Reducing Computed Tomography Scan Utilization for Pediatric Minor Head Injury in the Emergency Department: A Quality Improvement Initiative

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ABSTRACT

Background: The validated Pediatric Emergency Care Applied Research Network (PECARN) prediction rules are meant to aid clinicians in safely reducing unwarranted imaging in children with minor head injuries (MHI). Even so, computed tomography (CT) scan utilization remains high, especially in intermediate-risk (per PECARN) MHI patients. The primary objective of this quality improvement initiative was to reduce CT utilization rates in the intermediate-risk MHI patients.

Methods: This project was conducted in a Level I trauma pediatric emergency department (ED). Children < 18 years evaluated for intermediate-risk MHI from June 2016 through July 2019 were included. Our key drivers were provider education, decision support, and performance feedback. Our primary outcome was change in head CT utilization rate (%). Balancing measures included return visit within 72 hours of the index visit, ED length of stay (LOS), and clinically important traumatic brain injury (ciTBI) on the revisit. We used statistical process control methodology to assess head CT rates over time.

Results: A total of 1,535 eligible intermediate-risk MHI patients were analyzed. Our intervention bundle was associated with a decrease in CT use from 18.5% (95% confidence interval [CI] = 14.5% to 22.5%) in the preintervention period to 13.9% (95% CI = 13.8% to 14.1%) in the postintervention period, an absolute reduction of 4.6% (p = 0.015). Over time, no difference was noted in either ED LOS or return visit rate. There was only one revisit with a ciTBI to our institution during the study period.

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Conclusions: Our multifaceted quality improvement initiative was both safe and effective in reducing our CT utilization rates in children with intermediate-risk MHI.

Head injury is a common reason for emergency department (ED) evaluation in children, with recent estimates suggesting around 837,000 annual ED visits in children < 18 years of age, in the United States.[1] The majority of these are minor head injuries (MHI) with Glasgow Coma Scale (GCS) scores of ≥14 and rarely require neurosurgical intervention.[2] Despite this, use of CT scan in children with MHI in the United States is high and varies from 10% to 40%.[3–9] In a more recent cross-sectional study of pediatric ED visits for head trauma, utilizing National Hospital Ambulatory Medical Care Survey database, CT use in the United States continues to remain high at 32% with no significant annual linear trend (2007–2015).[10] CT overuse unnecessarily exposes children to potentially harmful ionizing radiation, while adding to health care costs, emphasizing the need for more galvanized efforts.

In 2009, the Pediatric Emergency Care Applied Research Network (PECARN) derived high-performing clinical prediction rules to accurately identify children at low risk of a clinically important traumatic brain injury (ciTBI) in whom CT might be unnecessary.[3] A ciTBI was defined as a head injury resulting in death, neurosurgical intervention, intubation for greater than 24 hours, or hospitalization for ≥ 48 hours due to traumatic brain injury. Based on the severity of injury mechanism and clinical presentation, the PECARN rules stratify children with MHI into low, intermediate, and high risk for ciTBI to determine need for CT imaging. The CT recommendation for high- and low-risk groups is binary (yes and no, respectively). Intermediate-risk MHI patients pose a challenge, because the rules recommend either CT or ED observation (based on clinical presentation and provider/parental preference). Implementation of PECARN rules in combination with clinical decision support systems and provider feedback has successfully reduced CT rates for all-risk MHI patients in both pediatric and community EDs.[7–9,11,12] Moving forward, the intermediate-risk MHI patients provide a challenging opportunity for improvement because CT scan utilization in this group remains high.

This initiative was part of a larger Michigan Emergency Department Improvement Collaborative (MEDIC) project with the aim of reducing head CT rates in children with all-risk MHI. Our specific project sought to improve head CT rates, in children meeting intermediate-risk criteria, a collaborative-wide pediatric quality measure. MHI patients are categorized as intermediate risk if they have one or more non–high-risk factor (<2 years—nonfrontal scalp hematoma, loss of consciousness [LOC] > 5 sec, not acting normally per parent, or severe mechanism of injury; 2–17 years—vomiting, severe headache, any LOC, or severe mechanism of injury) in absence of any high-risk factor (altered mental status, GCS ≤ 14, or signs of basilar/palpable skull fracture). Preliminary review demonstrated that the baseline CT rate for all-risk MHI patients in our ED was around 8%. Although our overall rates were low, we identified opportunities for improvement in CT use for intermediate-risk MHI patients. We noted that around one in five of our intermediate-risk patients was receiving a CT scan, although the majority of these scans were normal. Given that the reported risk of ciTBI in this category is 0.8% to 0.9%, there was an opportunity to safely reduce CT scan use in this subset of patients. Our team decided to adopt a bundled approach based on evidence-driven interventions. Our chosen drivers had been successfully applied in a similar setting to address overuse and variation in care.[7] Our rationale was that a combination of provider education, decision support, and feedback will address the needs of our diverse group at multiple levels and translate evidence into practice. This bundle was designed to close the knowledge gap, aid point-of-care decision making, and encourage engagement to effectively reduce CT utilization rates in children with intermediate-risk MHI. Our aim was to reduce head CT utilization rates from baseline 18.5% to less than 15% in the intermediate risk MHI patients in our ED.

METHODS

Study Design and Context

We designed and implemented a multifaceted quality improvement (QI) project with the aim of reducing the rate of head CTs in children visiting our ED who met PECARN intermediate risk criteria for MHI. The project received institutional review board waiver of review for QI.

This QI project was conducted from June 1, 2016, through July 31, 2019, in a free-standing children's hospital ED, a Level I trauma center with an annual ED volume of approximately 85,000 visits per year. Study periods were defined as follows: baseline (or the preintervention period), June 1, 2016, through June 30, 2017; and postintervention period, July 1, 2017, through July 31, 2019.

Our ED is staffed by approximately 55 providers with different levels of training. This includes 22 fellowship-trained pediatric emergency medicine (PEM) physicians, 12 PEM fellows, nine pediatricians, and 12 nurse practitioners. A decision to obtain a CT scan is always made in consultation with ED faculty in instances where trainees or nurse practitioners are involved. Additionally, in our center, all CT scan orders require a discussion between the ED provider and the radiologist (mostly trainees), before the scan is performed. If needed, the ED provider has the option to have a discussion with a radiology attending to decide the most appropriate imaging modality. This practice remained consistent and was adhered to throughout the study period. During the improvement initiative, our institution formally adopted PECARN guidelines for management of MHI patients.[3] It is likely that some providers were already using these prediction rules to guide CT decision making in children with MHI.

Study Population

Children < 18 years of age who were evaluated in our ED for MHI were eligible for the study. International Classification of Diseases, Tenth Revision (ICD-10), diagnosis codes for head or facial injury (Data Supplement S1, Table S1, available as supporting information in the online version of this paper, which is available at http://onlinelibrary.wiley.com/doi/10.1111/acem.14177/full) were used to identify the MHI population, which was subsequently confirmed by chart review. Patients with GCS < 14, penetrating head injury, presentation > 24 hours postinjury, trauma activation, nonaccidental trauma, focal neurologic deficit, presence of ventriculoperitoneal shunt and/or a history of brain tumor, bleeding disorder, or preexisting neurologic disorders were excluded. We elected to dichotomize age, categorizing children as either younger than 2 or 2 years and older in accordance with the PECARN prediction rules.[3] Electronic health records of eligible patients were abstracted by trained nurse abstractors for additional data elements relating to patient demographics, clinical presentation, CT use, outcome, and disposition. All eligible MHI patients were risk stratified and categorized as low, intermediate, and high risk of ciTBI per PECARN prediction rules.[3] Only patients with intermediate-risk MHI were included in the final analysis.

Data Collection

Our institution-specific data were obtained from the MEDIC's clinical data registry. MEDIC was established in 2015 as a QI network of unaffiliated hospitals linked by a clinical data registry within a structured implementation and incentive program. The goal of MEDIC is to improve quality and reduce low-value emergency care throughout Michigan. Our hospital is one of the 23 participating sites. CT utilization for pediatric MHI is one of the collaborative-wide pediatric quality measures. Electronic health record data for every ED visit from each site are sent to the MEDIC registry via automated data feed. For the predetermined QI measures, additional data are obtained via manual chart abstraction. The abstractors are trained during the orientation process and are audited annually. During 1:1 onboarding and annual reviews with the abstractors, 30 to 40 charts are reviewed by the MEDIC coordinating center staff. Additional teaching ensures that abstractors understand the questions, are able to find answers in the chart, and think critically when necessary. Common questions from abstracters are highlighted in group meetings several times a year and a process exists to ask and receive direction on individual cases as abstracters extract information.

The MEDIC coordinating center generates and provides both site-level and provider-level performance reports on a monthly basis. It is also available on a Web-based portal accessible 24 hours/day. This allows the site's clinical champion to readily access data, continually monitor performance, and share feedback. We also reviewed our institutional ED return visit database for supplemental information on return visits and missed ciTBI.

QI Strategy

Planning the Intervention. We assembled a multidisciplinary team of providers—with varied patient care roles and levels of training—to explore potential interventions and strategies from diverse viewpoints. The core team was led by a PEM physician and included a PEM fellow, pediatrician, radiologist, nurse practitioner, nurses, and a hospital administrator. The project leader was the division's Director of Quality Improvement, and the institution's clinical champion to the MEDIC QI program. The participating administrator had previously successfully implemented an electronic safety reporting system within our institution. Evidence-based literature was reviewed to outline a strategy for increasing awareness and adherence to guidelines. The core team met on a monthly basis to structure plan–do–study–act cycles, identify barriers, and analyze performance.

Improvement Activities: Drivers and Interventions. We carried out a multifaceted implementation strategy to improve provider engagement and decrease variability in care. Our team selected three key drivers based on published evidence, to effect behavior change and achieve the desired aim. These were provider education, decision support, and performance feedback. To address the key drivers, multiple interventions were developed and implemented (Figure 1).

Provider Education. Educational interventions were tailored to encourage adherence to the PECARN risk stratification–based approach for CT decision making. In accordance with the available evidence, we recommended observation in the ED (4 to 6 hours from the time of head injury) before obtaining a CT scan, as an important management strategy for intermediate-risk MHI patients.[13,14] We emphasized selective CT use in children with either multiple or worsening symptoms. We began with a MHI themed journal club that included discussions around the sentinel PECARN head injury article (July 2017). The project leader then gave a comprehensive presentation to the ED group to provide context including background and rationale for the project (August 2017). This was followed by a grand rounds talk for a hospital-wide audience to enhance awareness around the project (February 2018). Although formal shared decision-making tools were not deployed, providers were encouraged to engage and involve parents in the decision-making process by explaining the patient's risk of ciTBI to highlight the pros and cons of each management option (CT vs. observation). Educational formats including in-person education, discussions at medical staff meetings, and e-mail reminders were employed to maximize dissemination, augment understanding, and sustain engagement. To address caregiver education, we revised and updated the head injury and concussion-related discharge instructions.

Provider Decision Support. High-quality evidence was made available to clinicians at the point of decision making. The team initially created a clinical decision tool based on the PECARN prediction rules and adapted from a successfully implemented previous QI initiative[3,7] (Data Supplement S1, Figures S1 and S2). To simplify interpretation, a traffic light signal–based color-coded system was used where red, yellow, and green boxes represented high-, intermediate-, and

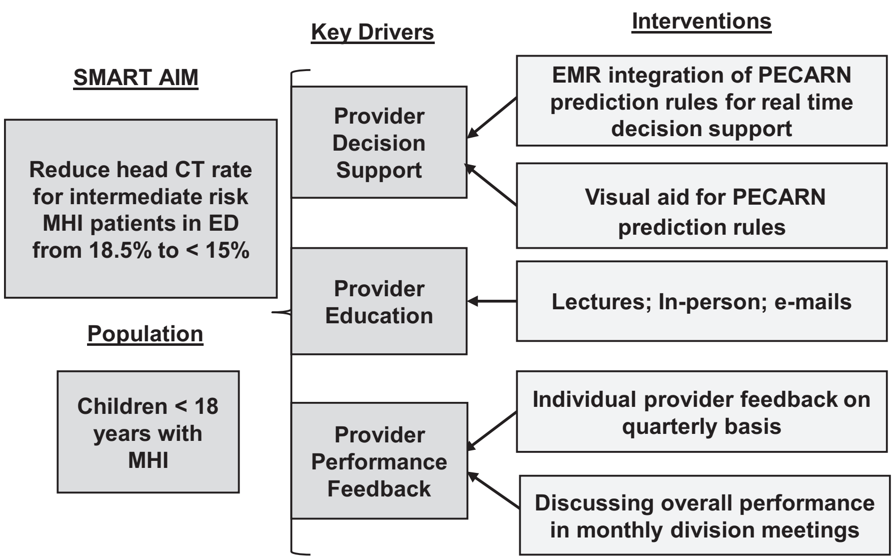

Figure 1. Key driver diagram to reduce head CT use in children with intermediate-risk MHI. EMR = electronic medical record; MHI = minor head injury; PECARN = Pediatric Emergency Care Applied Research Network.

low-risk MHI groups. For easy visualization and review, visual aids were posted in high-traffic patient care areas and at physician work places throughout the ED starting October 2017. Subsequently, the project leader collaborated with the local medical informatics team to integrate the PECARN head injury decision rule with the CT-Head/Brain (without contrast) order set in the electronic medical record (EMR) for real-time decision support. This tool was modeled on the previous work performed by Atabaki et al.[15] When placing a CT-Head/Brain (without contrast) order in the ED, a PECARN decision guide would appear based on the patient's age (<2 years or 2–17 years; Data Supplement S1, Figure S3). Providers could exit the guide if CT was not trauma related. If trauma related, providers were required to select data for seven fields based on patient's clinical presentation. The tool then analyzed the entered information in accordance with the PECARN risk stratification algorithm and gave appropriate recommendations: low risk, CT is not recommended; high risk, CT is recommended; and intermediate risk, consider CT or observation. The recommendation was not a hard stop because providers had the option to overrule it and order the CT scan. After multiple iterations the decision tool template was presented to our institution's emergency medicine clinical advisory group for their input and approval. It was then built into Cerner's testing domain for conducting test runs. An educational PowerPoint of the finalized version was distributed via e-mail to ED providers. Once optimal functionality was ensured, systemwide rollout and implementation occurred in June 2018.

Peer Comparison Performance Feedback. Peer comparisons have been touted as a strategy to address unnecessary variations and improve the value of care.[16] It is thought to encourage providers to learn from their higher-performing peers and get motivated to perform better. Individual feedback on personal CT utilization rates benchmarked to their peers was provided by the project lead. This enabled providers to compare their individual performance with that of their peers and the group. Performance reports were sent via e-mail on a quarterly basis starting December 2017. It included their individualized head CT rate, the group's aggregate performance and information on their peer CT utilization rates. During division meetings, top performers were acknowledged and invited to share possible reasons for their success, in a bid to encourage engagement. Low-performing providers met with the ED quality director to discuss strategies for improvement. The group's aggregate performance and progress were discussed regularly during the division meetings and allowed us to address barriers.

Study Measures

The primary study outcome was head CT utilization rate (%) for intermediate-risk MHI patients. It was defined as the number of intermediate-risk MHI patients with head CT scan/total number of intermediate-risk MHI patients. There are no published benchmark goals for CT use in intermediate-risk MHI patients. Previous improvement initiatives have reported postintervention rates varying from 21.6% to 35.9%, but our baseline was already lower than these rates.[11,12,17] We compared our baseline performance with top-performing sites within the MEDIC collaborative to frame our site-specific goal. Our group decided on CT rate less than 15% in intermediate-risk MHI patients, as an achievable benchmark for success. To monitor for the safety of the process and evaluate unintended consequences, the following balancing measures were selected: ED length of stay (LOS), 72-hour return visit rate for MHI-related complaints and the number of patients with missed ciTBI on return visits.

Data Analysis

We used statistical process control methods to analyze variation in the utilization of head CTs over time and to assess whether changes resulted in improvements. A bundled pre–post assessment strategy was adopted for this project because our interventions overlapped in time and lacked sufficient time between them to explore intervention-specific effect. Standard criteria were used to determine if observed changes were due to random variation (common cause variation) or a specific intervention (special cause variation). We did not specify a particular sample size a priori for our study, but tracked it on a monthly basis to minimize any potential noise in week-to-week variation. The percentage of intermediate-risk head injury patients that received a head CT were plotted monthly on the chart and improvement is seen as a decrease in the percentage of patients receiving a head CT over time. In addition, we compared proportions using the chi-square test and medians with Mood's test to evaluate the impact of our interventions on a priori selected balancing measures. An alpha of 0.05 was used, and these tests were appropriate given the exclusion of multiple patient visits. Individual comparison with participating sites within the MEDIC collaborative could not be performed because different sites were at different stages of local improvement efforts to decrease CT use in all-risk and intermediate-risk MHI patients.

RESULTS

Multiple interventions were rolled out from July 2017 to June 2018 (Data Supplement S1, Table S2). They were running concurrently and iteratively optimized. Regular input from our providers shaped our interventions to facilitate engagement and improve the implementation process. ED leadership's commitment to this initiative enabled participation and prioritization on behalf of the informatics team. There were no direct costs payable by our team, which precluded the formulation of a cost estimate to assist with replication. Visual aids were printed by the hospital administration. The EMR tool, which took nearly 9 months to develop and integrate, was built using our existing process of collaboration with the institution's informatics team. This integrated EMR tool was adapted directly from the PECARN rules, similar to Atabaki et al.[15]

There were a total of 9,352 pediatric ED visits for head and/or facial injury during the study period. Of the 6,496 eligible MHI visits, 1,535 (23.6%) were intermediate risk (557 preintervention, 978 postintervention) and included in the final analysis. Table 1 depicts the characteristics of the study patients. The majority of patients were male (63%) with a mean (±SD) age of 8.5 (±5.2) years. Age distribution, Emergency Severity Index (ESI) acuity, and disposition remained similar in pre- and postintervention periods.

The CT utilization rate for intermediate-risk MHI patients decreased significantly, from a baseline of 18.5% (95% CI = 14.5% to 22.5%) to 13.9% (95% CI = 13.8% to 14.1%) in the postintervention period, an absolute reduction of 4.6% ($p = 0.015$). This change corresponded to our group of interventions as shown in Figure 2. There was also a drop in all-risk MHI patient CT utilization rate from 7.8% (95% CI = 5.9% to 9.6%) to 5.6% (95% CI = 5.5% to 5.7%), an absolute reduction of 2.2% ($p = 0.001$; Figure 3).

CT utilization rates reduced significantly across both age groups and sex. Rates decreased from 27.5% to 18.2% ($p = 0.033$) and 17.4% to 13% ($p < 0.0001$) for < 2 years and 2 to 17 years age group, respectively. CT rates dropped from 19.2% to 15.3% ($p < 0.0001$) for males and from 17% to 11.7% ($p < 0.0001$) for females.

The significant decrease in use of CT scans at our center was not associated with any increase in patient morbidity or negative impact on ED LOS (Table 2). There was no significant difference in the proportion of intermediate-risk MHI patients returning to the ED within 72 hours of discharge. There was a slight

Table 1
Characteristics of Intermediate-risk MHI patients in the Preintervention and Postintervention Periods

Characteristics	Preintervention, *n* (%) June 2016–June 2017	Postintervention, *n* (%) July 2017–July 2019
Eligible intermediate-risk MHI patients	557 (100)	978 (100)
Proportion of intermediate-risk MHI patients	557/1,995 (27.9)	978/4,501 (21.7)
Eligible Intermediate-risk MHI patients/month, SD	42.8, 12.9	39.2, 11.6
Age 2–17 years	484 (87)	813 (83)
Male sex	369 (66)	594 (61)
Mode of arrival: private vehicle/walk-in	496 (89)	896 (91)
ESI acuity		
1	3 (0.5)	6 (0.6)
2	157 (28.2)	260 (26.6)
3	231 (41.5)	453 (46.3)
4	162 (29.1)	254 (26)
5	4 (0.7)	5 (0.5)
Discharged from ED	529 (95)	926 (94.7)

ESI = Emergency Severity Index; MHI = minor head injury.

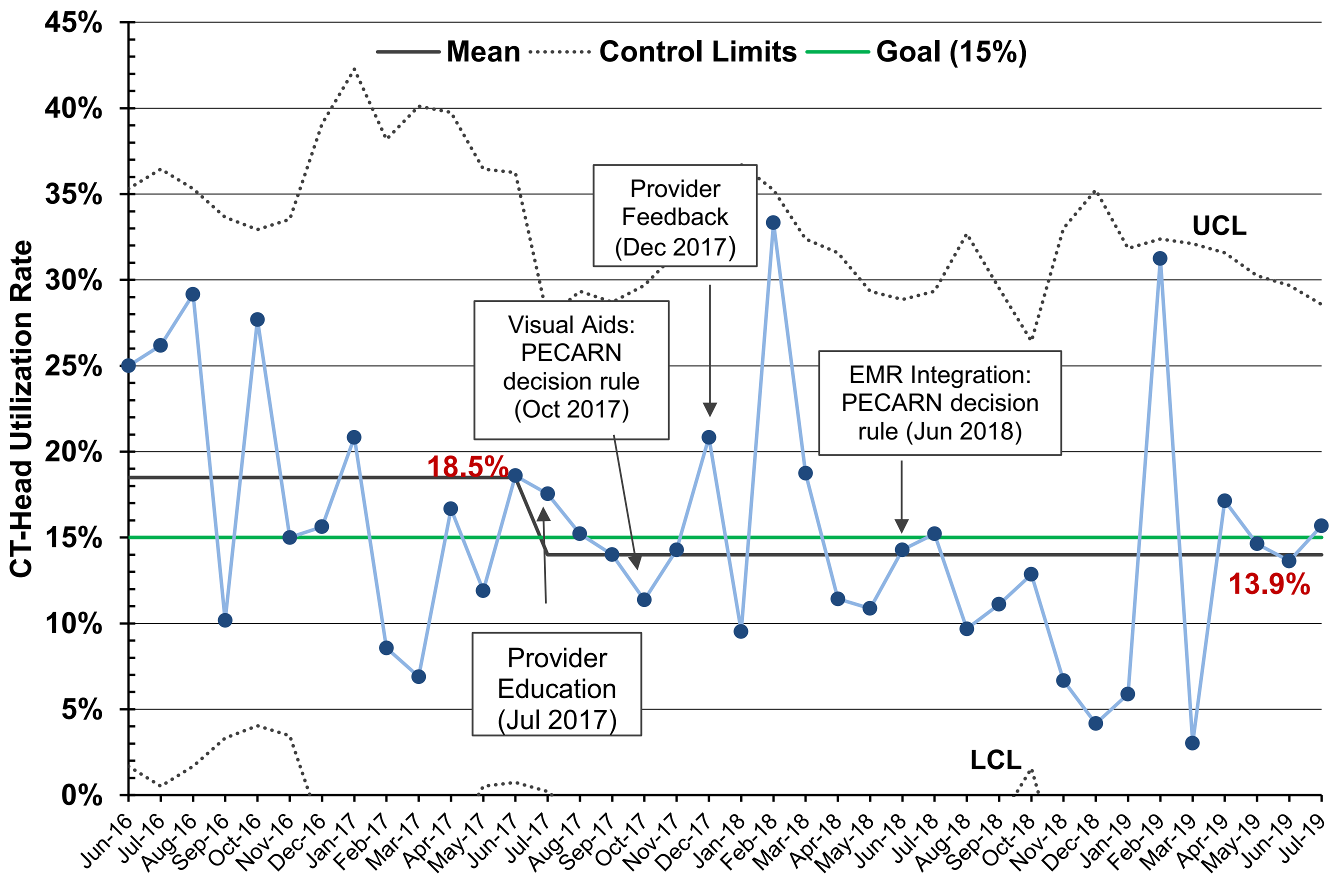

Figure 2. Statistical process control chart of change in CT-head rate over time of intermediate risk minor head injury patients. EMR = electronic medical record; LCL = lower control limit; PECARN = Pediatric Emergency Care Applied Research Network; UCL = upper control limit.

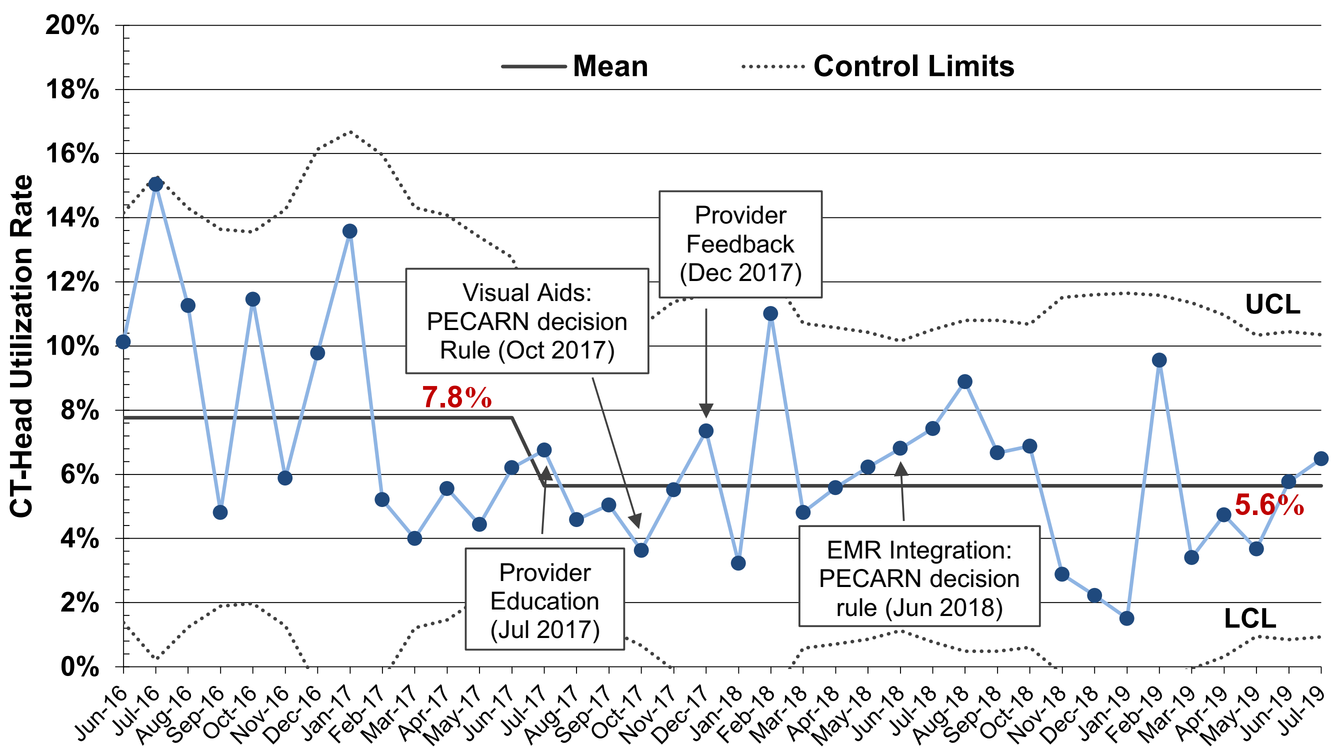

Figure 3. Statistical process control chart of change in CT-head rate over time of all-risk minor head injury patients. EMR = electronic medical record; LCL = lower control limit; PECARN = Pediatric Emergency Care Applied Research Network; UCL = upper control limit.

Table 2
Impact of the QI Initiative on Intermediate-risk MHI Patients

Variables	Preintervention,June 2016–June 2017	Postintervention,July 2017–July 2019	p-value
CT utilization rate	18.5% (103/557)	13.9% (136/978)	0.015
CT positivity rate for trauma-related findings	5.8% (6/103)	9.5% (13/136)	0.341
ED LOS	2.8 hours (Q1–Q3, 1.9–3.7)	2.9 hours (Q1–Q3, 2.0–3.9)	0.172
Rate of return visit	2% (11/557)	2.1% (21/978)	1
Admission < 24 hours during index visit	5% (28/557)	5.3% (52/978)	0.905
ciTBI* in return visit	None	One patient	1

Chi-square test and Mood's test were used to compare proportions and medians, respectively.
ciTBI = clinically important traumatic brain injury; LOS = length of stay; MHI = minor head injury; QI = quality improvement.
*Defined as head injury resulting in death, neurosurgical intervention, intubation for 24 hours, or ≥ 2 nights in the hospital for management of head injury on CT scan.

increase in ED LOS from 2.8 hours in the preintervention period to 2.9 hours in the postintervention period, but it was not significant (p = 0.172). There was no reported mortality in any of the groups. One patient on revisit in the postintervention period was found to have ciTBI. This was a 4-year-old boy who had initially presented to our ED 2 hours after a fall (5–6 feet) from his father's shoulder, hitting the back of his head on a hardwood floor. The patient had one episode of vomiting. There were no other presenting complaints. He had a small occipital hematoma. GCS was 15 and neurologic examination was normal. He was observed in the ED for around 3 hours (total of 5 hours postinjury) and then appropriately discharged home because he continued to appear well. He presented again (36 hours postinjury) to our ED with persistent headache and vomiting. He appeared tired, but had a normal GCS and neurologic examination. CT scan showed a posterior fossa epidural hematoma and a nondisplaced left occipital fracture. He successfully underwent evacuation of epidural hematoma and was discharged home with no deficits 4 days later.

DISCUSSION

To our knowledge, our QI initiative is one of only a few that specifically examines impact of focused interventions on reducing CT use in intermediate-risk MHI patients. Previously, a shared decision-making intervention (utilizing a head CT decision aid) for providers to use with parents of children with intermediate-risk MHI resulted in increased parental knowledge, decreased decisional conflict, and enhanced involvement in decision making.[17] However, there was no reduction in CT utilization rates (decision aid group 22% vs. usual care group 24%), which was thought to be due to PECARN prediction rules being already in practice at each of the participating sites before the trial commenced. In another multicenter study, implementation of decision support was associated with a modest decrease in head CT rate from 24.2% to 21.6%. This study only examined children with one isolated intermediate PECARN risk factor for ciTBI.[11] In a different initiative, based in a community setting, a PECARN-based pediatric closed head injury assessment tool was successful in decreasing CT use in both all-risk (37.7% to 16.9%) and intermediate-risk (62.5% to 35.9%) MHI patients.[12] Notably, this project was aimed at decreasing low-value CT scans for all-risk MHI patients and the study sample was small (133 intermediate-risk patients, 424 all-risk patients). Additionally, their reported baseline CT utilization rates were around four times higher than ours. In our project, intermediate-risk MHI patients were the primary focus. And by adopting a bundled approach—utilizing clinical decision aid integrated with existing workflow and regular provider feedback—our team attained a safe and significant reduction in CT use in this group. We were aware that the success of our project hinged on provider buy-in. For this reason, we sought input from our group at frequent intervals to encourage engagement, ensuring that our interventions align with the needs of our providers. To preserve physician autonomy and patient preference, our goals were realistic, relevant to our setting, and formalized by a consensus within our group, during meetings and e-mail communications in the planning and implementation process.

Although we focused on intermediate-risk MHI patients, it is likely that our approach influenced the reduction in CT rates for all-risk MHI patients. We feel that this was probably due to increased awareness and better adherence to PECARN prediction rules in general, as there were no other policies or process changes locally targeting specific risk categories, during the project period. The reduction in overall CT rate was driven by a reduction in intermediate and high-risk CT rates. While the high-risk group rate experienced a larger decline (48.2% to 40.1%) than the intermediate-risk group rate (18.5% to 13.9%), the larger size of the intermediate-risk group (1,535 patients vs. 310 patients) created a larger impact overall. CT utilization rates for low-risk MHI patients remained at < 1% throughout the study period.

The majority of children in the intermediate-risk group do not require CT scan if they can be observed for a period of time in the ED. This allows for selective CT use for children whose symptoms worsen or fail to improve during a period of ED observation.[13] Concern over the downstream time, costs, and risks of observation and/or hospitalization could motivate providers to immediately perform a CT scan in a child who meets intermediate criteria.[18] However, there was no significant increase in either ED LOS or hospitalization rates in the postintervention period, suggesting that our strategy was efficient, without negatively impacting either ED LOS or health care cost. The lack of increase in ED LOS may be explained by training regarding the observation process, which may have facilitated better communication with the parents, more timely reassessment, and faster disposition. Based on our experience, we too recommend clinical observation in the ED as an effective strategy that can safely reduce unnecessary CT scans, without missing ciTBI.

Decision aids translating high-quality evidence to guide clinical care have been successfully utilized by QI initiatives.[7,9,12] EMR decision support has been shown to safely decrease CT utilization in children with head trauma presenting to the pediatric ED.[8,15,19] Providing specific risk estimates of ciTBI via integrated decision support has been shown to reduce CT use from 24.2% to 21.6% in children with one isolated PECARN risk factor.[11] Our study reaffirms the impact of clinical decision aids as part of a QI initiative for minor head trauma in children. We believe that embedded electronic decision support can help provide rapid dissemination that may enhance guideline adoption and reduce the typical 17-year lag for knowledge translation.[20] Local informatics support should be sought to ensure usability and integration into normal workflow. In the case of MHI, providing evidence-based real-time access to risk stratification can help providers support their decision to forgo CT scan in low- and nonegligible-risk patients. As more hospitals transition to EMRs, adopting electronic decision tools seems the logical next step. We acknowledge that the development and deployment of this strategy can be time-consuming, expensive, and dependent on locally available informatics support, making widespread implementation challenging. In our institution, departmental collaboration with the informatics team already exists, with a standardized process in place, to facilitate approval and prioritization of EMR-related projects.

Peer comparison as a form of enhanced provider feedback was also a key component of our initiative because it is known to be an effective tool to drive behavioral change among clinicians.[21,22] It was one of the key drivers in a prior QI initiative to improve CT utilization rates for MHI in children.[7] Performance feedback using peer comparison can inspire and improve physician care quality, provided that the group is prepared to positively handle comparison in performance. Our team was agreeable to transparent sharing of performance data. Accurate data are needed for meaningful and tailored feedback. In centers like ours, striving for continuous access to robust data, a QI collaborative model like MEDIC can help address this barrier. MEDIC's data support was extremely valuable to the improvement effort and contributed substantially to the success of this project.

Finally, we think that our institution's policy of discussing the patient with the radiologist before obtaining a CT scan contributed to our low baseline CT rates for MHI patients. Our baseline was already lower than previously reported preintervention (21.6% to 62.5%) and postintervention rates (21.6% to 35.9%) for intermediate-risk MHI patients across both pediatric and community ED settings.[11,12,17] We believe that preapproval by a radiologist ensures due diligence on the part of ED providers, weighing the necessity of ordering CT scans, thus limiting the number of inappropriate studies. Depending on the local culture, and/or availability of radiologist, other centers could benefit by considering this simple yet effective measure to positively impact their CT utilization rates.

Our efforts safely and effectively reduced the use of CT scan for MHI in our ED. There was no reported mortality in either group during the study period. None of the patients in this project decompensated in the ED to require either immediate medical or neurosurgical intervention. There was no significant difference in the rate of MHI-related return visits to the ED within 72 hours. The revisits were mostly for postconcussive symptoms and associated with a good outcome. Our quality committee audited the single revisit with ciTBI and concluded that there was no diagnostic error because the patient was appropriately managed on both visits. Pediatric epidural hematomas can have subtle and delayed presentation as seen in our patient. Sencer et al.[23] in their series of 40 patients with posterior fossa epidural hematomas found that the time interval between trauma and admission was greater than 24 hours in more than 20% of their patient population. This case further reaffirms that besides careful assessment and observation, all head injury patients should get thorough discharge and return to ED instructions.

We believe that the intermediate-risk MHI group presents a challenging and significant opportunity to safely decrease radiation exposure in pediatric population. Focused QI efforts could potentially reduce low-value resource utilization and improve overall care. The observed reduction in use of CT for MHI at our center has been sustained for around 2 years and we continue to track our performance through MEDIC. Additionally, we have successfully applied a similar QI methodology to decrease low-value chest x-rays for common respiratory illness in our ED.

LIMITATIONS

There were limitations to this project. Firstly, though this QI project was a part of the MEDIC initiative, the data analyzed and presented are from a single large tertiary care children's hospital. This may limit generalizability to other centers. Second, we used billing codes to identify the study population, which has been shown to be prone to errors and inaccuracies.[24] That said, this approach allowed us to efficiently identify patients using EMR data. Third, although we tracked the return visits, we did not contact the families following discharge, so it is possible that some children may have presented to other local EDs for worsening or persistent symptoms. However, we feel that the likelihood of underestimating return visits or missing revisits for ciTBI was less, since we are the largest referral pediatric trauma center in the region. This is further supported by a previously published study suggesting that most patients return to the same institution for follow-up care.[25] Finally, we used a bundled approach for our interventions, which cumulatively helps us achieve our goals. Lack of process measures limits our capability to understand and describe the impact of individual interventions.

CONCLUSIONS

Our multifaceted quality improvement project resulted in safe and sustained reduction in computed tomography scan use for intermediate risk minor head injuries patients from 18.5% to 13.9% in our ED. We were able to achieve this reduction without increase in the number of return visits or ED length of stay. Our study reaffirms that clinical decision support along with provider education and peer comparison feedback is a successful strategy to inform effective resource utilization. With due commitment, we believe our methodology can be incorporated and implemented at other similarly resourced institutions to achieve reductions in computed tomography use in minor head injuries patients, especially those at intermediate risk for clinically important traumatic brain injury.

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Supporting Information

The following supporting information is available in the online version of this paper available at http://onlinelibrary.wiley.com/doi/10.1111/acem.14177/full

Data Supplement S1. Supplemental material.