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Retrospective database review of health care for traumatic brain injury pediatric patients

Smit Prafulchandra Shah, Rachana Tyagi

ABSTRACT

Aims: To assess changes in trends of health care for TBI patients aged 0–15 locally from 2009 to 2014 in a local university hospital. Methods: Retrospective review of local trauma database from 2009 to 2014 after IRB approval. Patients in the trauma database less than 16-year-old from 01/2009 to 12/2014 were included in the study. The sample size for the study was 601 pediatric patients. Frequency analysis of TBI was done. Distribution and percentages for types of TBI, insurance-coverage and mechanism of injury were also evaluated. Results: Health maintenance organizations (HMOs) were the major insurance providers for patients with falls, sports related injury, assaults and suicide. In addition, car insurance was the majority insurance provider in motor vehicle accidents (MVA) and Pedestrian accidents. Medicaid coverage by itself was higher in assaults, suicide and falls but was a minor contributor in sports, MVA and pedestrian accidents. Furthermore, HMOs and Car Insurance were significantly high in age 4 to 10 and 11 to 15 and HMO and Medicaid higher in age 0 to 3. HMOs were the most predominant form of insurance coverage when insurance coverage was analyzed yearly. There was an overall decrease in the average length of stay from 2009 to 2014 (Negative correlation of r = -7073. However, the LOS for each diagnosis was not significantly different. Majority of patients had concussion with mostly being disposed to Home. In addition, very few patients with concussion with multiple co-morbidities like subdural and epidural were disposed to OR for surgery after CT diagnosis. Patients with SAH mostly were disposed to PICU. The distribution of ages varied by type of injury with age 9 to 15 highest for epidural hematoma, skull fractures, contusions, subarachnoid hemorrhage and concussion. Public buildings, recreational places and street related injuries were increasing for ages 4 to 10 and 10 to 15 years. For all age groups, Peds and ICU plus PICU were the most common places for admission and there were very few dispositions to floor, ICU and OR. Finally, of all the imaging (75 percent of total sample) that was performed 68 percent were positive and 32 percent were negative. Conclusion: We note significant trends in the patterns of admission, diagnosis and injury. These changes could be related to the new insurance exchange program with better accessibility of health care along with an increase in Car Insurance coverage. The lower incidence of sports related injuries could be due to increased awareness and prevention efforts amongst parents and teenagers because of high school education programs. Changes in the trauma service protocol for management of pediatric head injury are likely responsible for our decrease in LOS. Further validation is required after analysis of procedures and outcomes through which we can determine whether it's the efficiency of health care delivery or whether healthier patients are admitted which is leading to the decreased LOS.

Keywords: Brain, Diagnosis, Insurance, Length, Stay, Traumatic

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INTRODUCTION

Traumatic Brain Injury (TBI) is a growing public health issue in the United States. It is caused by an external mechanical force that results in temporary cognitive & physical impairment along with diminished or altered state of consciousness. Globally, TBIs are an ever growing public health and economic burden that leads to increased health care costs which warrants early detection and timely intervention to improve prognosis [1]. As per the Centers for Disease Control (CDC), the number of hospitalizations and emergency department ED visits for TBI have been consistently increasing from 83 to 92 and 421 to 716 per 100,000 people respectively in the US between 2001 and 2010 [2]. Furthermore, patients who were unable to follow commands in the ED secondary to TBI were 6.9 times more likely to die, with an average life expectancy (LE) reduction of 12.2 years [3].

In the context of pediatric TBI, the etiology of the injury was determined to be age dependent in which infants & toddlers were the most susceptible to falls whereas preschool & school age children were more prone to pedestrian accidents involving a vehicle [4]. These injuries require intensive use of healthcare resources. A previous multicenter prospective study performed by Quayle et al. demonstrated that amongst children who had mild to moderate TBI, approximately 43% of them underwent more than one neurosurgical procedure [5]. In addition to initial TBIs, recurrent TBIs exacerbate post concussive symptoms including decreased cognitive ability and disability [6].

Sport-related TBIs in older children more commonly lead to repetitive insults that have demonstrated to have a higher rate of 'CTE (Chronic Traumatic Encephalopathy)' in not only concussive or sub-concussive injury but also in other injuries as well [7]. Increased public awareness of concussion and brain injuries has occurred due to the significant publicity of long-term cognitive deficits, depression and even suicides of prominent NFL players, the class action suit brought by the players union against the NFL, and education campaigns by many medical organizations, the CDC and the 'Heads Up football program and NFL-USA football partnership' [8]. Schools have responded by incorporating concussion education into the curriculum, successfully lowering the rates of sports related injuries [9].

Previous research has demonstrated the importance of neuroimaging in managing TBI patients in guiding appropriate surgical therapy by categorizing patients into mild to severe categories [10]. Early detection and quick intervention in TBI patients is extremely important in order to avoid major complications like increased ICP (Intracranial Pressure) secondary to cerebral edema which is frequently seen in TBI patients [11]. Continuous ICP monitoring has been correlated to lower mortality rates in severe TBI patients [12]. For minor pediatric head injuries, routine surveillance imaging following discharge alone may be sufficient in the great majority of cases.[13].

Even though not assessed by our study, the importance of pre-hospital care in TBI patients has also been demonstrated to be extremely important. A study performed in Arizona demonstrated that increased emphasis on pre-hospital TBI intervention which included improved protocols with pO2 measurement, PCO2 monitoring and post intubation status of PCO2 in EMS training led to reduced morbidity and mortality from TBIs [14]. Attention to detail during the critical period after admission to the ICU also improves outcome. Adherence to clinical indicators has been demonstrated improved GCS scoring as well as discharge survival. For instance, "Three indicators were associated with survival: absence of prehospital hypoxia (adjusted hazard ratios, 0.20; 95% CI, 0.08–0.46), early ICU start of nutrition (adjusted hazard ratios, 0.06; 95% CI, 0.01–0.26), and ICU Paco2 more than 30 mm Hg in the absence of radiographic or clinical signs of cerebral herniation (adjusted hazard ratios, 0.22; 95% CI, 0.06–0.8)" [15].

Obamacare also has increased the insurance coverage rates of the public by 2011-2012 during which it was implemented. This is not only expected to increase patient care but also increase the number of hospital visits for major medical conditions. Therefore, changes in the pattern of admissions, diagnosis and treatment of brain injury are expected over time. Like previous studies, by performing a multifactorial analysis in our study we also expect to explore better ways of classifying TBI patients based on mechanism of injury, pre-hospital as well as hospital based interventions and post treatment health status which in turn can lead to improved prediction of outcomes in TBI patients [16,17,18]. In this study we evaluate the effect of factors & sub factors on TBI that include (1) Mechanism of Injury vs Insurance type, (2) Insurance vs Age, (3) Insurance coverage per year, (4) Length of stay vs years for ages 0 to 15, (5) Average LOS for each MOI per year, (6) Diagnosis vs Disposition, (7) Diagnosis vs Age, (8) MOI vs Age group, (9) MOI per year, (10) Age vs ED Disposition, (11) Age vs location of injuries and (12) CT findings including percentage and true positive rate for each diagnosis.

MATERIALS AND METHODS

Retrospective review of patients in a local University Hospital trauma database from 2009 to 2014 was performed using PRISM software. Sample of population used was 601 pediatric patients in local trauma database younger than 16 years old from 01/2009 to 12/2014. Frequency analysis of TBI done by year, gender, race & hospital region. Distribution and percentages for types of TBI, insurance-coverage and mechanism of injury were also evaluated. Different factors assessed include (1) MOIs including falls, assaults, sports, suicide, assaults, pedestrian accidents, (2) insurance types including blue cross, Medicaid, car insurance and HMO, (3) length of stay, (4) different diagnosis including skull fracture, concussion, sub arachnoid hemorrhage, contusion, subdural and epidural hematomas, (5) dispositions floor, home, PICU and OR, (6) location of injuries home, public building, recreational and street and (7) CT findings along with its true positive rate. IRB approval was acquired.

RESULTS

From Diagnosis vs Age analyses demonstrated age group 9 to 15 years to have a higher incidence of Epidural Hematoma, Skull Fractures, Contusions, Subarachnoid hemorrhage and Concussion (Figure 1). However, age group 0 to 3 was highly susceptible Subdural Hematoma. Age 4 to 8 was the least susceptible to these injuries. From Diagnosis vs Disposition (percentages): Majority of home dispositions were concussion very few of which were taken to OR secondary to multiple medical comorbidities (Figure 2). All of the ICU dispositions were skull fractures. Majority of floor dispositions were subdural hematomas.

From Figure 3, Age vs ED disposition analyses demonstrated ICU be the major dispositions for all age groups. Least amount of dispositions were on floor and OR. From Figure 4, Age vs location of injuries analyses demonstrated age 0 to 3 to have highest incidence of injuries at home vs age 4 to 10 and 11 to 15 to have highest incidence in street related injuries. As the patients got older, there was a shift in trend of more injuries outside of home i.e. street, recreation and public buildings as compared to inside home.

From Figure 5, we can see MVAs and Falls were predominant mechanisms of injury for every year from 2009 thru 2014. From Figure 6, age groups 9 to 15 had the highest number of MOIs as compared to ages 0 to 3 and 4 to 8 years. From Figure 7, we can see an overall decrease in the LOS over 6 years with negative regression of r equal to (-0.71). However, from Figure 8, when we look at LOS for each diagnosis every year, there was no significant change in LOS annually.

From Figure 9, mechanism of injury vs insurance type, HMOs were majority of insurance providers for patients with falls, sports related injury, assaults and suicide. Car insurance was majority insurance provider in MVA and Pedestrian accidents. Medicaid coverage by itself was highest in assaults, suicide and falls but was a minor contributor in sports, MVA and pedestrian accidents. From Figure 10, number of patients per insurance type based on type of insurance. HMOs and Car Insurance being significantly high in all age groups. Also the distribution of patients from age group 0 to 3 and 4 to 10 was identical with Medicaid being identically covered in all three age groups. From Figure 11, HMOs were predominant form of insurance coverage for all 6 years.

From Figure 12, of all patients that underwent CT scan to detect bleeding sources from SAH, EDH, SDH and Skull Fx i.e. 75 percent of the total sample, 68 percent were positive and 32 percent were negative. The true positive rate based on our analysis for each diagnosis was as follows (includes mutiple imaging studies for same etiology): SAH was 91%, Epidural Hematoma 97%,

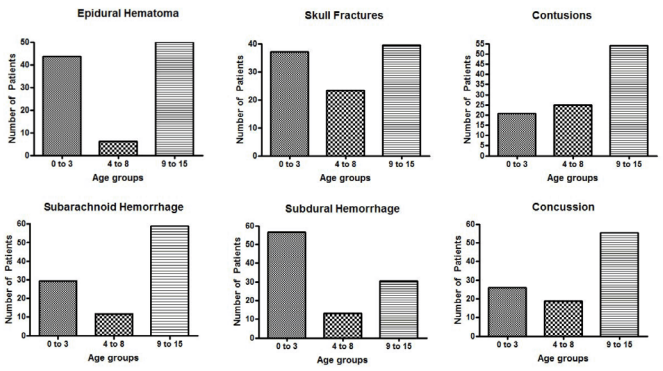

Figure 1: Distribution of number of patients per age group: age 9 to 15 highest for epidural hematoma, skull fractures, contusions, subarachnoid hemorrhage and concussion. However, subdurals were highest amongst 0 to 3. Age 4 to 8 was the least susceptible to any injuries.

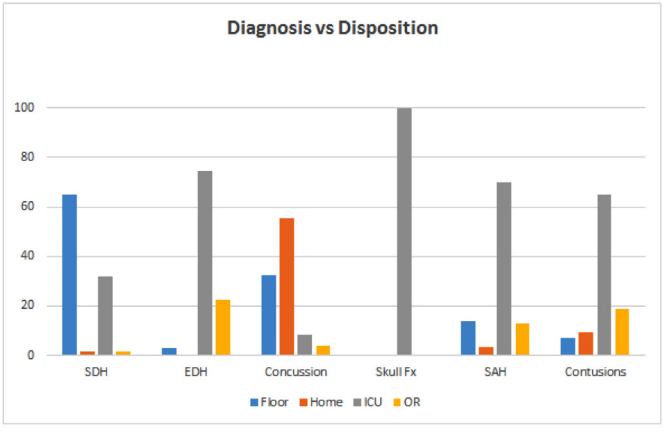

Figure 2: The majority of concussed patients were discharged home, with a few of these patients taken to the OR secondary to multiple diagnoses. All our skull fractures and most SAH and contusions were admitted to the ICU, while most of the SDH patients were admitted to the floor. Nearly all the EDH patients were at least monitored in the ICU, but >20% were taken directly to the OR.

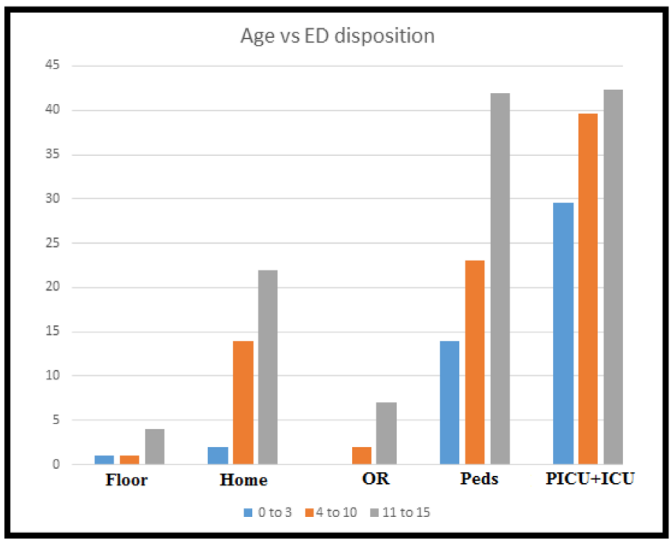

Figure 3: For all age groups, Peds and ICU were the most common places for admission. Very few dispositions to floor and OR. [Floor was mostly used for older childer 15 or 16 years and above vs peds was used for patient less than 15].

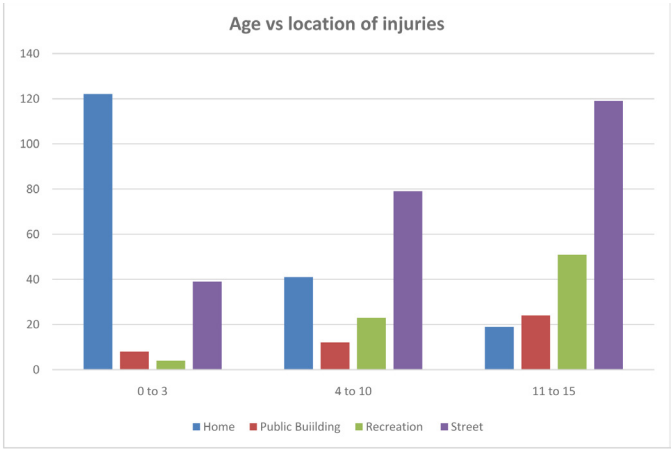

Figure 4: For age 0 to 3, highest incidence of injuries was at home, however public buildings, recreational places and street related injuries were increasingly common for ages 4 to 10 and 10 to 15 years.

Subdural Hematoma 98%, Contusion 86% and Skull fractures 96%.

DISCUSSION

From our research, we saw that there has been a steady decrease in the average length of stay for TBI patients. We believe the most significant factor was the change in the trauma team TBI management protocol that occurred between 2010 and 2011, as the LOS was relatively stable after 2012. We found different rate of types of injury between the age groups, as has been demonstrated previously, and is likely due to both the relative head to neck size and MOI. MVA and falls were the most predominant MOIs throughout 6 years, but with fewer pedestrian accidents than previous studies noted. This may be due to the pattern of EMS transports within

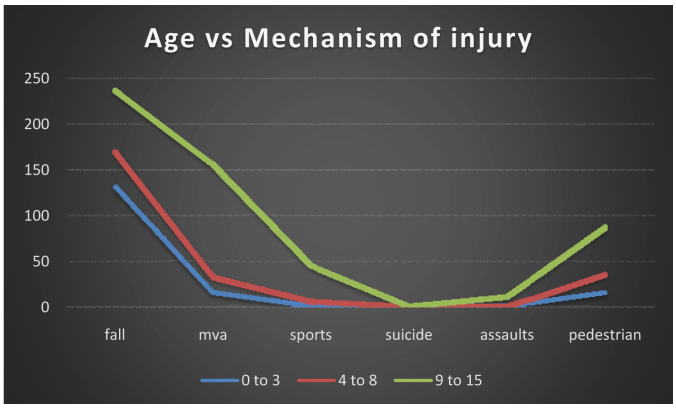

Figure 5: Age group 9 to 15 had the highest number of injuries for all MOI as compared to age group 0 to 3 and 4 to 8.

Figure 6: The percentage of Fall admissions decreased over time, whereas MVA and Pedestrian causes increased somewhat. The percentage of sports-related injuries varied, but generally increased over time, whereas suicides and assaults declined.

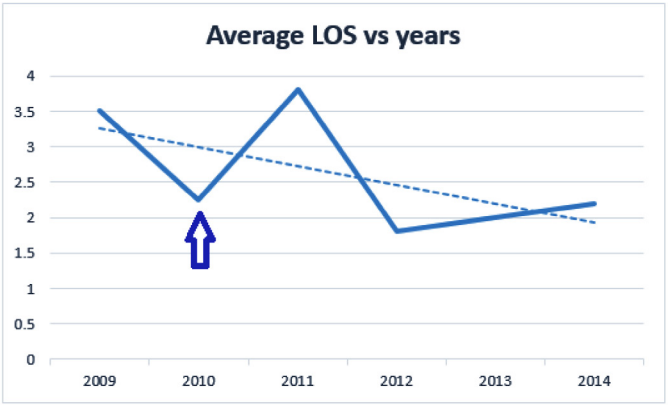

Figure 7: Overall demonstrated a negative regression (dotted lines) from 2009 to 2014 for all ages in the average length of stay (r = (-0.71)). Change in protocol demonstrated by arrow in the graph above in 2010-2011.

Figure 8: Over 6 years, no significant change in LOS (in days) was seen in all six diagnosis per year for every diagnosis.

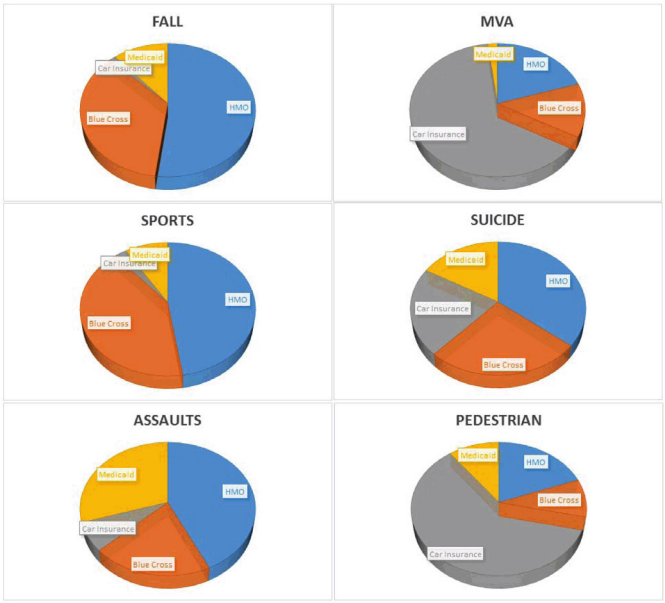

Figure 9: HMOs were majority of insurance providers for patients with falls, sports related injury, assaults and suicide. Car insurance was majority insurance provider in MVA and Pedestrian accidents. Medicaid coverage by itself was highest in assaults, suicide and falls but was a minor contributor in sports, MVA and pedestrian accidents.

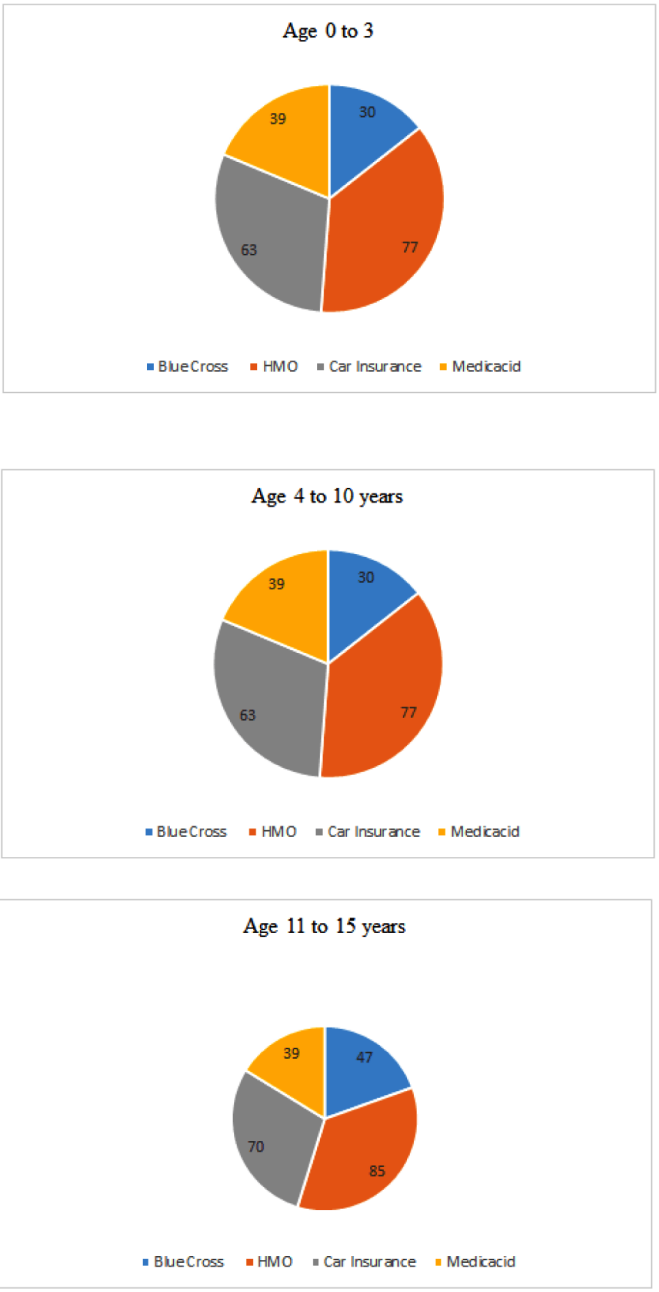

Figure 10: Number of patients per insurance type based on type of insurance. HMOs and Car Insurance being significantly high in all age groups. Also the distribution of patients from age group 0 to 3 and 4 to 10 was identical with Medicaid being identically covered in all three age groups.

New Jersey. Without a state-wide trauma system, many patients are transported to their local emergency room rather than a designated trauma center, and thus not admitted to our hospital.

Since most head injuries occurred at home or during recreational activities, it is important to counsel parents and children on home (for children from 0 to 3 years) and sports safety for older children. From a preventative stand point, many strategies can be implemented: for instance installing rugs and carpets to prevent hitting the head on a hard surface after a fall, installing good lighting over stair cases for better visualization, and installing furniture and beds away from windows as well as securing furniture and appliances to prevent them from toppling over onto children.

HMOs were the predominant form of insurance coverage and Car Insurance being significantly high for patients age 4 to 10 and 11 to 15, while HMO and straight

Figure 11: HMOs were the most predominant form of insurance coverage.

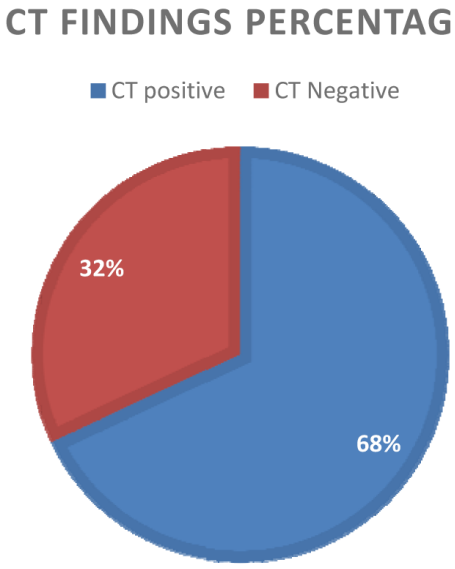

Figure 12: Of all the CTs that were performed, 68 percent had a positive finding noted in the official report and 32 percent were negative. The true positive rate based on our analysis for each diagnosis was as follows: SAH was 91%, Epidural Hematoma 97%, Subdural Hematoma 98%, Contusion 86% and Skull fractures 96%.

Medicaid were more common in age 0 to 3. Patients involved in MVAs and pedestrian struck accidents primarily had auto insurance coverage. This pattern may be attributable to the fact that after implementation of Obamacare, the number of people enrolling in HMOs could have probably increased.

Difference in overall rate of decline in LOS vs no change in per year could be attributed to the different types of patients that were admitted and evaluated. In other words, it is possible that severity of each patient with similar medical etiology could have been different which could have shown an overall decrease in LOS depending on the aggressiveness of treatment but would not show annual changes in LOS. Specifically, after new trauma protocol was placed in 2010-2011, the drop was even more rapid as demonstrated in the graph.

In addition, because of increasing health insurance coverage, it is possible that more parents were able to purchase car insurance. Accuracy of imaging can also be seen based on the true positive rate as mentioned in the results. It is possible that patients with concussions were purely diagnosed clinically without any imaging which could have contributed to lower true positive rate of 86 percent as compared to other diagnosis i.e. this could point to the fact that most of injuries with concussions were treated non-surgically which did not require invasive intervention due to early detection of symptoms with or without imaging.

CONCLUSION

Recent advancements in patient management and imaging technology in the field of Neurosurgery requires a multisystem team based approach to effectively manage TBI patients. Evidence-based recommendations regarding the need for imaging, appropriate level of observation and prevention measures are needed to decrease health care costs and reduce the number of TBIs in our pediatric patients.

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Author Contributions

Smit Prafulchandra Shah – Substantial contributions to conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published

Rachana Tyagi – Substantial contributions to conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published

Guarantor of Submission

The corresponding author is the guarantor of submission.

Source of Support

None.

Consent Statement

Written informed consent was obtained from the patient for publication of this study.

Conflict of Interest

Authors declare no conflict of interest.

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