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North American Survey on the Post-Neuroimaging Management of Children with Mild Head Injuries

Jacob K Greenberg, MD, MSCI[1], **Donna Jeffe, PhD**[2], **Christopher R Carpenter, MD, MSc**[3], **Yan Yan, MD, PhD**[4], **Jose A Pineda, MD**[5,6], **Angela Lumba-Brown, MD**[7], **Martin S Keller, MD**[4], **Daniel Berger, BA**[1], **Robert J. Bollo, MD, MS**[8], **Vijay Ravindra, MD**[8], **Robert P Naftel, MD**[9], **Michael Dewan, M.D.**[9], **Manish N. Shah, MD**[10], **Erin C Burns, MD**[11], **Brent R. O'Neill, MD**[12], **Todd C Hankinson, MD**[12], **William E Whitehead, MD, MPH**[13], **P David Adelson, MD**[14], **Mandeep S Tamber, MD, PhD**[15], **Patrick J McDonald, MD, MHSc**[16], **Edward S Ahn, MD**[17], **William Titsworth, MD**[17], **Alina N West, MD, PhD**[18], **Ross C Brownson, PhD**[4,19,20], **David D Limbrick Jr, MD, PhD**[1]

[1]Departments of Neurological Surgery, Washington University School of Medicine in St. Louis, St. Louis, MO.

[2]Departments of Medicine, Washington University School of Medicine in St. Louis, St. Louis, MO.

[3]Division of Emergency Medicine, Washington University School of Medicine in St. Louis, St. Louis, MO.

[4]Departments of Surgery, Washington University School of Medicine in St. Louis, St. Louis, MO.

[5]Departments of Pediatrics Washington University School of Medicine in St. Louis, St. Louis, MO.

[6]Departments of Neurology, Washington University School of Medicine in St. Louis, St. Louis, MO.

[7]Department of Emergency Medicine, Stanford University, Stanford, CA

[8]Department of Neurosurgery, University of Utah School of Medicine, Salt Lake City, UT

[9]Department of Neurological Surgery, Vanderbilt University Medical Center, Nashville, TN

[10]Department of Neurosurgery, McGovern Medical School at University of Texas Health Science Center at Houston, Houston, TX

[11]Department of Pediatrics, Oregon Health & Science University, Portland, OR

[12]Department of Neurosurgery, University of Colorado School of Medicine, Aurora, CO

[13]Department of Neurosurgery, Baylor College of Medicine, Houston, TX

[14]Barrow Neurological Institute at Phoenix Children's Hospital, Phoenix, AZ

[15]Department of Neurological Surgery, University of Pittsburgh School of Medicine, Pittsburgh, PA

Address correspondence to: Jacob K. Greenberg, M.D., M.S.C.I., St. Louis Children's Hospital, Washington University School of Medicine,One Children's Place, Suite 4S20, St. Louis, MO 63110, Telephone: 314-454-2810, Fax: 314-454-2818, jacobgreenberg@wustl.edu.

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[16]Division of Neurosurgery, University of British Columbia, Vancouver, CA

[17]Department of Neurosurgery, Johns Hopkins University School of Medicine, Baltimore, MD

[18]Department of Pediatrics, University of Tennessee Health Science Center, Memphis, TN

[19]Alvin J. Siteman Cancer Center, Washington University School of Medicine in St. Louis, St. Louis, MO.

[20]Prevention Research Center, Washington University School of Medicine in St. Louis, St. Louis, MO.

Abstract

Object: There remains uncertainty regarding the appropriate level of care and need for repeating neuroimaging among children with mild traumatic brain injury (mTBI) complicated by intracranial injury (ICI). To identify knowledge gaps and highlight avenues for future investigation, this study's objective was to investigate physician practice patterns and decision making processes for these patients.

Methods: We surveyed residents, fellows, and attending physicians from the following pediatric specialties: emergency medicine; general surgery; neurosurgery; and critical care. Participants came from 10 institutions in the United States and an email list maintained by the Canadian Neurosurgical Society. The survey asked respondents to indicate management preferences for and experiences with children with mTBI complicated by ICI, focusing on an exemplar clinical vignette of a 7-year-old female, Glasgow Coma Scale score 15, with a 5-mm subdural hematoma without midline shift after a fall down stairs.

Results: The response rate was 52% (n=536). Overall, 326 (61%) respondents indicated they would recommend ICU admission for the child in the vignette. However, only 62 (12%) agreed/strongly agreed that this child was at high risk of neurological decline. Half of respondents (45%; n=243) indicated they would order a planned follow-up CT (29%; n=155) or MRI scan (19%; n=102), though only 64 (12%) agreed/strongly agreed that repeat neuroimaging would influence their management. Common factors that increased the likelihood of ICU admission included presence of a focal neurological deficit (95%; n=508 endorsed), midline shift (90%; n=480) or an epidural hematoma (88%; n=471). However, 42% (n=225) indicated they would admit all children with mTBI and ICI to the ICU. Notably, 27% (n=143) of respondents indicated they had seen one or more children with mTBI and intracranial hemorrhage experience a rapid neurological decline when admitted to a general ward in the last year, and 13% (n=71) had witnessed this outcome at least twice in the past year.

Conclusions: Many physicians endorse ICU admission and repeat neuroimaging for pediatric mTBI with ICI, despite uncertainty regarding the clinical utility of those decisions. These results, combined with evidence that existing practice may provide insufficient monitoring to some high-risk children, emphasize the need for validated decision tools to aid the management of these patients.

Keywords

Traumatic brain injury; health services research; clinical decision making; survey research; intracranial injury

Introduction:

Head trauma is a leading public health issue affecting children, causing approximately 600,000 emergency department (ED) visits and up to 60,000 hospitalizations each year in the United States.[6,34] Healthcare encounters for traumatic brain injury (TBI) are increasing; the rate of ED visits for TBI increased more than eight times faster than the rate of overall ED visits between 2006–2010.[10,35] Generally characterized with a presenting Glasgow Coma Scale (GCS) score of 13–15,[9] mild TBI (mTBI) accounts for more than 90% of new TBI diagnoses and represents an increasingly important sub-type of TBI management.[10,30,35]

Substantial research has been dedicated to identifying which children with mTBI should undergo acute head computed tomography (CT) imaging. With the goal of reducing the substantial variations in head CT utilization,[33,37,41] three independent decisions tools were developed and validated in multicenter studies; these tools have significantly improved evidence-based guidance regarding mTBI imaging decisions.[4,13,32,38]

Comparatively less attention has been focused on the post-CT acute management of children with mTBI, including key questions such as the appropriate level-of-care and role of repeat neuroimaging. These questions have particular salience in the management of children with mTBI complicated by intracranial injury (ICI), where available evidence suggests that admission practices vary across specialties and that level-of-care decisions often fail to correlate with patients' evidence-based risk.[18,42] While there are emerging evidence-based tools to help guide level-of-care decisions,[18] it remains unclear what considerations currently influence physician decision making in this population. Likewise, there remains ongoing debate and uncertainty regarding the role of and indications for repeat neuroimaging in the management of these patients.[16,21,23,39]

Survey studies offer an efficient means of describing current practice, identifying knowledge gaps, and highlighting areas requiring further investigation.[7,31] With these motivations, we conducted a survey to characterize current practice patterns and identify influences on physician decision making in the post-neuroimaging acute care of children with mTBI complicated by ICI.

Methods:

Study Participants

This study was approved with exempt status by the Washington University in St. Louis Institutional Review Board (IRB) and was also approved by the IRB at each participating institution that deemed such oversight necessary.

Study participants came from ten institutions in the United States and from an email registry maintained by the Canadian Neurosurgical Society (see the online Appendix for a list of participating institutions).These centers were identified in part by solicitation at a meeting of the Pediatric Neurocritical Care Research Group. Study participants included attending and fellow physicians from the following pediatric disciplines involved in the care of mTBI:

emergency medicine; general surgery; neurosurgery; and critical care. Senior (PGY-4 and above) general surgery and neurosurgery residents were also surveyed.

Survey Development

Following standard survey methods,[29] we used literature review and input from a team of experts in clinical TBI practice and survey methodologies to develop a 50-item questionnaire to survey physicians about their attitudes and practices in the post-neuroimaging management of pediatric mTBI. Subsequently, we engaged in incremental evaluation and refinement of this preliminary tool, given the importance of pretesting in improving questionnaire quality.[11] First, detailed cognitive interviews were conducted with eight clinical experts in pediatric mTBI who were not part of the research team.[24,25] During these interviews, clinicians completed and provided feedback on the survey, including explaining what they thought the questions meant and how they arrived at their responses. Participants were paid $50.

After revising the survey based on these interviews, a pilot study of the same specialties listed above was conducted at Washington University School of Medicine. Respondents were entered to win one of four $50 prizes. Out of 134 surveys emailed, 68 were returned. Pilot data were examined to gauge response rates and to identify questions with minimal variability in responses (e.g. nearly all respondents agreed/strongly agreed), which were often dropped. Based on multidisciplinary review of the pilot data, a final survey was developed. The survey development is detailed in Figure 1.

Measures

The survey was divided into seven sections and took about 10 minutes to complete. Each of the first three sections focused on one of three clinical vignettes based in the ED. Respondents were asked to characterize the child’s injury and offer their professional opinions related to the appropriate acute management (e.g. next level-of-care and need for repeat neuroimaging). Multiple choice or 5-point Likert scaled response options ranging from “Strongly Disagree” (1 point) to “Strongly Agree” (5 points) were used. For this report, we focused on the vignette involving a 7-year-old girl, GCS 15, with a 5-mm subdural hematoma without midline shift after a fall down the stairs. This vignette was designed to illustrate a patient that available decision aids suggest is at low risk of neurological decline and therefore may not necessarily require ICU admission or planned repeat neuroimaging.[1,8,17,18] The full vignette is provided in the Appendix. The two other vignettes involved children without ICI and will be described in a forthcoming manuscript focused on that patient population.

The fourth section (*Influences on Decision Making*) asked respondents to select the clinical and radiological factors that influenced their decisions about the appropriate level-of-care for children with mTBI. In addition, respondents used a 5-point Likert scale (ranging from “Never” [1] to “Always” [5]) to rate the frequency that other factors, e.g. one’s “gestalt impression” and standard institutional practice, influenced their decision-making. The fifth section (*Recent Experiences with TBI patients*) asked respondents about their experiences observing mTBI (GCS 13–15) patients undergoing unexpected neurological decline or

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radiologic progression during the last year. The sixth section (*Shared Decision Making* [SDM]) used a previously developed guide to ask respondents how frequently various factors (e.g. medicolegal concerns) served as barriers to utilizing SDM in the post-neuroimaging management of pediatric mTBI patients.[28] The results from this section will be reported with the upcoming manuscript on the management of children without ICI. The final section (*Demographics*) included questions asking about respondents' characteristics and practice settings.

Survey Administration

Site principal investigators at each institution collected and shared email addresses of potential eligible participants with the Data Coordination site at Washington University in St. Louis. The voluntary survey was then administered via unique emails sent using the Qualtrics server (Qualtrics, Provo, UT) from 8/3/2016 to 1/30/2017. Surveys were completed anonymously. After the initial distribution, four follow-up emails were sent approximately one week apart to potential participants. Participants were offered $10 compensation.

Statistical Analysis

We analyzed surveys that had at least 50% of the survey items completed, and treated the remaining surveys as non-responses.[2] Descriptive statistics were reported for all items. The primary outcome was the level-of-care recommended for the child with mTBI complicated by ICI in the vignette. The secondary outcome was the decision to order planned repeat neuroimaging for this child before hospital discharge. This outcome was defined as those who "Agreed" or "Strongly Agreed" with ordering a repeat CT or MRI scan for the child.

After conducting univariate logistic regression analyses, variables with p-values < 0.2 for each outcome were entered into a multivariable logistic regression model using backwards selection, and variables with $p < 0.05$ were retained. Complete case analysis was used given the small amount of missing data. For respondent specialty, missing data were grouped in the "Other" category. Respondents "not sure" if their institution was a Level 1 trauma center were grouped in the "No" category.

For increased statistical power, we treated items with Likert-scaled responses as continuous numerical variables and reported the mean and standard deviation for each item. In cases where the linearity of continuous predictors with the outcome was questionable, we ensured that the final model did not change with these variables re-categorized into 3 groups: Strongly Disagree/Disagree; Neutral; Agree/Strongly Agree (data not shown). Statistical analyses were conducted using SAS version 9.4 (SAS Institute Inc, Cary, NC).

Results:

Out of 1,022 email surveys distributed, 536 respondents completed at least 50% of the survey items, yielding a 52% response rate. Emergency medicine constituted the largest group of respondents (38%), followed by critical care (25%), neurosurgery (21%), and general surgery (13%). Most respondents (63%) were attendings, male (52%), and worked at free-standing children's hospitals (76%). Only 5% of respondents practiced in Canada. Demographic information is shown in Table 1.

Respondents varied their responses regarding the appropriate terminology to characterize the injury in the vignette, which involved a 7-year-old girl with a GCS 15 head injury and a "5-mm subdural hematoma without midline shift or signs of herniation." Most respondents (59%) endorsed the term "GCS 13–15 head injury with ICI," while the remainder were split among the terms mild (13%), complicated mild (26%), moderate (28%), and severe (3%) TBI.

Responses to the vignette are listed in Table 2. Overall, 326 (61%) respondents indicated they would recommend ICU admission for the child in the vignette, though only 62 (12%) agreed/strongly agreed that this child was at high risk of neurological decline, with about one-third of respondents (36%; n=191) being neutral. The majority (77%, n=412) agreed/strongly agreed with involving family in their level-of-care decision. Slightly fewer than half of respondents (45%; n=243) indicated they would order a planned follow-up CT (29%; n=155) or MRI (19%; n=102) before hospital discharge, though only 64 (12%) agreed/strongly agreed that repeat neuroimaging would likely influence their clinical management. Planned repeat neuroimaging was most frequent among neurosurgeons (68%) and other unlisted specialties (68%), and less frequent among critical care physicians (49%), general surgeons (43%), and emergency physicians (29%).

Beyond this specific vignette, the clinical and radiologic factors that generally influenced respondents' decisions to admit children with mTBI complicated by ICI to the ICU are listed in Table 3. The most common factors influencing admission decisions included presence of a focal neurological deficit (95%), midline shift on CT (90%) and presence of an epidural hematoma (88%), with subdural hematoma (54%) and post-traumatic seizure (53%) being other common responses. Notably, 42% of respondents indicated they would admit all children with ICI to the ICU, regardless of the specific clinical or radiologic findings. Among other influences on decision-making, understanding of the medical literature (74% always/often utilized) and gestalt impression (69% always/often utilized) had the greatest impact (Appendix Table 1).

When asked about their experiences with TBI patients in the past 12 months, 27% indicated they had seen one or more "clinically stable children with GCS 13–15 closed head injury and intracranial hemorrhage, experience a rapid neurological decline when admitted to a general ward" in the last year, and 13% had witnessed this outcome at least twice in the past year (Appendix Table 2). In addition, 35% indicated they had recently seen clinically stable children with GCS 13–15 closed head injury and intracranial hemorrhage require neurosurgical intervention for an enlarging hematoma seen on repeat imaging, in the absence of any neurological decline.

Variables Associated with Level-of-care Decisions

In univariate analysis, we found a number of factors associated with the level-of-care decision in the vignette. These included demographic factors (e.g. specialty, training level); feelings about the importance of involving family; beliefs about the child's likely clinical course and the role of repeat neuroimaging; importance placed on understanding of the medical literature, gestalt impression, and malpractice liability; and recent experiences with TBI patients (Tables 1–2; Appendix Tables 1–2).

The multivariable model is shown in Table 4. In this analysis, critical care physicians (OR=2.2) general surgeons (OR=2.7), and neurosurgeons (OR=1.9) were at least twice as likely as emergency medicine physicians to recommend ICU admission. Physicians not working at a freestanding children's hospitals were also twice as likely to recommend ICU admission (OR=1.8). In addition, providers who believed that the child was at risk of neurological decline (OR=1.6), those who relied on their "gestalt impression" (OR=1.4), and those who would obtain a repeat CT (OR=1.3) or MRI (OR=1.3) were more likely to recommend ICU admission.

Variables Associated with Repeat Neuroimaging Decisions

In univariate analysis, we found a number of factors significantly associated with the decision to order repeat neuroimaging in the vignette. These included demographic factors (e.g. provider specialty and age), beliefs about the child's clinical course, and recent experiences with TBI patients. The complete univariate results are shown in Appendix Table 3.

The multivariable model of factors associated with planned repeat neuroimaging is shown in Table 5. In this analysis, physicians who favored ICU admission, those who believed repeat imaging was likely to influence their management, and respondents from neurosurgery and "other" unlisted specialties were more likely to order repeat imaging. Physicians from freestanding Children's hospitals were less likely to order repeat imaging. Repeat imaging behavior also varied with age and training level, with repeat neuroimaging being more common among respondents older than 50 versus younger than 40 years and less frequent among attendings compared to residents.

Discussion:

Although evidence-based indications for head CT imaging in pediatric mTBI have been established, there is a paucity of literature providing evidence for the routine post-neuroimaging management of these patients, including key topics such as the appropriate level-of-care and need for repeat neuroimaging.[1,8,18,21,22] Understanding clinicians' underlying cognitive processes is an essential component of evaluating management decisions and designing clinical decision-aids to support evidence-based practices.[15,27] Nonetheless, there are limited data describing provider practices and preferences in this domain. This multicenter, multidisciplinary survey sought to fill that void. We found that most physicians would admit a neurologically intact child with a small subdural hematoma to the ICU and nearly half would order routine repeat neuroimaging, despite low concern regarding this child's risk of neurological decline and low expectations regarding the utility of a follow-up scan. These practices varied across specialty and practice settings and appeared influenced by a number of provider beliefs, motivating and informing future studies of the appropriate level of care and need for repeat neuroimaging in this population.

Among children with mTBI and ICI that do not require upfront surgical intervention, one of the key decisions facing providers relates to the level-of-care required. In the vignette presented, we described a neurologically intact child with mTBI complicated by a small subdural hematoma, the most common type of ICI encountered in this population.[18] To our knowledge, all studies of this population characterize the child in this vignette as low risk of neurological decline and recommend against ICU admission;[1,8,17,18] yet 61% of respondents recommended ICU admission and 42% indicated they would recommend ICU admission for all children with ICI, though only 12% thought this child was at high risk high for neurological decline. These results highlight the wide variations and potentially avoidable resource utilization associated with current practices.

Beyond promoting potentially unnecessary ICU admissions, the variations in current practice may also place some patients at risk of significant harm. Supporting this notion, more than 25% of survey respondents reported that they had seen children with mTBI complicated by ICI experience neurological decline on a general ward in the last year. This result builds on existing evidence suggesting that current practice based on clinical gestalt not only sends many low risk children to the ICU, it also provides insufficient attention to the minority of patients truly at increased risk of neurological decline.[18] These findings emphasize the need for rigorously validated decision tools to support evidence-based level-of-care decisions.

The secondary outcome in this study focused on the need for routine repeat neuroimaging following mTBI complicated by ICI, a source of ongoing debate and investigation. Although several studies have suggested that repeat neuroimaging may be low yield,[3,12,39] other studies have reported high rates of radiologic progression.[16] Given that nearly half of respondents supported ordering repeat neuroimaging but only 12% thought it was likely to change clinical management, higher level multicenter evidence is needed to guide this important decision. These studies should evaluate not only rates of radiologic progression but also the frequency with which such information influences clinical management. Such data, combined with consideration of the impact of ionizing radiation, may inform the development of evidence-based recommendations regarding the role of routine repeat CT or MRI imaging.[5]

Successful uptake of level-of-care and repeat neuroimaging decision aids will depend on rigorous dissemination and implementation strategies,[19] which may be informed by the self-reported variations related to practice setting and provider beliefs revealed in this study. For example, the increased tendency toward ICU admission among those not at freestanding Children's hospitals highlights the role of institutional resources and experience which should be considered in designing broadly generalizable implementation efforts. Likewise, we found that neurosurgeons were significantly more likely than other specialties to order planned repeat neuroimaging for the child in the vignette. Given the key role that neurosurgeons have in this decision making process, future implementation studies should focus on studying the acceptability and usability of imaging decision aids in this population.

This study has several strengths, including rigorous survey development methods, a large sample size, and a multidisciplinary and multicenter respondent base. Nonetheless, it also has limitations. First, our response rate (52%), while good, was still below the standard of 60% set by some authorities.[26] However, survey response rates have decreased in recent years,[40] and the association between a lower response rate and nonresponse bias is unclear.[14,20] Second, to shorten the survey's completion time, we included only one exemplar case of a patient with ICI. While this limited the breadth of situations tested, it allowed for more detailed assessment of provider attitudes and influences on decision making. Third, the survey respondents were concentrated at academic tertiary or quarternary institutions and also at freestanding children's hospitals. Consequently, the results may not generalize to community settings or to children treated within a predominately adult institution, which may have different practices and availability of subspecialty care. Finally, this survey focused on physicians and did not investigate the perspectives of midlevel providers who are assuming a growing role in delivering emergency pediatric care.[36]

Conclusions:

This multicenter multidisciplinary survey indicated that there is wide variation in physician decisions related to the level of care and need for repeat neuroimaging for children with mTBI and ICI. The practices reported are associated with potentially avoidable resource utilization as well as possible patient harm. These observations, along with providers' uncertainty regarding the clinical utility of their recommendations, highlight the need for continued efforts to advance evidence-based decision aids. Once developed and validated, such evidence-based approaches may form the foundation for consensus guidelines to direct the safe, resource-efficient management of these patients.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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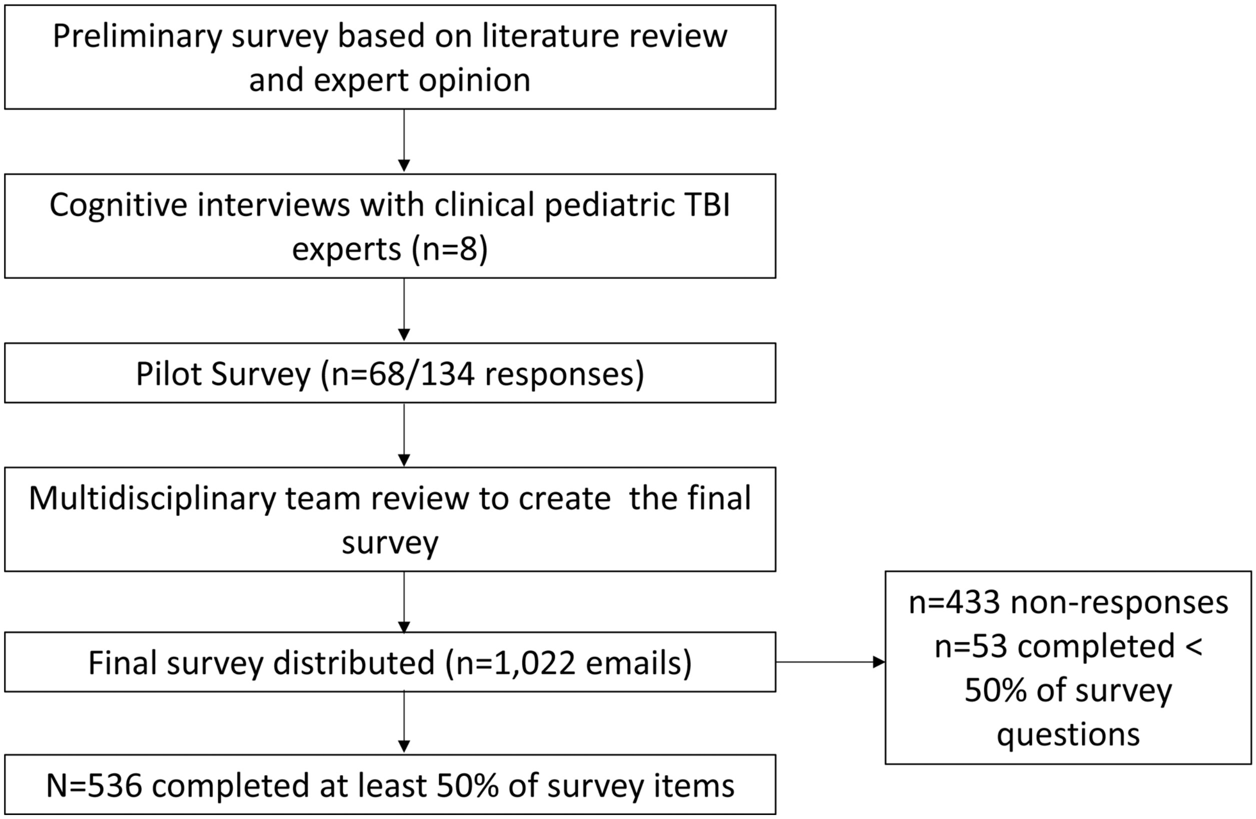

Figure 1:
Schematic depiction of the survey development process

Table 1:

Demographic characteristics of survey respondents. P-values refer to the univariate logistic regression predicting the level-of-care decision (floor vs. ICU) for the child in the clinical vignette.

	All (%)* n=536	Admit Floor (%)* n=208	Admit ICU (%)* n=326	P-value
Specialty				
Emergency Medicine	205 (38.3)	109 (52.4)	96 (29.5)	Ref
Critical Care	132 (24.6)	41 (19.7)	91 (27.9)	< 0.01
General Surgery	68 (12.7)	19 (9.1)	49 (15.0)	< 0.01
Neurosurgery	112 (20.9)	30 (14.4)	80 (24.5)	< 0.01
Other	19 (3.5)	9 (4.3)	10 (3.1)	0.63
Training Level				
Resident	91 (17.4)	19 (9.3)	72 (22.7)	Ref
Fellow	101 (19.3)	41 (20.1)	60 (18.9)	< 0.01
Attending	331 (63.3)	144 (70.6)	185 (58.4)	< 0.01
Age				
< 40	304 (58.1)	118 (57.8)	186 (58.7)	Ref
40–49	135 (25.8)	59 (28.9)	75 (23.7)	0.31
≥ 50	84 (16.1)	27 (13.2)	56 (17.7)	0.30
Gender				
Female	247 (47.7)	107 (52.7)	140 (44.7)	0.08
Male	271 (52.3)	96 (47.3)	173 (55.3)	Ref
Number of children with mTBI cared for per year				
0–20	135 (25.9)	41 (20.2)	94 (29.7)	< 0.01
20–39	155 (29.7)	57 (28.1)	96 (30.3)	0.12
≥ 40	232 (44.4)	105 (51.7)	127 (40.1)	Ref
Level 1 Trauma Center **				
Yes	494 (94.3)	193 (94.6)	299 (94.0)	Ref
No	30 (5.7)	11 (5.4)	19 (6.0)	0.78
Academic Medical Center ***				
Yes	499 (95.2)	197 (96.6)	300 (94.3)	Ref
No	25 (4.8)	7 (3.4)	18 (5.7)	0.25
Independent Children’s Hospital				
Yes	400 (76.3)	169 (82.8)	230 (72.3)	Ref
No	124 (23.7)	35 (17.2)	88 (27.7)	< 0.01
Hospital Location				
Urban	487 (93.1)	186 (91.2)	299 (94.3)	Ref
Non-Urban	36 (6.9)	18 (8.8)	18 (5.7)	0.17
Hospital Region				
Canada	27 (5.3)	13 (6.4)	13 (4.2)	Ref
Northeast	55 (10.7)	22 (10.8)	33 (10.7)	0.40
South	204 (39.7)	74 (36.5)	129 (41.8)	0.18

	All (%)* n=536	Admit Floor (%)* n=208	Admit ICU (%)* n=326	P-value
Midwest	31 (6.0)	10 (4.9)	21 (6.8)	0.18
West	197 (38.3)	84 (41.4)	113 (36.6)	0.48

*Percentage values reflect each level's proportion of the total number of respondents within a given column (floor vs. ICU). Discrepancies in column totals reflect a small amount of missing data for ICU admission (n=2), Training Level (n=13), Age (n=13), Gender (n=18), Number mTBI Children Cared for (n=14), Level 1 Trauma Center (n=12), Academic Medical Center (n=12), Independent Children's Hospital (n=12), Hospital Location (n=13), and Hospital Region (n=22).

**Not sure Counted as "Not Level 1"

***"Not Sure" counted as no

Table 2:

Respondent opinions and management preferences regarding the clinical vignette involving a 7-year-old girl, Glasgow Coma Scale score 15, with a 5-mm subdural hematoma after a fall down the stairs. Responses either involved selecting all appropriate choices or a Likert-scale ranging from Strongly Disagree (1 point) to Strongly Agree (5 points).

	All*	Admit Floor*	Admit ICU*	P-Value**
Appropriate Consults, n (%)				NA
Critical Care	124 (23.1)	5 (2.4)	119 (36.5)	
General Surgery	327 (61.0)	100 (48.1)	227 (69.6)	
Neurosurgery	532 (99.3)	205 (98.6)	325 (99.7)	
Pediatrics	15 (2.8)	8 (3.9)	7 (2.2)	
Other	2 (0.37)	1 (0.48)	1 (0.31)	
No consult indicated	1 (0.19)	0 (0)	1 (0.31)	
How would you characterize the injury, n, (%)				NA
Mild TBI	69 (12.9)	30 (14.4)	39 (12.0)	
Complicated mild TBI	138 (25.8)	59 (28.4)	79 (24.4)	
GCS 13–15 head injury with intracranial injury	317 (59.4)	127 (61.1)	189 (58.3)	
Moderate TBI	150 (28.1)	56 (26.9)	93 (28.7)	
Severe TBI	17 (3.2)	1 (0.48)	16 (4.0)	
Important to involve family in my decision regarding the appropriate level of care, mean (Stdev)	3.98 (1.03)	4.11 (0.94)	3.90 (1.08)	0.02
This child is likely to undergo neurological decline, mean (Stdev)	2.56 (0.80)	2.31 (0.69)	2.71 (0.83)	< 0.01
I am confident in my assessment of the risk of neurological decline, mean (Stdev)	3.85 (0.70)	3.82 (0.71)	3.88 (0.69)	0.33
Before discharge I would order a repeat CT scan,	2.59 (1.23)	2.27 (1.04)	2.79 (1.30)	< 0.01
Before discharge I would order a follow-up MRI scan, mean (Stdev)	2.41 (1.10)	2.17 (0.97)	2.56 (1.16)	< 0.01
Before discharge I would order repeat CT *and/or* MRI (Strongly Agree/Agree), n (%)	243 (45.4)	55 (26.4)	187 (57.5)	< 0.01
Repeat neuroimaging is likely to influence my clinical management, mean (stdev)	2.36 (0.89)	2.14 (0.75)	2.49 (0.94)	< 0.01
Within 2 weeks of discharge, this child should have a follow-up appointment with, n (%)				NA
A neurosurgeon	478 (89.2)	185 (88.9)	291 (89.3)	
A trauma surgeon	22 (4.1)	6 (2.9)	16 (4.9)	
Her primary care physician	364 (67.9)	136 (65.4)	228 (69.9)	
A neurologist	52 (9.7)	9 (4.3)	43 (13.2)	
Other	43 (8.0)	10 (4.8)	33 (10.1)	

* Discrepancies in column totals reflect the small amount of missing data for injury characterization (n=2), need for repeat CT (n=3), need for follow-up MRI (n=4), and influence of repeat neuroimaging (n=1).

** P-values refer to the univariate logistic regression predicting the level-of-care decision (floor vs. ICU) for the child in the clinical vignette. “NA” indicates not applicable, meaning the variable was not tested as a potentially clinically informative predictor.

Table 3:

Clinical and radiologic influences indicating the need for ICU observation for children with GCS 13–15 head injuries and intracranial injury. Respondents were asked to select as many options as they agreed with (yes/no option). There were 3 missing responses.

	N (%) Agreeing
I would admit all children with GCS head injuries and ICI to the ICU	225 (42.1)
Post-traumatic seizure	282 (52.9)
Severe mechanism of injury	325 (61.0)
Midline shift (< 5 mm)	480 (90.1)
Depressed skull fracture (depressed at least the width of the skull)	322 (60.4)
Epidural hematoma (no midline shift)	471 (88.4)
Subdural hematoma (no midline shift)	289 (54.2)
Subarachnoid hemorrhage (no midline shift or ventriculomegaly)	235 (44.1)
Cerebral contusion (no midline shift)	223 (41.8)
Intraventricular hemorrhage (no midline shift or ventriculomegaly)	336 (63.0)
GCS score 14	98 (18.4)
GCS score 13	300 (56.3)
Presence of a focal neurological deficit	508 (95.3)
Patient age < 2 years	331 (62.1)
Other	34 (6.4)

Table 4:

Results of the multivariable analysis predicting the level-of-care recommended for the child in the clinical vignette. Odds ratios greater than 1 indicate increased likelihood of recommending ICU admission.

	Odds Ratio (95% Confidence Interval)
Specialty	
Emergency Medicine	Ref
Critical Care	2.2 (1.3 – 3.6)
General Surgery	2.7 (1.4 – 5.0)
Neurosurgery	1.9 (1.1 – 3.3)
Other	0.32 (0.07 – 1.5)
Working at a freestanding Children’s hospital	
Yes	Ref
No	1.8 (1.1 – 3.0)
Perceived likeliness of neurological decline	1.6 (1.2–2.1)
Agreement with ordering a repeat CT scan	1.3 (1.1 – 1.5)
Agreement with ordering a follow-up MRI scan	1.3 (1.1 – 1.6)
Use of gestalt impression in decision making	1.4 (1.1 – 1.8)

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Table 5:

Results of the multivariable analysis identifying factors associated with repeat neuroimaging decisions for the child in the clinical vignette. Odds ratios greater than 1 indicate increased likelihood of recommending repeat neuroimaging.

	Odds ratio (95% Confidence Interval)
Would admit the child in Vignette #2 to the ICU	2.9 (1.8–4.6)
Agreement that repeat neuroimaging is likely to change clinical management	4.3 (3.1–6.1)
Specialty	
Emergency Medicine	Ref
Critical Care	1.8 (1.02 –3.2)
General Surgery	1.4 (0.70 – 3.0)
Neurosurgery	3.4 (1.7 – 6.8)
Other	8.2 (1.5 – 44.8)
Training Level	
Resident	Ref
Fellow	1.3 (0.57 – 2.9)
Attending	0.42 (0.18 – 0.97)
Age	
< 40	Ref
40 – 49	1.7 (0.85 – 3.4)
≥ 50	4.6 (2.2 – 9.8)
Working at a freestanding Children’s hospital	
Yes	Ref
No	1.8 (1.0 – 3.1)