RESEARCH ARTICLE

Impact on Hospital Resources of Systematic Evaluation and Management of Suspected Nonaccidental Trauma in Patients Less Than 4 Years of Age

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ABSTRACT

OBJECTIVE: There has been an increasing movement worldwide to create systematic screening and management procedures for atypical injury patterns in children with the hope of better detecting and evaluating nonaccidental trauma (NAT). A legitimate concern for any hospital considering implementation of a systematic evaluation process is the impact on already burdened hospital resources. We hypothesized that implementation of a guideline that uses red flags related to history, physical, or radiologic findings to trigger a standardized NAT evaluation of patients <4 years would not negatively affect resource utilization at our level II pediatric trauma center.

METHODS: NAT cases were evaluated retrospectively before and prospectively after implementation of the NAT guideline (n = 117 cases before implementation, n = 72 cases postimplementation). Multiple linear and logistic regression, χ^2, and Wilcoxon rank-sum tests were used to evaluate human, laboratory, technology, and hospital resource usage between cohorts.

RESULTS: Human (child abuse intervention department, ophthalmology, and evaluation by a pediatric surgeon for admitted patients), laboratory (urine toxicology and liver function tests), and imaging (skeletal survey and head or abdominal computed tomography) resource use did not differ significantly between cohorts (all $P > .05$). Emergency department and hospital lengths of stays also did not differ between cohorts. A significant 13% decrease in the percentage of patients admitted to the hospital was observed ($P = .01$).

CONCLUSIONS: Structured evaluation and management of pediatric patients with injuries atypical for their age does not confer an added burden on hospital resources and may reduce the percentage of such patients who are hospitalized.

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Seven hundred thousand victims of child abuse and neglect were reported to child protective services in 2014, and a nationally estimated 1580 children died of abuse and neglect at a rate of 2.13 per 100 000 children in the national population.[1] The evaluation of pediatric trauma patients presenting with suspected nonaccidental trauma (NAT) is complex, and although many victims of NAT receive first-line care at emergency departments (EDs), detection rates are often low.[2] The prevalence of abuse among children presenting to an ED varies from as few as 1% of those aged 0 to 18 years[3] to as high as 71% of young children with rib fractures.[4] The challenge is to identify these children correctly while remaining good stewards of ever decreasing resources in the current health care environment.

Missing NAT has profound medical and socioeconomic implications. From a medical standpoint, 31% of children diagnosed with abusive head trauma had their abuse missed on first presentation,[5] and 33% of children diagnosed with a healing abusive fracture had previously presented with an injury where abuse appeared to have been missed.[6] Early identification of NAT is critical because children who are victims of recurrent NAT experience significantly higher mortality (25%) compared with victims of initial NAT episodes (10%).[7] The social implications of undiagnosed NAT can also be ominous, with an estimated 12% of NAT fatality victims in the United States having received family preservation services in the previous 5 years.[8] Furthermore, child protective services reports may underestimate the true occurrence of abuse and neglect. The National Survey of Children's Exposure to Violence estimated that 1 in 4 children experience some form of child abuse or neglect in their lifetimes.[9] The total lifetime cost of child abuse and neglect is $124 billion each year.[1]

Strategies created to detect NAT include flowcharts or checklists designed to raise awareness of atypical injuries that may signal NAT,[3,10,11] algorithms to guide screening or evaluation in children with suspicious injuries,[12,13] and a screening index score to identify possible abuse.[14] We previously described[12] the implementation of a systematic guideline at a level 2 pediatric trauma center that standardized the evaluation of patients <4 years of age with suspected or confirmed NAT. This was not a generalized screening tool used on all pediatric patients presenting to the ED. Rather, this was an injury-focused screening algorithm triggered by the presence of red flags that, when followed, generated a standardized evaluation of patients with atypical injury suspect for abuse.

Any hospital considering changes related to NAT recognition and management is likely to raise concerns regarding unnecessary admissions, overuse of imaging studies, and risk of placing undue burden on human resources. The current study was designed to address those concerns and serve as an evaluation of the impact on hospital resource utilization of standardizing the evaluation of children <4 years of age with suspected NAT. Here we present an analysis of the impact of our guideline 2 years postimplementation, comparing relevant variables to those of suspected or confirmed NAT patients treated at our center in the 4 years before implementation.

METHODS

A systematic guideline designed to standardize evaluation and management of pediatric patients <4 years of age and presenting with injuries suspect for NAT was developed by a multidisciplinary Trauma Committee in 2013 at Mary Bridge Children's Hospital, a Washington-state verified level II pediatric trauma center.[12] After provision of education to providers in our system about NAT and the use of the tool, the guideline went live across the system on January 1, 2014. The guideline includes direction for identifying NAT red flags as well as management recommendations for laboratory orders, radiologic studies, and referrals for any patient with concern for NAT (see supplemental material).

Trauma cases in our system were identified as suspected/confirmed NAT using the criteria described in Maguire et al 2009,[15] such that any case was flagged if abuse was (1) confirmed in conference, court proceedings, or admitted by a perpetrator or witness; (2) confirmed by multidisciplinary assessment; (3) abuse defined by stated criteria; (4) stated as occurring; or (5) was stated as suspected. Of note, Maguire's third criterion was not routinely used by our trauma center because there is no abuse defined by stated criteria within our system. Once NAT was suspected or confirmed, the Trauma Registry was appropriately updated with International Classification of Diseases, Ninth Revision (ICD-9) or Tenth Revision (ICD-10) codes during the abstraction process. Patients were identified by these ICD-9 and ICD-10 codes in our Trauma Registry for inclusion in this study.

A suite of relevant data points were retrospectively extracted from the Mary Bridge Trauma Registry for all patients served by our institution in the 4 years before the go-live (2010–2013) who were identified as victims of suspected/confirmed NAT using Trauma Registry ICD codes as just described. The same data points were then prospectively captured for all such patients cataloged in the Trauma Registry in the 2 years after implementation (2014–2015). The MultiCare Health System Institutional Review Board reviewed and approved this study (institutional review board protocol 14.07).

To assess hospital resource utilization associated with guideline implementation, we compared the 2 cohorts (pre- and postimplementation) with respect to variables relevant to (1) human resources (consultation with the child abuse department, ophthalmology, and pediatric surgery), (2) laboratory/imaging resources (blood work, skeletal surveys, and computed tomography [CT] of the head and abdomen), and (3) hospital resources (ED and hospital lengths of stay (LOS) and hospital admission frequencies). We also evaluated demographics, injury data, and patient outcomes related to the variables of interest. Categorical associations were assessed using χ^2 tests. Analysis of variance and regression models were used to examine relationships with consideration of potential confounders. Wilcoxon rank-sum tests were used to analyze injury severity scores and LOS. Estimated differences are presented as positive for percentages that increased across time and negative for percentages that decreased across time.

All analyses were conducted in the R statistical computing environment,[16] and significance was assessed at the .05 level.

RESULTS

Patients

One hundred and seventeen patients with suspected/confirmed NAT were treated by our pediatric trauma program between 2010 and 2013 (before guideline implementation) and comprise cohort 1 (C1). Seventy-two patients were treated in the 2 years postimplementation (2014–2015) and comprise cohort 2 (C2). The percent of trauma patients with atypical injury suspect for NAT ranged from 4% to 8% annually (Table 1) but did not differ significantly by year ($P = .17$) or pre- to post-intervention ($P = .57$). Cohorts did not differ significantly with respect to demographic variables including sex (37% and 46% female; $P = .21$) and race (62% and 49% white; $P = .08$). Age distributions of the 2 cohorts were also comparable, with a mean age of 1.3 ± 2.2 years in C1 and 1.9 ± 2.7 years in C2. Although both cohorts included teenage patients (C1 range: 1 week–16 years; C2 range: 2 weeks–14.4 years), the majority of patients were <4 years of age (92% and 90%, respectively; Table 2). The percentage of patients on subsidized insurance at the time of their hospital encounter did not significantly differ by cohort (80.3% vs 77.5%; $P = .64$).

The proportion of patients who had received ED care (37% vs 40%) and/or had a history of child protective services involvement (28% vs 22%) before the cataloged injury was comparable ($P = .63$ and .36).

TABLE 1 Incidence of NAT in Trauma Population Across Study Period

Year	NAT	Accidental	% NAT	Total Trauma	*P*
2010	23	331	6.5	354	
2011	23	419	5.2	442	
2012	27	582	4.4	609	
2013	44	513	7.9	557	
2014	32	498	6.0	530	
2015	39	543	6.7	582	
Total	190	2886	6.2	3074	.21

Distribution of Injury Severity Score (ISS) was also comparable between cohorts ($P = .75$), with a severe ISS (>15) in 44% and 39% of patients in each cohort, respectively. Median ISS for NAT patients was 11 (interquartile range [IQR] = 17) compared with 4 (IQR = 7) for accidental trauma patients ($P < .001$). A linear regression model controlling for patient age, patient sex, and year of injury, revealed a significant 7.2-point increase in mean ISS for NAT patients compared with accidental trauma patients (95% confidence interval [CI] 6.2 to 8.2; $P < .001$).

Laboratory Resources

Use of alcohol/drug screens differed significantly between cohorts. The guideline recommends a comprehensive urine toxicology screen for patients <2 years of age with demonstrated altered consciousness. Nine patients in C1 (8%) compared with 16 patients in C2 (22%) were screened (estimated difference = 14%, 95% CI –4 to 25; $P = .004$). Four of the 9 patients (44%) in C1 screened positive for alcohol/drugs in their system (median age of tested patients 2.1 years) compared with 1 patient (6%) with positive drug results in C2 (median age of tested patients 0.5 years). Liver function tests (LFTs) were ordered for 103 (88%) patients in C1 and 68 (94%) patients in C2 ($P = .15$). Elevated LFTs were observed in 20 (19%) of the tested patients in C1 compared with 20 (29%) of the tested patients in cohort 2 ($P = .13$). Of the C1 patients with elevated LFTs, 12 (60%) had an abnormal finding on abdominal CT, compared with 7 (35%) in C2 ($P = .11$).

Imaging Resources

Skeletal surveys are recommended by the guideline for children <2 years of age with suspected NAT and for older patients if indicated. Skeletal surveys were performed on 90 of 93 (97%) such children in C1 and 47 of 51 (92%) in C2. We note that 1 patient in C1 under age 2 died in the ED and, in C2, 2 patients died within 2 hours of arrival; a third was too unstable to undergo a skeletal survey and later expired in the PICU. Skeletal surveys were performed on an additional 15 patients in C1 (ages 2.3–13.5 years) and 14 in C2 (ages 2.4–9.6 years). A logistic regression model controlling for age, ISS, presence of bruising,

TABLE 2 Demographics

	Cohort 1	Cohort 2	*P*
Patient *n*	117	71	
Female, *n* (%)	43 (36.8)	32 (45.1)	.19
Caucasian, *n* (%)	72 (61.5)	35 (49.3)	.10
0–12 mo	80 (68.4)	42 (59.2)	.42
1–4 y	28 (23.9)	21 (29.6)	
≥4 y	9 (7.7)	8 (11.3)	
Subsidized insurance, *n* (%)	94 (80.3)	55 (77.5)	.64
Age, mean (SD)	1.3 (2.2)	1.9 (2.7)	
Age, range	1 wk–16 y	2 wk–14.4 y	

and subsidized insurance revealed no significant difference between frequency of skeletal survey in the cohorts (odds ratio [OR] 0.9, 95% CI 0.3 to 2.5; $P = .81$). In our population, the proportion of fractures present in nonambulating infants was comparable (54% vs 49%; $P = .60$). A significantly lower percentage of undiagnosed healing fractures was observed postimplementation (31% vs 15%; estimated difference = –16%, 95% CI –3 to –28%; $P = .02$).

Computed tomography of the head was performed for 99 (85%) patients in C1 and 55 (76%) in C2. A logistic regression model controlling for age, presence of bruising, ISS strata (mild, moderate, severe), and subsidized insurance revealed no significant difference in use of head CT between cohorts (OR 0.7, 95% CI 0.3 to 1.5; $P = .34$), but that a severe ISS yielded a 7.4 increase in the odds of head CT compared with mild ISS (95% CI 2.4 to 22.8; $P < .001$). Hemorrhaging was present in 50 of 99 (51%) C1 patients and 34 of 55 (62%) C2 patients ($P = .18$). Abdominal and pelvic CT was performed on 46 (39%) patients in C1 and 26 (36%) in C2 ($P = .66$).

Human Resources

Consult patterns for patients with concern for NAT were comparable between cohorts. One hundred and nine (93%) and 71 (99%) of children in the 2 cohorts were referred to our institution's Child Abuse Intervention Department (CAID) ($P = .16$); we note that 4 children in C1 and 1 in C2 died in the ED before CAID referral was feasible. Our guideline recommends assessment by a pediatric surgeon for any admitted patient with suspected NAT. Before guideline implementation, pediatric surgery consulted on 81% of these patients (86 of 106) compared with 93% (52 of 56) postimplementation (estimated difference = 12%, 95% CI –2% to 22%; $P = .04$). The patients who were not evaluated postimplementation include 3 "social" admission, patients with mild ISS who were admitted at the behest of child protective services to provide additional time to determine safe placement of the child.

Our guideline recommends an ophthalmology consult for a dilated examination in patients <2 years old with an abnormal head CT, abnormal neurologic examination, and/or facial bruising. Ophthalmologic examinations were performed on 57 (49%) patients in C1 and 29 (40%) in C2 ($P = .26$). Frequency of retinal hemorrhaging in those examined by ophthalmology did not differ by cohort (54% vs 59%; $P = .71$). We note that 5 patients age >2 (range 2.7–5.6 years) were seen by ophthalmology (4 in C1 and 1 in C2). Hemorrhage was present in each of these patients, all of whom had a severe ISS. Odds of ophthalmology examination was not significantly associated with cohort in a logistic regression model controlling for age, ISS, presence of subdural/subarachnoid hemorrhage, and subsidized insurance (OR 1.0; $P = .99$). See Table 3 for additional details related to ophthalmology referrals.

Hospital Resources

ED and hospital lengths of stay did not differ between cohorts. Median hospital LOS in C1 was 3.3 hours (IQR = 2.8) compared with 3.6 hours (IQR = 2.8) in C2 ($P = .49$). Median ED LOS was shorter for admitted patients (3.3 hours, IQR = 2.3) compared with patients who were not admitted (4.4 hours, IQR = 2.6). An analysis of variance model evaluating the impact and interaction of hospital admission and cohort on LOS found the effect of admission to be significant ($F_{1171} = 6.9$, $P = .009$), but the effect of cohort and the cohort by admit interaction to be nonsignificant ($P = .89$ and $P = .34$, respectively). Compared with the accidental trauma population, median ED LOS was significantly longer for NAT patients (3.5, IQR = 3) than accidental trauma patients (2.9, IQR = 1.9; estimate = –0.6, 95% CI: –0.9 to –0.3; $P < .001$).

Median hospital LOS was identical for the 2 cohorts: 2 days with an IQR of 5 days. Rising ISS was significantly associated with an increased hospital LOS in an analysis of variance model adjusting for cohort, ISS, presence of intracranial hemorrhage, and subsidized insurance ($F_{4177} = 25.5$; $P < .001$). Median hospital LOS for patients with mild ISS was 1 day (IQR = 1) compared with 6 days (IQR = 9.5) for patients with severe ISS. Median LOS for NAT patients was double that of accidental trauma patients across the study time span (2 days, IQR = 5 vs 1 day, IQR = 1) and this difference was also significant ($P < .001$).

The frequency with which patients were admitted to the hospital was significantly lower postimplementation. Ninety-one percent of C1 (106 admits) was admitted to the hospital, but this percentage dropped by 13% during C2 (56 admits [78%]; 95% CI –24% to 2%; $P = .01$). Restricting to the subset of 109 patients with a mild or moderate ISS (<16), we further investigated the association between hospital admission and cohort using logistic regression and adjusting for sex, age, ISS, and subsidized insurance. In this model, membership in C2 remained significantly associated with decreased odds of hospitalization (OR 0.3, 95% CI 0.1 to 0.9; $P = .02$), and increasing ISS was significantly associated with increased odds of hospital admission (OR 1.4, 95% CI 1.1 to 1.6; $P = .002$). Two patients in C1 and no patients in C2 were readmitted to our institution within 30 days.

DISCUSSION

Our data demonstrate that structuring the evaluation and management of pediatric trauma patients presenting to an ED with atypical injury patterns suspect for abuse does not confer an added burden on hospital resources at the human, technological, or systemic levels. This is not a generalized screening tool to be used on all pediatric patients presenting to the ED. Instead, this is an injury focused screening algorithm that, when followed, generates a standardized evaluation of patients with atypical injury suspect for abuse. The primary finding of this assessment is the significant decrease in the percentage of patients admitted to the hospital. We hypothesize that this is due to more timely and appropriate evaluation and management of NAT. This finding, together with the lack of significant differences in the use of human, laboratory, and imaging resources, is strong evidence that structured evaluation and management of suspected/confirmed NAT will benefit the hospital system from a resource-use perspective.

Efforts to minimize inappropriate use of CT in children with traumatic brain injury are underway nationally,[17,18] as is work regarding intraabdominal injury[19,20] because radiation exposure in childhood may increase the likelihood of a radiation-induced malignancy.[21,22] There is a risk that in an effort not to miss abusive head trauma, clinicians may inappropriately overuse head CT. Our data demonstrate that a systematic approach to the screening and evaluation of NAT does not contradict established mild traumatic brain injury guidelines.[17] Special consideration regarding intraabdominal injury in NAT concerns LFTs. Elevated LFTs in suspected NAT warrant further investigation by CT.[23] This is not necessarily the case in accidental trauma because there are no validated studies examining laboratory values in screening for intraabdominal injury

TABLE 3 Ophthalmology Consults

	Cohort 1				Cohort 2			
	SDH/SAH		Total		SDH/SAH		Total	
	+	–	*n*	%	+	–	*n*	%
Patients referred to ophthalmology	43	23	66	—	28	7	35	—
Ophthalmology examinations performed	41	16	57	86	23	6	29	83
Hemorrhaging present	27	4	31	47	17	0	17	49

SDH/SAH, subdural/subarachnoid hemorrhage; +, positive finding; –, negative finding.

(only physical examination findings).[24] Nevertheless, a standardized approach to screening for abdominal injury using LFTs has not resulted in increased CT usage in this cohort.

There was no significant increase in the rate of NAT diagnosis among the general pediatric trauma population or change in distribution of ISS among patients with NAT during the study period of C2. Furthermore, appropriate resources were marshalled with involvement of pediatric surgery, CAID, and ophthalmology. Pediatric surgeons were noted to be important in the evaluation of NAT cases due to the high incidence of associated polytrauma.[25] NAT has an increased incidence of high ISS, craniotomy, exploratory laparotomy, and mortality when compared with accidental trauma and has prolonged ICU and hospital LOS.[12,26] Finally, Magoteaux et al[27] demonstrated that children with suspected NAT have less care-related concerns when admitted to a pediatric trauma service than a nonsurgical service. This analysis suggests that a targeted approach to screening for NAT is appropriate from both detection and resource utilization standpoints for patients presenting to the ED. It should be noted that more children were screened ($n = 44$) than diagnosed ($n = 32$) with NAT in 2014, the first year of the implementation of the guideline. However, given that these children had injuries concerning for trauma regardless of whether the etiology was accidental versus nonaccidental, their evaluation by the trauma service, including a pediatric surgery and child abuse specialist evaluation, was appropriate. Although we acknowledge that following the guideline may result in additional use of skeletal surveys, patients would have received a head and/or abdominal CT based on injury presentation, not suspicion of abuse.

Critics may argue that if there is already a suspicion of NAT, then a screening tool may be irrelevant. However, the authors note that attempts at screening entire populations are generally ineffective.[28] A recent systematic review of the validity of the population screening approach concluded that only 3 studies had been adequately conducted, and none could support the use of this generalized approach at detecting abuse.[28] Most NAT screening instruments are highly sensitive and do not effectively guide clinical evaluation. Another systematic review evaluating screening tools found both a lack of a gold standard for determination of abuse and that the quality of these studies was low.[29] Furthermore, this generalized “shotgun” approach to screening seems inappropriate in the current era of ever diminishing resources and value-based reimbursement. A combination of injury-specific tools and targeted screening algorithms may result in the optimal utilization of resources while still providing an effective screen for this patient population. This remains a work in progress, however, because existing “injury-specific” tools are either aimed at a specific population (aged <1 year presenting with a fracture[13]) or children <4 years admitted to PICU with trauma and bruising.[30] This study shows the value of case finding by systematic evaluation of children with suspicious injuries.

The primary limitation of our study is its lack of a financial impact analysis. Although we understand from the data that an additional burden has not been placed on our system by guideline implementation and that our hospital admissions decreased significantly, the magnitude of the associated savings remains unclear. Such an analysis is beyond the scope of this article but is an important area for future research. An additional direction for future research is assessing whether the screening and management guideline is improving identification of first-time injuries and whether the children in our postimplementation cohort were victims to repeat injuries at the same rate as children injured before implementation. The decrease in undiagnosed healing fractures between cohorts is interesting and raises the question of whether the guideline may be helping to identify NAT victims earlier in their abuse trajectory, potentially providing important resources to the child and family before escalation. Additional research is needed to assess the effects of the guideline of identification of NAT.

CONCLUSIONS

The authors present data that demonstrate the implementation of a standardized approach to the evaluation and management of NAT does not result in increased utilization of hospital resources. There was a decrease in hospitalization frequency and no change in the use of CTs in our study. We also report that adherence to the guideline resulted in optimization of appropriate consultations. For these reasons, the authors recommend a systematic approach to evaluation and management of NAT.

REFERENCES

1. Centers for Disease Control and Prevention. Child Abuse and Neglect Prevention Atlanta, GA: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, Division of Violence Prevention; 2016 [June 29, 2016]. Available from: www.cdc.gov/violenceprevention/childmaltreatment/
2. Sanders T, Cobley C. Identifying non-accidental injury in children presenting to A&E departments: an overview of the literature. *Accid Emerg Nurs*. 2005;13(2):130–136
3. Louwers EC, Korfage IJ, Affourtit MJ, et al. Effects of systematic screening and detection of child abuse in emergency departments. *Pediatrics*. 2012;130(3):457–464
4. Kemp AM, Dunstan F, Harrison S, et al. Patterns of skeletal fractures in child abuse: systematic review. *BMJ*. 2008;337:a1518
5. Jenny C, Hymel KP, Ritzen A, Reinert SE, Hay TC. Analysis of missed cases of abusive head trauma. *JAMA*. 1999;281(7):621–626
6. Thorpe EL, Zuckerbraun NS, Wolford JE, Berger RP. Missed opportunities to diagnose child physical abuse. *Pediatr Emerg Care*. 2014;30(11):771–776
7. Deans KJ, Thackeray J, Askegard-Giesmann JR, Earley E, Groner JI, Minneci PC. Mortality increases with recurrent episodes of nonaccidental trauma in children. *J Trauma Acute Care Surg*. 2013;75(1):161–165
8. U.S. Department of Health & Human Services, Administration for Children &

Families, Administration on Children, Youth and Families; Children's Bureau. Child Maltreatment. Available at: http://www.acf.hhs.gov/programs/cb/research-data-technology/statistics-research/child-maltreatment

9. Finkelhor D, Turner HA, Shattuck A, Hamby SL. Violence, crime, and abuse exposure in a national sample of children and youth: an update. *JAMA Pediatr*. 2013;167(7):614–621

10. Benger JR, Pearce V. Simple intervention to improve detection of child abuse in emergency departments. *BMJ*. 2002; 324(7340):780

11. Hoytema van Konijnenburg EM, Teeuw AH, Zwaard SA, van der Lee JH, van Rijn RR. Screening methods to detect child maltreatment: high variability in Dutch emergency departments. *Emerg Med J*. 2014;31(3):196–200

12. Escobar MA Jr., Pflugeisen BM, Duralde Y, et al. Development of a systematic protocol to identify victims of non-accidental trauma. *Pediatr Surg Int*. 2016;32(4):377-386

13. Higginbotham N, Lawson KA, Gettig K, et al. Utility of a child abuse screening guideline in an urban pediatric emergency department. *J Trauma Acute Care Surg*. 2014;76(3):871–877

14. Chang DC, Knight VM, Ziegfeld S, Haider A, Paidas C. The multi-institutional validation of the new screening index for physical child abuse. *J Pediatr Surg*. 2005;40(1):114–119

15. Maguire S, Pickerd N, Farewell D, Mann M, Tempest V, Kemp AM. Which clinical features distinguish inflicted from non-inflicted brain injury? A systematic review. *Arch Dis Child*. 2009;94(11):860–867

16. R Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at: www.R-project.org/. Accessed December 1, 2015

17. Kuppermann N, Holmes JF, Dayan PS, et al; Pediatric Emergency Care Applied Research Network (PECARN). Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. *Lancet*. 2009;374(9696):1160–1170

18. United States Nuclear Regulatory Commission. ALARA. 2016. Available at: www.nrc.gov/reading-rm/basic-ref/glossary/alara.html. Accessed December 19, 2016

19. Holmes JF, Lillis K, Monroe D, et al. Identifying children at very low risk of clinically important blunt abdominal injuries. *Ann Emerg Med*. 2013;62(2): 107–116-e2

20. Adelgais KM, Kuppermann N, Kooistra J, et al. Accuracy of the abdominal examination for identifying children with blunt intra-abdominal injuries. *J Pediatr*. 2014;165(6):1230–1235.e5

21. Pearce MS, Salotti JA, Little MP, et al. Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study. *Lancet*. 2012; 380(9840):499–505

22. Frush DP, Donnelly LF, Rosen NS. Computed tomography and radiation risks: what pediatric health care providers should know. *Pediatrics*. 2003; 112(4):951–957

23. Lindberg DM, Shapiro RA, Blood EA, Steiner RD, Berger RP; ExSTRA investigators. Utility of hepatic transaminases in children with concern for abuse. *Pediatrics*. 2013;131(2): 268–275

24. Mahajan P, Kuppermann N, Tunik M, et al; Intra-abdominal Injury Study Group of the Pediatric Emergency Care Applied Research Network (PECARN). Comparison of Clinician Suspicion Versus a Clinical Prediction Rule in Identifying Children at Risk for Intra-abdominal Injuries After Blunt Torso Trauma. *Acad Emerg Med*. 2015;22(9): 1034–1041

25. Larimer EL, Fallon SC, Westfall J, Frost M, Wesson DE, Naik-Mathuria BJ. The importance of surgeon involvement in the evaluation of non-accidental trauma patients. *J Pediatr Surg*. 2013;48(6): 1357–1362

26. Roaten JB, Partrick DA, Nydam TL, et al. Nonaccidental trauma is a major cause of morbidity and mortality among patients at a regional level 1 pediatric trauma center. *J Pediatr Surg*. 2006; 41(12):2013–2015

27. Magoteaux S, Gilbert M, Langlais CS, Garcia-Filion P, Notrica DM. Should Children with Suspected Nonaccidental Injury Be Admitted to a Surgical Service? *J Am Coll Surg*. 2016;222(5):838–843

28. Hoytema van Konijnenburg EM, Teeuw AH, Sieswerda-Hoogendoorn T, Leenders AG, van der Lee JH. Insufficient evidence for the use of a physical examination to detect maltreatment in children without prior suspicion: a systematic review. *Syst Rev*. 2013;2:109

29. Bailhache M, Leroy V, Pillet P, Salmi LR. Is early detection of abused children possible?: a systematic review of the diagnostic accuracy of the identification of abused children. *BMC Pediatr*. 2013; 13:202

30. Laskey AL, Stump TE, Hicks RA, Smith JL. Yield of skeletal surveys in children $\leq$18 months of age presenting with isolated skull fractures. *J Pediatr*. 2013; 162(1):86–89

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