

Estimating the Economic Burden of Abusive Head Trauma in  
Children in North Carolina

By  
Ivy Pointer, MD

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## Abstract

**Introduction:** Abusive head trauma causes significant morbidity and mortality in the pediatric population. Information on the economic burden of this condition is limited, making it difficult to determine how much funding to direct toward prevention. The *Period of PURPLE Crying®* is a promising abusive head trauma prevention program in the state of North Carolina. By collecting cost data on abusive head trauma victims and comparing it to the cost of the prevention program, the objective of this study is to demonstrate cost savings and suggest potential policy changes nationwide.

**Methods:** Using ICD-9 codes, we identified all children less than 3 years old admitted to the North Carolina Children's Hospital Pediatric Intensive Care Unit with traumatic brain injury between 2005 and 2010. Demographic data (age, gender, year, payer type), hospital and physician charges, length of stay, intensive care unit days, and ventilator days were collected on each patient. Charges were further divided into pharmaceutical, laboratory, blood product transfusion, and radiology charges. The cases were classified as abusive head trauma and accidental head trauma based on the CDC recommendations for determining abuse from ICD-9 codes. The mean cost of hospitalization per patient was calculated for each group. The cost of the prevention program per patient was calculated.

**Results:** 74 cases were identified with 27 cases of abusive head trauma and 47 cases of accidental head trauma or unknown etiology. The mean charges for hospitalization of abusive head trauma victims were \$99,970 with a median of \$64,643. The mean charges for the accidental head trauma group were significantly less at \$46,406. This difference was statistically significant in the 25<sup>th</sup> and 50<sup>th</sup> quartiles. There were also significant differences between the two groups in length of stay, PICU days, and ventilator days. The cost of the *Period of PURPLE Crying®* program is \$3.93 per infant exposed.

**Conclusion:** The charges of hospitalizing abusive head trauma victims average nearly \$100,000, significantly higher than the cost of caring for children with head trauma from other causes. For the charges associated with one abusive head trauma admission, 25,000 infants can be exposed to the *Period of PURPLE Crying®*. Preventing at least 6 cases per year would make this program cost effective. This program demonstrates the potential to provide significant costs savings through prevention.

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## Introduction

Abusive head trauma is the leading cause of infant death from injury and the most common cause of lethal child abuse.<sup>1</sup> Approximately 95% of all serious traumatic brain injuries in children less than 12 months old are secondary to abuse.<sup>2</sup> Based on a population-based study in the United States, the incidence of abusive head trauma is estimated to be 17 per 100,000 person-years in children less than 2 years old and 30 per 100,000 person-years in children less than 1 year old.<sup>1</sup> Mortality rates range from 13% to 27%.<sup>3-5</sup> Morbidity for survivors is high, with an estimated 45-60% percent of victims with significant neurologic deficits at the time of discharge from the hospital<sup>4-6</sup> and 68% with late neurologic sequelae.<sup>7</sup> Given the substantial morbidity and mortality associated with abusive head trauma, this condition places an undue burden on society, especially from an economic standpoint.

The exact economic burden of abusive head trauma is unknown. Studies in the 1990's reported estimated hospital charges alone in the range of \$25,000 to \$40,000 per victim.<sup>8-11</sup> These studies found that charges were significantly higher for abusive head trauma compared to accidental head trauma. Three of the four studies included only hospital charges, and the data were generated almost two decades ago.<sup>8,10,11</sup> The one study that examined physician charges was a small study of 13 child abuse cases and was not limited to abusive head trauma.<sup>9</sup> More research is needed to provide valuable insight into planning a prevention program and developing policy around that program.

The *Period of PURPLE Crying®* is a promising abusive head trauma prevention program currently underway in the state of North Carolina.<sup>12</sup> The program focuses on preparing parents of newborns to deal safely and explicitly with infant crying. This goal is accomplished through education about the nature of and appropriate responses to infant crying. In order for this prevention program to be widely accepted, it should be

effective at reducing abusive head trauma and provide demonstrable cost-savings. As of June 2009, sixteen states had legislation requiring hospitals to provide some form of education about abusive head trauma.<sup>13</sup> By collecting cost data on abusive head trauma victims and comparing it to the cost of the prevention program, the objective of this study is to evaluate for possible cost savings and consider potential policy changes nationwide.

## **Methods**

### *Data Collection*

This study was conducted at the N.C. Children's Hospital, a 140-bed university affiliated pediatric hospital with approximately 5900 annual admissions. The hospital serves children from all 100 North Carolina counties. The Pediatric Intensive Care Unit (PICU) is a twenty bed unit averaging almost 90 admissions per month. A database containing treatment, demographic, and cost data for a retrospective cohort of all patients less than 3 years old admitted to the PICU between September 1, 2005 and September 30, 2010 with traumatic brain injury as defined by the Centers for Disease Control and Prevention's (CDC) ICD-9 based definition<sup>14</sup>, was developed by the first author for this study.

The North Carolina Translational and Clinical Sciences (NC TraCS) Institute is the NIH Clinical and Translational Science Awards research unit at the University of North Carolina. NC TraCS staff assisted in creating a list of patients meeting the study criteria and extracting data from NC Children's Hospital records. The data were de-identified and stored with the Carolina Data Warehouse for Health (CDW-H) at the TraCS Institute for this study. In this study, we collected demographic data for each of

the identified patients, including age in months (calculated from birthday and admission date), sex, and payer type. We also collected diagnosis codes, year of admission, length of stay, PICU days, and ventilator days.

We used both hospital and physician billing information to determine total charges of admission for each patient. All calculations of cost in this study are based on charges, not actual costs or reimbursements. Charges were chosen due to the difficulty of accessing information on costs and the differing rates of reimbursements depending on payer type. All charges associated with the acute hospitalization were included in the analysis. Charges for each patient were grouped by pharmaceutical, laboratory, radiology (subdivided into MRI, CT, and X-ray charges), blood product transfusion, and physician charges. Physician charges were subdivided by subspecialty. For patients admitted from the N. C. Children's Emergency Department, these hospital and physician charges were also included. All data were de-identified prior to review and analysis by study personnel.

Each case was classified as definite abuse, probable abuse, accidental, or unknown cause based on the CDC's draft matrix for diagnosing child abuse from ICD-9 codes and E-codes.<sup>15</sup> Definite and probable abuse cases were consolidated as abusive head trauma; accidental and unknown causes were consolidated as accidental head trauma for this data analysis.

The *Period of PURPLE Crying*® is an ongoing abusive head trauma prevention program in the state of North Carolina. To determine the cost of this program per patient, the total cost was estimated and divided by the number of infants delivered at each of the participating facilities. The delivery information was obtained from state vital records. The total costs of the program included costs of materials, such as DVD's, personnel to coordinate the program at each hospital, and ongoing training. The coordinator costs were estimated using average earnings of nurses in the state of North

Carolina. Evaluation staff indicated that coordinators spent approximately twenty minutes per month attending to the needs of the program. Training costs included in-person training at participating facilities as well as internet-based training. Costs of initial program implementation were excluded from the calculation. In addition, the costs of the time nurses spend delivering the program were not included since 60% of the facilities were already delivering education about child abuse prevention prior to implementation of *PURPLE*. For the other 40% of facilities, it was assumed that the nurses could integrate *PURPLE* into the regular discharge activities.

This study was reviewed and approved by the Institutional Review Board for the Protection of Human Subjects. Requirement for informed consent was waived.

### *Data Analysis*

Stata 11 statistical software was used for all data analysis.<sup>16</sup> The main outcome of interest was the total charges for hospitalization of a patient with abusive head trauma. We calculated mean and median charges for each subcategory of expenditures as well as for the total charges for each hospitalization. All charges were adjusted for inflation to 2010 dollars by using the consumer price index for medical care services.<sup>17,18</sup> Because charges were not normally distributed, nonparametric tests were used to compare abusive head trauma and accidental head trauma groups. We used the Wilcoxon Signed-Rank test to compare the total charges, length of stay, PICU stay, ventilator days, radiology charges, and neurosurgery charges of the abusive and accidental groups, and we used Pearson's Chi-Square test to assess the difference in categorical variables of the groups. Finally, we used multiple regression analysis to compare the means of the abuse and accidental groups. Quartile regression analysis was used to compare differences at levels of 25<sup>th</sup> percentiles, medians, and 75<sup>th</sup> percentiles of maximum charges between the two groups.



## Results

We identified a total of 76 cases of head trauma in children less than 3 years old admitted to the UNC PICU between 2005 and 2010. Of these cases, two patients were admitted twice and only their first admission was used. The remaining 74 cases were reviewed with 27 classified as abusive head trauma, based on the CDC guidelines, and 47 classified as accidental or unknown. Table 1 outlines the characteristics of patients in the abusive and accidental head trauma groups. The unintentional injuries were primarily due to motor vehicle accidents (49%) and falls (30%). Eight patients had no diagnosis code to indicate the cause of injury and were included in the accidental head trauma group; these unknown causes make up 17% of the accidental injury group. Total charges for each cause of injury are represented by a scatter plot in Figure 1.

The mean total charges for children with abusive head trauma were \$99,970 with a range of \$17,276 to \$360,160 and standard deviation of \$86,925. The median total charges were \$64,643. Physician charges were the most costly subcategory, at an average of \$24,376, accounting for almost 25% of the average total charges. Radiology charges and pharmacy charges were the other major categories, accounting for 7% and 5% of the average total charges respectively. Figure 2 displays the contribution of each category of charges. The average length of stay for abusive head trauma patients was 19 days with an average of 9 days in the PICU and 8 days on a ventilator.

The abusive head trauma group also had significantly higher median charges for hospitalization than the accidental head trauma group (\$64,643 compared to \$25,017 ( $p=0.002$ )). Table 2 shows the medians for each of the subcategories of charges, with a significant difference between groups in pharmacy charges, laboratory charges, blood product charges, X-ray charges, physician charges, hospital charges, and total charges.

Quartile regression was also used to compare the groups with a statistically significant difference between the 25<sup>th</sup> and 50<sup>th</sup> percentiles of total charges. Table 3 shows the quartiles compared for both groups. We examined differences at the quartiles to determine whether overall differences between the two groups were caused simply by a clumping of particularly expensive cases, for example, rather than higher costs across the board. Quartile analysis is a good way of illustrating the consistency of the differences.

Length of stay, PICU days, and ventilator days were significantly higher in the abusive head trauma group than in the accidental head trauma group, as shown in Table 4 and Figure 3. The categorical variables of MRI, intracranial pressure (ICP) monitor, and intubation were compared between the two groups (Table 4). Abusive head trauma patients were more likely to be intubated ( $p=0.03$ ) and to have an ICP monitor ( $p=0.04$ ). There was no significant difference between groups in the use of MRI.

Regression analysis was used to determine if any of the demographic factors explained charges for admission or other variables. The patient's age, sex, and payer type had no effect on the charges or any other dependent variables in the study.

The cost of the *Period of PURPLE Crying*® prevention program overall is an estimated \$500,000 per year, and that expenditure is intended to cover the implementation of the program at the time of each of the approximately 125,000 births in North Carolina per year. The cost per child of *PURPLE*, then, is estimated to be approximately \$3.93 per child exposed. The cost per child exposed is exponentially lower than the cost of treating a single case of abusive head trauma.

## Discussion

The substantial morbidity and mortality associated with abusive head trauma has been established by prior studies.<sup>1-7</sup> The economic burden, however, has not been fully or recently explored. The results of this study demonstrate the extensive costs associated with the acute care of victims of abusive head trauma. Over 60% of the abusive head trauma victims in this study were Medicaid recipients and another 26% were covered by TriCare. Other studies have also found that more than half of abusive head trauma victims are Medicaid recipients.<sup>8,10,11</sup> Thus, a substantial portion of the economic burden associated with caring for these children is born by the public. For the cost of caring for one child with abusive head trauma, approximately 25,000 infants could be exposed to the *Period of PURPLE Crying*® prevention program. The cost of prevention for the 125,000 births per year in the state of North Carolina is estimated to be \$500,000. If exposure to this program reduces abusive head trauma in North Carolina by 6 cases per year, the program would be cost effective. As a part of the necessary monitoring process to determine *PURPLE*'s true preventive effect, active surveillance to assess mortality and hospitalization rates is currently underway in the state.

In a similar hospital-based prevention program targeting new parents at the time of birth, Dias et al demonstrated an almost 50% reduction in cases of abusive head trauma from 41.5 cases per 100,000 live births to 22.2 cases per 100,000 live births.<sup>19</sup> If the *Period of PURPLE Crying*® achieves similar results and prevents 19 cases per 100,000 live births, the state, private insurance companies, and families in the state of North Carolina together would save up to \$1.5 million in acute medical care costs.

The high cost of hospitalizing children with abusive head trauma has been demonstrated in prior studies but those costs are significant underestimates of the true cost, since these studies almost always exclude physician charges.<sup>8-11</sup> Physician

charges in our analysis accounted for \$25,000 or 25% of the total charges. Including the physician charges is an essential step toward constructing true estimates of the cost of caring for these children, and a more accurate estimate gives policymakers a better idea of the cost effectiveness of prevention, quite apart from prevention's potential to spare a life.

The mean hospital charges of abusive head trauma in this study are higher than those reported in prior studies, which may be due to the inclusion of three patients in the abusive head trauma group who required tracheostomy and gastrostomy tube placement. These charges were significant, resulting in total charges of over \$200,000 for each patient. The 75<sup>th</sup> percentile comparison between the two groups did not achieve statistical significance despite the difference in charges of close to \$50,000, likely due to the inclusion of these three patients in the study. The median hospital charges of this study (\$43,400) correlate more closely to mean charges reported in other studies, which range from \$25,000 to \$40,000<sup>8,9</sup>. Ettaro et al. reported, median hospital charges of \$18,500 in 1999 dollars<sup>8</sup>. This amount converts to almost \$30,000 in 2010 dollars, which correlates more closely to the median charges in this study<sup>17,18</sup>.

For patients who were admitted directly from the N.C. Children's Hospital Emergency Department, those charges were included in the hospital and physician charges. Only 48 of the 74 patients had emergency department charges included and of those, only 11 (23%) were in the abusive head trauma group. Most accidental trauma patients are transferred from other facilities to the emergency department to be assessed by the trauma team on arrival. Abusive head trauma cases may not be recognized as trauma initially, as the history provided by the parents often does not include a history of trauma. It is not until further evaluations are performed that the diagnosis of abusive head trauma is assigned. These patients are frequently transferred from other facilities directly to the PICU and therefore do not incur Emergency

Department charges. In this study, the lack of emergency department charges for many abusive head trauma patients likely underestimates the total charges and underestimates the difference between the abusive and accidental head trauma groups.

Previous studies looking at the cost of abusive head trauma have not sorted the charges by department to determine the specific expenses of caring for these children. This study shows that physician charges, pharmacy charges, and radiology charges are the most expensive subcategories. The abusive trauma group's generally longer mean length of stay and PICU days also contribute substantially to the high costs.

The differences between abusive head trauma and accidental head trauma in cost and length of stay have been previously demonstrated. The present study, however, provides more specific data on how the actual charges differ by department. The differences achieved statistical significance in most departments except radiology and neurosurgery. The total radiology charges were close to statistical significance and it would be interesting to investigate this difference in a larger study. Many abusive head trauma victims require additional radiologic studies in order to make a definitive diagnosis of abuse. Therefore, we would expect charges for this group to be higher in the radiology department. We expected that the increased severity of abusive head trauma would lead to higher neurosurgery charges and more frequent neurosurgical procedures. Although this group was more likely to have an ICP monitor placed, the actual numbers were very small, with only 11 patients requiring ICP monitoring. Further research with a larger sample population could determine if there are differences between the two groups in these departments. Understanding the categorical costs of caring for these children may lead to more efficient or judicious use of available resources, thus decreasing the overall costs.

The major limitation of this study is the small sample size. Because the data were significantly skewed, medians and quartiles were used to compare abusive and

accidental head trauma groups. Previous studies have shown significant differences in the cost and length of stay between these two groups and this study reinforces those results.<sup>10</sup> We also found significant differences between the groups in ventilator days and PICU days, suggesting that abusive head trauma patients tend to suffer more severe injuries.

Another limitation of this study is the single center location for data collection. The location for this study is a regional pediatric trauma center and may be more likely to admit the more severe cases of traumatic brain injury than do other facilities, thus increasing costs. Because this center cares for more abusive head trauma patients than does any other hospital in the state of North Carolina, however, it was deemed an appropriate surrogate for determining the cost of caring for this population.

A third limitation that this study shares with several previous studies is the use of ICD-9 codes to identify abuse cases. This method of diagnosing child abuse has been validated in previous studies, although cases of abuse may be missed through this data collection process.<sup>20</sup> In addition, eight patients in this study had no E-code to determine cause of injury and were included in the accidental head trauma group. If these cases were missed abuse cases, the charges for abusive head trauma and the difference between the two groups would likely be underestimated.

The use of charges as a surrogate for cost measurement is not the optimal way to estimate the health care costs associated with this condition. However, charges were chosen due to the impracticality of obtaining true cost data and the variability of reimbursement rates. Charges reflect what the state and other payers are asked to pay for the medical care, and they serve as a starting point to understanding the costs of care.

This study examines the significant charges associated with the acute hospitalization of victims of abusive head trauma but does not begin to estimate the

larger total cost to society. The costs of these patients continue after hospital discharge with rehabilitation and various therapies, home nursing care, foster care, and costs associated with disability, including the potential for loss of a lifetime of productivity. These subsequent costs are much more difficult to estimate, especially in the pediatric population, given the limited literature available, but they need to be considered since they likely present a substantial additional burden to the state.

## Conclusion

The potential cost-savings from the prevention of abusive head trauma in infants and young children is substantial. The immediate hospitalization of abusive head trauma victims alone leads to average charges of almost \$100,000. This estimate does not include post-discharge therapies and societal costs. Given this sizeable economic burden, increasing the funding of prevention programs, such as the *Period of PURPLE Crying®*, could have significant political, economic, and societal implications. In the absence of unlimited health care resources, advocates for prevention need to demonstrate cost-savings in addition to improved health outcomes. Abusive head trauma prevention has the potential to be a cost-effective way to improve the health and wellbeing of children. Only sixteen states currently require some form of education for new parents about abusive head trauma at discharge from the hospital, and there is no standard or recommended program.<sup>13</sup> Implementing a policy requiring hospitals nationwide to engage in an effective, standardized abusive head trauma prevention program and directing increased funding to support the policy could substantially improve health outcomes and reduce overall health care spending.





## Tables and Figures

Table 1: Patient Characteristics for Children Less Than 3 Hospitalized at NC Children's Hospital Stratified by Accidental Versus Abusive Head Trauma

Characteristic	Abusive Head Trauma (n=27)	Accidental Head Trauma (n=47)
Male Sex	15 (56%)	27 (57%)
Age:		
< 12 months	19 (70%)	24 (51%)
12 to 23 months	4 (15%)	14 (30%)
> 23 months	4 (15%)	9 (19%)
Payer type		
Medicaid	17 (63%)	27 (57%)
Private insurance	3 (11%)	13 (28%)
State health plan	0 (0%)	1(2%)
Tricare	7 (26%)	5 (11%)
Self-pay	0 (0%)	1 (2%)
Year of admission		
2005	4 (15%)	2 (4%)
2006	6 (22%)	8 (17%)
2007	5 (19%)	12 (26%)
2008	5 (18%)	11 (23%)
2009	5 (19%)	10 (21%)
2010	2 (7%)	4 (9%)

Table 2: Median Hospital Charges Comparing Abusive Head Trauma and Accidental Head Trauma Victims at NC Children's Hospital. By Specific Type of Charge

	<b>Abusive Head Trauma</b>	<b>Accidental Head Trauma</b>	<b>p value</b>
Pharmacy charges	\$2972	\$724	p<0.01
Lab charges	\$2672	\$358	p<0.01
Blood product charges	\$314	\$89	p<0.01
MRI charges	\$1214	\$1180	p=0.21
CT charges	\$1589	\$904	p=0.37
X-ray charges	\$949	\$398	p<0.01
Radiologist charges	\$2125	\$1413	p=0.06
Total radiology charges	\$6356	\$4215	p=0.06
Total hospital charges	\$43,380	\$19,420	p<0.01
Physician charges	\$19,851	\$6929	p<0.01
Neurosurgery charges	\$421	\$388	p=0.97
Total charges	\$64,643	\$25,017	p<0.01

Table 3: Quartiles for Total Charges Comparing Abusive Head Trauma and Accidental Head Trauma Victims at NC Children's Hospital.

<b>Quartile</b>	<b>Abusive Head Trauma</b>	<b>Accidental Head Trauma</b>	<b>p value</b>
25 <sup>th</sup> %ile	\$35,845	\$17,068	p<0.01
50 <sup>th</sup> %ile	\$64,643	\$26,017	p<0.01
75 <sup>th</sup> %ile	\$126,396	\$75,275	p=0.06

Table 4: Summary Statistics of Key Variables Comparing Abusive Head Trauma and Accidental Head Trauma Victims at NC Children's Hospital

		<b>Abusive Head Trauma (n=27)</b>	<b>Accidental Head Trauma (n=47)</b>	<b>p value</b>
Total charges (\$)	Mean (SD)	\$99,970 (86,925)	\$46,406 (48,007)	p<0.01
	Median	\$64,643	\$25,017	p<0.01
Length of stay (days)	Mean (SD)	19 (20)	6 (8)	p<0.01
	Median	14	3	p<0.01
PICU stay (days)	Mean (SD)	9 (11)	3 (4)	p<0.01
	Median	5	1	p<0.01
Ventilator days (days)	Mean (SD)	8 (12)	3 (5)	p=0.01
	Median	5	0	p=0.01
MRI % (n)		78% (21)	60% (28)	p=0.11
ICP Monitor % (n)		26% (7)	9% (4)	p=0.04
Intubation % (n)		70% (21)	45% (19)	p=0.03

Figure 1: Scatterplot of Total Charges by Cause of Injury for Children Admitted to NC Children's Hospital with Traumatic Brain Injury

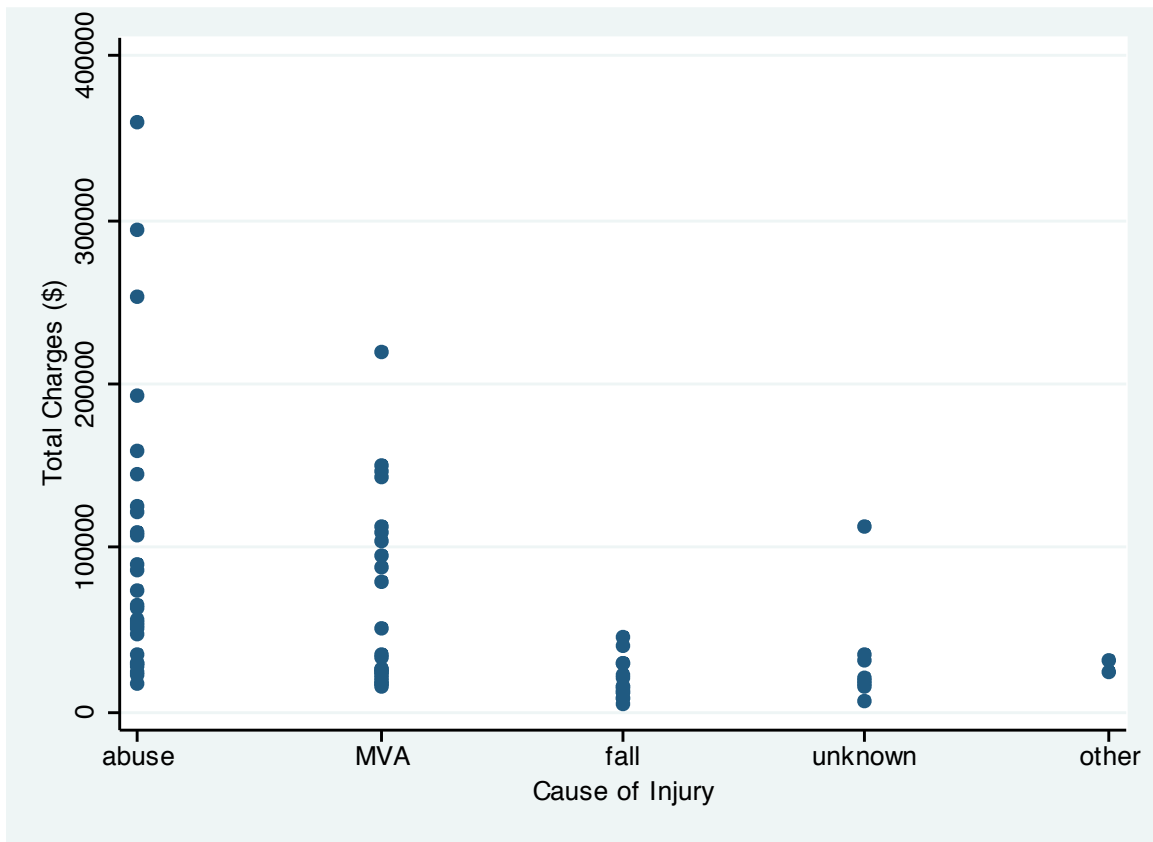


Figure 2: Mean Charges by Category for Children Admitted to NC Children's Hospital with Traumatic Brain Injury

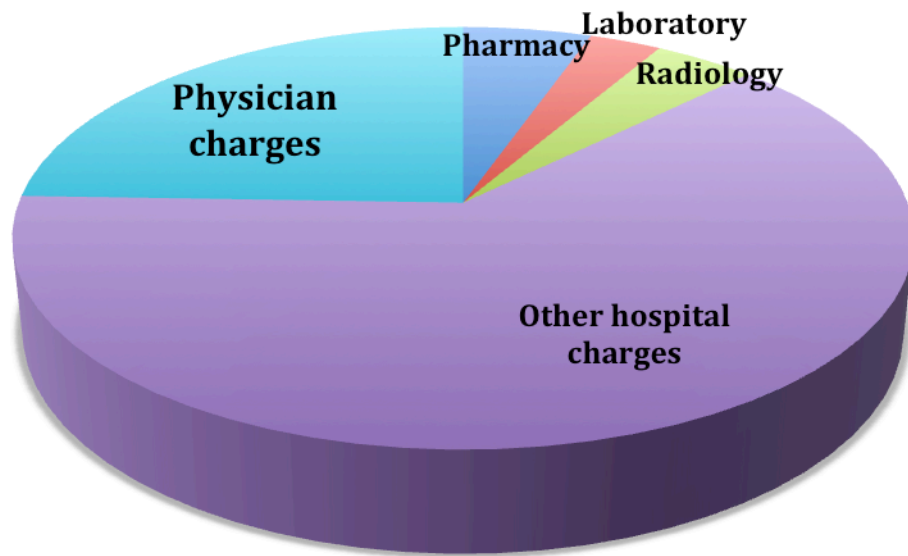
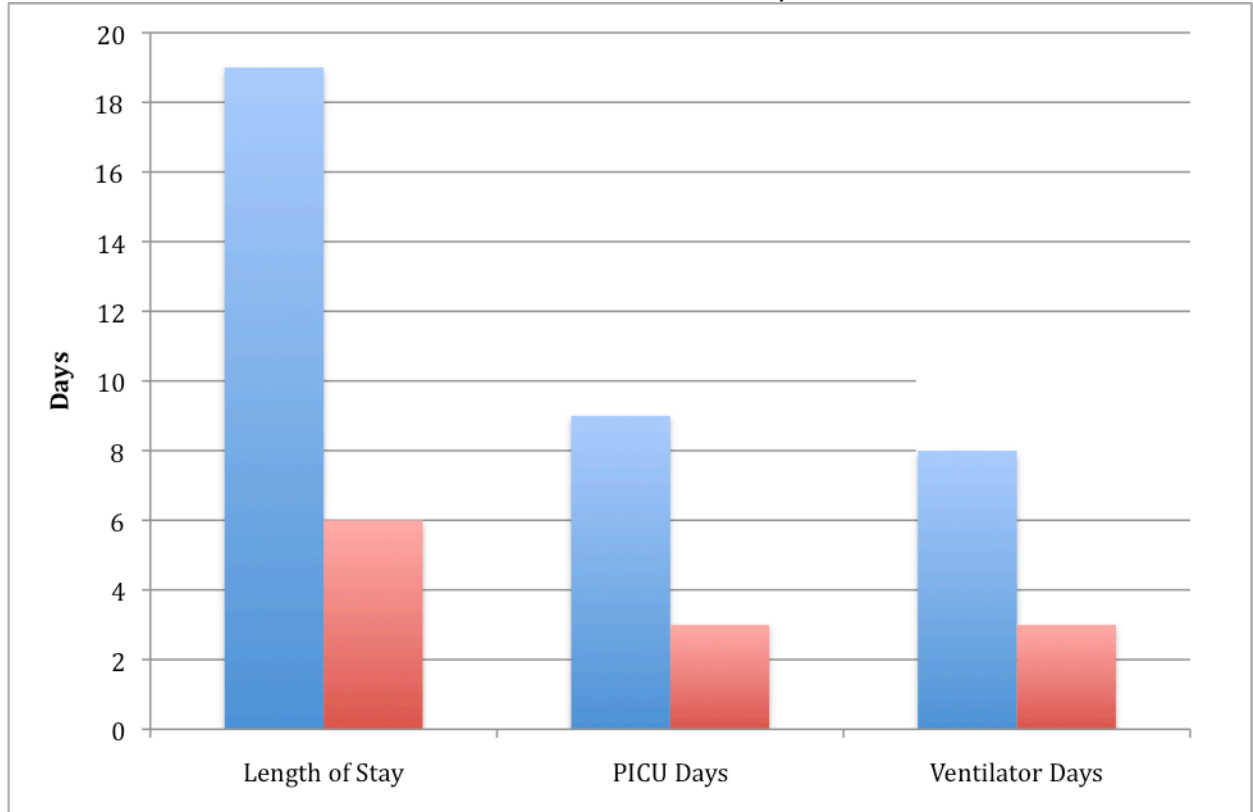


Figure 3: Comparison of Variables between Abusive Head Trauma and Accidental Head Trauma Victims at NC Children's Hospital



## **Appendix 1: Limited Systematic Review of the Cost of Abusive Head Trauma**

Abusive head trauma is the leading cause of infant death from injury and the most common cause of lethal child abuse<sup>1</sup>. Approximately 95% of all serious traumatic brain injuries in children less than 12 months old are secondary to abuse<sup>2</sup>. The morbidity for survivors is also significant with an estimated 55 percent with neurologic deficits and 65 percent with visual impairment<sup>4</sup>. Based on a population-based study in the United States, the incidence is estimated to be 17 per 100,000 person-years in children less than 2 years old and 30 per 100,000 person-years in children less than 1 year old<sup>1</sup>. The economic burden of this disease is likely significant considering the substantial morbidity and mortality. However, the literature examining the extent of this economic burden is limited. Gaining an understanding of the health care costs associated with abusive head trauma could help guide prevention efforts.

The purpose of this limited systematic review is to review existing literature on the cost of abusive head trauma in order to more thoroughly estimate the economic burden of this form of child abuse.

### **Methods:**

Using the MeSH heading of “shaken baby syndrome,” I performed an initial search on PubMed on January 25, 2011. I limited the search to “humans,” “English,” and “infants up to 23 months,” yielding 264 citations. I added the MeSH terms “cost,” “economics,” and “health care cost” to “shaken baby syndrome” in three separate searches (with the same limits), which resulted in zero citations. I subsequently changed the MeSH term to “child abuse” and “costs and cost analysis” with the same

limits, generating 20 citations. These abstracts were reviewed for their relevance to the study question, and six citations were found to be appropriate for inclusion.

The search was repeated on PubMed using the keywords “child abuse” and “cost,” yielding 86 citations. These citations were reviewed and one additional study was found to be relevant.

### **Search Results:**

The published information on the cost of abusive head trauma in children is limited. Of the seven studies reviewed, four studies evaluated the cost of child abuse. One study focused on the cost effectiveness of using head computed tomography in the diagnosis of abusive head trauma but not the overall cost of the disease, and therefore not relevant to this clinical question<sup>21</sup>.

Two of the seven papers evaluated the role of home visits in decreasing child abuse and neglect, and thus decreasing costs<sup>22,23</sup>. These papers, based on a single study, provide interesting insight into an economic evaluation of a prevention program targeting child abuse. The intervention in this case was parental education through weekly visits from a health worker. The costs of care for the women were calculated for the control group and intervention group. However, there were not statistically significant cost savings in the intervention group in any of the variables assessed. The cost of child abuse and neglect was not addressed.

Of the four studies that estimated the economic burden of child abuse with specific data on abusive head trauma, all four used data from the 1990's and report mean charges of hospitalization for the patients in the study.<sup>8-11</sup>.

Rovi et al used the 1999 National Inpatient Sample of Healthcare Costs and Utilization Project to collect cost data on children with diagnosis codes of abuse or neglect. Using ICD-9 codes, they collected data on all inpatient hospital stays in the



database for children with diagnoses of abuse, including “shaken infant syndrome.” Demographic data including age, gender, race, and income as well as length of hospital stay, hospital characteristics, number of diagnoses and procedures, and total charges, were collected for each patient. Of the 966 identified abuse cases, twenty-one percent were diagnosed as “shaken infant syndrome.” Overall, the patients with a diagnosis of abuse or neglect had double the length of stay and total charges of those without a diagnosis of abuse or neglect. They also had double the diagnoses and more procedures. The mean total charges for patients diagnosed with “shaken infant syndrome” was \$30,311, with a standard error of \$2928, the highest mean charges of all of the abuse diagnoses<sup>11</sup>.

Libby et al collected data from 1993 to 2000 on 814 unintentional head injury cases and 283 inflicted head injury cases. Their primary objective was to compare the cost and length of stay between the two groups. They also collected gender, race/ethnicity, and insurance type. They estimated severity using All Patient-Refined Diagnosis-Related Groups severity index and collected mortality information. Mean total charges for the inflicted cases were \$25,481.26 with a standard deviation of \$31,421.72 compared to \$10,879.71 in the unintentional group with a standard deviation of \$22,932.13. This difference was found to be significant ( $p < 0.01$ ) with costs in the inflicted head trauma group 89% higher than the unintentional head trauma group. The study also found a significantly higher length of stay in the inflicted head trauma group of 8.9 days compared to 3.52 days ( $p < 0.05$ ). Other characteristics associated with inflicted head injury in the study were younger age, higher severity level, mortality rate, and Medicaid insurance<sup>10</sup>.

Ettaro et al reviewed medical records of all children under 3 years of age admitted from 1995 to 1999 with traumatic brain injury. They identified 385 cases and used the medical records to classify them as abusive or accidental head trauma.

Information collected included basic demographic information, information about the injury, insurance status, length of stay, and discharge status. Hospital charges associated with the event were collected and adjusted to 1999 dollars using the Medical Care Component of the Consumer Price Index. Of the 385 cases, 377 were included with 61 identified as “presumptive abuse” and 28 as “suspicious for abuse.” These two categories were then combined into one category of abused subjects. The abuse cases were more likely to be less than one year old ( $p<0.001$ ) and to have Medicaid as their insurance provider ( $p<0.001$ ). The mortality rate was also significantly higher in the abused group at 10.1% compared with 2.1% ( $p=0.003$ ). Abused subjects had significantly higher hospital charges and lengths of stay than the non-abused subjects. The mean hospital charges for abused subjects were \$40,082 (standard deviation \$58,004) compared with \$15,671 (standard deviation \$41,777), which was a significant difference ( $p<0.001$ ). The range of charges in the abused group was substantial, \$1,131 to \$315,618 with a median of \$18,494. The mean for abused subjects admitted to the intensive care unit was even higher at \$68,074<sup>8</sup>.

Irazuzta et al collected retrospective data on all patients admitted to the Pediatric Intensive Care Unit between 1991 and 1994. Of the 937 admissions, 13 were child abuse cases, all of which are described as inflicted head trauma. They collected age, outcome, severity of illness, length of stay, and hospital and physician charges on each patient. The child abuse cases in this study were found to be younger in age, greater in severity, and more costly than the other cases. The mean hospital charges for the child abuse cases were \$30,684 with a standard deviation of \$22,697. The mean total medical bills (including physician charges) were \$35,641. When compared to patients with similar severity indices, the child abuse patients had significantly higher daily hospital charges<sup>9</sup>.

The mean total charges for abusive head trauma reported in the studies reviewed were between \$25,000 and \$40,000 based on data from the 1990's. Each of the studies reported a significant difference between abusive and non-abusive head trauma in terms of cost and length of stay<sup>8-11</sup>. The increased length of stay compared to the unintentional cases demonstrated by these studies further points to the significant economic burden of abusive head trauma in children.

### **Discussion:**

Each of these studies collected cost data on abusive head trauma patients and estimated an average cost per patient. The study by Rovi et al explicitly focuses on hospital charges only and does not take into account physician charges<sup>11</sup>. Only the study by Irazuzta et al provides the mean total medical charges, including physician charges<sup>9</sup>. The other studies do not specifically mention whether or not physician charges are included but discuss "hospital charges." Therefore, the data is not inclusive of all costs incurred by patients with abusive head trauma.

The means reported for hospital charges have significant standard deviations in each of the studies. The high standard deviation indicates that the data is spread out over a large range. Only one study reports a median, which may be more useful in this situation since the hospital charges data may not be normally distributed<sup>8</sup>.

Two of the studies rely on ICD-9 codes to identify the abusive head trauma cases<sup>10,11</sup>. Using hospital discharge diagnoses to track abusive head trauma has been researched and found to be an acceptable way to collect data for this condition<sup>20</sup>. Although it is likely that some cases of abuse are missed through this strategy, it is difficult to hypothesize whether the missed cases would change the mean costs of care for abusive head trauma. The results reporting increased costs of abused patients

compared to non-abused patients would be strengthened if some cases of abuse were missed.

Each of these studies offers insight into some of the financial cost of abusive head trauma during the time period studied. More research is needed to examine current costs given that it has been between 10 and 20 years since this data was collected. Given the significant changes in health care costs since that time, it is difficult to extrapolate the current costs of caring for these children.

All of the studies report total costs for the admission of children with abusive head trauma but have no subtotal cost data, such as pharmaceutical costs, laboratory costs, radiology costs, or procedural costs. Further research with more specific cost data may provide greater insight into the economic burden of this condition.

An understanding of the economic burden of abusive head trauma in children would provide valuable information in developing child abuse prevention programs. An effective educational program to target abusive head trauma needs to both change health outcomes and provide evidence of cost-savings to policymakers. Without a clear estimate of the economic burden of the condition, it is impossible to compare prevention costs. The studies in this review provide a starting point of the cost of abusive head trauma, which can direct further research in this area.

Reference	Study Design	Study Population	Number of Subjects	Pertinent Outcomes Measured	Mean Hospital Charges
Ettaro et al (2004)	Restrospective comparative case series	Children < 3 yo admitted with TBI	377 (288 unintentional, 89 inflicted)	Length of stay, hospital charges	Unintentional: \$15,671 (SD \$58,004) <i>median</i> : \$4249 Inflicted: \$40,082 (SD \$41,777) <i>median</i> : \$18,494
Irazuzta et al (1997)	Retrospective cohort study	All patients admitted to PICU, categorized by disease	937 (13 child abuse cases)	Mortality, length of stay, hospital charges	Child abuse: \$30,684
Libby et al (2003)	Retrospective cohort study	Children < 3 yo admitted with TBI	1097 (814 unintentional, 283 inflicted)	Hospital charges, length of stay	Unintentional: \$10,879.71 (SD \$22,932.13) Inflicted: 25,481.26 (SD \$31,421.72)
Rovi et al (2004)	Retrospective observational study	Children hospitalized with diagnostic code for abuse	966 children hospitalized for abuse or neglect (21.1% shaken infant syndrome)	Mortality, length of stay, hospital charges	Shaken infant syndrome: \$30,311 (SE \$2928)

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