The Utah Pediatric Trauma Network, a statewide pediatric trauma collaborative can safely help nonpediatric hospitals admit children with mild traumatic brain injury

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BACKGROUND: Created in 2019, the Utah Pediatric Trauma Network (UPTN) is a transparent noncompetitive collaboration of all hospitals in Utah with the purpose of improving pediatric trauma care. The UPTN implements evidence-based guidelines based on hospital resources and capabilities with quarterly review of data collected in a network-specific database. The first initiative was to help triage the care of traumatic brain injury (TBI) to prevent unnecessary transfers while ensuring appropriate care. The purpose of this study was to review the effectiveness of this network wide guideline.

METHODS: The UPTN REDCap database was retrospectively reviewed between January 2019 and December 2021. Comparisons were made between the pediatric trauma center (PED1) and nonpediatric hospitals (non-PED1) in admissions of children with very mild, mild, or complicated mild TBI.

RESULTS: Of the total 3,315 cases reviewed, 294 were admitted to a non-PED1 hospital and 1,061 to the PED1 hospital with very mild/mild/complicated mild TBI. Overall, kids treated at non-PED1 were older (mean, 14.9 vs. 7.7 years; $p = 0.00001$) and more likely to be 14 years or older (37% vs. 24%, $p < 0.00001$) compared with those at PED1. Increased admissions occurred post-UPTN at non-PED1 hospitals compared with pre-UPTN (43% vs. 14%, $p < 0.00001$). Children admitted to non-PED1 hospitals post-UPTN were younger (9.1 vs. 15.7 years, $p = 0.002$) with more kids younger than 14 years (67% vs. 38%, $p = 0.014$) compared with pre-UPTN. Two kids required next-day transfer to a higher-level center (1 to PED1), and none required surgery or neurosurgical evaluation. The mean length of stay was 21.8 hours (interquartile range, 11.9–25.4). Concomitantly, less children with very mild TBI were admitted to PED1 post-UPTN (6% vs. 27%, $p < 0.00001$) and more with complicated mild TBI (63% vs. 50%, $p = 0.00003$) than 2019.

CONCLUSION: Implementation of TBI guidelines across the UPTN successfully allowed nonpediatric hospitals to safely admit children with very mild, mild, or complicated mild TBI. In addition, admitted kids were more like those treated at the PED1 hospital. (*J Trauma Acute Care Surg.* 2023;95: 376–382.

LEVEL OF EVIDENCE: Prognostic/Epidemiological; Level IV.

KEY WORDS: Pediatric trauma; collaborative; regional trauma system; guidelines.

Traumatic injuries remain the leading cause of death and disability among children and can lead to a substantial loss of years of potential life.[1] Optimizing the care of injured kids is needed to reduce mortality, improve short- and long-term outcomes, and to contain the overall cost of care. To achieve this, the Institute of Medicine has recommended trauma systems be established that allow for the regionalization of care in a coordinated manner with oversight and accountability to ensure that the systems are functioning appropriately.[2]

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In 2015, the Utah Department of Health published the outcomes and trends of Utah's Trauma System.[3] This showed that the case fatality rate of Utah's youth (ages 0–19 years) was consistently higher than that reported by the National Trauma Database. This higher mortality rate was a result of the increased death of children treated at all other hospitals within the state other than Primary Children's Hospital (PCH), the only American College of Surgeons verified pediatric trauma center (vPTC). Because of the vastness of the state and location of PCH, access to a vPTC within 60 minutes is limited to a relatively small geographic region.[4] Therefore, most injured children receive initial care at facilities that are not pediatric trauma verified, and some have very limited pediatric resources. To complicate things further, a study we published in 2015 demonstrated that over a 10-year period, 27% of children transferred to PCH could probably have been prevented with additional resources at local facilities.[5] Not surprising, these children were significantly more likely to have a traumatic brain injury (traumatic brain injury [TBI], 65% vs. 51%; $p < 0.001$).

To help "right size" pediatric trauma care, that is, to treat the right kid at the right place and at the right time, the Utah Pediatric Trauma Network (UPTN) was created during the 2018

legislative session and an annual appropriate given under the Utah Department of Health through the passage of a joint Senate resolution. The private-public partnership between the Utah Department of Health and PCH was finalized in 2019 formalizing this network. The UPTN is a transparent noncompetitive collaboration of all 51 hospitals in Utah with the purpose of improving pediatric trauma care, through categorization of each facility within each region based on hospital resources and capabilities, the implementation of evidence-based guidelines based on these categories, and frequent review of data collected in a network-specific database. The first initiative was to help triage the care of TBI to prevent unnecessary transfers while ensuring appropriate care. The purpose of this study was to review the effectiveness of the network wide TBI guideline.

PATIENTS AND METHODS

UPTN Creation

Creation of the UPTN started in 2017 where the initial concept of the network was discussed with Utah Senator Jani Iwamoto. A provision was found within Utah code under the Utah Emergency Medical Services System Act, calling for "the department [of health to]…establish a pediatric quality improvement resource program."[6] Up until this time, no such program existed. A proposal to create the UPTN was presented to the Utah Senate Health and Human Services Committee without success. Over the next several months, support would be garnered through the Utah Department of Health, Utah Medical Association, Utah Hospital Association, and lobbyist for the University of Utah and Intermountain Healthcare. During the 2018 Utah legislative session, a Senate Joint Resolution was sponsored by both Senator Iwamoto and Representative Ray Ward to create the network. This was presented at the Utah Social Services Appropriations Subcommittee as well as the Utah House Health and Human Services Committee. The resolution passed both committees and would eventually be passed by the greater legislative body allowing for the creation of UPTN with an annual appropriation of $250,000. Falling under the responsibility of the Utah Department of Health, a legal contract was created with Intermountain PCH, making the UPTN a public-private partnership able to use the resources and expertise of both the Utah Government and level 1 pediatric trauma center. After hiring a formal program manager, the UPTN set out to establish a network using the recommendations from the Institute of Medicine to improve pediatric emergency care, mainly, regionalization, coordination, and accountability.[2]

Regionalization

The Utah Department of Health has divided the state into five trauma regions based on geographic location (Northern, Central, South Central, Southwest, and Southeast). Each region has its own distinct geography with hospitals of differing capabilities and levels of pediatric experience. The UPTN began to set up councils within each region made up of members from each hospital in that region tasked with improving regional pediatric trauma care. First, each hospital would need to identify their pediatric resources and capabilities. To do so, four categories (PED-ED, PED, PED+, and PED1), which are described in detail in Figure 1, were created. Hospitals then self-selected into the category that best fit their institution.

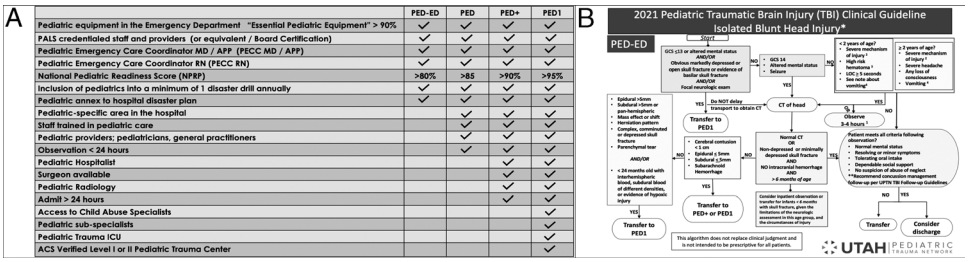
Next, each hospital would identify a pediatric emergency care coordinator (PECC), ideally one at the physician or advanced practice provider (APP) level and another from a nursing level.[2] These individuals participate in quarterly UPTN regional council meetings, implement UPTN guidelines at their facility, and ensure data entry into the UPTN database. Ultimately, this organization will help the UPTN understand how kids are cared for within each region and provide additional trauma support to these nonpediatric hospitals. Representation from each regional council is encouraged to participate in an operational council, which meets biannually to review the progress and direction of the entire network.

Coordination

Triage and transfer guidelines were created for UPTN using pediatric trauma subspecialty experts in the area the guideline addressed. For example, for TBI, experts in pediatric neurosurgery, radiology, emergency medicine, and trauma surgery were used. The guidelines were evidence based using the most recent literature on the subject and formatted to guide physicians and APPs with little pediatric experience through the evaluation and initial management of an injured child. The guidelines were not created as a one size fits all but rather built to account for the hospital categorization. Thus, recommendations are given according to an individual hospital's resources and capabilities. Additional appendices are also provided for each guideline as needed to give rational and insight into certain aspects of the guidelines and provide additional help during treatment. Once the guideline is completed, it goes through several passes of editing to make sure all involved specialties are satisfied and is then presented to the State Trauma System Advisory Council for approval. All guidelines undergo review every 2 years. Traumatic brain injury was the first guideline completed in 2019 and seen in Figure 1. Since then, multiple other guidelines have also been created. All are published on the UPTN website (www.utahptn.org). Educational videos from content experts were also created and published on the website as an additional resource.

Accountability

The ability for data to help make decisions and drive improvement within UPTN is one of the most important aspects of the network. To do so, granular data as to the effectiveness of the guidelines are needed. The state trauma registry is unable to provide the detail needed in a timely manner, so a UPTN-specific REDCap database was created and housed on a state server. Specific criteria were created to direct each hospital as to which treated children should be included in the database. The PECC at each hospital is responsible for data submission on a quarterly basis. The data are reviewed by UPTN leadership monthly and then quarterly at regional UPTN performance improvement meetings. Additional opportunities for data review include quarterly case review, biannual operational council meetings, and the annual conference. As needed, individual case review is performed when initiated by the referring non-PED1 center or PED1 center to evaluate effectiveness of the guidelines, especially when the guideline was not followed appropriately, that is, child transferred when guideline recommended admission at the referring facility.



	PED-ED	PED	PED+	PED1
Pediatric equipment in the Emergency Department "Essential Pediatric Equipment" > 90%	✓	✓	✓	✓
PALS credentialed staff and providers (or equivalent / Board Certification)	✓	✓	✓	✓
Pediatric Emergency Care Coordinator MD / APP (PECC MD / APP)	✓	✓	✓	✓
Pediatric Emergency Care Coordinator RN (PECC RN)	✓	✓	✓	✓
National Pediatric Readiness Score (NPRP)	>80%	>85	>90%	>95%
Inclusion of pediatrics into a minimum of 1 disaster drill annually	✓	✓	✓	✓
Pediatric annex to hospital disaster plan	✓	✓	✓	✓
Pediatric-specific area in the hospital		✓	✓	✓
Staff trained in pediatric care		✓	✓	✓
Pediatric providers; pediatricians, general practitioners		✓	✓	✓
Observation < 24 hours		✓	✓	✓
Pediatric Hospitalist			✓	✓
Surgeon available			✓	✓
Pediatric Radiology			✓	✓
Admit > 24 hours			✓	✓
Access to Child Abuse Specialists				✓
Pediatric sub-specialists				✓
Pediatric Trauma ICU				✓
ACS Verified Level I or II Pediatric Trauma Center				✓

Figure 1. Utah Pediatric Trauma Network hospital self-categorizations (*A*) and TBI guideline (*B*). ACS, American College of Surgeons; CT, computed tomography; ICU, intensive care unit; LOC, loss of consciousness; NPRP, National Pediatric Readiness Program; PALS, Pediatric Advances Life Support; PECC, pediatric emergency care coordinator; TBI, traumatic brain injury.

A dashboard was created, and access was given to PECCs at all participating hospitals. Currently, there are 29 different analyses of data within the dashboard. At time of manuscript preparation, 50 of 51 hospitals (98%) within Utah were actively submitting data.

TBI Severity

To more fully understand the severity of TBI experienced by children treated within the network, a grading scale was created in collaboration with our pediatric neurosurgeons and physical rehabilitative medicine physicians. This was based on previous work by the Veteran Affairs on mild traumatic brain injuries in veterans and military personnel.[7] This allows the network to understand which children with isolated TBI can be safely treated at a local facility versus those who require transfer to a higher category hospital. In addition, return to play and follow-up instruction are given according to the level of severity. The five levels of TBI severity (very mild, mild, complicated mild, moderate, and severe) are detailed in Figure 2.

Study Methods

Upon institutional review board approval (IRB_00147474), the UPTN REDCap prospective database was retrospectively reviewed from January 1, 2019, to December 31, 2021. A total of 3,315 cases had been entered for that period from 43 participating hospitals (84%) within the network. Review revealed 10 duplicate records, which were excluded. In addition, eight children were initially evaluated at a non-PED1 hospital and then transferred to an out-of-state hospital for definitive care. These children were also excluded from the study. Cases were then divided into two groups, those admitted to the PED1 hospital (1,470) and those admitted to a non-PED1 hospital (1,827). Analysis was only performed on patients admitted with very mild, mild, or complicated mild TBI as described previously, with 1,061 cases at the PED1 hospital and 294 cases at the non-PED1 hospitals. Because UPTN was formally established in 2019 with implementation of the TBI protocol later that year, the groups were further divided into a pre-UTPN group (2019) and post-UPTN group (2020–2021). Thus, 337 were analyzed in the pre-UPTN group admitted to the PED1 hospital and 40 to a non-PED1 hospital. In the post-UPTN groups, 724 were admitted to the PED1 hospital and 254 to a non-PED1 hospital (please see the patient flow diagram in Fig. 3).

Both cohorts of patients were compared for overall demographics (age, sex, region, trauma activation), age younger than 14 years, Glasgow Coma Scale (GCS) score, shock-index pediatric adjusted (SIPA), isolated TBI, TBI severity (very mild, mild, or complicated mild), additional injuries, overall hospital course, length of stay (LOS), imaging, transfer information, and disposition (<24 hours, >24 hours, transfer). Comparisons were made to the overall cohorts (PED1 vs. non-PED) and within the cohorts (pre-UPTN vs. post-UPTN). The χ^2 test, a two-tailed *t* test, or the Kruskal-Wallis test of parametric medians (n = 2 groups) was used to evaluate for statistical significance using a p value of <0.05. The reporting of data in this study used the checklist for reports of cohort studies as recommended by the Strengthening the Reporting of Observational Studies in Epidemiology statement[8] (please see the checklist provided in Supplemental Digital Content, Supplementary Data 1, http://links.lww.com/TA/C839).

RESULTS

Overall, kids treated at non-PED1 hospitals were older (mean, 14.9 vs. 7.7 years; $p = 0.00001$) and more likely to be 14 years or older (37% vs. 24%, $p < 0.00001$) compared with those at the PED1 hospital. Between the two types of institutions,

TBI Severity	Glasgow Coma Scale (GCS)	Loss of Consciousness (LOC)	Alteration of Consciousness (AOC)	Post Traumatic Amnesia (PTA)	CT of Head (or MRI)	Return to Play	Follow up
Very Mild**	15	None to < 1 minute	None	None to < 1 hour	Normal	1 week	1-2 weeks with PCP or concussion clinic as needed
Mild**	13 to 15	None to < 30 minutes	None to < 24 hours	None to < 24 hours	Normal	2 weeks	
Complicated Mild	13 to 15	None to < 30 minutes	None to < 24 hours	None to < 24 hours	Abnormal*	3 months	1-3 weeks with concussion clinic
Moderate	9 to 12	> 30 minutes	> 24 hours	1-7 days	Normal or Abnormal*	6 months	4 weeks with Rehabilitation Specialist
Severe	3 to 8	> 24 hours	> 24 hours	> 7 days	Normal or Abnormal*	12 months	

*Abnormal: Subarachnoid hemorrhage (SAH), Subdural hematoma (SDH, Fracture, Epidural Hematoma (EDH), Parenchymal contusion, Diffuse Axonal Injury/Shear (DAI)
** TBI Severity determination may also be based on other factors such as previous concussions

Figure 2. Levels of TBI severity. PCP, primary care physician.

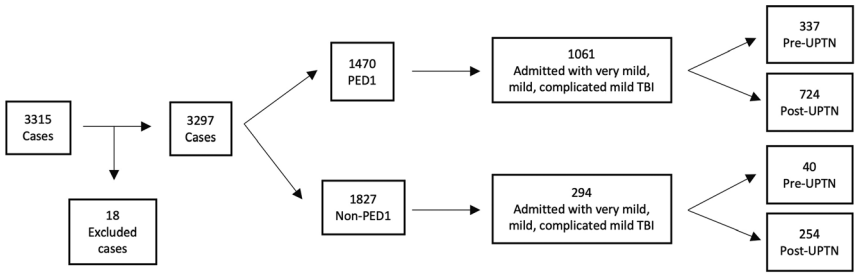


Figure 3. Patient flow diagram. TBI, traumatic brain injury.

sex, median GCS, and median SIPA did not differ significantly for those admitted. More children with isolated TBI were admitted to the PED1 hospital (75% vs. 66%, $p = 0.01$). In addition, more children with very mild TBI (51% vs. 13%, $p < 0.00001$) and fewer children with complicated mild TBI (16% vs. 59%, $p < 0.00001$) were admitted to the non-PED1 hospitals. The overall LOS was significantly shorter for those admitted to the non-PED1 hospitals (21.8 vs. 34.8 hours, $p = 0.000001$), which was reflective in more children staying <24 hours at the non-PED1 hospitals (67% vs. 42%, $p < 0.00001$) (please see Table 1 for a summary of these results).

Children admitted to the non-PED1 facilities underwent analysis comparing those admitted in the pre-UPTN period to those admitted after initiation of UPTN (post-UPTN). There was an increase in admissions post-UPTN compared with pre-UPTN (14% vs. 47% vs. 39%, $p < 0.00001$). In addition, children admitted post-UPTN were younger (15.7 years vs. 9.6 years vs. 8.6 years, $p = 0.003$) with more kids being younger than 14 years (38% vs. 66% vs. 69%, $p = 0.001$) compared with the pre-UPTN group. Although there was not a significant change in the percentages between the two periods, more children were admitted in the post-UPTN period with very mild TBI (21 vs. 62 vs. 67), mild TBI (14 vs. 37 vs. 46), and complicated mild TBI (5 vs. 26 vs. 16) than in the pre-UPTN period. There were no significant differences in the sex of the child, median GCS, median SIPA, percentage of isolated TBI, LOS, or disposition between the two time periods. A summary of these results is seen in Table 2.

Of those children admitted to a non-PED1 hospital, a total of 12 children underwent transfer. Ten of these children (four in 2020 and six in 2021) underwent same-day transfer to another non-PED1 center for admission (five, PED+; one, PED, four, PED-ED). On review, six underwent transfer with an isolated head injury, three for multiple injuries, and one with a laceration and fracture. Analysis of these children was included with the non-PED1 hospitals as described previously. In addition, two children required next-day transfer to a higher-level center (1 to PED1, 1 to regional PED+ hospital) after initial admission to a non-PED1 facility. The child transferred to the PED1 hospital was admitted for just under 6 days, whereas the one transferred to the PED+ hospital was admitted for less than 24 hours. Neither required intensive care unit admission, surgery, or neurosurgical evaluation.

Those children admitted to the PED1 center were also analyzed comparing the pre-UPTN and post-UPTN periods. There was no significant change in age, percentage of children younger than 14 years, sex, or median GCS. Children admitted in the post-UPTN period did have a higher median SIPA (0.9 vs. 1 vs. 1, $p = 0.005$), and more were admitted for >24 hours (53% vs. 61% vs. 60%, $p = 0.07$). More children with isolated TBI were admitted (69% vs. 76% vs. 79%, $p = 0.012$) during the post-UPTN period, although fewer children with very mild TBI (27% vs. 10% vs. 2%, $p < 0.00001$) and more with complicated mild TBI (50% vs. 64% vs. 62%, $p = 0.00003$) than in the pre-UPTN group. A summary of these results is presented in Table 3.

TABLE 1. Overall Cohort

Overall	PED1	Non-PED1	*p*
N	1,061	294	
Age, median (IQR), y	7.7 (2.6–13.7)	14.9 (3.5–16.0)	0.0001*
Children <14 y	811 (76%)	186 (63%)	<0.00001*
Male	643 (61%)	173 (59%)	0.59
GCS, median (IQR)	15 (15–15)	15 (14–15)	0.71
SIPA, median (IQR)	1 (0.8–1.2)	0.8 (0.7–1)	0.05
Isolated TBI	793 (75%)	198 (67%)	0.01*
Other injuries	268 (25%)	96 (33%)	0.01*
TBI severity			
Very mild	137 (13%)	150 (51%)	<0.00001*
Mild	300 (28%)	97 (33%)	0.12
Complicated mild	624 (59%)	47 (16%)	<0.00001*
LOS, median (IQR), h	34.8 (19.9–71.0)	21.8 (11.8–25.4)	0.000001*
Disposition			
<24 h	442 (42%)	197 (67%)	<0.00001*
>24 h	618 (58%)	87 (30%)	<0.00001*
Transfer out**	0 (0%)	2 (0.7%)	NA

*Statistically significant.
**After initial admission.
IQR, interquartile range; NA, not applicable.

DISCUSSION

This study demonstrates that implementation of a regional trauma network within the state of Utah allowed for more children with very mild, mild, and complicated mild TBI to receive care closer to home without transfer. Utah Pediatric Trauma Network guidelines allowed for increased post-UPTN admissions at non-PED1 hospitals for these types of injuries. In addition, the children admitted more closely resembled those admitted to the PED1 facility; in other words, they were more characteristic of pediatric patients. Moreso, the children admitted to the PED1 center in the post-UPTN period were more likely to have more complex TBI, further validating the functionality of the network.

TABLE 2. Non-PED1 Admissions for Very Mild, Mild, or Complicated Mild TBI Comparing 2019 (Pre-UPTN Period) to 2020 to 2021 (Post-UPTN Period)

Non-PED1	2019	2020	2021	*p*
N	40 (14%)	139 (47%)	115 (39%)	<0.00001*
Age, median (IQR), y	15.7 (9.7–16.9)	9.6 (3.2–15.8)	8.6 (3.4–15.2)	0.003*
Children <14 y	15 (38%)	92 (66%)	79 (69%)	0.001*
Male	25 (63%)	88 (63%)	60 (53%)	0.18
GCS, median (IQR)	15 (14–15)	15 (14–15)	15 (14–15)	0.64
SIPA, median (IQR)	0.8 (0.7–1)	0.8 (0.7–1)	0.9 (0.8–1)	0.38
Isolated TBI	22 (55%)	96 (69%)	80 (70%)	0.2
Other injuries	18 (45%)	43 (31%)	35 (30%)	0.2
TBI severity				
Very mild	21 (53%)	67 (48%)	62 (54%)	0.69
Mild	14 (35%)	46 (33%)	37 (32%)	0.95
Complicated mild	5 (13%)	26 (19%)	16 (14%)	0.47
LOS, median (IQR), h	23 (17.6–41.7)	17.8 (9.6–25.3)	17.4 (12.9–23.6)	0.09
Disposition				
<24 h	24 (60%)	94 (68%)	79 (69%)	0.59
>24 h	16 (40%)	41 (29%)	30 (26%)	0.25
Transfer out**	0 (0%)	0 (0%)	2 (2%)	NA

*Statistically significant.
**After initial admission.
IQR, interquartile range; NA, not applicable.

Relatively few transfers occurred for those kids admitted, and none were unsafe during their care.

Several studies have demonstrated the efficacy of a regional trauma network to improve outcomes while allowing for care to be delivered at hospitals best suited and most appropriately located.[9–18] The Washington State Trauma System (established 1990), the Northern Ohio Trauma System (established 2010), and the Arkansas Trauma System (established 2010), created and funded through their respective state legislative processes, have demonstrated improved outcomes in the treatment of patients with traumatic injuries.[9,11,14,16] Within 2 years of creation, the Arkansas Trauma System also demonstrated that fewer patients were admitted to nondesignated centers with a 20% reduction in the odds of inpatient death for patients with

TABLE 3. PED1 Admissions for Very Mild, Mild, or Complicated Mild TBI Comparing 2019 (Pre-UPTN Period) to 2020 to 2021 (Post-UPTN Period)

PED1	2019	2020	2021	*p*
N	337	392	332	0.11
Age, median (IQR), y	8.3 (2.8–13.4)	7.4 (2.4–13.7)	7.6 (2.9–14.1)	0.53
Children <14 y	262 (78%)	304 (78%)	244 (73%)	0.13
Male	202 (60%)	248 (63%)	193 (58%)	0.35
GCS, median (IQR)	15 (15–15)	15 (15–15)	15 (15–15)	0.36
SIPA, median (IQR)	0.9 (0.8–1.2)	1 (0.8–1.3)	1 (0.8–1.2)	0.022*
Isolated TBI	234 (69%)	297 (76%)	263 (79%)	0.012*
Other injuries	103 (31%)	96 (24%)	69 (21%)	0.012*
TBI severity				
Very mild	91 (27%)	40 (10%)	6 (2%)	<0.00001*
Mild	79 (23%)	100 (26%)	121 (36%)	0.0005*
Complicated mild	167 (50%)	252 (64%)	205 (62%)	0.0001*
LOS, median (IQR), h	30.7 (20.1–72.9)	35.9 (19.7–69.6)	36.5 (19.9–71.8)	0.97
Disposition				
<24 h	158 (47%)	153 (39%)	132 (40%)	0.07
>24 h	179 (53%)	239 (61%)	200 (60%)	0.07
Transfer in**	187 (55%)	259 (66%)	214 (64%)	0.008*

*Statistically significant.
**At initial admission.
IQR, interquartile range.

and without severe injuries.[16] Similarly, the Northern Ohio Trauma System demonstrated an increase in the number of patients treated at the level 1 trauma center with an overall increase in survival for admitted patients 2 years after implementation (odds ratio, 0.79; 95% confidence interval [CI], 0.67–0.94).[11] Another study of the Northern Ohio Trauma System specifically looking at the collaboration's effect on the treatment of TBI demonstrated a significant reduction in the mortality rate of all patients treated with TBI (6.2–4.9%, $p = 0.005$) and those with TBI and head Abbreviated Injury Scale score of ≥3 (19–14%, $p < 0.0001$).[13] It is interesting that several studies have demonstrated improved outcomes from a regional trauma system that does not correspond to the number of level 1 trauma hospitals within that system.[12,18,19] In other words, it is not the number of trauma centers that makes a difference but the collaboration of centers within the system.

While pediatric specific data is sparse, two studies highlight improvement in pediatric trauma care through regional systems.[15,17] Murphy et al.[15] described the addition of a vPTC to the already established inclusive Delaware Trauma System in 2006, resulting in a significant decrease in the rate of blunt trauma-related splenectomies equivalent to published benchmark levels by the American Pediatric Surgical Association (11% to 2.7%, $p = 0.012$). More recently, Tessler et al.[17] described their experience treating pediatric solid organ injury within the Washington State Trauma System. They found that the risk of surgery in children younger than 16 years treated at a lower-level trauma center for a low-grade (I–III) solid organ injury was not significantly different from those treated at a higher-level center (relative risk [RR], 2.19; 95% CI, 0.80–6.01). In addition, the risk of splenectomy was not significantly different between the two types of centers (RR, 0.84; 95% CI, 0.11–2.16), and children at lower-level centers were more likely to have a shorter LOS (RR, 0.63; 95% CI, 0.45–0.88).

Many studies discuss what is required to allow for regional trauma systems to be effective, highlighting several characteristics.[1,2,9,10,20] First, at the minimum, state or federal funding is needed for system support, such as for a program manager, data and administrative support, and performance improvement expenses. Second, the system should have broad stakeholder participation. For all hospitals to participate, the system needs to be transparent, noncompetitive, and all inclusive. Next, evidence-based protocols should be used throughout the network. They should not be created as a "one size fits all" but rather according to the experience, available resources, and capabilities of each facility. These protocols can help guide triage and transfer as well as in-patient care. Finally, data reporting into a system registry must be mandatory for all participating facilities. Constant monitoring, analyzing, and surveillance of these data should be used to drive improvement at the individual participating hospitals and across the entire system.

As demonstrated by this study, with the aforementioned principles as a guide, even low resource hospitals with little pediatric experience can become more comfortable caring for more patients locally. First, the guidelines were customized to the specific hospital category (PED-ED, PED, PED+). Second, the guidelines only recommend that the lowest-risk patients be cared for at the non-PED1 facilities. For example, it is recommended that a PED-ED center can observe for 4 to 6 hours a patient with the risk of a clinically important TBI (defined as death, neurosurgery, intubation >24 hours, or admission >2 days) of <0.02% to 0.05% but not admit if needed. Whereas the PED centers can admit these children for upwards of 24 hours, a PED+ center can admit for >24 hours, and, if needed, a child with the next level of risk of clinically important TBI at <0.9%. It is recommended that all other patients be transferred to the PED1 facility. Finally, frequent monitoring of the data with discussion of outlying occurrences, case review, and data analysis at performance improvement meetings will allow each hospital to confidently care for these children, allowing for corrections and adjustments to the overall system when needed. In our experience, we have found that, through implementation of well-written guidelines, tailored to the resources and capability of the hospital, with collection and frequent review of data, nonpediatric hospitals can gain the confidence and experience needed to take care of younger patients.

Since implementation of the UPTN TBI guidelines, several other guidelines have been created and executed including cervical spine, thoracolumbar trauma, blunt chest trauma, blunt abdominal trauma, blunt pelvic trauma, open fracture, burn injury, child physical abuse, and expedited trauma transfer. Variables for each of these guidelines have been added to the database for analysis and review. A significant increase in state financial support is currently being pursued, which will give annual funding to each participating hospital for a data analyst as well as pediatric trauma education and community outreach. The amount received will be proportional to hospital category. Once this additional funding is in place, the network will start working on in-patient protocols and benchmarks of care which will also be collected and regularly monitored to ensure optimized care and outcomes for all pediatric trauma patients admitted to any participating hospital. Finally, a separate trauma telehealth program exists at the PED1 center that is not formally a part of UPTN. Non-PED1 hospitals can request a telehealth consultation lead by the PED1 trauma APP team. Any imaging obtained at the referring institution is uploaded and overread by a pediatric radiologist as part of the consultation. Based on the telehealth evaluation and overread, the APP then uses the UPTN guidelines to help the referring provider determine the ability to discharge or the need for admission or transfer based on the referring hospital category (PED-ED, PED, or PED+). The trauma telehealth program started after initiation of UPTN and now serves as an important adjunct allowing for direct evaluation and assistance, when needed, in the management of some injured kids treated remotely. It is anticipated that telemedicine will help reinforce the protocols across the network, triage patients who do not quite fit within the guidelines, and assist in the care of those admitted to the non-PED1 center when needed. Based on previous studies, we believe that a telemedicine program is needed and will be an important adjunct to strengthening the network as a whole.[21–24]

There are several limitations to this study. First, this study describes the results of guidelines implemented through the UPTN. The results might not be applicable to other regions or trauma systems, as this was based on how pediatric trauma care occurs within Utah (one vPTC, two level I adult trauma centers, several level II adult trauma centers, and many lower-level centers across a large geographic area). Second, we created the

hospital self-categories. They are not validated and may not be applicable to other hospitals. Third, data submission is dependent on the participating facilities in the network. Although there is training and review of the data occurs on a regular basis, currently, there are no formal processes put into place to validate the data; therefore, some errors in data may have occurred. Finally, it is possible that this study demonstrates more of a capture of these admissions from the non-PED1 hospitals than an actual increase in admissions. We do not believe that this is the case; however, we do know that UPTN provides a forum to evaluate the care of injured kids across the state. In addition, thorough data submission and analysis will allow for data-driven changes to improve such care.

CONCLUSION

We found that creation of the UPTN, a statewide, noncompetitive, inclusive collaborative of all Utah hospitals, along with implementation of TBI guidelines, which were customized to the specific category of hospital using it, successfully allowed nonpediatric hospitals to safely admit children with very mild, mild, or complicated mild TBI. In addition, these hospitals admitted children who were more reflective of pediatric patients treated at the vPTC. At the same time, there was a corresponding drop in admissions of children with isolated very mild TBI at the vPTC.

AUTHORSHIP

S.J.F. contributed in the study design, data acquisition, data analysis, statistical support, manuscript preparation, manuscript editing and revision, and manuscript submission. R.A.S. contributed in the study design, data analysis, statistical support, manuscript editing, and revision. M.E. contributed in the study design, data acquisition, data analysis, manuscript editing, and revision. K.L. contributed in the study design, data acquisition, manuscript editing, and revision. K.W.R. contributed in the study design, data analysis, manuscript editing, and revision.

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DISCLOSURE

The authors declare no conflicts of interest.

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