government hospital	0.015	0.7658	

* Statistically significant at the $\alpha = 0.05$ level

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Chapter 5: Conclusion

Dissertation Summary

The United States spends over $750 billion in healthcare costs annually in areas such as unnecessary services, inefficiently delivered services, excess administrative costs, prices that are too high, missed prevention opportunities, and fraud (IOM, 2013). This dissertation focused on prevention and policy opportunities to reduce healthcare spending on injury, the number one cause of youth death and disability. The goal was to identify areas of youth injury where healthcare costs could be reduced while maintaining or improving healthcare quality and outcomes. The first research study in Chapter 2, focused on missed prevention opportunities in youth sports by identifying athletes associated with higher costs. The second study in Chapter 3, analyzed trauma response charges and their association with volume and trauma center ownership to identify trauma center factors that were associated with high prices, as well as potential explanations, and the impact of higher prices on youth. The third study, Chapter 4, centered on the inefficiencies associated with mild to moderately injured youth who were trauma alerted and taken to a trauma center (TC) for treatment.

Healthcare Spending

There is a lack of awareness of the size and scope of youth sports injury in terms of healthcare costs (Centers for Disease Control and Prevention [CDC], 2013; Cumps, Verhagen, Annemans, & Meeusen, 2008; Knowles et al., 2007; Yang et al., 2007). In Florida from 2010 – 2014, sports injuries in youth ages 5 to 18 cost $24.5 million and 10,397 days for inpatient care and $87 million and 536,893 hours for ED care, supporting the literature by Frisch, Croisier, Urhausen, Seil, and Theisen (2009); Khan et al. (2012); Knowles et al. (2007); Lawrence, Spicer, and Miller (2015); Leadbeater, Babul, Jansson, Scime, and Pike (2009); and Mitchell (2004) that costs from sports injury are significant. Most sports injuries are minor but some are severe enough to warrant a trauma alert which comes with a trauma alert response charge.

High trauma response charges can raise healthcare spending for injured youth who have no insurance or are under-insured and expected to pay the charge, as well as all insured youth, by raising costs of insurance companies and eventually insurance premiums (Brown, 2014). Trauma alert responses ranged from $197 to $66,000 for TCs in Florida. Youth patients in Florida had a total of $40 million in trauma response charges over a 3-year time period with an average charge of $9,280. Volume was significantly inversely associated with trauma response charges, with every decrease in patient equaling a .01% increase in charges. For-profit TCs were positively associated with trauma response charges; charges more than doubled if a TC was for-profit. Government owned TCs were negatively associated with trauma response charges, which were half of not-for-profit TC's charges. For-profit TCs were severity inelastic to trauma response charges meaning that a change in a patient's injury severity level did not equal a change in trauma center charges. Higher trauma response charges led to an estimated excess of $6.5 to 8.3 million in healthcare charges for injured youth during 2012 to 2014. Not every youth who received a trauma alert had a severe injury, which leads to excess healthcare spending.

Overtriage is an economic issue that leads to inconvenience and costs for the patient and family and wasted valuable resources of EMS and TCs (Ciesla et al., 2015; McSwain, Rotondo, Meade, & Duchesne, 2011) when mild to moderately injured youth are misclassified. Injured youth who received a trauma alert even when their injuries were mild to moderate according to an ICD-9 Injury Severity Score (ICISS), who did not require surgery, were hospitalized less than 24 hours, and discharged to home were misclassified. Youth patients were misclassified 24.5%

of the time and their costs were 45.3% of total costs indicating misclassified youth patients cost more than had they been properly classified patients as having a mild or moderate injury. This was confirmed in the regression model, as misclassified patients increased cost by 86.9% compared to youth patients who had been properly classified.

Policy Implications

Despite the millions of youth who play sports in the United States, there have been few population level strategies for prevention of sports injury. Research needs included the assessment of sports injury by population to design appropriate injury prevention programs (Finch, 2012; Knowles et al., 2007). Patient factors associated with higher inpatient costs were older age and male supporting evidence from Yang et al. (2007) that these groups had more hospitalizations from sports injury. The present analysis suggests prevention programs should target sports, such as baseball, basketball, bike riding, football, rollerskating/skateboarding, and soccer as they have the total highest costs for both ED patients and inpatients. In addition, although counts were low, patients playing non-contact sports were found to have significantly higher costs and length of stay than patients playing full contact and limited contact sports. There were few observations compared with patients injured from contact and limited contact sports, but injuries from non-contact sports that required hospitalization were severe warranting further research into these sports.

The volume and ownership associations with TCs have implications for new TC policy in Florida. Designating TCs that will take patients from existing TCs may increase trauma response charges. Ownership type of TC will influence trauma response charges as well. Guidelines should be further developed to correctly triage youth. Firearm, motor vehicle traffic, and transport were significantly, positively associated with misclassification, meaning further considerations are indicated when triaging youth patients. This is consistent with Ciesla et al. (2015) that high energy transportation related injury mechanisms are associated with overtriage. It also confirms that mechanism of injury alone is not entirely effective to use for triage, as only some mechanisms are reliable as demonstrated by Lerner et al. (2011). Policies may also be developed to take youth with minor injury to trauma centers without the trauma alert or to local hospitals where a transfer can occur if needed (Lehmann et al., 2007; McSwain et al., 2011).

There is opportunity to lower healthcare spending in each of the areas of youth injury researched. The first way to lower cost is prevention of youth injury from sport, the second way is public policy that does not reward low volume TCs with paying high trauma alert response prices, and finally proper triage and trauma classification of injured youth. These suggestions are meaningful steps to reduce healthcare spending on injured youth without affecting quality or healthcare outcomes.

Future Research

Research is needed to identify which injury prevention programs would most benefit the targeted youth athletes and sports. There is also a research need to compare the costs of these programs with the cost savings from them to determine the most beneficial program(s) to implement as public health funding is a valuable, limited resource. Non-contact sports injuries need additional study in areas such in injury rates in this population to determine prevention priorities and how the injuries happened to design prevention efforts.

Further research is necessary to determine how trauma alert response charges are derived, the influence of nearby trauma center pricing on charges, and the effect of TC ownership on trauma activation levels. Research into why mild to moderately injured youth are trauma alerted would be beneficial in determining how to prevent misclassification and overtriage; which may include qualitative research with paramedics. Translational research is needed in all areas of youth injury to apply these and other findings into practice.

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Appendix A: Table of Counties of Omitted Hospitals

Table A1: County of Hospitals Omitted in Inpatient Time Regression Model

County	Number of Hospitals Omitted
Alachua	1
Broward	4
Charlotte	2
Collier	1
Duval	1
Highlands	1
Martin	1
Miami-Dade	4
Palm Beach	4
Pinellas	1
Okaloosa	1
Okeechobee	1
Orange	1
Osceola	2
Sarasota	1
Volusia	3

Appendix B: Table of Florida Trauma Centers

Table B1: Florida TCs with Level and Teaching Status, 2012 - 2014

AHCA #	Name	Level	Teaching	Trauma Charge Counts	Annual Counts
Not-for-profit					
100001	UF Health Jacksonville	I	Yes	2119	706
100006	Orlando Regional Medical Center	I	Yes	2970	990
100012	Lee Memorial Hospital	II	No	2237	746
100019	Holmes Regional Medical Center	II	No	2051	684
100025	Sacred Heart Hospital	II/Pediatric	No	1194	398
100075	St Joseph’s Hospital	II/Pediatric	No	521	174
100113	UF Health Shands Hospital	I	Yes	1616	539
100128	Tampa General Hospital	I	Yes	1822	607
100135	Tallahassee Memorial Hospital	II	Yes	703	234
100157	Lakeland Regional Medical Center	II	No	1302	434
100250	All Children's Hospital	Pediatric	No	15	5
110199	Nicklaus Children’s Hospital	Pediatric	Yes	38	13
120001	Arnold Palmer Medical Center	Pediatric	Yes	236	79
Government					
100017	Halifax Health Medical Center	II	Yes	1171	390
100022	Jackson Memorial Hospital	I	Yes	6535	2178
100038	Memorial Regional Hospital	I	No	447	149
100039	Broward Health Medical Center	I	No	2292	764
100086	Broward Health North	II	No	1211	404
For-profit					
100010	St Mary's Medical Center	I	No	2961	987
100026	Bay Medical Center Sacred Heart Health	II	No	169	56
100032	Bayfront Medical Center - St Petersburg	II	Yes	1312	437
100209	Kendall Regional Medical Center	I	No	3158	1053
100212	Ocala Regional Medical Center	II	No	1223	408
100213	Blake Medical Center	II	No	1344	448
100226	Orange Park Medical Center	II	No	397	132
100246	Lawnwood Regional Medical Center	II	No	2034	678
100256	Regional Medical Center Bayonet Point	II	No	1658	553
100258	Delray Medical Center	I	No	3257	1086