

**ANALYSIS OF PEDIATRIC UTILIZATION OF ORANGE COUNTY EMERGENCY
MEDICAL SERVICES AND SECONDARY HEALTH IMPACT ANALYSIS OF
PEDIATRIC TRAUMA**

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Introduction

Epidemiology of injury-related death

In the United States, trauma continues to be a significant public health problem and cause of preventable morbidity and mortality. According to the Centers for Disease Control and Prevention (2014), injury, both unintentional and violence-related, accounted for 51.3% of all deaths among 1 – 44 year olds, making injury the leading cause of death in this age group in 2011. It is estimated that 2.8 million people are hospitalized with an injury every year, and more than \$496 billion are spent in medical care and lost productivity secondary to injury each year (CDC, 2014; Finkelstein, Corso, Miller, & Associates, 2006).

In California, there were 17,201 injuries that resulted in death among an estimated population of 37,826,160 accounting for a mortality rate of 45.5 per 100,000 people in 2012 (California Department of Public Health, 2014). Most deaths due to injury occur in the Los Angeles, San Diego, Riverside, and Orange counties of southern California. In 2012, Orange County alone suffered 1,071 deaths among 3,071,933 people, which amounts to 34.8 deaths per 100,000 people (CDPH, 2014). Twenty of the total deaths that year occurred in children ages 0 to 14 (CDPH, 2014).

Trauma systems

Given the burden of morbidity and mortality secondary to injury, trauma systems have become important components in ameliorating the potentially negative effects of trauma on the population, and they have evolved substantially over the last four decades (Mullins, 1999). Defined as an organized approach to patients who are acutely injured which occurs in a defined geographic area and provides optimal care that is integrated

with local or regional EMS systems, the main goal of a trauma system is to enhance the health of the community by coordinating a well-integrated response to care of the injured patient through the provision of pre-hospital care, acute-care facility care, post-hospital care, and injury prevention education (Hoyt & Coimbra, 2007; American Association for the Surgery of Trauma, 2014). Indeed, trauma systems improve the quality and outcomes of trauma care, with evidence in the scientific literature showing that trauma systems are effective in reducing mortality by up to 15 – 20% (Lorch, Myers, & Carr, 2010; Mann, Mullins, Mackenzie, Jurkovich, & Mock, 1999; Mackenzie, 1999; Jurkovich & Mock, 1999; Mullins & Mann, 1999).

The triage of pediatric patients within trauma systems is based on the expectation that similar effects will occur for children (Mooney, Gutierrez, Chen, Forbes, & Zurakowski, 2013). Hospitalization of injured children has been shown to decrease more rapidly in states that implement trauma systems compared to states without, and more severely injured and brain-injured children are admitted to trauma centers in trauma system states following injury (Mooney et al., 2013). This suggests that trauma systems may 1) decrease potential complications and the need for hospitalization following injury, and, 2) result in more appropriate triage and transport of severely injured patients to facilities that can provide specialized care, such as pediatric neurosurgery, orthopedics, and intensive care.

The Orange County Trauma System

The trauma system has been in effect in Orange County since June of 1980, and early studies following the implementation of the trauma system showed the system was beneficial, resulting in decreased death rates following vehicular trauma, a reduction in

the proportion of potentially salvageable deaths, and an increase in appropriate surgical interventions for traumatized patients, with no significant change in the utilization of hospitals or emergency departments (West, Cales, & Gazzaniga, 1983; Cales, 1984; Cales, Anderson, & Heilig, 1985). More recent findings in the literature are consistent with these early results, showing that trauma systems generally improve outcomes (Mann et al., 1999; Mackenzie, 1999; Jurkovich & Mock, 1999; Mullins & Mann, 1999).

Currently, Orange County's trauma system incorporates three adult trauma centers (ATC): Mission Regional Medical Center (level II) in Mission Viejo; Western Medical Center (level II) in Santa Ana; and UC Irvine (UCI) Medical Center (level I) in Orange. UCI, as an adult trauma center with added qualifications (ATC-AQ), is the only center currently qualified to care for traumatized pediatric patients.

The Children's Hospital of Orange County (CHOC) has recently been approved as a designated level II pediatric trauma center (PTC) by Orange County Healthcare Agency Emergency Medical Services, and is planning to begin accepting pediatric trauma patients ages 0 – 14 years in the coming months. CHOC is unique in that it will have the capacity to provide highly specialized surgical care in the setting of a pediatric intensive care unit (PICU), as well as crucial longitudinal pediatric rehabilitation and support services for patients who suffer traumatic injury.

Health Impact Assessment: CHOC as a Level II PTC

Health Impact Assessments (HIA) have been defined as “a combination of procedures, methods, and tools by which a policy, program or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population” (National Research Council, 2011). Examples of the utility of the

HIA have been demonstrated in various publications (UCLA School of Public Health, 2014).

The purpose of this HIA is to evaluate the potential health effects that CHOC as a PTC II will have on pediatric patients, their families, and the Orange County and neighboring communities at large. Many hypothetical proximal and distal outcomes are plausible, some of which are illustrated in Figure 1. By reviewing the scientific literature, analyzing the OC-MEDS database, and consulting with experts in government, healthcare, and trauma systems, this HIA will inform physicians, government agents, community members, and other key stakeholders as to the key elements that a pediatric trauma center will address. Presumably, CHOC as a PTC II will help eliminate disparities in the care of injured children, a problem that has been reported in the literature previously (Petrosyan, Guner, Emami, & Ford, 2009).

It is the aim of this paper to provide a comprehensive, evidence-based presentation of the potential effects of a PTC on the Orange County and neighboring communities, generally, and on pediatric trauma patients in Orange County, specifically.

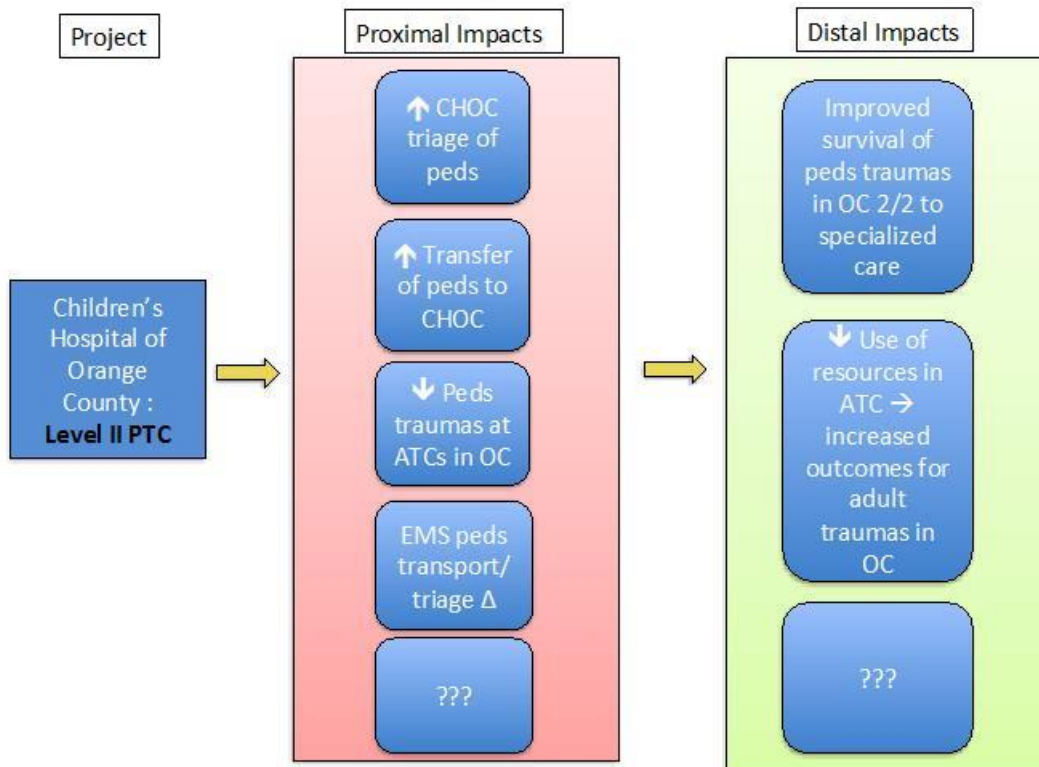


Figure 1. Logic framework demonstrating the potential proximal and distal impacts of CHOC as a level II pediatric trauma center.

Evidence regarding the impact of pediatric trauma centers

It has been estimated that between 40 – 70% of pediatric patients die prior to arriving at a facility that can provide definitive and intensive care for trauma patients (Acosta, Delgado, Gisoni, Raghunathan, D’Souza, Gilbert, Spain, Christensen, & Wang, 2010). Due to physiologic and anatomic differences as compared to adults, pediatric trauma patients have unique needs that must be considered early in their triage and transport to a facility capable of managing pediatric trauma patients (Junkins, O’Connell, & Mann, 2006; American College of Surgeons, 2014). Indeed, the American College of Surgeons acknowledges that “injured pediatric patients have special needs that are optimally provided in the environment of a children’s hospital with demonstrated expertise in, and commitment to, pediatric care and trauma care” (ACS, 2014).

Although trauma centers have been shown to improve outcomes among injured patients, controversy exists concerning the impact of PTCs and adult trauma centers (ATCs) on outcomes for children who suffer injury (Junkins et al., 2006; Petrosyan et al., 2009). Whether injured children have better outcomes at a PTC as compared to an ATC is an area of continued controversy, and research continues to evolve in this area. Despite this, some investigators have identified significant benefits and positive outcomes for children treated at PTCs, some of the results of which are discussed below.

Review of the Scientific Literature

In the early 1990s, research examining the effectiveness of pediatric trauma centers began to demonstrate the potential benefits of such a method of streamlined care for injured children. Nakayama, Copes, and Sacco (1992) reviewed the Pennsylvania state trauma registry data from 1986 – 1989 ($n = 4,615$, ages 0 – 15 y), and showed that the mortality rate was significantly higher in rural non-pediatric centers as compared to PTCs and urban non-PTCs. In addition, when stratified for probability of survival ($P(s)$) based on TRISS methodology, PTCs showed a trend toward higher survivability for patients with a $P(s)$ of 30 – 60% compared to other centers (Nakayama et al., 1992).

Cooper and colleagues (1993) compared data from 1989 for pediatric trauma discharge records in the state of New York ($n = 14,234$) with data from PTCs participating in the National Pediatric Trauma Registry ($n = 17,098$). Their results showed that PTCs more commonly treat children who have suffered more severe (higher ISS) brain and internal injuries compared to hospitals in a state without a trauma system. Moreover, they found that although fatality was similar in PTCs versus undesignated hospitals for most diagnoses for equal injury severity, overall survival was ten times

greater in PTCs for patients who suffered moderate (ISS 15 – 19) brain, internal, and skeletal injuries (Cooper, Barlow, DiScala, String, Ray, & Mottley, 1993).

In 1996, Hall, Reyes, Meller, Loeff, and Dembek reviewed data from the Cook County Hospital PTC, to assess differences in outcomes for pediatric trauma cases as compared to the Major Trauma Outcomes Study (MTOS) and the National Pediatric Trauma Registry (NPTR). For 1,797 children ages 0 – 15 y, they found a significant reduction in mortality for patients who sustained blunt trauma and were treated at a PTC as compared to the MTOS, but not the NPTR. In addition, this study was one of the earliest to report a low incidence of surgical intervention for blunt trauma to the liver (4%) and spleen (21%) for children treated at PTCs, compared to their reported 37 – 58% and 43 – 53% surgical intervention rates, respectively, for similar injuries in children treated at ATCs (Hall et al., 1996).

Potoka, Schall, Gardner, Stafford, Peitzman, and Ford (2000) conducted a retrospective review of 13,351 pediatric trauma patients ages 0 – 16 from the Pennsylvania Trauma Outcome Study registry (PTOS), comparing outcomes among the different types of trauma centers in the state, which included 2 PTCs, 5 ATCs with added qualifications to treat pediatrics (ATC-AQ), 6 level I ATCs (ATC I), and 13 level II ATCs (ATC II). The investigators found that overall mortality was lowest at PTCs, with ATC-AQs having a trend toward higher mortality. When stratified by ISS, children with ISS <15 treated at an ATC I had a higher mortality rate than PTCs; in addition, for an ISS >15, the mortality rate at PTCs was comparable to ATC-AQ, with ATC I and ATC II having a higher mortality rate than PTCs. Consistent with Hall et al. (1996), 10-14 year

olds with blunt trauma treated at PTC had lower MR than all others centers. Other findings included:

- Lower mortality rate at PTCs vs. ATC-AQ for neurosurgical interventions for moderate head injury (trend for lower mortality rate for severe head injury)
- More splenectomies performed at ATCs than PTCs, with the splenectomy mortality rate being lower at PTCs than ATC-AQs and ATC I
- More liver surgery at ATCs than PTCs, with the mortality rate being lower at PTCs than ATCs

Although considered important in the analysis of the impact of PTCs, overall mortality for injured pediatric patients only offers one lens from which to view outcomes for these patients. It is vital to consider how these patients fare after their initial resuscitation and stabilization, since they may require long term support to continue to lead productive, fruitful lives as they grow into adulthood. Potoka, Schall, & Ford (2001) again retrospectively examined the PTOS registry, this time assessing *functional* outcome for 2,087 severely injured (ISS >15) children ages 2 -16 among the various trauma centers in Pennsylvania. Measures of functional outcome included feeding, locomotion, transfer mobility, social interaction, and expression, and whether they were dependent or independent to perform these activities. Their results showed that at discharge, PTCs had a lower proportion of dependent children in the feeding, locomotion, social interaction, and expression domains as compared to ATC-AQs. As compared to ATC I, there were lower proportions of dependent patients in all 5 categories at PTCs. For head injuries,

functional outcome in all 5 categories was improved at PTCs vs. ATC-AQs and ATC I. Overall median length of stay (LOS) in the hospital was shorter at PTCs vs. all ATCs (Potoka et al, 2001).

Densmore and colleagues in 2006 conducted a retrospective review of the Kids' Inpatient Database for 2000, which encompassed data from 27 states ($n = 79,673$) to characterize pediatric trauma care by hospital types and identify associated outcomes within the 0 – 20 age range. They found that most pediatric patients tend to receive care outside of children's hospitals, and that mortality, length of stay, and total hospital charges were greater in children's units and adult hospitals as compared to children's hospitals; additionally, children's units in adult hospitals had the least desirable outcomes. Overall, and for children aged 0 – 10 y with a severe injury ($ISS > 15$), mortality was higher in children's units and adult hospitals versus children's hospitals for fractures, intracranial injury, and internal injury (Densmore, Lim, Oldham, & Guice, 2006).

Pracht et al. (2008) reviewed Florida's Agency for Healthcare Administration inpatient discharge database to compare outcomes among designated trauma centers (DTC) versus non-trauma centers (NTC), and furthermore, within DTCs, pediatric designated (PTC) trauma centers versus non-pediatric designated trauma centers (nPTC). After evaluating 27,313 patients ages 0 – 19 y between 1995 – 2004, they found that overall among 0 – 19 y, treatment in a DTC was associated with a 3.15% reduction in the probability of mortality versus a NTC; no difference was observed when stratifying for 0 – 15 year olds. Furthermore, within DTCs, an 8% reduction in the probability of mortality was associated with having received treatment in a PTC versus an nPTC, as

well as a 6% reduction in the probability of mortality for 0 – 15 year olds (Pracht, Tepas, Langland-Orban, Simpson, Pieper, & Flint, 2008).

Other investigators have specifically reported on the effect of receiving treatment in a facility with a designated pediatric intensive care unit (PICU). Farrell, Hannan, and Cooper (2004) analyzed children between 1994 - 1998 less than 13 years old (n = 8,180) in the New York State Trauma Registry who incurred blunt injuries, comparing hospitals with a dedicated PICU with facilities that did not have a PICU. Although no statistically significant differences in mortality rates were observed across hospital types, rates in hospitals with PICUs were lower than other hospitals except non-trauma centers, which cared for less severely injured children.

In 2010, Acosta et al. reported on the characteristics of 2,798 patients directly admitted to an ATC I with a PICU versus patients who were transferred to that study center during the years 2000 – 2007. In this study, 16.2% were transferred, with these patients being younger, having a higher median ISS, and a higher proportion requiring admission directly to the PICU. Interestingly, transfer patients encompassed a higher proportion of fall victims (31.3%) versus motor vehicle collisions (26.9%) than did the study center (16% vs. 59.1%), respectively, with head injuries being the most common injuries. 23.7% of transfer requests were denied due to lack of bed capacity, with requests primarily being made for a PICU, neurosurgery, and orthopedic intervention. Transferred patients were associated with public insurance or uninsured status, and drove longer miles to the study center. The overall median straight-line distance from out-of-catchment hospitals to the study center was 61.2 miles, versus 33.6 miles to the closest capable facility.

In 2013, Wang and colleagues reported on the California Office of Statewide Health and Planning Department patient discharge database covering the years 1999 – 2011, examining 77,874 patients ages 0 – 18 years old to assess the association between mortality and receiving care at a trauma center versus a non-trauma center, and within trauma centers, those receiving care at a pediatric trauma center versus an adult trauma center. Results showed that 67.1 % of patients received care in a trauma center, and half of these were older adolescents. The overall mortality rate was 5.3%, with a greater proportion of blacks and Hispanics, having poorer SES, and having public insurance receiving care in trauma centers. Trauma centers had a higher mortality rate versus non-trauma centers (6.1 vs. 3.8%). Only 25% of study patients received care in a PTC, and a marginal 0.64 percentage point increase (non-significant) was observed in the mortality rate for patients receiving treatment in a PTC versus an ATC (Wang, Saynina, Vogel, Newgard, Bhattacharya, & Phibbs, 2013).

Profile of Orange County

Understanding the population in Orange County is crucial in attempting to predict the potential impact of a PTC on the community. Below, baseline demographic data is presented, as well as an analysis of data from the OC-MEDS database concerning pediatric trauma and triage.

The Orange County Population

In 2013, Orange County had an estimated 3,114,363 residents (United States Census Bureau, 2014). There were approximately 990,000 households, with a mean of 3 persons per household (US Census Bureau, 2014). Approximately 20% of the population in 2010 was < 14 years old (6.4% 0 – 4y; 6.6% 5 – 9y; 7% 10 – 14y) (California State University Fullerton, 2014). By proportion, racial/ethnic groups consisted of whites

(44.1%), Hispanic (33.7%), Asian/Pacific Islander (17.2%) and blacks 1.5%; all other races made up 3.1% of the Orange County population.

In 2010, Anaheim, Santa Ana, and Irvine combined contained 837,287 of the Orange County population, accounting for 29% of the overall population (CSUF, 2014). Santa Ana held the largest proportion of children ages 0 - 14 per that city's population (25.6%), followed by unincorporated areas of OC (23.3%), and Rancho Santa Margarita (23.1%).

Review of the OC-MEDS database

The OC-MEDS database was retrospectively reviewed to collect pediatric patient data in Orange County from August 2013 to February 2014. The total number of pediatric calls requiring EMS services was 4,086. Most of the patients requiring emergency medical service were adolescents (11 – 14y, n = 1192), followed by toddlers (1 – 3y, n = 1152) and school-age children (6 – 10y, n = 864) (Figure 2).

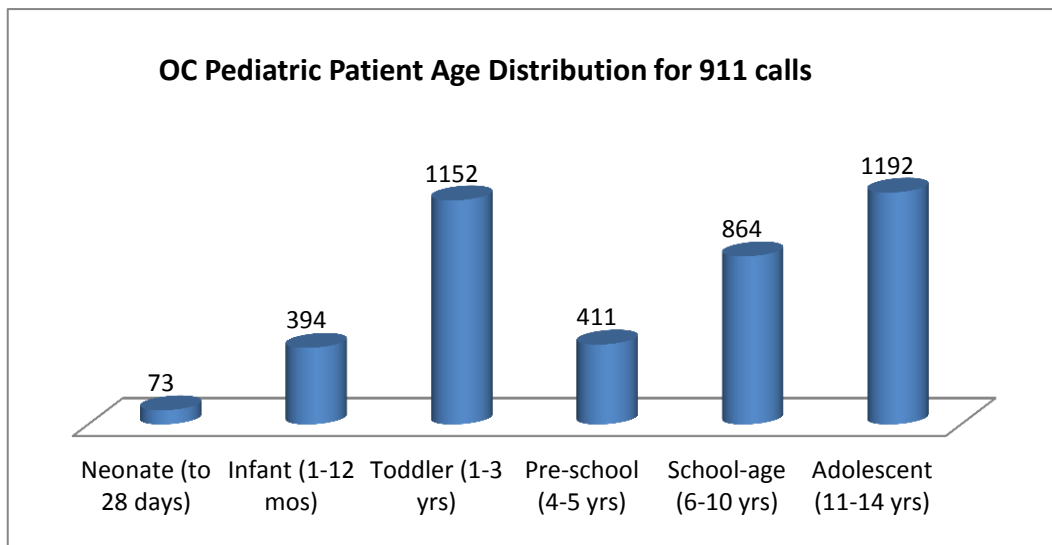


Figure 2. Pediatric patient age categories for 911 calls, Aug 2013 - Feb 2014.

Among most (92%) of the 911 calls made during the same time period, the top three “primary impressions” of the healthcare problem documented by healthcare personnel were: 1)

seizure, 2) traumatic injury, and 3) fracture/sprain (Figure 3). This data does not distinguish the number of seizures that may have been secondary to head/brain injury. Thus, the actual number of seizures as a primary neurologic problem might be lower, while the number of traumatic injuries (with a seizure as a sequelae) may be higher. Combined, the total percentage of traumatic calls among all pediatric patient calls was 31%.

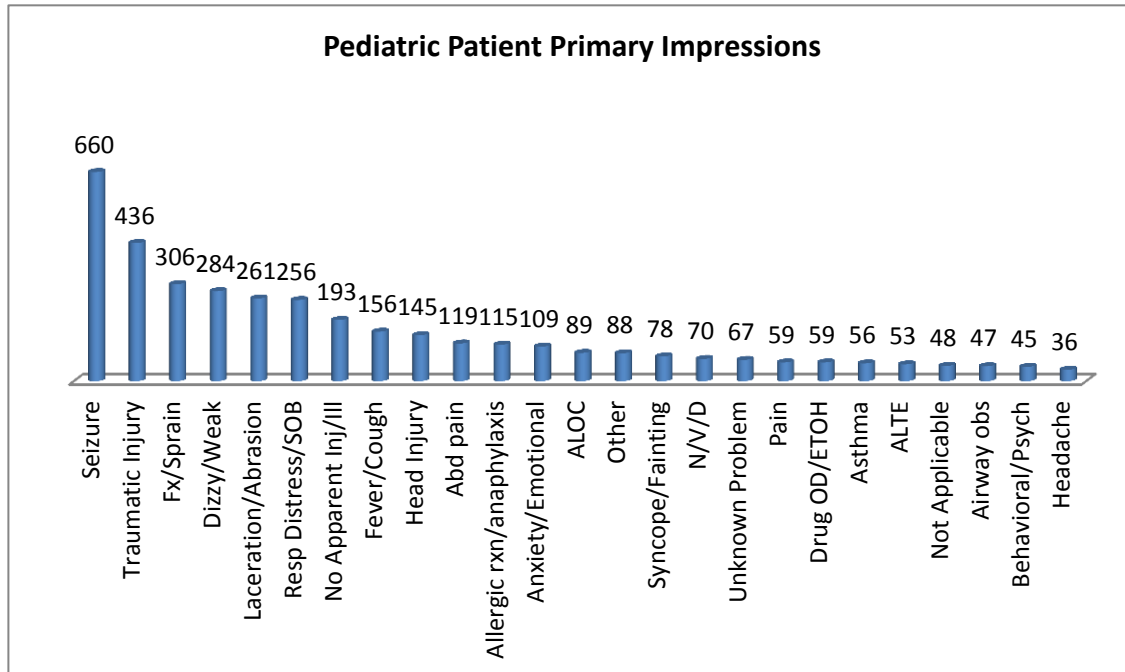


Figure 3. Top 25 primary impressions for 911 phone calls made, August 2013 to February 2014.

When examining pediatric patient disposition following arrival of paramedics, 37% (1517/4085) and 28% (1149/4085) required ALS and BLS during transport, respectively (Figure 4). For transported patients, the top three destinations for pediatric patients were CHOC (17%, 470/2781), Mission Hospital (13%, 364/2781), and Hoag Hospital (8%, 231/2781) (Figure 5).

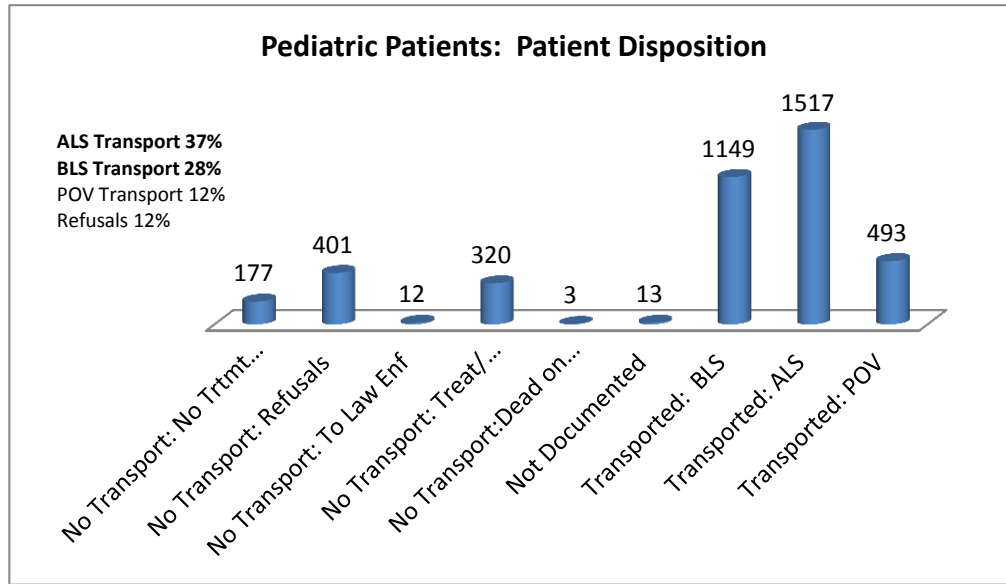


Figure 4. OC pediatric patient disposition, August 2013 – February 2014.

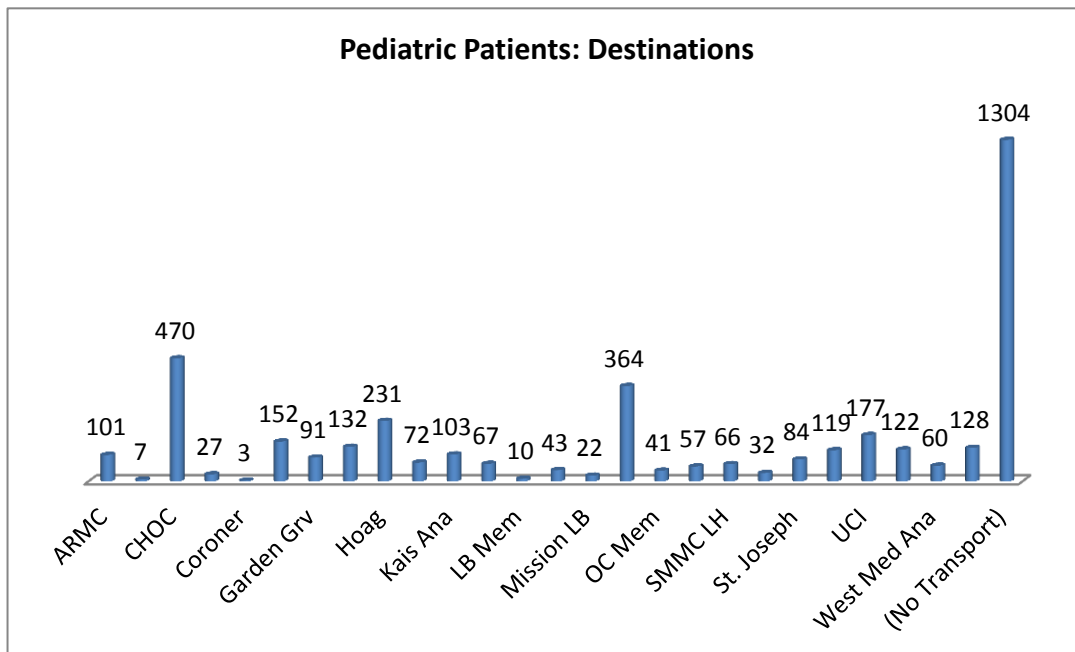


Figure 5. OC pediatric patient destinations, August 2013 – February 2014.

Figure 6 shows the type of injury sustained among all reported traumas (n = 1,149). 38% of the calls were secondary to a non-specified traumatic injury, followed by a fracture/sprain (27%, 306/1149), laceration/abrasion (23%, 261/1149), and head injury (13%, 145/1149). One traumatic arrest occurred (Figure 6).

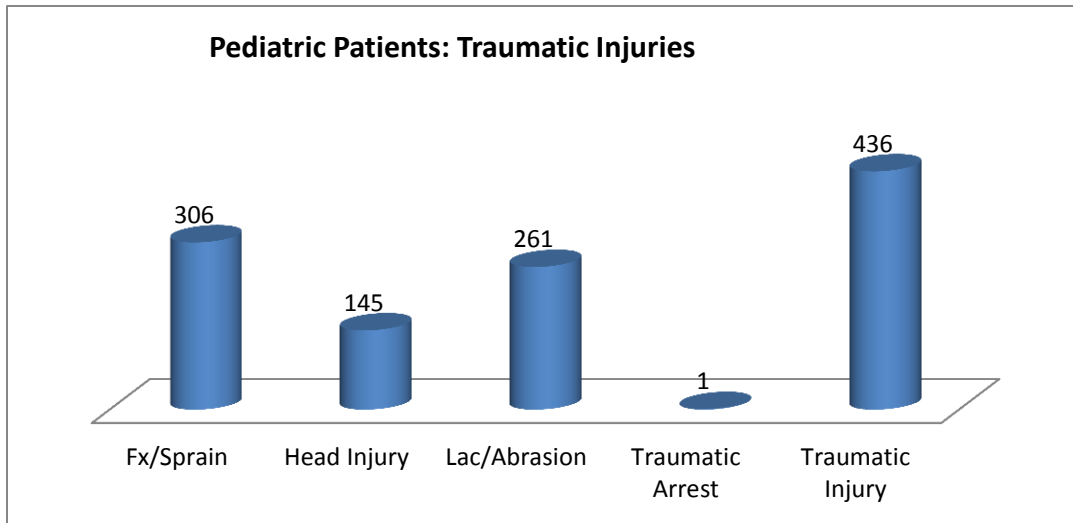


Figure 6. Types of traumatic injuries, August 2013 – February 2014.

Destination reasons are presented in Figure 7. The majority of patients (34%) were transported to a specific location due to the facility being the “closest”. 30% did not document a reason, and 18% were transported due to patient/family preference. Figure 8 details a comparison of the destinations of all patients versus patients who sustained traumatic injuries. Although most pediatric patients are transported to CHOC overall, the largest proportion of traumatic cases are transported to Mission Hospital, followed by UCI and Western Medical Center in Santa Ana.

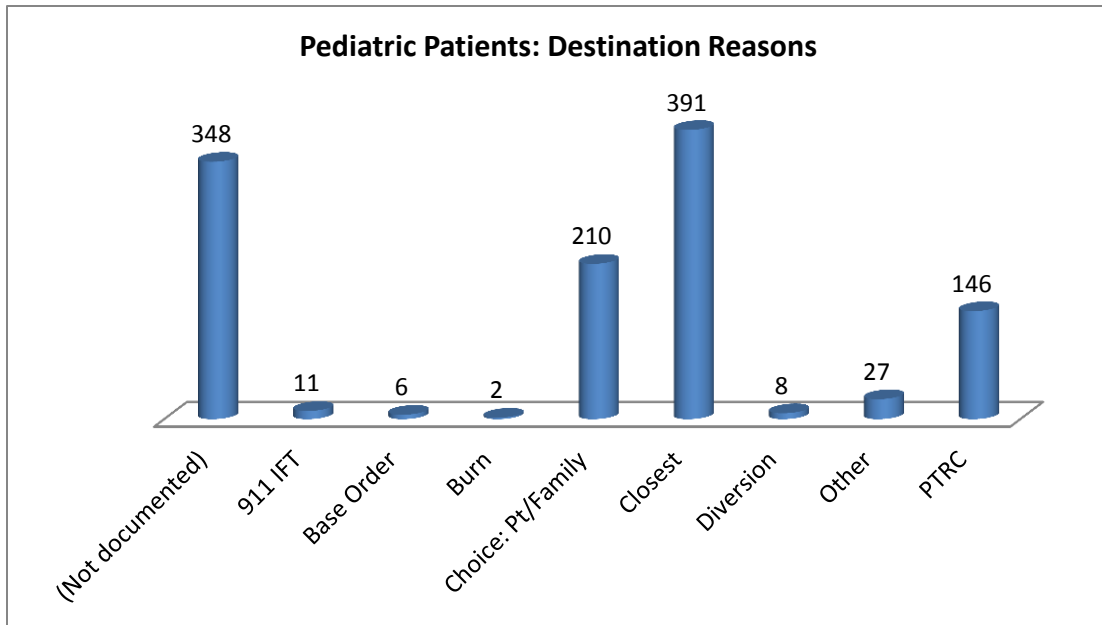


Figure 7. Reported reasons for destination, August 2013 – February 2014.

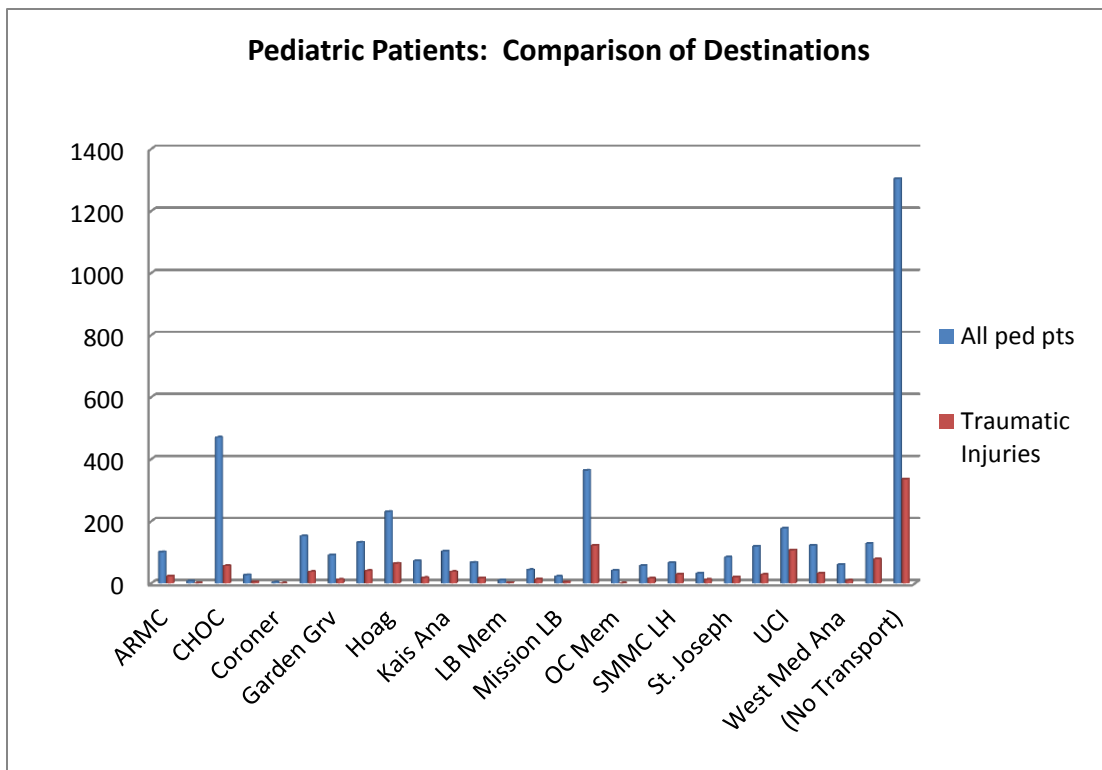


Figure 8. Comparison of destinations for all hospitals, all versus traumas.

Interfacility transfer data was summarized for 2010 – 2013 and is presented below. For inter-facility transfers, trauma continues to be the primary reason (Figure 9), with 74% of the transfers going to UCI, followed by Western Medical Center SA (20%), and Mission (6%) in 2013 (Figure 10).

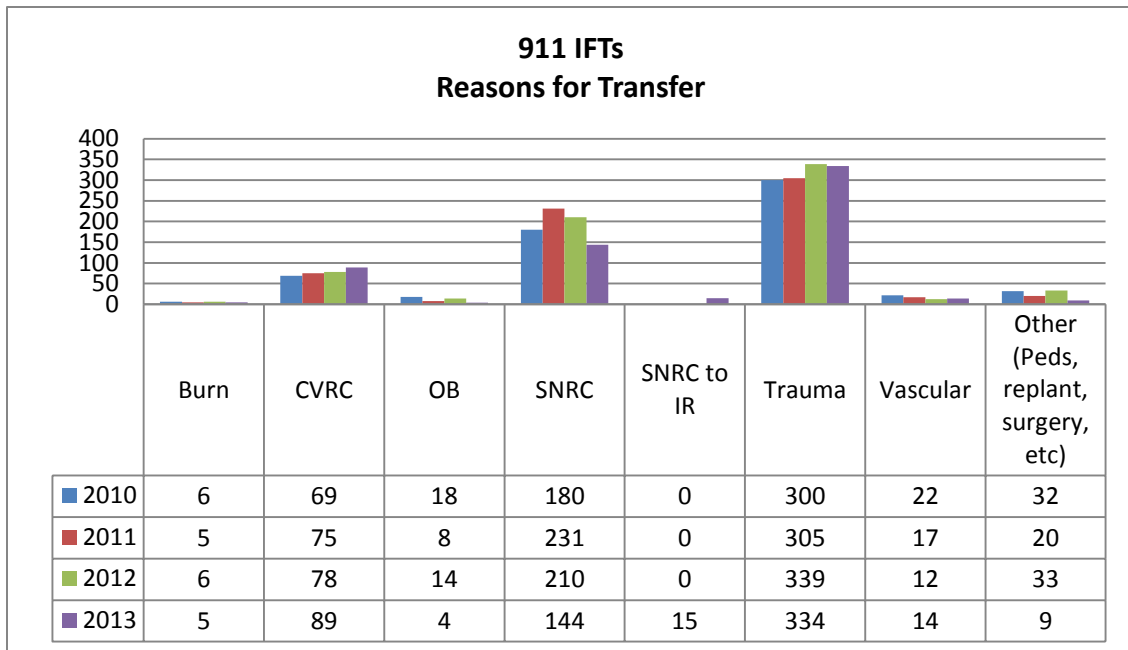


Figure 9. Reasons for inter-facility transfer (IFT) in Orange County, 2010 - 2013.

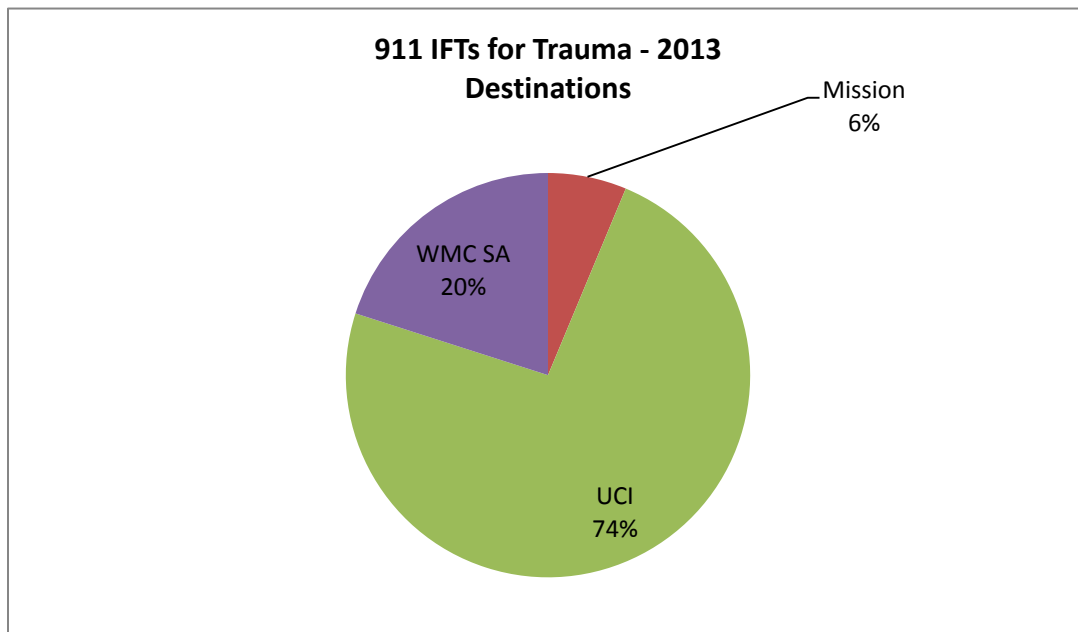


Figure 10. IFT transfer destinations for trauma, 2013.

To further characterize the distribution of pediatric trauma in Orange County, a heat map was generated for patients with ages less than or equal to 14 y, with a primary or secondary impression of traumatic injury, and whose destination was a paramedic trauma receiving center. The data span the period from November 2013 – November 2014. Figure 11 shows that most pediatric trauma occurs in Anaheim and the area surrounding Santa Ana. Isolated pockets of concentrated pediatric trauma exist in Westminster, Fountain Valley, Huntington Beach, and Laguna Beach. Figure 12 shows the absolute counts of pediatric traumas for the same time period. Consistent with figure 11, Anaheim, Huntington Beach, Westminster/Garden Grove, and Santa Ana reported the highest numbers of trauma across the county.

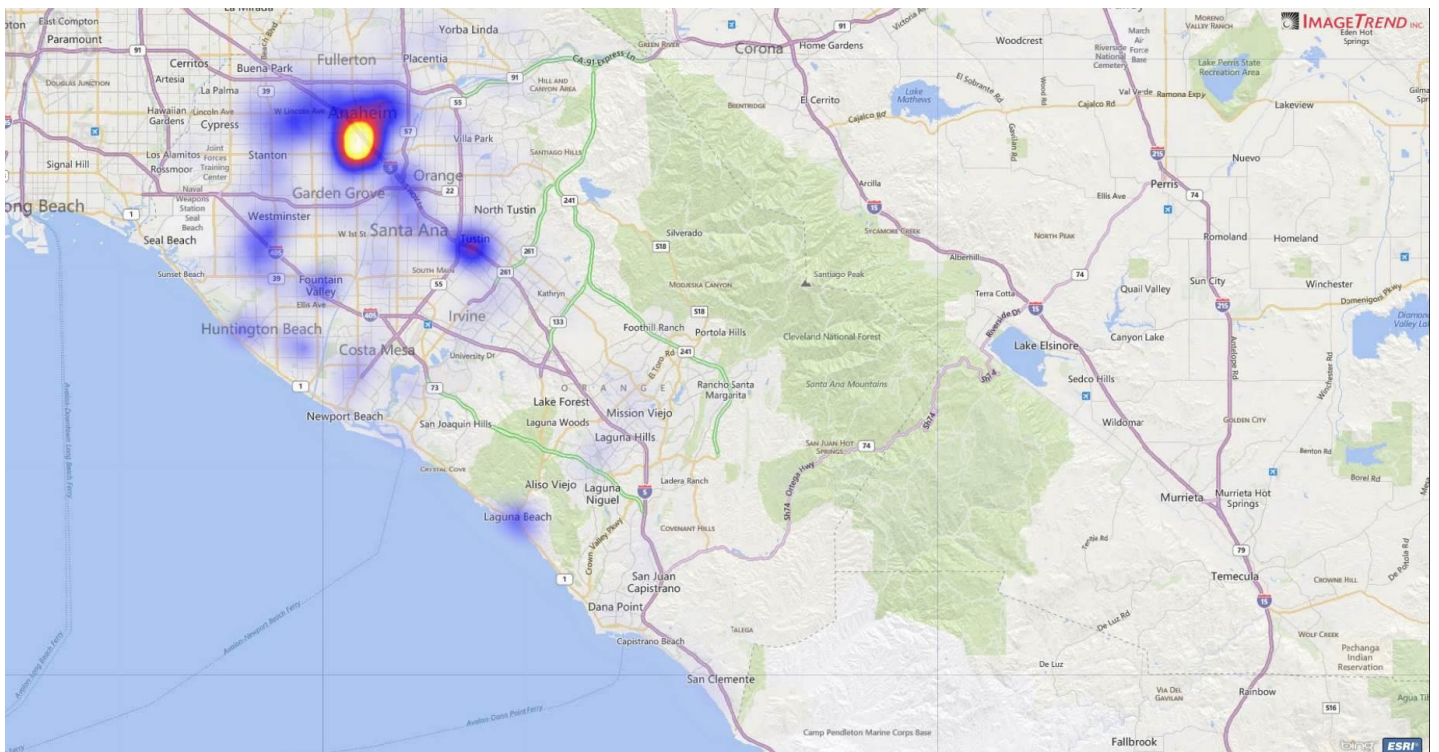


Figure 11. Heat map of pediatric trauma in Orange County, 11/2013 - 11/2014.

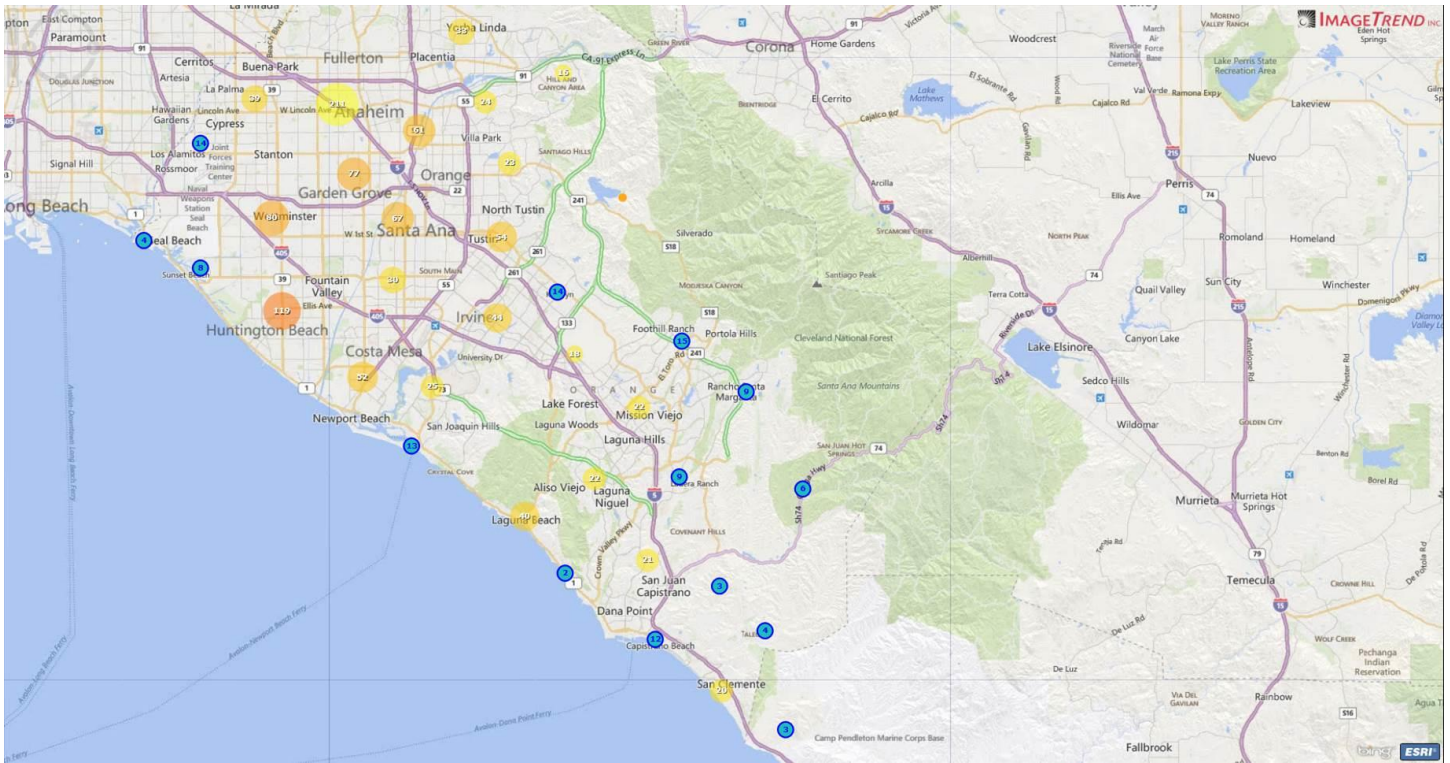


Figure 12. Absolute counts of pediatric traumas in Orange County, 11/2013 - 11/2014.

Discussion

Injury continues to be the number one cause of death in the United States (CDC, 2014). With respect to children, injury results in more death than all other causes combined, with a greater number of years of potential life lost than SIDS, cancer, and infectious diseases (American Academy of Pediatrics (AAP) and Pediatric Orthopaedic Society of North America (POSNA), 2008). The financial costs of caring for injured children are tremendous; it has been estimated that childhood injury results in approximately \$14 billion in lifetime medical spending, \$1 billion in resource costs, and \$66 billion in present and future work losses (AAP & POSNA, 2008).

Strategic, targeted efforts to prevent injury and care for those who suffer trauma are crucial components of trauma systems. Certainly, trauma systems have played an

important role in mitigating the negative consequences associated with traumatic injury, with data showing that their implementation reduces death by 15% - 20% (Lorch, Myers, & Carr, 2010; Mann, Mullins, Mackenzie, Jurkovich, & Mock, 1999; Mackenzie, 1999; Jurkovich & Mock, 1999; Mullins & Mann, 1999). Adult trauma centers (ATC) are important adjuncts within modern trauma systems. With regard to the care of the pediatric trauma patient, ATCs with added qualifications (ATC-AQ) have proved useful in managing pediatric trauma. Specifically, pediatric trauma centers (PTC) are devoted entirely to the care of the pediatric trauma patient. Their utility in regard to improving outcomes as compared to ATCs has been studied in the past, with results generally showing that PTCs improve outcomes along a number of variables.

From the above studies, several important generalizations regarding the potential benefits of a pediatric trauma center can be made. Notably:

- PTCs may have lower overall mortality rates for traumatized children than ATCs
- PTCs have lower mortality rates for spleen and liver injuries
- PTCs more commonly treat more severely injured children, particularly with brain/head, internal organ, and musculoskeletal injuries
- PTCs tend to manage traumatized children more conservatively than do ATCs
- PTCs lead to improved functional outcome at discharge as compared to ATCs
- Length of stay and total hospital charges for trauma cases are lower in children's hospitals than children's units in general hospitals and adult hospitals
- Pediatric trauma patients tend to receive more care outside of PTCs
- Receiving care in a dedicated PICU may be associated with a lower mortality rate
- Disparities exist in the triage, transport, and existence of PTC facilities able to provide definitive care of injured pediatric patients
- Racial/ethnic minorities, patients with low socioeconomic status, and patients with public insurance tend to receive care in trauma centers

The American Academy of Pediatrics recognizes that the unique needs of children must be integrated into trauma systems, with the call for every state to identify appropriate facilities with proper resources to care for injured children and the provision of necessary procedures to monitor the care of injured children (AAP & POSNA, 2008). Consistent with these recommendations, the National Expert Panel on Field Triage has developed an algorithm to guide providers who treat trauma patients (Figure 13) (CDC National Expert Panel on Field Triage, 2012). After initial assessment, any patient (including pediatrics) with a derangement in vital signs or specific types of injuries is to be transported to a trauma center with the highest level of care within the trauma system. Where the pediatric patient is known to have fallen greater than ten feet or 2-3 times the height of the child, the patient is to be transported to the *closest* trauma center. Generally, any child who suffers traumatic injury should be triaged preferentially to a pediatric-capable trauma center.

Based on the above findings regarding the impact of PTCs on pediatric trauma patients, it is expected that the implementation of CHOC as a level II PTC to serve Orange County and surrounding communities as a regional PTC will result in similar, beneficial outcomes for pediatric patients.

Models for pediatric trauma triage in Orange County

Several options to adapt the current Orange County trauma system with CHOC as a level II PTC are considered in this report and are discussed below in some detail.

Where available, consideration of the scientific data and consultation with experts in the field is used to inform how each of the theoretical models might best serve the

community. It is important to note that no perfect model exists, and the field concerning PTCs is very much in evolution. With respect to CHOC as an upcoming level II PTC, and

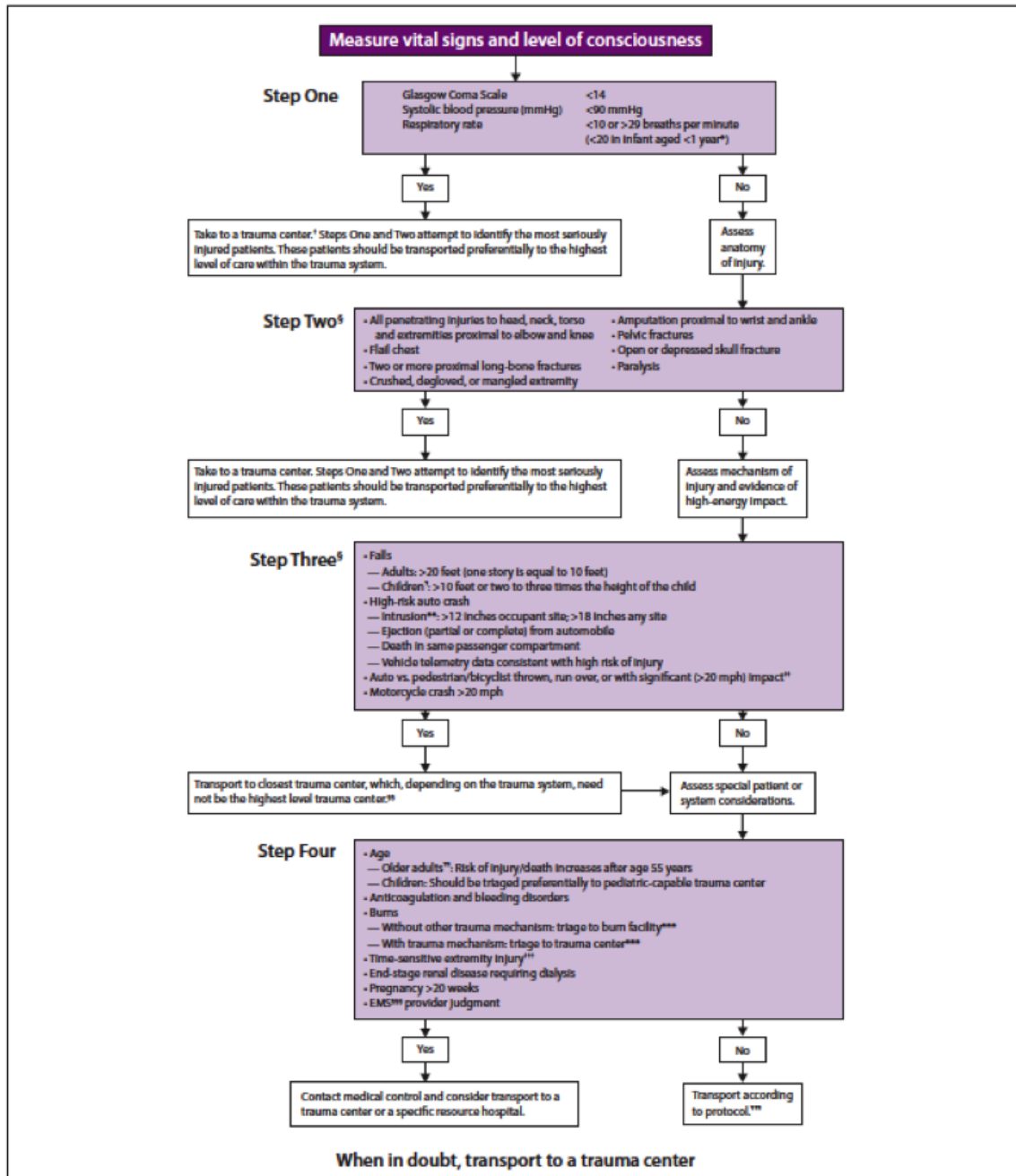


Figure 13. Field Triage Decision Scheme, United States, 2006. From: NEPFT, 2012.

extant trauma centers in Orange County, three models are proposed. In particular, pediatric trauma cases:

- 1) can be managed with CHOC as the *only* receiving center for Orange County.
- 2) can be managed with CHOC *and* UCI as the receiving centers for Orange County.
- 3) can be managed by triaging and transporting patients to the nearest capable trauma center, which includes CHOC Orange, UCI, and CHOC Mission.

Model 1: CHOC as the only receiving pediatric trauma center for Orange County

Review of the scientific literature supports the triage and transport of pediatric trauma patients to a local and/or regional PTC where available (ACS, 2014; CDC National Expert Panel on Field Triage, 2012; AAP & POSNA, 2008.). With this option, CHOC would be the primary center evaluating and managing all pediatric trauma in Orange County and surrounding communities. Interestingly, our data shows that most children in the county are currently primarily transported to CHOC Orange.

CHOC recently opened its doors in 2013 as a Pediatric Emergency Department, with administrators estimating approximately 36 admissions to the ED per day (Stratton). However, since their opening, CHOC has received greater than 200 (non-trauma and trauma) ED admissions per day, which is more than 5 times the initial estimate. Although data have not been collected, it is reasonable to conclude that this input is creating a significant strain on physicians and staff, as well as requiring a considerable amount of hospital resources to care for these admissions. Furthermore, with this model, specifically transporting *more* trauma cases to CHOC's ED for primary evaluation will further strain providers and drain precious resources. This will result in substandard care for pediatric patients, which may affect a variety of different outcomes.

Another important variable to be considered is the distance a pediatric trauma patient would need to be transported within this model. The southernmost city in Orange County is San Clemente, which is approximately 31 miles from CHOC. Under ideal traffic conditions, it would take approximately 32 minutes for a patient to be transported to CHOC. Considering the additional time that elapses post-trauma while waiting for EMS to arrive, it could easily take greater than 45 minutes for a patient to be transported to CHOC Orange, which approaches the limits of the “golden hour” for pediatric patients. The golden hour refers to the critical period in the care of trauma patients during which provision of appropriate care in a timely fashion may limit morbidity and mortality (Little, 2010).

A final important consideration worth noting with CHOC Orange as the only receiving center is how to manage, for example, a *family* that has undergone a motor vehicle accident. It would be less than ideal to separate the family unit by sending adults to an ATC and children to a PTC during such a critical period in both treatment and subsequent recovery. However, under this model there would be no other option but to separate the family for appropriate management in the above or a similar scenario.

Thus, utilizing CHOC as the only countywide receiving center for pediatric trauma conceivably would have a potentially negative impact for the reasons described above, as well as other unforeseeable reasons.

Model 2: CHOC and UCI as the receiving centers for Orange County

Currently, UCI maintains status to treat pediatric trauma patients as a level I ATC-AQ. CHOC Orange and UCI are approximately 2.2 miles apart. Such a model, which utilizes both trauma centers, would potentially reduce the burden of over-triaging

that CHOC might face were it the only receiving center for the entire county. In addition, there would be no need to separate families who have been involved in a MVA, as the entire family unit could be transported to UCI for management.

However, as in the above example under model 1, pediatric patients who would be transported from the furthest city in South Orange County (San Clemente) would elapse greater than thirty minutes under ideal traffic conditions to be transported to either CHOC or UCI given their proximity to each other. With the theoretical considerations regarding the golden hour detailed above, this scenario would again be less than beneficial for the pediatric patient who has suffered a devastating injury. CHOC at Mission Regional Medical Center in South Orange County, and important trauma center capable of managing these patients, would be bypassed as patients are transported to CHOC Orange or UCI, an unethical practice from both a medical-surgical and public health perspective.

Thus, utilizing CHOC and UCI as the only countywide receiving centers for pediatric trauma conceivably would have a potentially negative impact, as a disparity in the triage and transport of South Orange County patients to CHOC Orange and UCI, both centers which are in north-central areas of the county, would be created.

Model 3: Transport patients to the nearest trauma-capable receiving center.

The American College of Surgeons (2014) and the CDC National Expert Panel on Field Triage (2012) recommend that patients who suffer trauma, including pediatrics, be transported to the nearest facility capable of managing such patients. Where available, pediatric patients should be transported to a PTC or ATC-AQ. This model is currently in practice within Orange County's trauma system and incorporates UCI, Western Medical

Center, and Mission Hospital as receiving centers. Only UCI and Mission are capable of managing pediatric patients. Under model 3, CHOC Orange, UCI, and CHOC Mission Hospital would serve as the receiving centers for all pediatric traumas in the county, and Western Medical Center would defer all pediatric traumas to CHOC Orange. Consistent with the above recommendations, review of the OC-MEDS database shows that the primary reason for destination location was the facility being “closest”, a guideline that is already in practice.

An important advantage with this model is that cities in South Orange County could transport pediatric trauma patients to CHOC at Mission. Using our example as above, patients in San Clemente would be approximately 12 miles from CHOC mission, which amount to an estimated 15 minutes away. Seal Beach, the furthest city to the west of Orange County, would preferentially transport patients to UCI or CHOC, which are approximately 15 miles apart or an estimated 20 minutes of driving time. La Habra, the northernmost city, is approximately 15 miles away from UCI, or an estimated 20 minutes. Using similar predetermined estimates, all cities in the county would be assigned a specific pediatric trauma receiving center, based on shortest distance and shortest estimated time to transport patients. Given the above examples of cities at extreme locations in the county, it is reasonable to predict that transport times would be similar or less given that remaining cities in the county are closer distances to the three county-wide pediatric capable trauma centers.

Our data shows that most pediatric trauma is concentrated in Anaheim, Santa Ana, and Garden Grove. Conveniently, these cities are located near major freeways, which facilitates transport to either CHOC Orange or UCI under the current model. As

described above, having both UCI and CHOC Orange in close proximity would theoretically allow for diversion of patients to UCI, thus reducing the burden on CHOC.

Our data also showed that most EMS call during our study period occurred for adolescents (11 – 14y), followed by toddlers (1 – 3y). Another option within model 3 would be to develop a triage strategy where older adolescents, who are presumably more mature, are preferentially treated at UCI, while toddlers are treated at CHOC, which is designed to provide crucial longitudinal and child life services for younger children. Similarly, another option within this model would be to transfer severely injured children from UCI and CHOC Mission to CHOC Orange following stabilization for more specialized care and long term management.

Conclusion and Recommendation

Based on the above assessment, we conclude that development and implementation of the Children’s Hospital of Orange County in the city of Orange, CA, as a level II pediatric trauma center will have a lasting positive health impact on children who suffer traumatic injury in our community, specifically, and in surrounding communities, generally. Incorporation of CHOC into Orange County’s existing trauma system will best serve the needs of the community under model 3 as detailed above, and we recommend that pediatric trauma patients be triaged and transferred by EMS services to the nearest pediatric capable trauma center, which includes CHOC Orange, UCI, or CHOC Mission.

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