Abstract

Bias in the Workup for Non-Accidental Trauma (NAT) in Patients Under Age 1 Brought to the Emergency Department for a Reported Fall
By Ava Voss

BACKGROUND: Non-Accidental Trauma (NAT), or child abuse, is critical to recognize in a clinical setting due to the potential for long-term sequelae, but screening for NAT has the potential for bias. The primary mode of screening for NAT in children less than 1 year of age is with skeletal survey, which is used to detect occult fractures. The purpose of this study is to evaluate discrepancies in the workup for NAT.

METHODS: Observations less than one year old with admitting ICD-9-CM codes of "fall" from the National Trauma Data Bank were included. With demographic data, these observations were categorized into six race categories. The primary outcome was whether or not a skeletal survey was done. Other variables included socioeconomic status, location of the incident, Injury Severity Score (ISS), Traumatic Brain Injury (TBI), and two hospital type variables. Overall odds ratios (OR) for skeletal survey were calculated, and confidence intervals and p-values were calculated based on the chi-square and Fisher's exact tests. Multivariable linear regression was also performed.

RESULTS: There were 38,948 observations primarily identified with this method, of which 10.4% received a skeletal survey. In crude analysis, Black or African American (1.56 [1.43, 1.69]) and American Indian or Pacific Islander (1.54 [1.16, 2.05]) race groups, paying with Medicaid (1.87 [1.73, 2.01], and injuries that occurred at home, had a high ISS, and were associated with TBI had significantly higher odds of receiving a skeletal survey. Presenting to pediatric hospitals or teaching hospitals also increased the odds of receiving a skeletal survey. In logistic regression analysis, race, primary payment method, location, ISS, TBI, hospital type, and teaching hospital are all statistically significant predictors of receiving a skeletal survey.

CONCLUSIONS: This study suggests there is a screening bias in the workup for non-accidental trauma in children less than one year of age. This bias may lead to over-screening of certain racial and socioeconomic groups and under-screening in others. This study highlights the importance of screening algorithms and guidelines in the workup of non-accidental trauma in order to reduce missed cases of child abuse and decrease overuse of screening tools due to bias.

Bias in the Workup for Non-Accidental Trauma (NAT) in Patients Under Age 1 Brought to the Emergency Department for a Reported Fall

Introduction

Non-Accidental Trauma (NAT), or child abuse, is critical to recognize in a clinical setting due to the potential for long-term sequelae. According to the CDC, child abuse and neglect are common, and 1 out of every 7 children are affected (CDC, 2019). Abuse and neglect at a young age negatively impact neurodevelopment, social and cognitive behaviors, adoption of high-risk behaviors as an adult, and are a leading cause of early death and disease (Jenny, Hymel, Ritzen, Reinert, & Hay, 1999). In the non-ambulatory infant, a skeletal fracture or head trauma or an unwitnessed mechanism warrant high suspicion for physical abuse. Falling from a low height is a common history given by caregivers of infants who are victims of physical abuse. Complete skeletal imaging is routinely used to identify occult fractures in suspected physical abuse and is recommended for all children < 2years of age in which NAT is suspected. In infants < 1 year of age, occult fractures due to NAT is present in about 25% of skeletal surveys (Belfer, Klein, & Orr, 2001).

In a large retrospective cohort study, Jenny et al estimated that 80% of deaths from non-accidental head trauma may have been predicted by earlier detection of child abuse. The last decade has brought about an increase in the standardization of NAT workup, and several studies have supported an increase in detection of NAT with improved guidelines and protocols (Kim et al., 2017; Rangel et al., 2009; Riney et al., 2018). In addition to avoiding missing cases of NAT, these guidelines may help decrease unnecessary screening of minorities. For example, a study from 2002 using data from Children's Hospital of Philadelphia found that abusive injury was more common among minority children compared to white children, and minority children were also more likely to get a workup for child abuse with a skeletal survey, concluding that there may be a racial difference in the evaluation and reporting of abuse (Lane, Rubin, Monteith, & Christian, 2002). A literature review conducted by Maina et al found implicit racial bias associated with poorer pain management, different treatment recommendations, and other disparities in empathy and management expectations (Maina, Belton, Ginzberg, Singh, & Johnson, 2018). This study examines racial and socioeconomic biases in screening for NAT in children using the National Trauma Data Bank.

Methods

Study Design

This study uses data from the National Trauma Data Bank (NTDB), years 2010 through 2014. The NTDB is the largest collection of US trauma data from over 680 Level I-IV trauma centers, with 95% of Level 1 centers reporting to the data bank. The NTDB is not a population-based dataset and is subject to the limitations of convenience samples. The data are not weighted and include ICD codes, demographic information, insurance status, hospital characteristics, and other variables. For this study, a retrospective cohort was created with admissions from children under age 1 year who presented to any trauma center with a reported fall. Encounters with ICD-9 codes E880-E888.9, indicating any accidental fall, were included. The NTDB is de-identified and exempt from Institutional Review Board approval by Emory University.

Observations included / excluded

The cohort includes 38,948 observations of accidental falls in children under one year of age. The National Trauma Data Bank does not record unique individuals; therefore, some individuals may be repeated in the dataset if he or she was admitted to a reporting trauma center on more than one occasion. Because the cohort is defined by observations that had an ICD-9 code for any accidental fall, the focus of this study is the screening and workup of NAT, and not on diagnosis. Child abuse diagnosis requires a multidisciplinary team and often occurs outside of the hospital after an investigation that may last months. A trauma database study does not have accurate data on occurrences outside the hospital. Age less than one year was chosen because children are less ambulatory at that age, under more direct adult supervision, and are presumed to be less likely to have a significant fall from a high surface.

Observation characteristics

For each observation, characteristics included gender, age less than one year old, race, primary method of payment, Injury Severity Score (ISS), location where the injury occurred, and hospital types. Primary factor of interest was self-reported race and ethnicity, grouped into non-Hispanic White, Black or African American, Pacific Islander or American Indian, Asian, Hispanic or Latino, and other or mixed race. Secondary exposures included primary method of payment, Injury Severity Score (ISS), environment where injury occurred (home vs not at home), traumatic brain injury (TBI) diagnosis, and hospital types, including teaching hospital or non-teaching hospital and pediatric vs adult hospital. Primary method of payment, a proxy for socioeconomic status, was grouped into private insurance, Medicaid, and Medicare/self-pay/other. ISS, a calculated trauma score based on the worst injury in each body region (head and neck, face, chest, abdomen, extremities, and other external) and ranges from 0-75, with 0 being no injuries. Due to the right-skewed distribution of this variable, ISS was dichotomized into ISS <11 and ISS ≥ 11, which was a purely statistical decision and not clinically relevant. The two hospital variables were teaching hospital vs not a teaching hospital and pediatric vs adult trauma centers.

Outcome

The outcome of interest was whether or not the patient received a skeletal survey (procedure code 88.31), a set of X-ray images ordered in children as a primary method of screening for non-accidental trauma. Skeletal surveys image all the major bones of the body to detect occult fractures with various stages of healing, which could be an indication that the child is being abused. This variable is dichotomous.

Analysis

Crude odds ratios (OR) and confidence intervals for skeletal survey were calculated, based on chi-square and Fisher's exact tests. A multivariable logistic regression model was created to evaluate associations between skeletal survey and patient characteristics. SAS 9.4 (SAS Institute Inc. Cary, North Carolina). All procedures used two-sided testing at a significance level (α) of 0.05.

Results

Characterization of the cohort

Of the observations included in the cohort, 10.4% received a skeletal survey. Table 1 shows the characteristics of these observations. The majority of the observations were male (57.4%). Medicaid was the most common primary method of payment (46.8%), and 24.6% were diagnosed with a TBI.

Additionally, most observations occurred at home (78.4%). In terms of the hospital characteristics, 53.5% of patients were admitted to an adult hospital, and 58.4% of all the hospitals in the study were teaching hospitals.

Results of analyses

Crude odd ratios for having received a skeletal survey among the different analysis groups, including race, primary method of payment, location where injury occurred, ISS, TBI, and hospital types, note statistically significant difference in the odds of receiving a skeletal survey. Except for Hispanic/Latinos All race groups had a statistically significant higher odds of receiving skeletal survey? when compared to Non-Hispanic White (Table 2). Having Medicaid increased the odds of receiving a skeletal survey compared to private insurance (1.87 [1.73, 2.01]). However, having Medicare, self-pay, or other decreased the odds of receiving a skeletal survey compared to private insurance (0.68 [0.59, 0.77]). Injuries that occurred at home, had a high ISS, and were associated with TBI all high higher odds of receiving a skeletal survey. Observations presenting to pediatric hospitals or teaching hospitals had a higher odds of receiving a skeletal survey as well.

In logistic regression analysis, race, primary payment method, location, ISS, TBI, hospital type, and teaching hospital are all statistically significant predictors of receiving a skeletal survey (Table 4). The adjusted R^2 of this analysis is 0.0385. All race groups had a statistically significant risk of receiving a skeletal survey when compared to non-Hispanic white when adjusting for these covariates. Two groups had an increased odds of receiving a skeletal survey, which included Black or African American (1.28 [1.17, 1.40]) and Native American or Pacific Islander (1.44 [1.07, 1.95]). The remaining groups had a decreased odds of receiving a skeletal survey, including Asian (0.58 [0.43, 0.78]), Hispanic or Latino (0.85 [0.77, 0.94]), and Other or Mixed Race (0.65 [0.54, 0.77]).

Discussion

In this cohort, Black or African American and American Indian or Pacific Islander race groups had higher odds of receiving screening for skeletal survey. Additional predictors include Medicaid, occurrence of the incident at home, high injury severity, TBI, and presenting to a pediatric hospital and/or teaching hospital. This demonstrates a discrepancy in the ordering of skeletal surveys, which is evidence of a bias in the way providers screen for non-accidental trauma. Children less than age one are less likely to be ambulatory, and a fall should raise suspicion of NAT equally across groups. Race and socioeconomic status, determined via primary method of payment, were statistically significant predictors for receiving a workup for NAT. These indicate potential biases in the screening of NAT, and some groups may be under-screened and others over-screened.

This is an especially high-risk cohort, given all children were less than one year old, 1 in 4 were diagnosed with a TBI, and the vast majority of these incidents occurred at home. Yet, only 10% of these observations received a skeletal survey, which indicates providers may be underscreening for NAT, especially among non-Hispanic white, Asian, and Hispanic children, who had comparatively lower odds of receiving a skeletal survey. This is especially concerning given it has been estimated that up to 25% of all skeletal surveys in children less than 1 year of age may be positive for occult fracture, concerning for NAT (Belfer et al., 2001).

Other important predictors in the workup of NAT include Injury Severity Score, which was expected given higher scores indicate more severe injury. TBI is often in algorithms for the workup of suspected

NAT, and these data support its continued use as a predictor of NAT. Additionally, adult and pediatric trauma centers may differ in the screening for NAT, as there is a higher odds of receiving a skeletal survey among pediatric hospitals and teaching hospitals.

Rangel et al described racial bias in the form of overuse of skeletal survey in African American patients with data from Cincinnati Children's Hospital, but at the time of this writing, this analysis has not been done with national data, such as the NTDB. Many have noted the importance of early detection of NAT due to risk of long-term sequalae and even death, and this study affirms the important of screening algorithms in preventing the morbidity and mortality from unrecognized NAT (CDC, 2019; Jenny et al., 1999; Prevention, 2019). This study raises concern for potential screening biases in the absence of such algorithms.

Limitations

While the strengths of this study include the sample size, national representation, and diversity of the study population, it is not possible to know the clinical scenarios in each of the observations. For example, many diagnoses are not made for months after discharge because a NAT diagnosis requires a multidisciplinary team and a thorough investigation, as many cases are not straightforward. There also may be issues with delayed or inaccurate coding of child abuse. Some institutions use head computerized tomography (CT) in combination with clinical reasoning and physical examination to rule out NAT in lieu of a skeletal survey. However, if a clinician is to completely rule out NAT, a skeletal survey would be necessary in order to detect occult injuries and healing fractures that are not readily apparent on physical examination. Most hospital guidelines, including the one used at Children’s Healthcare of Atlanta, require a skeletal survey to rule out NAT. Additionally, the adjusted R^2 for each of these models is extremely low, which indicates there are unknown variables that may better explain the variation in the models. Lastly, note that these data are from years 2010-2014, which is before many institutions released algorithms for NAT and may explain inconsistent screening. The impact of these guidelines and the consistency of their use is an area requiring further research.

Recommendations

Screening of NAT with skeletal survey should be correlated with actual diagnoses of NAT to determine the role of implicit bias in the workup and evaluation of child abuse.

Conclusions

This study suggests there is a screening bias in the workup for non-accidental trauma in children less than one year of age. This bias may lead to over-screening of certain racial and socioeconomic groups and under-screening in others. This is concerning given the high morbidity and mortality associated with victims of physical child abuse, and the high-risk population included in this cohort. This study highlights the importance of screening algorithms and guidelines in the workup of non-accidental trauma in order to reduce missed cases of child abuse and decrease overuse of screening tools due to bias.

Table 1: Cohort Demographics for Observations in the National Trauma Data Bank (NTDB) Admitted for a ICD-9 Diagnosis of Fall and Were Less Than One Year of Age

GENDER	Total (n)	%
Male	22336	57.4
Female	16602	42.6
Total	38938	100

PRIMARY METHOD OF PAYMENT	Total (n)	%
Medicaid	19377	49.7
Private/Commercial	13887	35.7
Medicare, Self-Pay, Other	5684	14.6
Total	38948	100

LOCATION	Total (n)	%
Home	30525	78.4
Not at Home	8423	21.6
Total	38948	100

RACE	Total (n)	%
Non-Hispanic White	22466	57.8
Hispanic or Latino	6675	17.2
Black or African American	6172	15.9
Other or Mixed Race	2410	6.2
Asian	839	2.2
American Indian or Pacific Islander	284	0.7
Total	38948	100

Injury Severity Score (ISS)	Total (n)	%
1 to 10	31546	81.0
11 to 75	7401	19.0
Unknown	2819	7.2
Total	38947	100

TRAUMATIC BRAIN INJURY (TBI)	Total (n)	%
Negative	29275	75.4
Positive	9556	24.6
Total	38831	100

TYPE OF HOSPITAL	Total (n)	%
Adult Hospital	20701	53.3
Pediatric Hospital	18098	46.7
Total	38799	100

TEACHING HOSPITAL	Total (n)	%
Teaching Hospital	22740	58.4
Not a Teaching Hospital	16208	41.6
Total	38948	100

Table 2: Crude Odds Ratios for Receiving Skeletal Survey by Each Factor of Interest For Observations in the National Trauma Data Bank (NTDB) That Were Admitted for a ICD-9 Diagnosis of Fall and Were Less Than One Year of Age

Race	**Received skeletal survey (n)**	**Total (n)**	**Odds Ratio of receiving a skeletal survey**	**CI Lower**	**CI Upper**
Non-Hispanic White	2228	22466	1.00	------	------
American Indian or Pacific Islander	56	284	*1.54	1.16	2.05
Asian	51	839	*0.59	0.44	0.78
Black or African American	904	6172	*1.56	1.43	1.69
Hispanic or Latino	657	6675	0.99	0.90	1.09
Other or Mixed race	162	2410	*0.65	0.55	0.77
Total	4058	38846			
Primary Payment Method					
Private	1090	13887	1.00	------	------
Medicaid	2658	19377	*1.87	1.73	2.01
Medicare, Self-Pay, Other	310	5684	*0.68	0.59	0.77
Total	4058	38948			
Location					
Not at home	559	8423	1.00	------	------
Home	3499	30525	*1.82	1.66	2.00
Total	4058	38948			
Injury Severity Score					
1 to 10	3284	31546	1.00	------	------
11 to 75	665	4583	*1.46	1.34	1.60
Total	3949	36129			
TBI					
Negative for TBI	2989	29275	1.00	------	------
Positive for TBI	1069	9556	*1.11	1.03	1.19
Total	4058	38831			
Pediatric Hospital					
Adult Hospital	1515	20701	1.00	------	------
Pediatric Hospital	2539	18098	*2.07	1.93	2.21
Total	4054	34745			
Teaching Hospital					
Not a Teaching Hospital	1090	16208	1.00	------	------
Teaching Hospital	2968	22740	*2.08	1.94	2.24
Total	4058	38948			

Table 3: Multiple Logistic Regression for Odds of Receiving Skeletal Survey (n=35,873)

Race	**Odds Ratio of receiving a skeletal survey**	**Lower**	**Upper**
Non-Hispanic White	1.00	------	------
American Indian or Pacific Islander	*1.44	1.07	1.95
Asian	*0.58	0.43	0.78
Black or African American	*1.28	1.17	1.40
Hispanic or Latino	*0.85	0.77	0.94
Other or Mixed race	*0.65	0.54	0.77
Primary Payment Method			
Private	1.00	------	------
Medicaid	*1.72	1.59	1.86
Medicare, Self-Pay, Other	*0.65	0.57	0.74
Location			
Not at home	1.00	------	------
Home	*1.67	1.51	1.83
Injury Severity Score			
1 to 10	1.00	------	------
11 to 75	*1.45	1.32	1.59
TBI			
Negative for TBI	1.00	------	------
Positive for TBI	*1.17	1.09	1.27
Pediatric Hospital			
Adult Hospital	1.00	------	------
Pediatric Hospital	*1.83	1.71	1.97
Teaching Hospital			
Not a Teaching Hospital	1.00	------	------
Teaching Hospital	*1.77	1.64	1.91

Adjusted $R^2 = 0.0385$

* indicates statistical significance

Bibliography

Belfer, R. A., Klein, B. L., & Orr, L. (2001). Use of the skeletal survey in the evaluation of child maltreatment. *The American Journal of Emergency Medicine, 19*(2), 122-124. doi:https://doi.org/10.1053/ajem.2001.21345

CDC. (2019). *Child Abuse and Neglect Factsheet*. Retrieved from https://www.cdc.gov/violenceprevention/childabuseandneglect/fastfact.html

Jenny, C., Hymel, K. P., Ritzen, A., Reinert, S. E., & Hay, T. C. (1999). Analysis of Missed Cases of Abusive Head Trauma. *JAMA, 281*(7), 621-626. doi:10.1001/jama.281.7.621

Kim, P. T., McCagg, J., Dundon, A., Ziesler, Z., Moody, S., & Falcone, R. A. (2017). Consistent screening of admitted infants with head injuries reveals high rate of nonaccidental trauma. *Journal of Pediatric Surgery, 52*(11), 1827-1830. doi:https://doi.org/10.1016/j.jpedsurg.2017.02.014

Lane, W. G., Rubin, D. M., Monteith, R., & Christian, C. W. (2002). Racial Differences in the Evaluation of Pediatric Fractures for Physical Abuse. *JAMA, 288*(13), 1603-1609. doi:10.1001/jama.288.13.1603

Maina, I. W., Belton, T. D., Ginzberg, S., Singh, A., & Johnson, T. J. (2018). A decade of studying implicit racial/ethnic bias in healthcare providers using the implicit association test. *Social Science & Medicine, 199*, 219-229. doi:https://doi.org/10.1016/j.socscimed.2017.05.009

Prevention, C. f. D. C. a. (2019). Child Abuse and Neglect Factsheet.

Rangel, E. L., Cook, B. S., Bennett, B. L., Shebesta, K., Ying, J., & Falcone, R. A. (2009). Eliminating disparity in evaluation for abuse in infants with head injury: use of a screening guideline. *Journal of Pediatric Surgery, 44*(6), 1229-1235. doi:https://doi.org/10.1016/j.jpedsurg.2009.02.044

Riney, L. C., Frey, T. M., Fain, E. T., Duma, E. M., Bennett, B. L., & Murtagh Kurowski, E. (2018). Standardizing the Evaluation of Nonaccidental Trauma in a Large Pediatric Emergency Department. *Pediatrics, 141*(1), e20171994. doi:10.1542/peds.2017-1994