Using Computer Alert Systems in the Emergency Room to Screen for Child Abuse

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**Original Project Title:** Using the Electronic Medical Record to Improve Outcomes and Decrease Disparities in Screening for Child Physical Abuse

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ABSTRACT

Background:
Child maltreatment is a leading cause of morbidity and mortality in the United States. Many children who are injured or die from abuse have been previously evaluated by a physician. Numerous studies demonstrate that physicians fail to consistently screen for abuse and that persistent and pervasive disparities in screening exist related to patient and hospital characteristics. The electronic medical record (EMR) is useful in improving screening rates in a wide variety of diseases, thereby allowing for early intervention and improved outcomes.

Objectives:

(1) To develop and validate an EMR-based Child Abuse Clinical Decision Support System (CA-CDSS) in a pediatric hospital emergency department (ED), determine whether physician compliance with evidence-based guidelines for evaluation of child physical abuse improves with CA-CDSS, and compare compliance rates by patient and provider characteristics when physicians do and do not receive CA-CDSS.

(2) To develop a CA-CDSS in the EMR at 2 general EDs and determine whether physician compliance with evidence-based guidelines for evaluation of child physical abuse improves with CA-CDSS.

(3) To assess whether embedding a validated 5-item child abuse screen (CAS) in the EMR in 13 general EDs increases identification and reporting of suspected abuse.

Methods:

Objective 1: To identify children < 2 years old at risk for physical abuse, we coded 30 triggers into the EMR at a pediatric hospital ED. We measured characteristics of the trigger system (eg, accuracy) using the decision of a multidisciplinary child protection team as the reference standard for diagnosis followed by a 7-month randomized controlled trial (RCT) to assess physician compliance with American Academy of Pediatrics (AAP) guidelines for physical abuse evaluation. For patients randomized to be cases, the treating physician received a pop-up alert containing a link to the physical abuse–specific order set. For patients randomized to be controls, no alert or link appeared, but physicians could search for the order set in the order catalog. Compliance with AAP guidelines was compared between groups, and associations with patient and physician demographics were evaluated.

Objective 2: We developed a trigger system at 2 general EDs using a similar approach to the pediatric ED. A 9-month baseline period was followed by a 10-month postintervention period. During the baseline period, physicians were unaware of the CA-CDSS. During the
postintervention period, providers received a pop-up alert for patients who triggered; the alert suggested use of the physical abuse–specific order set.

**Objective 3**: A prospective observational study compared rates of reports to Child Protective Services (CPS) among children who did and did not have a completed 5-item CAS. This was done in all 13 general EDs, including the 2 described above.

**Results:**

**Objective 1**: Sensitivity and specificity of the trigger system for identifying children < 2 years old with physical abuse were 96.8% (95% CI, 92.4%-100.0%) and 98.5% (95% CI, 98.3%-98.7%), respectively. Positive and negative predictive values were 26.5% (95% CI, 21.2%-32.8%) and 99.9% (95% CI, 99.9%-100.0%), respectively.

Compliance with AAP guidelines was high in both cases and controls without a difference between groups. Physicians were more likely to be compliant when patients had public insurance and if physicians were pediatric ED fellowship trained, had more than 10 years’ experience, or were male.

**Objective 2**: A total of 242 children < 2 years old triggered the CA-CDSS—86 during baseline and 156 during the postintervention. Of the triggers, 81% (195 of 242) were considered appropriate (eg, not overtriggers). Compliance with the AAP guidelines was low and did not change in the postintervention group.

**Objective 3**: A 5-item CAS was completed in 11 612 children, with a completion rate of 68%; 1.9% were positive. The rate of reports to CPS was higher when children were screened than when they were not (1.3% vs 0.5%; \( P < .0001 \)). No difference in the screening rates occurred based on patient or hospital characteristics.

**Conclusions:**

**Objective 1**: An EMR-based trigger system can identify young children who need to be evaluated for physical abuse. The lack of a difference in compliance with AAP guidelines in the randomized controlled trial (RCT) was likely because of the high baseline compliance and patient-level randomization, which allowed for contamination of the groups. The rapid uptake of the child abuse–specific order sets demonstrated the high acceptance of this clinical decision support.

**Objective 2**: The much lower baseline compliance with AAP guidelines at the general EDs was expected, but the low compliance after implementation of the CA-CDSS and the lack of use of the physical abuse–specific order set was disappointing. Different approaches may need to be used in general EDs vs pediatric EDs to improve compliance with AAP guidelines.
**Objective 3**: An EMR-based child abuse screening tool can be successfully implemented across multiple locations. The increasing screening rate over the course of the study suggests clinical acceptability. The lack of a difference in the odds of screening or reports to CPS according to race or income is encouraging.

**Limitations and subpopulation considerations:**

**Objective 1**: The quality of the reference standard, which was the decision of a multidisciplinary child protection team, may have provided an overestimate of sensitivity because not every child evaluated in the ED undergoes evaluation by the child protection team. The design allowed for group contamination and limited the ability to detect group differences.

**Objective 2**: The before-and-after design was a limitation, although this would have been more significant had we seen group differences.

**Objective 3**: The observational study design was a limitation; there could have been differences between the children who were and were not screened, which may have affected the likelihood of reporting to CPS.
**Advanced practice providers (APPs):** Nurse practitioners and physician assistants who can evaluate emergency department (ED) patients independently

**American Academy of Pediatrics (AAP):** An American professional association of pediatricians

**Child Abuse Clinical Decision Support System (CA-CDSS):** The system of clinical decision support, developed as part of this award, that is embedded in the electronic medical record (EMR). The CA-CDSS includes the trigger system, the child abuse screen (CAS), the Child Abuse Reporting Form (CARF), provider pop-up alerts, and child physical abuse—specific order sets/powerplans, all of which are defined below. There are 3 different CA-CDSS within the University of Pittsburgh Medical Center (UPMC) hospital system—one at the pediatric hospital ED (Children's Hospital of Pittsburgh of UPMC; specific aim 1), one at 2 of the general EDs (UPMC Hamot and Mercy; specific aim 2), and one at the other 11 general EDs (specific aim 3). A summary of what was included in each CA-CDSS is included in Figure 1.

**Figure 1.** A summary of the 3 CA-CDSS developed as part of this award

<table>
<thead>
<tr>
<th>Specific aim #1: Pediatric ED (CHP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA-CDSS = trigger system + pop-up alerts + child abuse order set/powerplan</td>
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</table>

<table>
<thead>
<tr>
<th>Specific aim #2: 2 general EDs (UPMC Hamot and Mercy)</th>
</tr>
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<tbody>
<tr>
<td>CA-CDSS = trigger system + child abuse screen (CAS) + pop-up alerts + child abuse order set/powerplan</td>
</tr>
</tbody>
</table>

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<tr>
<th>Specific aim #3: 11 general EDs</th>
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<tbody>
<tr>
<td>CA-CDSS = child abuse screen (CAS) + pop-up alert (no order set and no trigger system)</td>
</tr>
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</table>

**Child Abuse Reporting Form (CARF):** A form within the electronic medical record at the University of Pittsburgh Medical Center that was developed as part of this award. This form provides documentation that a report of suspected child maltreatment had been made to the authorities and provides guidance to mandated reporters about the type of information that should be provided to Child Protective Services (CPS). This form, which can be found in a folder
within the EMR called “Abuse Reporting,” allows all providers to quickly determine whether a child they are evaluating has been previously reported to CPS.

**Child Abuse Screen (CAS):** A 5-item child maltreatment screen that was evaluated as part of this award and is a modified version of the validated ESCAPE screen. The CAS is administered by either the triage or primary nurse to all children < 13 years of age who present for care at any of the 13 general EDs in the University of Pittsburgh Medical Center.

**Child maltreatment:** The physical, sexual, or psychological mistreatment or neglect of a child. The term *child maltreatment* is often used interchangeably with *child abuse*.

**Child physical abuse–specific order sets/powerplans:** A series of orders grouped together in the electronic medical record that was developed as part of this award; it allows providers to easily order recommended testing for young children with suspected child physical abuse. All the testing recommended by the American Academy of Pediatrics is prechecked in the order set and tests that are recommended in certain situations are included with descriptions of when they may be needed.

**Child protection team (CPT):** A team of medical professionals with expertise in the field of child maltreatment that evaluates cases of suspected child maltreatment, usually in a hospital setting. Using the CPT assessment as the reference standard for defining abuse has been used previously by our group and others in abuse-related clinical research. The CPT provides written documentation for all consultations and assesses the likelihood of abuse as “not abuse,” “possible/concerning for abuse,” “probable/highly concerning for abuse,” or “definitive abuse.”

**Child Protective Services (CPS):** The governmental agency in the United States responsible for providing child protection, which includes responding to reports of child abuse or neglect. Some states use other names, such as Department of Children & Family Services, Department of Social Services, or simply Social Services.

**Cruising:** When a baby is able to walk while holding onto furniture or other objects. It is the final developmental stage prior to independent walking ([https://www.parents.com/advice/babies/baby-development/when-will-my-baby-start-cruising/](https://www.parents.com/advice/babies/baby-development/when-will-my-baby-start-cruising/)).

**Electronic medical record (EMR):** A digital version of a paper medical chart that contains all of a patient’s medical history. It is sometimes referred to as the electronic health record (EHR). The EMR used at the University of Pittsburgh Medical Center is Cerner.

**ESCAPE:** An acronym for “screening for child abuse at emergency departments, implementation of an optimal protocol” ([https://repub.eur.nl/pub/41238/130628_Louwers,%20Eveline%20Charlotte%20Fleur%20Mari](https://repub.eur.nl/pub/41238/130628_Louwers,%20Eveline%20Charlotte%20Fleur%20Mari)).
The ESCAPE project was initiated in 2007 by Louwers and colleagues in the Netherlands with the goal of developing an effective and feasible implementation protocol for screening for child abuse at emergency departments.\textsuperscript{40}

\textit{Indicated report:} A term in the CPS system that refers to cases in which the local CPS agency determines that a case of suspected maltreatment meets the state definition of maltreatment. When this occurs, the report is \textit{indicated}. A related term is a \textit{founded report}, which refers to a case in which there is a judicial decision that a child was abused. For this research report, indicated cases will include both founded and indicated cases.

\textit{Pop-up alert:} A small window that pops up on the computer screen in the EMR to make a physician aware of a potentially important situation that may require a response. The pop-up alert developed as part of this award is related to the possible need to evaluate for child abuse.

\textit{Skeletal survey:} A set of 19 to 21 X-rays that are part of the evaluation of young children with suspected physical abuse. The skeletal survey is used to detect occult fractures.

\textit{Triggers:} The individual fields or combination of fields within the EMR that result in the provider receiving a pop-up alert when these fields have certain values.

\textit{Trigger system:} The combination of all the triggers.

\textit{University of Pittsburgh Medical Center (UPMC):} A hospital network in western Pennsylvania that includes 13 general hospitals, 1 pediatric hospital, and 1 psychiatric hospital. All the hospitals other than the psychiatric hospital participated in this award.
BACKGROUND

On June 22, 2011, Kieron Barley died when he was just 22 months old, after he was violently shaken and beaten by his mother’s paramour. Just 1 month before his death, he was seen 3 times by a local emergency department (ED) with mild signs of abuse. The significance of these minor injuries, including bruising, appear to have not been recognized by the physicians caring for him. Unfortunately, this type of story is all too common. In 2014, the Miami Herald published “Innocents Lost,” a story about 477 children in Florida killed because of abuse. The story, which won 2 Pulitzer Prizes, includes a photo of every child who died and reviews the multiple missed opportunities to potentially save their lives.

Child abuse is a leading cause of death and disability in children. More than 3 million reports are made to Child Protective Services (CPS) every year in the United States. More than 700,000 are verified as being victims of abuse annually and almost 1600 children die each year because of abuse; this is almost 4 times more than the number of children who die every year from cancer. About 80% of children who die from abuse are < 4 years of age and most of these children die because of physical abuse; 64.5% (856 of 1327) of the deaths due to maltreatment in 2015 were in children < 2 years old. For every child who dies, thousands of others are injured, many with lifelong and devastating consequences of their abuse. Accurate and timely recognition of the early signs of abuse is key to decreasing morbidity and mortality. Conversely, failure to recognize abuse in its less severe forms can result in ongoing abuse and increased morbidity and mortality. Numerous studies have demonstrated that a significant proportion of children who suffer severe morbidity and/or mortality because of abuse have been previously evaluated by a physician who did not recognize the abuse at the initial presentation.

The long-term consequences of child abuse cannot be overestimated. Multiple studies have demonstrated that being a victim of child abuse can result in significant lifelong adverse health, social, and economic consequences, including behavioral problems, an increased risk for delinquency, adult criminality, violent behavior, and an increased risk of chronic diseases and mortality. In addition, lasting disability from physical injury, reduced health-related quality of
life, and lower levels of adult economic well-being have been linked to having a history of child abuse.\textsuperscript{12,13} A recent study by Fang and colleagues estimated the lifetime burden of child abuse to be $210,012 per victim of nonfatal abuse and $1,272,900 per victim of fatal child abuse.\textsuperscript{14} By comparison, the lifetime cost of a stroke per person is estimated at $159,846.\textsuperscript{15}

The ability to decrease morbidity and mortality from child abuse through early recognition could alter the lives of tens of thousands of children each year. Children who are victims of abuse are among the most vulnerable children in our society; medical providers are in a unique position to intervene on behalf of children who do not otherwise have a voice.

Research is needed to determine how to improve early diagnosis of child physical abuse. Child physical abuse is an ideal disease to screen for—it results in significant morbidity and mortality if misdiagnosed and the outcome is improved with early, proper diagnosis. Early recognition of physical abuse in infants and young children is difficult. Caretakers rarely, if ever, provide an accurate history of how a child sustained his or her injuries and the victims are too young to provide information to the physician. The history may be inaccurate for several reasons, including caretakers who bring the child for medical care but who are unaware of the abuse and caretakers who intentionally provide false information to the physician either because they are concerned about the consequences if they tell the truth and/or because they are protecting another adult. Young victims of physical abuse often have occult injuries that are not suspected based on history or physical examination. These occult injuries can be identified only by screening tests such as the skeletal survey and/or head CT (computed tomography).\textsuperscript{16-21}

Evidence-based recommendations published by the American Academy of Pediatrics (AAP) relate to screening for physical abuse in infants and young children (Table 1).\textsuperscript{17} Despite these recommendations, numerous studies demonstrate that physicians fail to consistently screen for abuse even in high-risk situations.\textsuperscript{22,23} Studies have shown persistent and pervasive disparities in screening practices related to patient and hospital characteristics.\textsuperscript{2,23-28} These studies have consistently demonstrated that nonwhite, publicly insured children with injuries are more likely than white, privately insured children with the same injuries to undergo evaluation for child abuse. Whether the racial differences in the screening, evaluation, and reporting are directly
related to differences in risk is unclear. In a recent study using data from the Pediatric Health Information System, when white, privately insured children with injuries underwent physical abuse screening at the same rate as nonwhite, publicly insured children, the white, privately insured infants were more likely to be diagnosed with abuse. These data suggest that the lower level of screening in white children is not justified by racial or insurance-related differences in risk. In contrast, another study using national child welfare and public health data suggests that underlying risk factors that disproportionately affect black families may explain these socioeconomic and racial differences in screening rates.

Table 1. American Academy of Pediatrics Guidelines for Evaluating Children < 2 Years of Age With Injuries Concerning for Physical Abuse

<table>
<thead>
<tr>
<th>Clinical Scenario</th>
<th>American Academy of Pediatrics Recommended Evaluation</th>
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</thead>
<tbody>
<tr>
<td>Not yet cruising&lt;sup&gt;a&lt;/sup&gt; infant &lt; 12 months of age with a fracture(s)</td>
<td>Skeletal survey, CBC/platelets, liver function tests, calcium, magnesium, phosphorus, alkaline phosphatase</td>
</tr>
<tr>
<td>Infant &lt; 6 months of age with bruise(s)</td>
<td>Skeletal survey, neuroimaging (CT or MRI), CBC/platelets, PT/PTT, von Willebrand screen, Factor VIII, Factor IX (von Willebrand and factors not needed if the bruise is in the shape of an object), liver function tests</td>
</tr>
<tr>
<td>Infants 6 to 12 months not yet cruising with a bruise(s)</td>
<td>Skeletal survey, CBC/platelets, PT/PTT, von Willebrand screen, Factor VIII, Factor IX (von Willebrand and factors not needed if the bruise is in the shape of an object), liver function tests</td>
</tr>
<tr>
<td>Infants &lt; 12 months of age with a non-motor-vehicle-associated intracranial hemorrhage</td>
<td>Skeletal survey, CBC/platelets, PT/PTT, Factor VIII, IX, d-dimer, fibrinogen, liver function tests</td>
</tr>
<tr>
<td>Children &lt; 2 years of age reported to Child Protective Services for concerns of physical abuse</td>
<td>Skeletal survey</td>
</tr>
</tbody>
</table>

<sup>a</sup> Cruising is when an infant is able to walk while holding onto furniture or other object. It is the final developmental stage prior to independent walking.

Abbreviations: CBC, complete blood cell count; CT, computed tomography; MRI, magnetic resonance imaging; PT, prothrombin time; PTT, partial thromboplastin time
There is also evidence of disparities in rates of abuse evaluation and diagnosis between general hospitals and pediatric hospitals, with general hospitals having lower rates of both screening and diagnosis. In a classic study by Trokel and colleagues, hospital type (general vs pediatric) was associated with large variations in the frequency of diagnosis of child abuse. This variation was not related to observed differences in the patients or their injuries; rather, it was felt to be the result of systematic underdiagnosis in general hospitals.22 In a more recent study by Wood and colleagues,32 teaching hospitals were more likely than nonteaching hospitals to evaluate young children with fractures for physical abuse using a skeletal survey. The annual volume of young, injured children in a general hospital was associated with the probability of performing this evaluation. This disparity is critically important because most children in the United States are evaluated at general hospitals and not pediatric hospitals.22

Despite extensive data demonstrating poor compliance with screening recommendations as well as disparities in screening, only 1 study has evaluated an intervention to improve screening rate and decrease disparities. Rangel and colleagues implemented a clinical guideline recommending a skeletal survey in all infants with a skull fracture or an intracranial injury for which the history of injury could “not be verified by witnesses outside the immediate family.” Prior to implementation of the guideline, black infants underwent a skeletal survey significantly more frequently than white infants (91% vs 69%), consistent with previous studies. After implementation of the guideline, no racial disparity in screening rates occurred. The rate of diagnosis of abuse also increased after implementation of the guideline, suggesting fewer missed cases of abuse in the white infants.25 These data suggest that adoption of evidence-based practices in child abuse screening can decrease racial disparity and improve early recognition of abuse.

Numerous experiences outside the field of child abuse have demonstrated that clinical guidelines alone are insufficient to standardize care and improve quality of care in the long term.33-35 Emerging literature demonstrates that the electronic medical record (EMR) can be used to improve screening rates in a wide variety of diseases, thereby allowing for early intervention, decreased disparities, and improved outcomes.36-39 Despite the significant
morbidity and mortality from child abuse, no study, to our knowledge, has evaluated the use of the EMR to improve child abuse screening in an ED setting.

Any Child Abuse Clinical Decision Support System (CA-CDSS) that is embedded into the EMR needs to provide support at each of 3 critical steps of child protection—identification of the suspicion of maltreatment, evaluation of the suspicion, and reporting to CPS (Figure 2).

**Figure 2.** The steps that must occur for a child who has been maltreated to be protected from further maltreatment. A successful electronic medical record–based CA-CDSS needs to include support at each step.

```
<table>
<thead>
<tr>
<th>Identify suspicion of maltreatment</th>
<th>Properly evaluate suspicion of maltreatment</th>
<th>Mandated Reporting: Provide CPS with clear documentation of maltreatment-related concerns</th>
</tr>
</thead>
<tbody>
<tr>
<td>THE HAND-OFF</td>
<td></td>
<td>CPS makes accurate safety assessment based on information from the mandated reporter</td>
</tr>
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The goal of this study was, therefore, to combine expertise in the fields of medical informatics and child abuse pediatrics to develop the first comprehensive, EMR-based CA-CDSS. We designed this CA-CDSS to assist medical providers in identifying children with suspected maltreatment, performing the proper evaluation, and reporting their concern to CPS. Within this vulnerable population of children with suspected maltreatment—either because of abuse or neglect—is a particularly high-risk subgroup: children < 2 years of age with injuries that are suspicious for physical abuse. As a result, a significant amount of the CA-CDSS relates to identifying and evaluating child physical abuse in this age group. The studies described below have the potential to alter the way in which hundreds of thousands of vulnerable children are evaluated each year in EDs across the United States and to decrease morbidity and mortality from one of the leading causes of death and disability in children.
Aims and Hypotheses

Primary Hypothesis

Hypothesis 1: Physician compliance with evidence-based guidelines for evaluating child physical abuse at a pediatric ED improves, and disparities in compliance related to patient and physician characteristics decrease, when CA-CDSS is embedded in the EMR.

Specific Aim 1: To develop and validate an EMR-based CA-CDSS in a pediatric hospital ED; determine whether physician compliance with evidence-based guidelines for evaluation of child physical abuse improves with CA-CDSS; and compare compliance rates by patient race, insurance status, and provider characteristics when physicians do and do not receive CA-CDSS, using an RCT design.

Secondary Hypotheses

Hypothesis 2: Physician compliance with evidence-based guidelines for evaluating child physical abuse in general EDs improves when CA-CDSS is embedded in the EMR.

Specific Aim 2: To develop a CA-CDSS in the EMR at 2 general EDs and determine whether physician compliance with evidence-based guidelines for evaluating child physical abuse improves with CA-CDSS, using a before-and-after design.

Hypothesis 3: Embedding a child abuse screen (CAS) in the EMR in general EDs increases the identification and reporting of suspected child abuse, and these increases are not related to patient or hospital characteristics.

Specific Aim 3: To assess whether embedding a validated 5-item CAS in the EMR in 13 general EDs increases the identification and reporting of suspected abuse and whether differences occur based on patient and/or hospital characteristics, using an observational design. A summary of the specific aim/s is shown in figure 1
PARTICIPATION OF PATIENTS AND OTHER STAKEHOLDERS

All stakeholders and their backgrounds are listed in Appendix A. Because of the nature of the population of interest—children who are possible victims of child maltreatment—there was no direct patient involvement in the design and conduct of the research or in the dissemination of findings. The formal stakeholder group was developed to represent the best interests of the study patients. As described below, many medical and nonmedical professionals, some of whom were also end-users of the CA-CDSS, were also engaged in the research and significantly affected the study’s various components. In the responses below, we describe the role of both the formal stakeholders and the partners. Formal stakeholders are the 15 to 20 people described in Appendix A who participated throughout the entire duration of the award. These stakeholders were listed in the funding application, provided letters of support, participated in stakeholder meetings, and were compensated by the award.

In contrast, partners are collaborators, including end-users and clinical leaders at the 13 general hospitals and 1 pediatric hospital clinical sites. Partners were not compensated and did not participate in the stakeholder calls. They participated in phone and email exchanges related to the award, assisted with training the end-users, provided ongoing feedback about different aspects of the project, and offered ad hoc recommendations and troubleshooting.

Types and number of stakeholder and partners involved
Our group of 15 to 20 formal stakeholders participated throughout the duration of the award. These stakeholders, other than those who were employees of University of Pittsburgh Medical Center (UPMC), were compensated. The group underwent some additions (with new sites and roles in the sites) as well as some replacements (retired or took other positions). These stakeholders have a variety of backgrounds and experiences and include clinicians (physicians, social workers, nurses), medical informatics specialists, nonprofessional caregivers of abuse victims, patient advocacy group representatives/policymakers, and a survivor of abuse. Our full list of stakeholders is located in Appendix A.
Partner involvement
Prior to the integration of a validated 5-item CAS into all 13 general EDs, a child abuse response team was developed at each ED. Each child abuse response team comprised a lead nurse (usually the nurse trained as the sexual assault nurse examiner at each site), the director of case management or social work, and the ED director. Each person on these teams represented partners as defined above.

How the balance of stakeholder perspectives was conceived and achieved
From the project’s inception, we recognized the importance and value of including multiple perspectives. This is particularly true for a project in a multidisciplinary field such as child welfare. We wanted to balance the perspectives of patients, which we did by including a father and grandmother of abused children and an adult survivor of abuse, with those of clinicians, policymakers, and professional organizations. We wanted a relatively equal balance of nonprofessionals and professionals as well as a balance of professionals involved in direct patient care vs policy. We achieved this by identifying and recruiting the formal stakeholders as described below.

Partners
Because the evaluation of the universal 5-item CAS (specific aim 3) was a supplement to the original PCORI award, the formal stakeholder group was well established by the time the supplement started. As a result, we decided to have 3 stakeholders (the PI and the site PIs from UPMC Hamot and Mercy) participate on the child abuse response teams rather than add additional stakeholders to the formal stakeholder group.

Methods used to identify and recruit stakeholder partners
Dr. Berger has been a practicing child abuse pediatrician at UPMC Children’s Hospital of Pittsburgh (CHP) as well as a clinical researcher for more than 15 years. She has also been involved in child abuse–related advocacy locally, regionally, and nationally. These activities have resulted in many long-term relationships in this field, which allowed for identification of a group of highly qualified and passionate stakeholders. Her long-term collaboration with many of the formal stakeholders, which pre-dated this award, allowed her to recruit every stakeholder she approached by speaking with them about the study and how they could help.
The identification and recruitment of stakeholders for this project was, therefore, a culmination of almost a decade of relationships. Every one of these stakeholders has personally seen children suffer significant morbidity or mortality because of child abuse. And each of these stakeholders has a long-standing passion to improve the identification of child maltreatment and, specifically, to decrease the disparities in child abuse screening that contribute to the high morbidity and mortality.

**Methods, modes, and intensity of engagement**
The formal stakeholders were engaged on both an informal and a formal basis. Formally, the stakeholders held quarterly meetings at CHP. Stakeholders could attend in person or by phone. At these meetings, the stakeholders were apprised of progress in the study, monitored the conduct of the study, evaluated the results, and, ultimately, assisted in replication and dissemination plans. Stakeholders received the slides and agenda several days before each conference call so they could prepare to discuss them. Each call was a lively conversation, often with many informal follow-up discussions and emails.

Informally, the stakeholders worked with Dr. Berger and the study staff to provide periodic expertise and input into the parts of the study in which they have expertise. Additionally, stakeholders were invited to participate in our update calls with PCORI research program staff. Many of them did participate in all these calls. The intensity of engagement was, therefore, variable throughout the study and by stakeholder.

The partners from each site were engaged at each step of the process, from making suggestions for word changes to the 5-item CAS to providing feedback about barriers to completing it and suggesting process changes to enhance compliance. The Partners have become critical in sustaining the 5-item CAS, which is now part of clinical practice, and remain involved through monthly conference calls with all the site nurses. These meetings are conference calls rather than in-person meetings because the hospitals in the UPMC Health System are spread across more than 120 miles of western Pennsylvania.
Adoption of research evidence into practice
Stakeholder involvement and commitment was crucial to the success and implementation of this study at all levels. By involving the stakeholders described above, from the project’s conception through the adoption of the CA-CDSS and 5-item CAS into clinical practice, we have maximized the possibility of success. Including stakeholders with a long-standing passion for this disease also maximized the possibility of success. Specifically, development of the research question occurred because of the many years of collaboration among many of the stakeholders.

Examples of how the engagement of stakeholders changed a specific aspect of the research
During one of our regularly scheduled quarterly stakeholder calls, we were discussing the challenges of integrating a trigger system into the EMR at UPMC Hamot and Mercy because of their lack of pediatric-specific forms and the lack of discrete fields in the EMR. One of the nonprofessional formal stakeholders (Ms. Palm) had recently seen an article about a paper screening tool for child abuse and raised the question of whether we could put a child abuse screening tool in the EMR. After the call, the PI conducted a literature search and found a recently published study from the Netherlands about a validated paper-based screening tool called ESCAPE. Mr. Kidwell, the head of UPMC Risk Management and one of the stakeholders, agreed to review the screen and assist us in making appropriate changes because of the difference in mandated reporting laws in Pennsylvania and the Netherlands (where the ESCAPE screen was developed and validated). The Netherlands does not have mandated reporting, but physicians, nurses, and all other members of the health care team are mandated reporters in Pennsylvania. It was critical that any screen we used did not mandate a report to CPS for every positive result. We then had to receive buy-in from the UPMC hospital system to allow us to integrate a new screen into the EMR. Two other stakeholders—Drs. Suresh and Rosenthal—were able to make connections to the chief medical informatics officer of the health system. After multiple outreaches, we were able to work with leadership in the hospital system to allow the 5-item CAS to replace the domestic violence screen in children < 13 years old (for whom the idea of domestic violence is not relevant because any sexual activity < age 13 is sexual abuse in Pennsylvania).
The subsequent quarterly stakeholder meeting included a discussion about how, in general, ED (vs pediatrics EDs) children are often not completely undressed during their evaluation. Michele Poole, a grandmother and foster parent of a child who was abused, shared the story of her own family and how they found out one of her granddaughters had been abused when, after hospital discharge, a social worker found a bruise that was not discovered in the hospital because it was in the diaper area. Ms. Poole suggested finding a way to remind providers within the EMR to undress children, including removing a baby’s diaper, to better see if the child has bruising or marks. The group agreed this was important and brainstormed ideas to help integrate this practice into the EMR. Ultimately, we included the statement (including capitals), “ALL CHILDREN < 4 YRS OF AGE MUST BE UNDRESSED COMPLETELY . . . children greater than 4 yrs should be completely undressed if any of the screening questions are positive or if you have concerns for abuse or neglect” on the CAS form.

The initial conversation at the quarterly stakeholder meeting, which ultimately resulted in our applying to PCORI for a supplement to our original award, is a clear demonstration of how having a diverse, engaged group of stakeholders can strengthen a project.
METHODS

The methods section is divided into 2 sections. The first, more detailed section focuses on specific aim 1. The second, briefer section is dedicated to specific aims 2 and 3.

Study Design/Interventions/Study Outcomes

Specific Aim 1: To develop and validate an EMR-based CA-CDSS in a pediatric hospital ED; determine whether physician compliance with evidence-based guidelines for evaluating child physical abuse improves with CA-CDSS; and compare compliance rates by patient race, insurance status, and provider characteristics when physicians do and do not receive CA-CDSS, using an RCT design.

Development of the trigger system in a pediatric ED

We selected triggers to include in the trigger system after reviewing child abuse literature and electronic data entry fields available in the CHP EMR. A total of 30 triggers were embedded into the EMR; these are detailed in Appendix B. The triggers incorporate discrete fields used throughout a patient’s encounter. Discrete fields are data points that can have only certain values as opposed to being free text (eg, a data field can have only a “yes” or “no” value). A constraint of the current version of our EMR is the inability of free text (eg, a nurse documenting “I am worried about child abuse”) to generate alerts. Among children at risk for physical abuse, we were particularly interested in identifying children whose injuries met 1 of the 5 specific scenarios for which the AAP has guidelines for evaluation: fracture in a noncruising infant, bruise in a < 6-month-old, bruise in a noncruising 6- to 12-month-old, intracranial injury in a noncruising infant not in a motor vehicle crash, and an injury reported to CPS for concern of physical abuse in a child < 2 years old.

Once the triggers were coded into the EMR, the trigger system was run on “silent mode” from October 21, 2014, to April 6, 2015. This 6-month silent mode was needed to correct any coding errors and calculate the characteristics of the CA-CDSS, to determine whether it was accurate enough to be used in clinical practice. During this silent mode period, research staff were able to see which clinicians would receive alerts if the trigger system were “live.” There was no
impact on clinical care and physicians did not know that the trigger system was being tested. During this time, study personnel, including the hospital’s chief medical informatics officer, PI, and research coordinator, identified coding errors (eg, use of an “or” term instead of an “and” term) and triggers that were producing a large number of overtriggers (eg, chief complaint of “mouth injury” in children < 1 year old). Errors were corrected and overtriggers removed by hospital information technology personnel.

Owing to ethical concerns that a potentially abused child could be identified by the trigger system but not by the treating physician, the PI reviewed the ED documentation for all subjects who triggered the trigger system while in silent mode. When the research team had a concern that child abuse should have been considered by the treating physician, the case was referred to the chief of the division of emergency medicine. The division chief then reviewed the case and determined whether the child needed to be brought back to the ED for further evaluation/testing. The process by which any patient was brought back was the same process that is used clinically in the ED when additional information becomes available after a patient is discharged (eg, a blood culture becomes positive). CPS was not called directly because in no case was there reasonable suspicion that the injuries were the result of abuse, but only concern that either more information or an additional evaluation was needed.

**Calculation of the sensitivity and specificity of the trigger system at CHP (silent mode)**

All reported data, including the specificity and sensitivity of the trigger system, are based on analyses performed after all coding changes were complete. Calculating the sensitivity, specificity, and negative and positive predictive values for identifying physical abuse was the primary outcome of this part of the study and was calculated using the baseline/silent mode data.

We defined true positives as children who triggered the trigger system and were subsequently evaluated by and classified by the hospital-based child protection team (CPT) as having possible, probable, or definite physical abuse. True negatives were children who were seen in the ED, did not trigger the trigger system, and were either not evaluated by the hospital-based CPT or were evaluated but not classified as having possible, probable, or definite physical abuse. False
negatives were children who did not trigger the trigger system but were evaluated by and classified by the hospital-based CPT as having possible, probable, or definite physical abuse. False positives were either (1) children who triggered the trigger system but for whom it was not reasonable that a physician would consider the possibility of abuse (eg, overtriggers); or (2) children for whom it was reasonable to be concerned about abuse but who were ultimately either (a) not evaluated by the hospital-based CPT team or (b) evaluated by the CPT but not diagnosed as possible, probable, or definite abuse. We established these definitions, including the definition about whether it was appropriate that a physician would be concerned about physical abuse given the clinical scenario (Table 2) prior to the start of the study. The decision about whether to have the hospital-based CPT evaluate each patient was independent of the research study and was based on clinical judgment and hospital policies and procedures that mandate a CPT evaluation in certain scenarios (eg, infant with intracranial hemorrhage who is admitted to the hospital).

The evaluation of the CPT rather than the decision of CPS about whether each case was determined to be abuse was intentional. The CPT is a team of medical professionals with expertise in the field of child maltreatment that evaluates cases of suspected child maltreatment, usually in a hospital setting. The CPT provides written documentation for all consultations and assesses the likelihood of abuse as “not abuse,” “possible/concerning for abuse,” “probable/highly concerning for abuse,” or “definitive abuse.” The diagnosis of the CPT is a medical diagnosis that is independent of state law. All 3 specific aims focused on improving the identification, evaluation, and reporting of maltreatment by medical providers. Identifying, evaluating, and reporting suspected abuse is the role of medical providers in the CPT system. In contrast, the role of the CPS system is to appropriately respond to these concerns. Significant data from around the country demonstrate that sometimes CPS does not appropriately respond to many of the reports of suspected child abuse.

In addition, there is significant variability in CPS indication rates, which is dependent on state and local interpretation of the federal and state child abuse laws rather than on differences in the cases. If 2 children have the exact same injuries, both of which are determined by the CPT
to be definite abuse, one case can be indicated—determined by CPS to meet the state
definition of abuse—in a given county or state and the other may not be indicated as abuse.
The reasons for this difference are beyond the scope of this discussion but include issues such
as who is considered a potential perpetrator of child abuse under different state laws and
whether cases can be indicated as abuse if the person who committed the abuse is unknown.
This is why we used the decision of the CPT, rather than the decision of CPS, as a reference
standard. Many cases of suspected abuse reported to CPS that are labeled as probable or
definite by a CPT are not indicated as abuse by CPS. Allegheny County, where Children’s
Hospital of Pittsburgh of UPMC is located, has an indication rate of less than 5%—the lowest in
the state and one of the lowest in the country. The counties surrounding it have significantly
higher indication rates because of differences in legal interpretation of the laws. If we had used
CPS indication rates as the diagnostic reference standard to assess the accuracy of the trigger
system for the children who live in Allegheny County, virtually all of the triggers would be
considered false positives; but if we had assessed the triggers with a group of children with the
same injuries who live in one of the surrounding counties where the indication rates are
significantly higher, the false-positive rate would be much lower.

Table 2. Reasons Why—or Why Not—it Was Reasonable for a Physician to Be Concerned About
Physical Abuse

<table>
<thead>
<tr>
<th>Possible Reasons Why It Was Reasonable for a Physician to Be Concerned About Physical Abuse</th>
<th>Possible Reasons Why It Was Not Reasonable for a Physician to Be Concerned About Physical Abuse</th>
</tr>
</thead>
</table>
| 1. Patient has an injury that should result in screening for physical abuse based on the AAP guidelines (eg, bruise, petechiae, subconjunctival hemorrhage, fracture, or intracranial hemorrhage in a child who is not yet cruising)  
2. Patient has a nonspecific symptom that is known to be associated with child abuse or there is concern that physical abuse is the etiology of the infant’s symptoms (eg, fussy infant, infant with apparent life-threatening event (ALTE) or apnea, vomiting without diarrhea, failure to thrive)  
3. Patient is the sibling of a child with known or suspected physical abuse | 1. Concern is for another type of abuse (eg, sexual abuse, neglect) but not physical abuse  
2. A miscode resulted in the trigger (eg, the chief complaint of “assault” was inadvertently entered when it should have been “asthma” and the system had already triggered prior to correction)  
3. There is an injury, but it is not appropriate that a physician would |
4. Patient has been involved in an incident of domestic violence
5. Patient has been a victim of child abuse in the past
6. An adult (eg, parent, bystander, professional) raises concerns of abuse
7. Unexplained death (eg, possible co-sleeping/unsafe sleep)
8. Misassessment by a medical professional (eg, a nurse believes that an infant has a bruise and documents it, causing the system to trigger, but the physician ultimately decides that it is a birthmark, not a bruise)

There was concern that a child in the true-negative group could potentially be a false negative (eg, a patient missed by the trigger system, by the ED physician caring for the child, and by the policies and procedures that mandate a CPT evaluation). Given the size of the true-negative cohort, it would have been impractical to review all the ED records to determine if any patients in this cohort could have been false negatives. Another approach would have been to refer a randomly selected group of patients to the CPT for an evaluation; however, this would not have been possible for multiple reasons, including that the research team knew no identifying information about patients who did not trigger the alert system, so it would not have been possible to identify these children to conduct an evaluation. Also, the institutional review board (IRB) would not have allowed the study to be done without consent if the CPT had direct interaction with patients for whom there was no clinical indication to be involved. Retrospective review of a random selection of children who did not trigger the trigger system, to assess for the possibility of a false negative, was considered, but an alternative approach—which we believe was a better approach—was used instead. We selected for review a nonrandom sample of children who were at high risk of being false negatives. This nonrandom sample included all children who were evaluated by the CPT in the year after silent mode ended, because this group was likely to be the highest risk group within the entire cohort of true negatives. We reviewed all ED visits for these patients that occurred during silent mode to determine whether they represented a potentially missed abusive event.

Training of Providers
Prior to the start of the RCT, both providers (physician/advanced practice provider [APP]) and nursing end-users received training. The PI conducted in-person trainings at scheduled ED
provider meetings. All providers received an email that included a description of the CA-CDSS, screenshots of the pop-up alert and order sets, and a description of what would occur if they clicked the different choices on the alert. The research team also provided individual feedback to physicians who had questions throughout the RCT. The study staff developed a “nursing quicksheet” with study information and EMR screenshots and trained several nursing leaders in the ED. These nurses conducted trainings for the ED nursing staff during regularly scheduled nursing staff meetings.

Evaluation of the effect of the CA-CDSS on provider compliance with AAP guidelines

Once the CA-CDSS and the provider interface had been developed, we performed an RCT from April 8, 2015, to November 10, 2015, to evaluate the effect of the CA-CDSS on provider compliance. Subjects in the RCT were automatically randomized to the RCT-case or RCT-control group based on the fifth digit from the right of the FIN (visit) number, the first number in the FIN that is random. Patients with an odd number were randomized to controls and even to cases. Although randomization at the patient level increases the likelihood of crossover among groups, provider-level randomization was not possible because multiple physicians care for each patient and because the attending physician often does not get linked to a patient until after the CA-CDSS is triggered and the chart is opened for the first time.

For subjects randomized to the RCT-case group, the physicians or APPs received the pop-up that alerted them to the possibility of abuse. As described above, the pop-up required that providers select 1 of 3 options—“yes,” “not now,” or “no, never”—in response to the question about whether they wanted to be linked to the powerplan. For subjects in the RCT-control group, the physicians/APPs did not receive an alert, but they could access the powerplan by searching the Cerner order catalog for “ED Physical Abuse Powerplan.” The search option was provided because we felt it was unethical to not allow access to the powerplan. In addition, owing to ethical and medicolegal concerns raised about the possibility of an abused child being recognized by the CA-CDSS but randomized to the RCT-control group and missed clinically, the PI reviewed the ED visit for each subject in the control group. When the PI had concern that a child abuse evaluation should have been conducted, he or she referred the case to the chief of

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the division of emergency medicine, who then reviewed the case and determined whether the child needed to be brought back to the ED for further evaluation/testing.

We assessed compliance by reviewing the EMR to determine whether each of the tests included in the AAP guidelines was completed prior to patient discharge from the ED or the hospital, if the child was admitted. The completion or lack of completion of each test, and not the result, was documented. We assessed compliance as “fully compliant,” “partially compliant,” “not compliant,” or “met clinical scenario but clinical judgment made evaluation unnecessary.” We defined fully compliant as completing both a skeletal survey and liver function tests and a complete blood count with platelets; partially compliant as completing either a skeletal survey or bloodwork; and not compliant as not completing either. We used “met scenario but clinical judgment made evaluation unnecessary” for situations exhibiting a clear reason why a child abuse evaluation was not clinically indicated. For example, we used this selection when an injury occurred in a public place and/or when a child had a known underlying medical condition (eg, hemophilia) that would predispose him or her to a given injury. We did not include subjects in this last group in the denominator for the purposes of calculating compliance. Although the AAP guidelines suggest that, in some situations, other bloodwork such as calcium and phosphorus in cases of infants with fractures may be needed, we did not include these in the compliance assessment because their completion may be necessary only when a given injury is thought to be the result of abuse (vs evaluating for possible abuse) and these tests would be used to evaluate for a medical cause for the injury.

Specific Aim 2: To develop a CA-CDSS in the EMR at 2 general EDs and determine whether physician compliance with evidence-based guidelines for evaluating child physical abuse improves with CA-CDSS, using a before-and-after design.

A similar protocol was in place for developing the trigger system at the 2 general EDs, UPMC Hamot and Mercy. The lack of discrete fields—fields that can have only certain values as opposed to being free text—in the EMR at UPMC Hamot and Mercy required a different approach to developing triggers. As a result, the source of the triggers at UPMC Hamot and Mercy was a combination of the CAS, specific discharge diagnoses, and a free text scan of the
chief complaint and nursing-focused assessment for specific text. This is the first time, to our knowledge, that free text scanning has been used for an EMR-based trigger system. The triggers embedded into the EMR are listed in Appendix B. The triggers are based on the words and age ranges of the triggers, which were validated within the CHP trigger system. We were not able to validate the free text scanning tool at UPMC Hamot and Mercy with the exception of evaluating the overtrigger rate (14%). Overtriggers were cases in which triggers based on the free text screening rules would not have reasonably raised the concern for abuse. For example, the word “broke” in an infant < 6 months of age is a trigger that is meant to capture if an infant might have broken a bone (which is highly concerning for abuse in this age group), but if the focused assessment/chief complaint in a 3-month-old included the sentence “the father speaks broken English,” the infant would trigger the alert system even though clearly this should not raise the concern for abuse. This would be labeled as an overtrigger. The free text scanning was used only in combination with the CAS and never in isolation. We could not calculate the sensitivity/specificity of the trigger system at UPMC Hamot and Mercy because there is no clinical gold standard available for identifying abuse at the general EDs that is equivalent to the CHP Child Protection Team. We also could not calculate how many children were identified clinically, but not identified by the trigger system, until we initiated the Child Abuse Reporting Form (CARF), which is the searchable EMR-based documentation that a report has been filed with CPS. The CARF was introduced during silent mode, but it was not used consistently until the “live period.” Now that the CARF is being used virtually 100% of the time when a report is being filed with CPS, we plan to obtain data that will allow us to better calculate the false-negative rate (cases identified clinically—defined as making a report to CPS—but missed by the trigger system).

We performed a before-and-after analysis (vs an RCT) at UPMC Hamot and Mercy. We initially planned to evaluate the effect of the CA-CDSS on compliance as an RCT, but because of the results of the CHP study, which is described below, as well as a much smaller than expected sample size at UPMC Hamot and Mercy, we used a preintervention–postintervention design. PCORI was aware of this change.
The 9-month silent mode (preintervention) period spanned September 29, 2015, to May 10, 2016. We developed the provider interfaces and order sets during this period. This was followed by a 10-month live period (postintervention) from May 11, 2016, to January 31, 2017. During both the silent mode and the live period, the same data were collected on subjects who triggered the CA-CDSS (see p. 44: Data collection and sources). During the live period, providers received a pop-up alert (Appendix F, Figure F6) whenever a patient triggered. The alert suggested the use of the physical abuse–specific order set (powerplan) to encourage its use by providers. In addition, the respective ED directors educated providers about the availability of the powerplan. Finally, individual physicians received feedback and education from the PI when they did not use the powerplan in a situation in which it could have been used. We performed our analysis after the end of the live period.

The order set at UPMC Hamot and Mercy differs from the order set at CHP; it takes into account differences in training between adult and pediatric physicians and the limited capacity of community hospitals to care for infants and young children. As a result, the powerplans focus on when a transfer to CHP is appropriate, when testing should be done if a transfer is planned, and when reporting to CPS is needed.

Specific Aim 3: To assess whether embedding a validated 5-item child abuse screen in the EMR in 13 general EDs increases the identification and reporting of suspected abuse and whether differences occur based on patient and/or hospital characteristics, using an observational design.

Cerner is the EMR used throughout the UPMC hospital system. However, the Cerner platform, which is used in the pediatric ED at CHP is entirely different from the one used in the general EDs at UPMC Hamot and Mercy. This means that the forms, order sets, and provider interface are all different. As a result, a different CA-CDSS needed to be developed for the general EDs. Developing triggers in the EMR of the general EDs was challenging because of the lack of pediatric-specific forms and the use of free text (vs check boxes) and charting by exception. Charting by exception means that abnormalities, such as abnormal physical examination findings, are documented as free text and not as check boxes at UPMC Hamot and Mercy.
Check boxes are the most common way in which the trigger system is triggered. We considered several possible ways to trigger alerts to the physicians. Ultimately, we decided to take advantage of the domestic violence screen the UPMC hospital system has required to be completed for all patients. For pediatric patients, the nurses answer the domestic violence screen by checking “not applicable” and then writing in the reason of “pediatric patient.” Because nurses are required to open the domestic violence screen, we looked into the possibility of integrating a child abuse screen in place of the domestic violence screen for children. After discussions with the UPMC leaders, we learned that it would not be possible to integrate a child abuse screen only at UPMC Hamot and Mercy because all the hospitals share the same forms. However, the hospital system was willing to integrate the child abuse screen at all 13 of its hospitals where children are evaluated.

We completed a review of the literature to identify whether a validated child abuse screen was in use in the United States. We did not find one, but we became aware of the ESCAPE tool, a child abuse screen that has been well studied and validated in the Netherlands.\textsuperscript{40,41} We proposed to PCORI to fund an assessment of the usability of a modified ESCAPE screen (referred to in this report as the CAS) and evaluate its effect on identifying and reporting child maltreatment.

While the CA-CDSS at UPMC was being evaluated at Hamot and Mercy, the 5-item CAS was being evaluated at the 13 general EDs. This prospective observational study compared the rates of reports to CPS among children who did and did not have a CAS completed. We considered the possibility of performing an RCT at the hospital, provider, and patient levels and a preevaluation–postevaluation, but none were possible. An RCT at the hospital, provider, or patient level was not possible because once a new form, such as the CAS, is activated in the Cerner EMR, it must be active at all 13 UPMC sites for all patients and all providers. An RCT would have meant that all subjects would have the CAS performed with the results documented in the EMR, but only some providers would be made aware of the positive CAS result with the alert. This contrasts with CHP, in which the entire CA-CDSS (trigger system plus alerts plus order set) could be randomized. Both medicolegal and ethical concerns were raised.
about documenting a positive CAS but not providing alerts to some providers. A pre-evaluation–
post-evaluation also was not possible because prior to implementation of the 5-item CAS, none
of the hospitals had a standard way to document when a report was made to CPS. As a result,
we would not be able to measure one of the primary outcomes: the number of reports made to
CPS prior to the implementation of the CAS. As part of this project, we developed a Child Abuse
Reporting Form (Appendix F, Figure F7) that allowed for tracking of reports; this is described in
detail below. This form went live on the same day as the CAS, which is also described in more
detail below.

Because of all the issues discussed above, the CAS evaluation (specific aim 3) was, therefore, an
observational study.

The CAS was evaluated over several phases:

Phase 1: Modification of the ESCAPE Tool and Development of a Child Abuse Reporting
Form
ESCAPE was developed in the Netherlands, a country without mandated reporting of suspected
child maltreatment. In response to the potential medicolegal implications of a positive CAS in a
country such as the United States, where health care providers are mandated reporters of
suspected child maltreatment, we rephrased the ESCAPE questions for interpretability,
combined 2 questions, and altered the wording so that a “yes” answer always indicated a
positive response. We then modified the wording with the input from the UPMC Risk
Management attorney such that a positive screen did not necessarily require mandated
reporting under the Pennsylvania Child Protective Services Law. This modified screen was
referred to as the Pilot UPMC CAS. The ESCAPE screen and Pilot UPMC CAS are in Appendix D.

Because sending a report to CPS was a primary outcome, the ability to track when reports of
suspected maltreatment were made to CPS was a critical component of the study. Prior to the
initiation of the CAS, there was no standard way to document the reports to CPS in the EMR
and no standard place to put them. For example, a nurse may have documented the report to
CPS in a nursing note, a physician may have mentioned it in his or her clinical record, or a case
manager or social worker may have noted it in his or her consultation and report. At other
times, there was no documentation at the time of the ED visit; a call to the hospital from CPS to follow up on a previous report was the only evidence that a report had been filed. It is very likely that reports were also made to CPS that were not documented at all in the EMR. As a result, we developed the Child Abuse Reporting Form (CARF) that serves as internal documentation that the health care system has made a report to CPS and provides guidance to the mandated reporter about what information CPS needs to respond appropriately to a report. The CARF is located in a folder in the EMR labeled “Abuse Reporting” so that any clinician caring for the child can easily see whether any reports have been made previously.

**Phase 2: Integration of the Screen Into the EMR and Training of Nurses**

The pilot screen was integrated into the EMR; access to the screen was triggered by a primary nurse’s response to the question, “Is the child < 13 years of age?” We used the age cutoff of 13 because the CAS was intended to replace the domestic violence screen; the state of Pennsylvania considers any sexual activity prior to the age of 13 to be sexual abuse—as such the concept of domestic violence is not relevant in this age group. If any question on the screen was positive (defined as a “yes” on any of the 5 CAS items), the physician/advanced practice provider received a pop-up alert upon chart-opening that required acknowledgment (Appendix F, Figure F8). Each provider received one alert per patient. This alert was seen by providers at all the general EDs except UPMC Hamot and Mercy, where the alert also prompted the provider to use the child abuse–specific order set that was not available at the other EDs.

Using an online module, approximately 500 ED nurses at all 13 EDs were trained in how to use the screening tool and how to interpret the questions.

**Training of APP and physician providers**

Several weeks before the project “went live,” all the ED medical directors received an onboarding packet that included general education about child abuse, screenshots of the CAS, case examples, and contact information for questions. The medical directors were responsible for disseminating this education to their providers. We were not able to receive approval from the health care system to require a physician module similar to the nurse online module, but we were able to give a required 1-hour presentation at an annual risk management conference.
for all providers, which occurred less than 1 year after the start of the CAS. **Piloting of Screen**

The pilot UPMC CAS was implemented January 24, 2016, to March 15, 2016, as a nonmandatory screen at UPMC Hamot and Mercy, 2 of the 13 EDs in the UPMC network (see Appendix E for a description of all the UPMC hospitals). A total of 2599 children aged < 13 years were seen at the 2 hospitals during the pilot period; a CAS was completed for 43% (n = 1102). Based on end-user feedback, we made several word changes to the CAS. The final CAS is shown in Appendix F, Figure F9.

**“Go-Live” of the CAS: Study Setting and Population**

After the pilot period, the screen was disseminated to all UPMC EDs. From March 16, 2016, to September 15, 2016, all children aged < 13 years who were evaluated in any of the 13 UPMC-affiliated EDs were eligible to have the CAS completed. The 5-item CAS was mandatory (which is denoted by the yellow color of each field), but it was not considered a “hard stop,” meaning that nurses could move to other forms without first completing the 5-item CAS. Hard stops are rarely approved by the hospital system and are used for situations such as a positive suicide screen and or an order for a medication for which the patient is documented to have a life-threatening allergy. Having the CAS as a mandatory screen means that nursing supervisors can track completion of the screen and cite nurses for not completing them. Importantly, if the CAS was positive, the provider was REQUIRED to acknowledge the alert that a patient might be a victim of abuse. In this way, the alert was a hard stop. We have no way to know if the provider carefully read the alert, only that he or she acknowledged it with a click on the alert.

We collected data over the 6-month period and performed analyses at the end of the study period.

**Forming the Study Cohort**

**Specific Aim 1: Pediatric ED (CHP)**
The study population at CHP included all children < 2 years of age who were brought for care in the CHP ED and who triggered the trigger system. The inclusion and exclusion criteria were coded into the EMR and were defined by the code; they are included in Appendix B. Some of these criteria were inclusion (eg, fracture as chief complaint) and some were exclusion (eg,
motor vehicle crash coded as mechanism of injury). Only children < 2 years were included because children in this age group are at highest risk of morbidity and mortality from abuse and are particularly vulnerable to being misdiagnosed. This is also the age group for which evidence-based guidelines exist for medical evaluation. It would be very difficult to develop a set of triggers for children older than 2 years of age because the same physical examination findings and X-ray findings that are specific for abuse in children < 2 years of age are almost always the result of accidents in older children. For example, bruises in a 3-month-old are highly concerning for physical abuse, while bruises in a 12-year-old are almost always accidental and part of normal childhood activities. Triggering a child abuse trigger system in a 12-year-old with bruises would clearly be inappropriate.

The exclusion criteria (eg, motor vehicle crash) were included because, in these circumstances, physical abuse would not be a concern. It is possible that a parent driving under the influence could have caused the crash and that a report to CPS or police would be needed. The focus of the trigger system, however, is on physical abuse only. An infant involved in a motor vehicle crash related to parental impairment would not need a skeletal survey or other testing that is needed in suspected physical abuse cases and recommended in the pop-up.

Because informed consent was waived, all children who triggered the CA-CDSS were enrolled.

**Specific Aim 2: 2 General EDs (UPMC Hamot and Mercy)**
As with CHP, the study population at UPMC Hamot and Mercy included all children < 2 years of age who sought care in the UPMC Hamot or Mercy ED and who triggered the trigger system. The inclusion and exclusion criteria were coded into the EMR and were defined by the code; they are included in Appendix B.

**Specific Aim 3: Evaluation of the CAS in 13 General EDs (including the 2 general EDs in specific aim 2)**
All children < 13 years of age who were registered at any of the 13 UPMC EDs during the 6-month study period were enrolled. We used the age cutoff of 13 was used because the CAS was intended to replace the domestic violence screen. The hospital system is required to have a domestic violence screen for all patients 13 years of age and older. The CAS offered an
opportunity for an age-appropriate violence screen for children < 13 years of age. Although child maltreatment does occur in children aged 13-18 years, it is not as common and very rarely results in significant morbidity and mortality. We would not have been able to get the UPMC hospital system’s support to add the child abuse screen on top of the domestic violence screen for this age group; therefore, we decided to limit the child abuse screen to children < 13 years of age.

The age-related inclusion criterion differs between the trigger systems at UPMC Hamot and Mercy and the CAS. This is because the specific triggers based on discharge diagnosis and chief complaint, for example, are age dependent and are not specific for abuse in older children. The triggers other than the CAS focus only on physical abuse, while the CAS focuses on both physical abuse and neglect and allows a nurse to raise concern about sexual abuse or other concerns in the “comment” question.

Study Setting
Specific Aim 1: Pediatric ED (CHP)
CHP is a children’s hospital that is certified as a pediatric level I trauma center in which the providers have specific pediatric training. The ED evaluates approximately 80 000 children annually.

Specific Aim 2: 2 General EDs (UPMC Hamot and Mercy)
UPMC Hamot and Mercy are urban teaching hospitals in the UPMC network. The physicians are general ED physicians without specific pediatric training. UPMC Mercy is in the city of Pittsburgh < 5 miles from CHP. UPMC Hamot is in Erie, Pennsylvania, which is about 2 hours from Pittsburgh.

Specific Aim 3: 13 General EDs (Evaluation of the CAS)
As discussed above, we could not roll out the 5-item CAS in only a subset of hospitals because all 13 of the general EDs in the UPMC system use the same EMR. As a result, we used all non-CHP EDs in the UPMC health system to evaluate the 5-item CAS. While this was difficult from a training and implementation standpoint, it provided a very large sample size and allowed us to evaluate the 5-item CAS in rural and urban, teaching and nonteaching hospitals. A brief
description of all 13 hospitals can be found in Appendix E.

Follow-up
All components of this study occurred in real time. There was no follow-up component:
Response to any positive CAS was done by the clinical team in real time.

Data Collection and Sources
Almost all the data for all parts of the study were directly downloaded from the EMR. The EMR
is an acceptable data source for the studies performed as part of this award. The data
downloads were automated and emailed to study personnel at regular intervals. For the
evaluation of the trigger system, some data were collected by hand from the EMR because the
data could not be directly downloaded.

Because the data were downloaded directly from the EMR, there was very little (<1%) missing
data for any given variable. We monitored missing data to ensure that the proportion of
missing data did not increase, which could have suggested that a change in clinical practice was
taking place. Because of the very small amount of missing data, we used listwise deletion to
address the missing data rather than a formal attempt to interpolate the relatively few missing
data points. Listwise deletion is a method for handling missing data in which an entire record is
excluded from analysis if any single value is missing.42

Specific Aim 1: Pediatric ED (CHP)
Data that were directly downloaded included designation as case or control, date of ED visit,
medical record number, encounter number, chief complaint, all discrete fields from the nursing
evaluation forms, age, race (as collected by the patient registrar), gender, zip code, insurance
(private, public, no insurance), the trigger that activated the trigger system and the time/date it
was activated, whether certain orders were placed (X-rays, skeletal surveys, subspecialist
consult requests), whether a report to CPS was made, and whether a physical abuse–specific
order set was ordered. For purposes of analysis, we combined patients with public insurance
and no insurance into a single group. Although multiple choices for race were available, we
analyzed it as a dichotomous variable (Caucasian, not Caucasian) because the number of
subjects with races other than Caucasian and African American was too small to show any statistically significant difference. Race was collected during the registration process as part of clinical care. Additional data added by the study staff related to whether the provider was compliant with evidence-based guidelines.

**Specific Aim 2: 2 General EDs (UPMC Hamot and Mercy)**
Data that were directly downloaded from the EMR were similar to that for CHP and included the facility where the patient was evaluated, date of ED visit, medical record number, encounter number, age, race (as collected by the patient registrar), gender, zip code, insurance (private, public, no insurance), trigger that activated the trigger system and the time/date it was activated, discharge diagnosis, responses to questions 2 and 3 of the 5-item CAS (which are specific to physical abuse concerns), chief complaint, focused assessment of chief complaint, radiology orders placed, whether a skeletal survey was ordered, discharge instructions, and whether a report to CPS was made. Additional data added by the study staff related to whether the provider was compliant with evidence-based guidelines.

**Specific Aim 3: 13 General EDs (Evaluation of the CAS)**
For every patient < 13 years of age evaluated at any of the 13 UPMC EDs, the following data were included in the weekly data report: ED site, date of ED visit, medical record number, encounter number, age, race, gender, zip code, CAS results, whether a report to CPS was filed, and the data from the CARF.

**Analytical and Statistical Approaches**
**Specific Aim 1: Pediatric ED (CHP)**
Evaluation of sensitivity, specificity, and negative and positive predictive values of the trigger system was the primary outcome. Secondary outcomes included the proportion of cases in which the provider was compliant with the AAP guidelines for evaluation of suspected physical abuse in the RCT-control vs RCT-case group vs preintervention group as well as the proportion of cases in which the provider was compliant by patient race and insurance status. This outcome is relevant to patients because the study’s goal is to improve the evaluation of young children with injuries that are concerning for physical abuse, to maximize the likelihood that
abuse will be identified early and reported to CPS. Early identification and intervention are the best ways to decrease morbidity and mortality from abuse. The secondary outcomes are important because of the well-documented racial and socioeconomic biases in the evaluation of young children with injuries that are concerning for abuse. Specifically, as discussed previously, studies have documented that a white child is less likely than a black child with the same injury to be properly evaluated for physical abuse; when insurance is used as a proxy for socioeconomic status, children of low socioeconomic status are more likely to be evaluated even if they have the same injury as a child with high socioeconomic status.

Specific Aim 2: 2 General EDs (UPMC Hamot and Mercy)
The primary outcome was the proportion of cases in preintervention and postintervention groups in which the provider was compliant with the AAP guidelines for evaluation of suspected physical abuse. The secondary outcome was the proportion of cases in which the provider was compliant by patient race and insurance status. We defined compliance the same way for UPMC Hamot and Mercy subjects as for CHP subjects. For children who were transferred from either UPMC Hamot to Mercy (where there is a burn unit), UPMC Hamot to CHP, or UPMC Mercy to CHP, we considered the entirety of the evaluation at both sites when assessing compliance. For purposes of analysis, we included the data from both evaluations in a single line of data. For example, if a 12-month-old patient was evaluated at UPMC Hamot for a burn, a report was filed with CPS, and then the child was transferred to UPMC Mercy, where a skeletal survey was conducted, all this information would be included in a single line of data to assess compliance with AAP guidelines.

Specific Aim 3: 13 General EDs (Evaluation of the CAS)
The primary outcome for this portion of the study at all the 13 UPMC EDs was the comparison of the rate of reporting of suspected child abuse to CPS in children who did and did not have a CAS completed. The secondary outcome was to evaluate whether screening differences occurred by patient race and/or socioeconomic status or by hospital characteristics (urban vs rural, teaching vs nonteaching. These outcomes are clinically relevant because the study’s overall goal is to improve early identification of child abuse and to assess whether using a
screening tool can do this. The secondary outcome is clinically relevant because of the recognized disparities in identifying and reporting abuse by patient and hospital characteristics.

We used chi-square tests to compare the proportions of children with a report filed to CPS according to whether they were screened and whether the screen was positive or negative. We performed 2 sets of multivariable logistic regression models. The first was designed to explore the association between the outcomes of interest (eg, abuse screening and reporting to CPS) and the subject demographics (child’s age, sex, race, and income). To explore how the hospital’s structural characteristics affected these outcomes, we created models that controlled for the demographic characteristics of the sample while incorporating variables representing teaching status, hospital size, and rural vs urban location. We clustered the variance by facility in all models.

To reduce the potential for bias from children having multiple presentations (such that the characteristics of children who are frequent attenders to an ED would be overrepresented in the model), we created a data set at the level of the individual, as opposed to the event. For subjects with more than 1 encounter, we used the first encounter for the data set.

**Conduct of the Study at All Sites**
The conduct of this multisite, multicomponent study involved multiple IRB protocols and approvals. Because UPMC Hamot maintains its own IRB, the study had to be submitted both to the University of Pittsburgh IRB (which is the IRB for all UPMC hospitals other than UPMC Hamot) and to the Hamot IRB. In addition, both IRBs requested different study protocols with separate IRB approvals for different parts of this study. As a result, 7 IRB approvals are associated with this study; they are described in Table 3. All the protocols associated with these IRBs have been submitted as a separate attachment. A waiver of informed consent was granted for all parts of the study and at all sites, so all patients were included in the evaluation.
<table>
<thead>
<tr>
<th>Name of Study</th>
<th>Summary</th>
<th>IRB Number</th>
<th>Date of Initial IRB Approval</th>
<th>Status</th>
<th>Most Recent Approval Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using the Electronic Medical Record to Improve Outcomes and Decrease Disparities in Screening for Child Physical Abuse</td>
<td>This is the main study evaluating the CA-CDSS at CHP and UPMC Mercy.</td>
<td>PRO13100176 (Pitt IRB)</td>
<td>11/21/2013</td>
<td>Expedited review</td>
<td>9/30/2016</td>
</tr>
<tr>
<td>Usability Evaluation for PRO13100176</td>
<td>This is the usability study needed to develop the trigger system. It allowed us to ask end-users for feedback about the trigger system, pop-up alert, and order set.</td>
<td>PRO13110248 (Pitt IRB)</td>
<td>12/17/2013</td>
<td>Exempt</td>
<td>n/a</td>
</tr>
<tr>
<td>PCORI End-user Feedback PRO13100176</td>
<td>This study allowed us to get anonymous feedback from end-users about their experience with the CA-CDSS.</td>
<td>PRO15050244 (Pitt IRB)</td>
<td>7/7/2015</td>
<td>Exempt</td>
<td>n/a</td>
</tr>
<tr>
<td>Evaluation of a Mandatory Child Abuse Screen</td>
<td>This study evaluated the 5-item CAS at adult EDs. It also includes some end-user feedback.</td>
<td>PRO15050482 (Pitt IRB)</td>
<td>7/30/2015</td>
<td>Expedited review</td>
<td>7/1/2016</td>
</tr>
<tr>
<td>Using the Electronic Medical Record to Improve Outcomes and Decrease Disparities in Screening for Child Physical Abuse—Clinical Usability Addendum (Trigger-Qualtrics)</td>
<td>This is the main study evaluating the CA-CDSS at UPMC Hamot only.</td>
<td>IRB No. 14-03-01 (Hamot IRB)</td>
<td>3/3/2014</td>
<td>Expedited review</td>
<td>12/6/2016</td>
</tr>
<tr>
<td>Using the Electronic Medical Record to Improve Outcomes and Decrease Disparities in Screening for Child Physical Abuse</td>
<td>This is the usability study for the trigger study, asking about feedback on the trigger system, pop-up alerts, and order sets at the Hamot location only.</td>
<td>n/a</td>
<td>6/25/2014</td>
<td>Exempt</td>
<td>n/a</td>
</tr>
<tr>
<td>Evaluation of a Mandatory Child Abuse Screen</td>
<td>This is the 5-item CAS study at UPMC Hamot.</td>
<td>IRB No. 15-10-02 (Hamot IRB)</td>
<td>10/6/2015</td>
<td>Exp</td>
<td>10/4/2016</td>
</tr>
</tbody>
</table>
There were 2 significant changes in the study from the initial award proposal:

**Removal of randomization at the UPMC Hamot and Mercy sites**
Although the initial plan was to perform an RCT at UPMC Hamot and Mercy, we could not do this for several reasons. First, the CAS was being done on all patients and could not be done on only some patients. As a result, an RCT would have meant that all patients were having the CAS performed with the results documented in the EMR, but only some providers would be made aware of the positive CAS result with the alert. Both medicolegal and ethical concerns were raised about documenting a positive CAS but not providing alerts to some providers. In addition, during silent mode, the trigger rate was much lower than we had anticipated based on our initial sample size calculation. Because of this lower trigger rate, the time that would have been needed for an RCT trial would have been far longer than the time of the current award period. We also knew that at CHP, where we did an RCT, we had to stop the randomization because once the CA-CDSS was live, physicians were searching for and finding the physical abuse–specific order sets even when they did not receive a trigger (or even before they would have received the trigger in cases in which there would have been a trigger).

**Addition of the CAS supplement**
As discussed above, the supplement to the award that evaluated a universal 5-item CAS was a significant change from the initial award proposal.
RESULTS

Because we obtained a waiver of informed consent for all parts of the study by both the University of Pittsburgh IRB (which provides research approvals for all UPMC hospitals other than UPMC Hamot) and the Hamot IRB, we enrolled all eligible subjects. Because we conducted the study at a single point in time, no subject attrition occurred. We registered this study in HSRProj (HSRProject ID: HSRP20143284).

Primary Hypothesis

(Hypothesis 1): Physician compliance with evidence-based guidelines for evaluation of child physical abuse at a pediatric ED improves, and disparities in compliance related to patient and physician characteristics decrease, when CA-CDSS is embedded in the EMR.

Specific Aim 1: To develop and validate an EMR-based CA-CDSS in a pediatric hospital ED; determine whether physician compliance with evidence-based guidelines for evaluation of child physical abuse improves with CA-CDSS; and compare compliance rates by patient race, insurance status, and provider characteristics when physicians do and do not receive CA-CDSS, using an RCT design.

Demographics of the population during silent mode at CHP

The trigger system ran on silent mode for 6 months. During this time, 226 children triggered an alert. Mean (SD) age was 9.1 (6.5) months. The gender and race of children < 2 years old who triggered were similar to those of all children < 2 years old seen in the CHP ED. More children < 2 years old with public insurance triggered an alert compared with all children < 2 years old seen in the CHP ED (Table 4).
Table 4. Comparison of Demographics of All Children < 2 Years of Age Seen at CHP ED With Those Who Triggered the Trigger System During Silent Mode

<table>
<thead>
<tr>
<th></th>
<th>Children Who Triggered (Baseline/Silent Mode) (n = 226)</th>
<th>All Children &lt; 2 Years Old Seen in CHP ED in Fiscal Year 2015 (n = 21 349)</th>
<th>Chi-square/P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (% male)</td>
<td>137 (61%; 95% CI, 60%-67%)</td>
<td>11 917 (56%; 95% CI, 55%-57%)</td>
<td>0.54/.449</td>
</tr>
<tr>
<td>Race (% Caucasian)</td>
<td>152 (68%; 95% CI, 61%-73%)</td>
<td>12 834 (60%; 95% CI, 60%-61%)</td>
<td>1.13/.287</td>
</tr>
<tr>
<td>Insurance (% with public insurance)</td>
<td>174 (77%; 95% CI, 71%-82%)</td>
<td>13 164 (62%; 95% CI, 61%-62%)</td>
<td>4.81/.028</td>
</tr>
</tbody>
</table>

The mean (SD) trigger rate as a proportion of all children evaluated in the ED was 0.6 (0.1%).

The most common first triggers during silent mode at the CHP site were an order for a skeletal survey (31.9%), concern for abuse or report of child abuse documented on the prearrival form (16.8%), and chief complaint of assault or suspected child abuse and neglect (15.9%). Each embedded trigger alerted at least once (Appendix B).

*Calculation of sensitivity and specificity of the trigger system (Table 5)*

During silent mode at the CHP site, 62 children < 2 years old were diagnosed with possible, probable, or definite physical abuse by the hospital-based CPT; 60 triggered the trigger system and 2 did not. The sensitivity of the trigger system for children < 2 years old who were referred to the CPT was, therefore, 96.8% (95% CI, 92.4%-100%).

There were 10 710 children < 2 years old who did not trigger the trigger system and either were not evaluated by the hospital-based CPT (n = 10 673) or were evaluated but were not assessed as having possible, probable, or definite abuse (n = 37).

There were 46 children < 2 years old who triggered the trigger system but in whom study staff determined that there was no reason to be concerned about physical abuse; the reasons for
these false positives/overtriggers were “concern for neglect or sexual abuse, not physical abuse” (n = 27), a miscode (n = 18), and a birth injury recognized prior to the ED visit (n = 1).

There were also 121 subjects who triggered the trigger system and for whom it was reasonable to be concerned about abuse, but they either were not evaluated by the CPT or were evaluated by the CPT but ultimately were not diagnosed as having possible, probable, or definite abuse. These subjects are, therefore, considered in the cohort of false positives. The specificity of the trigger system was, therefore, 98.5% (95% CI, 98.3%-98.7%). The PPV (positive predictive value) and NPV (negative predictive value) were 26.5% (95% CI, 21.2%-32.8%) and 100% (95% CI, 99.9%-100%), respectively.

Table 5. 2 x 2 Contingency Table of the Characteristics of the Trigger System

<table>
<thead>
<tr>
<th>Trigger Fired</th>
<th>Diagnosis of Possible, Probable, or Definite Physical Abuse by the Hospital-based Child Protection Team</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive</td>
</tr>
<tr>
<td>Positive</td>
<td>60 (60 seen by the CPT)</td>
</tr>
<tr>
<td>Negative</td>
<td>2 (2 seen by the CPT)</td>
</tr>
<tr>
<td></td>
<td>Negative</td>
</tr>
<tr>
<td>Positive</td>
<td>166 (34 seen by the CPT)</td>
</tr>
<tr>
<td>Negative</td>
<td>10,710 (37 seen by the CPT)</td>
</tr>
<tr>
<td></td>
<td><strong>PPV = 26.5%</strong></td>
</tr>
<tr>
<td></td>
<td><strong>NPV = 100.0%</strong></td>
</tr>
</tbody>
</table>

Sensitivity = 96.8% Specificity = 98.5%

The PI and study staff reviewed the 2 false negatives to determine whether a change in the triggers could potentially increase the sensitivity without significantly affecting the overtrigger rate. One patient was in the ED < 1 hour before being transferred to the Pediatric Intensive Care Unit. Because of the severity of the injuries, there was no real-time documentation in the EMR. This infant was immediately identified clinically as needing a consultation by the hospital-
based CPT. The other infant was evaluated by the hospital-based CPT after a skeletal survey performed as part of the in-patient admission for failure to thrive demonstrated a fracture. During the ED visit, there had been no concern for physical abuse.

As described previously, we further evaluated a nonrandom sample of children in the true-negative cohort—those who were evaluated by the CPT in the year after the end of silent mode. In total, 210 children were evaluated by the CPT in the year after silent mode. Of these, 40 had a total of 61 ED visits that had occurred during silent mode. Of the visits, 97% (59 of 61) were unrelated to trauma; most were for respiratory symptoms and/or fever. Two visits represented possible opportunities to identify maltreatment. The first was a 6-month-old with a closed head injury and a bruise who was observed for 4 hours and discharged. The subsequent CPT referral was for a tooth injury at 10 months of age; it was assessed as not being the result of abuse. The second patient was a 9-month-old who was seen in the ED for a routine physical examination prior to foster care placement owing to poor housing conditions. In the physician note (which is free text and cannot be used to trigger) a “dime-sized brown bruise on left upper calf” was noted. There was no concern for abuse. The subsequent CPT referral was for medical neglect. Based on these data, the presence of a significant number of false negatives in the true-negative cohort is unlikely.

We recognize that it is likely that the sensitivity of the trigger system is lower than the 96.8% reported above. As a result, we evaluated what the sensitivity would be if both 0.1% and 0.3% of the children in the cohort of 10,673 were actually false negatives. If 0.1% of the children in the cohort were false negatives (n = 11 missed cases of abuse), the true sensitivity and specificity of the cohort would be 82% and 98.5%, respectively. This is equivalent to missing 15% of all the children with abuse in the cohort (11 of 71). If 0.3% of the children in the cohort were false negatives (n = 32 cases of missed abuse), the true sensitivity and specificity of the cohort would be 63.8% and 98.5%, respectively. This is equivalent to missing 36% of all the children with abuse in the cohort (34 of 94). Because the rate of physical abuse in the cohort of 10,673 is, at most, 0.6% (based on national statistics about the rate of physical abuse in infants, the highest risk population) and because the trigger system identified 0.6% of the population (n
= 60 children) with abuse as defined by our reference standard, we believe it is highly unlikely that our trigger system is missing more than 0.1% (15%) of the children with physical abuse.

**Result of the RCT: Evaluation of provider compliance with AAP guidelines**
Once we had demonstrated the accuracy of the trigger system, a 7-month RCT of the CHP CA-CDSS was performed to evaluate the effect of an entire CA-CDSS, including the provider alerts, nursing alerts, and order sets, on physician compliance with the evidence-based guidelines for evaluating children < 2 years of age with suspected physical abuse.

**Patient demographics**
During the 7-month RCT, 306 children triggered 147 cases and 159 controls (Figure 3). Overall, the mean (SD) age was 8.7 (6.3) months, with 66% Caucasian and 56% male; there was no difference in these demographic variables between the baseline/silent mode and the RCT or between groups within the RCT.
Figure 3. Flowchart of patients who triggered the alert system during the CHP RCT
Provider demographics
Forty-two APPs and physicians evaluated all the subjects; 74% were female, 71% had fewer than 10 years of experience, 83% were white, and 57% had completed a pediatric emergency medicine fellowship. The remaining 43% were either currently in a pediatric emergency medicine fellowship or were general ED trained.

Compliance
Compliance with AAP guidelines was high in both groups (85% RCT-case vs 77% RCT-control; Figure 3) without a statistical difference between groups. Compliance with the AAP guidelines in the 3 groups for each of the clinical scenarios is shown in Table 6.

Table 6. Compliance With American Academy of Pediatrics (AAP) Guidelines in Each of 5 Clinical Scenarios in the 3 Study Groups at CHPa

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Noncruising Infant &lt; 12 Months of Age With a Fracture</th>
<th>Infants &lt; 6 Months of Age With Bruise(s)</th>
<th>Infants 6-12 Months Not Yet Cruising With a Bruise(s)</th>
<th>Infants &lt; 12 Months of Age With a Non-motor-vehicle-associated Intracranial Hemorrhage</th>
<th>Children &lt; 2 Years of Age Reported to Child Protective Services for Concerns of Physical Abusea</th>
<th>Overall Compliance in Children Who Met 1 or More Clinical Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline/preintervention</td>
<td>78% (38 of 49) - fully compliant</td>
<td>81% (13 of 16) - fully compliant</td>
<td>84% (16 of 19) - fully compliant</td>
<td>100% (18 of 18) - fully compliant</td>
<td>96% (22 of 23) - fully compliant</td>
<td>84% (83 of 99) - fully compliant</td>
</tr>
<tr>
<td></td>
<td>16% (8 of 49) - partially compliant</td>
<td>6% (1 of 16) - partially compliant</td>
<td>16% (2 of 19) - partially compliant</td>
<td></td>
<td></td>
<td>10% (10 of 99) - partially compliant</td>
</tr>
<tr>
<td></td>
<td>6% (3 of 49) - not compliant</td>
<td>13% (2 of 16) - not compliant</td>
<td></td>
<td></td>
<td></td>
<td>6% (6 of 99) - not compliant</td>
</tr>
<tr>
<td>RCT-control</td>
<td>78% (18 of 23) - fully compliant</td>
<td>90% (19 of 21) - fully compliant</td>
<td>86% (6 of 7) - fully compliant</td>
<td>100% (14 of 14) - fully compliant</td>
<td>100% (16 of 16) - fully compliant</td>
<td>86% (49 of 57) - fully compliant</td>
</tr>
<tr>
<td></td>
<td>4% (1 of 23) - partially compliant</td>
<td></td>
<td>14% (1 of 7) - partially compliant</td>
<td></td>
<td></td>
<td>3.5% (2 of 57) - partially compliant</td>
</tr>
</tbody>
</table>

a CHP = Children's Hospital of Philadelphia.
<table>
<thead>
<tr>
<th>Time Period</th>
<th>Noncruising Infant &lt; 12 Months of Age With a Fracture</th>
<th>Infants &lt; 6 Months of Age With Bruise(s)</th>
<th>Infants 6-12 Months Not Yet Cruising With a Bruise(s)</th>
<th>Infants &lt; 12 Months of Age With a Non-motor-vehicle-associated Intracranial Hemorrhage</th>
<th>Children &lt; 2 Years of Age Reported to Child Protective Services for Concerns of Physical Abuse&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Overall Compliance in Children Who Met 1 or More Clinical Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCT-case</td>
<td>17% (4 of 23) - not compliant</td>
<td>10% (2 of 21) - not compliant</td>
<td>12% (1 of 8) - partially compliant</td>
<td>100% (14 of 14) - fully compliant</td>
<td>100% (13 of 13) - fully compliant</td>
<td>17% (4 of 23) - not compliant</td>
</tr>
<tr>
<td></td>
<td>81% (26 of 32) - fully compliant</td>
<td>90% (19 of 21) - fully compliant</td>
<td>88% (7 of 8) - fully compliant</td>
<td>100% (14 of 14) - fully compliant</td>
<td>100% (13 of 13) - fully compliant</td>
<td>10% (2 of 21) - not compliant</td>
</tr>
<tr>
<td></td>
<td>6% (2 of 32) - partially compliant</td>
<td>22% (2 of 9) - not compliant</td>
<td>13% (4 of 32) - not compliant</td>
<td></td>
<td></td>
<td>10.5% (6 of 57) - not compliant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6% (2 of 21) - not compliant</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>3% (2 of 73) - partially compliant</td>
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<td></td>
<td></td>
<td>8% (6 of 73) - not compliant</td>
</tr>
</tbody>
</table>

<sup>a</sup> Children who met more than 1 clinical scenario (eg, bruise and fracture) are included each relevant category.

<sup>b</sup> Clinical scenario 5 requires only completion of a skeletal survey, so partial compliance is not an option.

Even though providers in the control group had to search for the physical abuse–specific order set, both groups used it with the same frequency. A total of 51 physical abuse–specific order sets were used during the RCT; 43 (84%) of these were for children who met 1 of the 5 clinical scenarios being evaluated and 8 were for children who did not meet a scenario. There was no difference in powerplan use between the RCT groups even though providers of children in the RCT-control group had to search for the powerplan (27 of 85 RCT-case vs 16 of 72 RCT-control; \( P > .05 \)). In every case in which the powerplan was used, the provider was fully compliant with the AAP guidelines; no subjects had partial compliance. Overall, the proportion of patients with partial compliance decreased during the RCT (10 of 99 preintervention vs 4 of 130 RCT-control + RCT-case; \( P = .04 \)).

The lack of group difference in the RCT was likely because of the unexpectedly high compliance in the control group combined with the rapid adoption of the abuse order set by all providers.

*Relationship between patient and physician demographics and compliance*
In all groups (baseline/silent mode, RCT-case, and RCT-control), physicians were more likely to be compliant with AAP guidelines when patients had public insurance ($P = .02$). Physicians who were general pediatrics trained or currently in fellowship were more likely to be not compliant or partially compliant ($P < .000$). Physicians with more than 10 years of experience were more likely be compliant ($P = .01$), as were male physicians ($P = .04$). There was no relationship between physician demographics and patient race ($P = .98$), an important finding given prior studies demonstrating racial disparities in compliance.

Of physicians, 31% (13 of 42) had at least 1 incident of noncompliance. Three physicians had more than 1 incident of noncompliance: 1 physician had a 50% (4 of 8) noncompliance rate, 1 had a 40% (2 of 5) noncompliance rate and 1 had a 16% (2 of 12) noncompliance rate. The incidents of noncompliance occurred in all 3 groups (baseline/silent mode, RCT-case, and RCT-control).

**Secondary Hypotheses**

*Hypothesis 2*: Physician compliance with evidence-based guidelines for evaluation of child physical abuse in general EDs improves when CA-CDSS is embedded in the EMR.

*Specific Aim 2*: To develop a CA-CDSS in the EMR at 2 general EDs and determine whether physician compliance with evidence-based guidelines for evaluation of child physical abuse improves with CA-CDSS, using a before-and-after design.

A 9-month silent mode (“before”) period was followed by a 10-month live period at UPMC Hamot and Mercy. A total of 242 children < 2 years of age triggered the trigger system; 86 during silent mode and 156 during the live period (Figure 4). Table 7 shows the demographic data for the patients who triggered an alert compared with all children < 2 years of age evaluated in those EDs. There is a striking difference in the proportion of children who triggered the trigger system who had public insurance (~80%) compared with the proportion of all children < 2 years of age evaluated at UPMC Hamot and Mercy (~20%).

**Table 7.** Comparison of Demographics of All Children < 2 Years of Age Seen at UPMC Hamot and Mercy During the Silent Mode and Live Period With Demographics of Children Who Triggered the Trigger System
In 81% (195 of 242) of the patients who triggered the trigger system, the trigger was considered appropriate, meaning that the scenario that resulted in a trigger should have raised the concern for abuse (Figure 4). We assessed the appropriateness of the triggers using the same criteria at UPMC Hamot and Mercy as at CHP. Of the overtriggers, 70% (33 of 47) were because of the free text scanning (e.g., the word “burn” in the chief complaint of a 3-month-old is a trigger but the chief complaint of “burning up with fever” in a 3-month-old would also trigger because the text contained the word “burn” and the child is within the age group coded to trigger for this chief complaint).

**Compliance (Figure 4)**

Compliance with the AAP guidelines for evaluation of suspected physical abuse was 57% (4 of 7) during silent mode and 51% (22 of 43) in the live period ($p = .87$). There was no statistical difference in compliance between the baseline/silent mode and live data. Importantly, compliance was 86% (5 of 6) in the 6 cases in the live period in which the physician used the physical abuse–specific order set. We have not completed the data analysis related to patient race and insurance.

The lack of improvement in compliance after introduction of the CA-CDSS is likely because of a combination of factors, including the relatively infrequent rate of alerts for any given provider; overall alert fatigue, which is a significant issue in adult hospitals and may result in providers...
acknowledging the alert without reading it; and limited provider knowledge about child maltreatment, which may lead to overriding of the recommendations in the alert. These hypotheses are supported by our end-user feedback (Appendix C).

_Hypothesis 3:_ Embedding a child abuse screen in the ED in general EDs increases the identification and reporting of suspected child abuse, and these increases are not related to patient or hospital characteristics.

_Specific Aim 3:_ To assess whether embedding a validated 5-item CAS in the EMR in 13 general EDs increases the identification and reporting of suspected abuse and whether differences occur based on patient and/or hospital characteristics, using an observational design.

The CAS evaluation involves the integration of a 5-item universal mandatory child abuse screen at all 13 of the UPMC EDs. There were 17,163 unique children < 13 years of age who were seen in the EDs of the 13 facilities during the 6-month study period. The mean age of the cohort was 5.83 years; most were white (72.1%) and resided in areas with median annual incomes of $25,000 to $45,999 (71.1%). A higher proportion of children were evaluated in the first 13 weeks of the 6-month intervention (54.1%) compared with the latter 3 months. Also, the number of children seen varied among EDs (Table 8).
Figure 4. Flowchart of patients who triggered the alert system at UPMC Hamot and Mercy
Table 8. Demographics of Children Seen at the 13 EDs During the Evaluation of the 5-item CAS

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>6781</td>
<td>(39.5)</td>
</tr>
<tr>
<td>4-7</td>
<td>4695</td>
<td>(27.4)</td>
</tr>
<tr>
<td>8-12</td>
<td>5687</td>
<td>(33.1)</td>
</tr>
<tr>
<td>M</td>
<td>7891</td>
<td>(46.0)</td>
</tr>
<tr>
<td>F</td>
<td>9272</td>
<td>(54.0)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>12 372</td>
<td>(72.1)</td>
</tr>
<tr>
<td>Black</td>
<td>3528</td>
<td>(20.6)</td>
</tr>
<tr>
<td>Other*</td>
<td>1263</td>
<td>(7.4)</td>
</tr>
<tr>
<td>Median income ($)</td>
<td>Median, mean</td>
<td>41 471, 44 025</td>
</tr>
<tr>
<td>0-24 999</td>
<td>1265</td>
<td>(7.4)</td>
</tr>
<tr>
<td>25 000-49 999</td>
<td>12 198</td>
<td>(71.1)</td>
</tr>
<tr>
<td>50 000-74 999</td>
<td>2737</td>
<td>(16.0)</td>
</tr>
<tr>
<td>&gt; 75 000</td>
<td>838</td>
<td>(4.9)</td>
</tr>
<tr>
<td>Unknown</td>
<td>125</td>
<td>(0.7)</td>
</tr>
<tr>
<td>Hospital</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>2714</td>
<td>(15.8)</td>
</tr>
<tr>
<td>B</td>
<td>1070</td>
<td>(6.2)</td>
</tr>
<tr>
<td>C</td>
<td>1215</td>
<td>(7.1)</td>
</tr>
<tr>
<td>D</td>
<td>4210</td>
<td>(24.5)</td>
</tr>
<tr>
<td>E</td>
<td>1689</td>
<td>(9.8)</td>
</tr>
<tr>
<td>F</td>
<td>1470</td>
<td>(8.6)</td>
</tr>
<tr>
<td>G</td>
<td>969</td>
<td>(5.7)</td>
</tr>
<tr>
<td>H</td>
<td>104</td>
<td>(0.6)</td>
</tr>
<tr>
<td>I</td>
<td>1520</td>
<td>(8.9)</td>
</tr>
<tr>
<td>J</td>
<td>1615</td>
<td>(9.4)</td>
</tr>
<tr>
<td>K</td>
<td>101</td>
<td>(0.6)</td>
</tr>
<tr>
<td>L</td>
<td>181</td>
<td>(1.1)</td>
</tr>
<tr>
<td>M</td>
<td>305</td>
<td>(1.8)</td>
</tr>
<tr>
<td>Duration of trial</td>
<td>Weeks 1-13</td>
<td>9281</td>
</tr>
<tr>
<td></td>
<td>Weeks 14-26</td>
<td>7822</td>
</tr>
</tbody>
</table>

\* Includes those who declined to provide this information, those with multiple selections, and those who selected Asian, Alaska Native, American Indian, Chinese, Filipino, Guam/Chamorro, Hawaiian, Indian (Asia), Japanese, Korean, Other Asian, Other Pacific Islander, Samoan, and Vietnamese.
Of the 17,163 children evaluated in the EDs, 11,599 (68%) were screened for abuse using the 5-item CAS. Prior to the initiation of the CAS, no systematic screening for abuse was conducted in any of the 13 EDs. We compared the cohort of children who were screened (n = 11,599) with those who were not screened (n = 5,564). Younger children were more likely to be screened, but there were no race or income differences in the odds of being screened. There were also no significant differences in the odds of being screened by teaching status of the hospital, size, or urban vs rural location of the ED.

Overall, the odds of being screened were higher in the second half of the intervention period compared with the first half (odds ratio [OR] 1.42; 95% CI, 1.12-1.79); the odds of being screened increased by an average of 3% for every week of the 25-week trial. We were unable to assess whether other variables, such as reason for visit, severity of condition, past medical history, and history of repeated visits, might have affected the likelihood of being screened. CAS screening rates over time are shown in Figure 5.

**Figure 5. CAS screening rates over time**

Overall, 221 (1.9%) of the screens were positive. In total, 169 reports were made to CPS: 111 (66%) from children with a positive screen, 35 (21%) from children with a negative screen, and 23 (14%) from children who were not screened. The rate of reports to CPS was significantly higher in children who were screened compared with those who were not (1.3% vs 0.4%; P < .0001). Of patients with a
positive 5-item CAS, 50% had a report filed compared with 0.3% of those with a negative result ($P < .0001$; Table 9).

**Table 9.** Comparison of Rates of Reporting to Child Protective Services Based on the Result of the 5-item CAS

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>%</th>
<th>Report to Child Protective Services</th>
<th>n</th>
<th>(%)</th>
<th>$P$ Value$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total in sample</td>
<td>17</td>
<td>163</td>
<td></td>
<td>169</td>
<td>(1.0)</td>
<td></td>
</tr>
<tr>
<td>Total screened</td>
<td>11</td>
<td>600</td>
<td></td>
<td>146</td>
<td>(1.3)</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Total not screened</td>
<td>5563</td>
<td>(32.4)</td>
<td></td>
<td>23</td>
<td>(0.4)</td>
<td></td>
</tr>
<tr>
<td>Positive CAS</td>
<td>222</td>
<td>(1.9)</td>
<td></td>
<td>111</td>
<td>(50.0)</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Negative CAS</td>
<td>11</td>
<td>378</td>
<td></td>
<td>35</td>
<td>(0.3)</td>
<td></td>
</tr>
</tbody>
</table>

$^a$ $P$ values calculated with Pearson chi-square test.

Tables 10 and 11 give the results of multivariable logistic regression models, showing the likelihood of having a 5-item CAS completed, having a positive CAS, and having a report to CPS, according to demographics of the sample and facility.

**Outcomes according to facility characteristics:** There were no differences in the odds of being screened based on urban vs rural hospital location, teaching status, or size. EDs in urban locations and teaching hospitals were more likely to have a positive CAS.
Table 10. Odds Ratios Associated With CAS, a Positive CAS, and Report to Child Protective Services, According to the Demographics of the Sample

<table>
<thead>
<tr>
<th></th>
<th>CAS OR 95% CI</th>
<th>Positive CAS OR 95% CI</th>
<th>Report to CPS OR 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-3 Reference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-7</td>
<td>0.80 (0.74-0.87)</td>
<td>0.69 (0.53-0.89)</td>
<td>0.58 (0.42-0.80)</td>
</tr>
<tr>
<td>8-12</td>
<td>0.68 (0.59-0.79)</td>
<td>0.42 (0.34-0.52)</td>
<td>0.42 (0.28-0.62)</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1.00 (0.95-1.06)</td>
<td>1.03 (0.80-1.32)</td>
<td>1.12 (0.88-1.44)</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Reference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>0.99 (0.86-1.15)</td>
<td>0.55 (0.37-0.82)</td>
<td>0.55 (0.28-1.09)</td>
</tr>
<tr>
<td>Other&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.09 (0.89-1.35)</td>
<td>0.45 (0.24-0.83)</td>
<td>0.27 (0.08-0.86)</td>
</tr>
<tr>
<td><strong>Income ($)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-24 999 Reference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 000-49 999</td>
<td>1.08 (1.01-1.15)</td>
<td>0.80 (0.47-1.34)</td>
<td>1.27 (0.87-1.84)</td>
</tr>
<tr>
<td>50 000-74 999</td>
<td>1.07 (0.97-1.18)</td>
<td>0.83 (0.33-2.04)</td>
<td>1.63 (0.94-2.83)</td>
</tr>
<tr>
<td>&gt;75 000</td>
<td>1.08 (0.97-1.21)</td>
<td><strong>0.31 (0.18-0.54)</strong></td>
<td>0.30 (0.03-2.79)</td>
</tr>
<tr>
<td><strong>Duration of intervention at time of CAS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;13 weeks</td>
<td><strong>1.42 (1.12-1.79)</strong></td>
<td>1.43 (0.86-2.38)</td>
<td><strong>1.90 (1.27-2.83)</strong></td>
</tr>
<tr>
<td>Any screen</td>
<td></td>
<td></td>
<td><strong>2.90 (1.67-5.02)&lt;sup&gt;b&lt;/sup&gt;</strong></td>
</tr>
</tbody>
</table>

All models are adjusted for day of the week, time of ED attendance, and facility.

<sup>a</sup> Includes those who declined to provide this information, those with multiple selections, and those who selected Asian, Alaska Native, American Indian, Chinese, Filipino, Guam/Chamorro, Hawaiian, Indian (Asia), Japanese, Korean, Other Asian, Other Pacific Islander, Samoan, and Vietnamese.

<sup>b</sup> Refers to the OR of having a report to CPS if a CAS was completed (compared with not having a CAS completed).
### Table 11. Odds Ratios Associated With Completing a CAS, a Positive CAS, and Report to CPS, According to Characteristics of the Facility

<table>
<thead>
<tr>
<th>Location</th>
<th>CAS</th>
<th>Positive CAS</th>
<th>Report to CPS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR 95% CI</td>
<td>OR 95% CI</td>
<td>OR 95% CI</td>
</tr>
<tr>
<td>Rural</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td>Urban</td>
<td>1.19 (0.81-1.76)</td>
<td>1.60 (1.08-2.39)</td>
<td>1.57 (1.00-2.46)</td>
</tr>
<tr>
<td>Teaching status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td>Yes</td>
<td>0.84 (0.52-1.36)</td>
<td>1.87 (1.01-3.46)</td>
<td>2.09 (1.22-3.58)</td>
</tr>
<tr>
<td>Bed numbers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;200</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td>200+</td>
<td>0.87 (0.62-1.23)</td>
<td>0.98 (0.60-1.60)</td>
<td>1.17 (0.67-2.05)</td>
</tr>
</tbody>
</table>

All models are adjusted for age, sex, race, income, and duration of intervention at the time of ED attendance.
DISCUSSION

As with all other portions of this report, we will be separating the Discussion section by specific aim.

Specific Aim 1: Pediatric ED (CHP)

The results of our study demonstrate that it is possible to develop a trigger system that is both sensitive and specific for identifying young children who may need to be evaluated for physical abuse. This is the first time, to our knowledge, that an EMR-based CA-CDSS has been developed. The lack of a difference in compliance with AAP guidelines before and after the CA-CDSS went live was primarily because of the high baseline compliance. The original sample size calculation performed before the start of the study assumed a baseline compliance rate of 70% based on the data from Wood and colleagues.\textsuperscript{23} We calculated the baseline compliance rate based on our own preintervention data during the RCT. With a baseline compliance rate of 70%, we needed a sample size of 112 (56 control, 56 case) to detect an increase in screening compliance to 90% with 80% power and a 1-sided type 1 error rate of 0.05. We expected the enrollment of 112 subjects who met one of the clinical scenarios to take 6 months. With the actual baseline compliance rate of 84%, we would have needed 830 subjects (415 control, 415 case) to obtain the same power and type 1 error rate to detect an increase in compliance to 90%. Given the rate of enrollment, the expected study period would have been approximately 4 years. Extending the study period was not an option both because of funding restrictions and because the likelihood of detecting group differences would likely have decreased over time as physicians became aware of the powerplan.

A second issue that affected our ability to demonstrate a significant difference between intervention and controls resulted from the need for patient-level randomization, which led to contamination, as described previously. The quality of the reference standard (eg, the evaluation by the hospital-based CPT) and the possibility that we overestimated the specificity of the trigger system are also potential limitations. If an abused child was not known to the CPT, did not trigger the trigger system, and did not raise clinical concern for abuse, the patient could be inappropriately considered a true negative when, in fact, that patient was a false negative. We have no way to be sure that there are no false negatives within the true-negative group, but we assessed the significance of this limitation by reviewing the ED
records for all patients for whom there was concern for abuse in the year after the end of silent mode
and assessing whether they were seen in the ED during silent mode and inappropriately labeled as a
true negative. We found no missed cases, which suggests that it is unlikely that there are many abused
children within the true-negative cohort.

Our data demonstrate rapid physician acceptance of the physical abuse powerplan. The fact that
physicians caring for subjects randomized to the RCT-control group searched for the powerplan in the
order catalog strongly suggests that they felt that it was useful. The decrease in the proportion of
patients who had only a partially compliant evaluation suggests that the proportion of the children
who would undergo all recommended testing could be increased to more than 90% if all providers
used the powerplan.

Although we were unable to show a difference in compliance among groups, the CA-CDSS has been
part of clinical practice at our institution since the end of the RCT. ED providers overwhelmingly liked
receiving the CA-CDSS; when given the choice of maintaining only the powerplans or both the
powerplans and the alerts, they wanted to maintain both. There are potentially negative effects of
having a CA-CDSS, which might not improve compliance; for example, if the alerts contribute to alert
fatigue and, thereby, potentially affect the utility of other clinical decision support systems or, more
importantly, if the presence of the CA-CDSS resulted in unnecessary testing and/or evaluations by the
CPT. Our data do not demonstrate an increase in either testing or referrals to the CPT, suggesting that
this concern is not an issue with the current CA-CDSS. Given the rates of morbidity and mortality from
child abuse, providers in our hospital were not concerned about alert fatigue.

The association of patient insurance with compliance was not unexpected and is consistent with prior
literature.\textsuperscript{2,23} Similarly, the association between increased compliance and pediatric emergency
medicine fellowship training is consistent with our hypothesis that pediatric-trained physicians are
more likely to follow AAP guidelines for the clinical scenarios. It also suggests that a CA-CDSS could be
particularly useful in EDs in which the providers are not pediatric trained and, therefore, baseline
compliance is likely to be lower.\textsuperscript{22} The data also suggest that targeted education to the few physicians
with more than one incident of noncompliance could have a significant effect on overall compliance.
Finally, our data suggest that the CA-CDSS should be evaluated in hospitals with lower baseline
compliance with AAP guidelines, to better assess its efficacy in potentially decreasing morbidity and mortality from child physical abuse.

Limitations for the CHP site: As discussed above, the high baseline compliance rate combined with contamination secondary to the need to randomize at the level of the patient rather than the provider limited the ability to detect group differences. These limitations prevented a true evaluation of the efficacy of the CA-CDSS.

Specific Aim 2: 2 General EDs (UPMC Hamot and Mercy)
Overall, our results at the UPMC Hamot and Mercy sites were disappointing. We had low compliance before and after implementation of the CA-CDSS and almost no use of the physical abuse–specific order set despite developing multidisciplinary child abuse teams at both EDs and providing extensive and repeated education to nurses and providers. Location was likely a factor: UPMC Hamot, which is the much larger of the 2 sites, is more than 2 hours from CHP, so the study team could not be onsite as frequently as the team at CHP. The relationships that exist between the PI and CHP providers and nurses have grown over almost 20 years, whereas the relationships with UPMC Hamot and Mercy were developed in large part because of this award. Another issue was the extremely large number of providers at both UPMC Hamot and Mercy. Because of the way in which provider staffing is done, many of the providers do not work for UPMC but for a parent company, and the providers can be sent to work shifts in any of the UPMC hospitals. As a result, a given provider engages with the CA-CDSS infrequently, given the low pediatric volume at each individual site. Thus, giving individual providers feedback about specific cases did not bring about broader use of the CA-CDSS because those specific providers might not evaluate another case of suspected abuse for several years. The time it will take to see a change in compliance at UPMC Hamot and Mercy might be much longer than the time that was funded by this award. We are continuing to track powerplan usage and compliance and plan to reassess both in 12 months.

Another limitation is the problem of alert fatigue. The EMR at CHP has very few embedded alerts, but multiple alerts are already embedded at the general hospital EDs. The potential influence of alert fatigue on provider responsiveness to the pop-ups is supported by the end-user feedback at the general EDs.
Specific Aim 3: 13 General EDs (Evaluation of the CAS)
To our knowledge, this is the first study to report on the use of an EMR-based CAS in a network of general hospital EDs. The implications of this research are relevant for hospitals aiming to improve their rates of reporting of suspected child maltreatment. Considering the high number of children who are affected by maltreatment, and the social and physical consequences of such abuse,\(^{43}\) the impact of an intervention that facilitates the identification of such children is meaningful. This study had 3 key findings. First, an EMR-based child maltreatment screening tool can be successfully implemented across multiple locations. Notably, the average screening rate over the 25 weeks of the intervention was 68%, with an increase over the course of the study (Figure 5). This rate surpasses that of other studies using paper-based tools.\(^{40,41}\) Avoiding manual entry of the screen data into the EMR platform may also have positive effects on data accuracy and timeliness of communication with other providers.

Second, our intervention yielded no significant differences in the odds of screenings or reports according to race or income, despite published evidence for racial and socioeconomic bias in these practices.\(^{26,44}\) Interestingly, in our sample, children of black or other race were less likely to have a positive screen than white children, as were low-income children compared with those having household incomes > $25 000. One interpretation is that the screen itself may be less valid in this population (with a lower positive predictive value), such that the patient and provider are more likely to negatively assess these children and caregivers in relation to the questions in the CAS. Alternatively, unmeasured factors, such as reason for visit, severity of condition, past medical history, and history of repeated visits, may contribute to these differences.

Third, we report no significant differences in the odds of screening according to hospital location, teaching status, and size. This is heartening, as it shows that the rural, small, and nonacademic hospitals in this geographical region are as responsive as their counterparts in urban and teaching hospitals when taking on new and innovative approaches to improve patient care. We also found that urban and teaching hospitals were more likely to have positive screens and to file a report with CPS. This finding is consistent with the literature.\(^{22}\) It may reflect that child maltreatment is more common in the communities that visit these hospitals; any variation may be because of factors not included or fully controlled for in the model. It is also possible that families with abused children preferentially
choose these EDs, or that human factors associated with the training of staff or the validity of the
screen make these EDs more likely to identify and report these children. Importantly, we note the
improvements in screening and reporting rates over the course of the trial. This demonstrates that
human and process factors, such as familiarity with the screening tool and general awareness of child
maltreatment, may be influencing these outcomes, such that further increases in these rates may
occur over time.

The primary nurse completes the CAS; our results demonstrate that nurses in hospitals with all
characteristics were responsive in their willingness to complete the CAS. There were also increased
reports to CPS at these hospitals for children who were screened—some of this increase may be
because of the alert that is automatically generated to the physician, but many of these reports could
be made by the nurse who completed the screen. All health care providers, including nurses and
physicians, are mandated reporters in Pennsylvania. This differs from the issue of compliance with AAP
guidelines, which was evaluated in specific aim 2; compliance with AAP guidelines is entirely
dependent on the physician/APP. The end-user feedback described in Appendix C also supports that
nurses were more likely than physicians to believe that the CA-CDSS influenced their clinical decision
making. These data further support the need to increase physician/APP buy-in to improve compliance
with AAP guidelines.

The most important limitation of specific aim 3 is the study design itself. As discussed previously, an
observational study was the only option given limitations within the hospital system and the EMR and
well as ethical concerns about randomization. Differences between the children who received the CAS
(68% of the sample) compared with those who were not screened (32% of the sample) could affect the
likelihood of reporting to CPS. While we found no significant differences in the screening rate according
to the child’s race, socioeconomic position, or sex, we were not able to consider the impact of the
reason for ED visit or clinical acuity as variables in the multivariable model estimating the odds of
screening. These factors may, in part, explain why some children were not screened. However, it is
difficult to ascertain the impact of such a selection bias, or its direction.

Another limitation is that our screening tool was a modified version of ESCAPE, a validated Dutch
questionnaire. Best practice would have been to reassess its validity, reflecting our alterations to the
phrasing, structure, and mode of delivery. However, given the minimal nature of our modifications, it is unlikely that the validation metrics have altered significantly from those cited in previous trials.

Second, to reduce the potential for bias from children having multiple presentations (such that the characteristics of children who are frequent attenders to an ED would be overrepresented in the model), we created a data set at the individual level as opposed to the event level. In total, 2966 children (17.3% of sample) were evaluated in the ED multiple times over the trial period, including 35 children who had a positive screen on their initial visit. Repeat attendance is not in itself associated with the risk of abuse or neglect,\textsuperscript{45,46} and is likely confounded by socioeconomic factors and/or the presence of chronic disease. However, this is an important group to consider, as evidence shows that more than 25% of abused children have a subsequent episode of maltreatment within 24 months.\textsuperscript{47,48}

We reviewed the emergency record for all the children in our study who had multiple ED visits and a positive CAS, and did not find any prior opportunities for UPMC staff to identify maltreatment.

**Specific Aims 1 through 3**

**Implementation of study results/scalability/generalizability**

The CA-CDSS has been transitioned from research to clinical practice at CHP and UPMC Hamot and Mercy. The universal 5-item CAS is part of clinical practice at all 13 EDs (including UPMC Hamot and Mercy). As of February 2017, all 13 Eds, not just UPMC Hamot and Mercy, had access to the physical abuse–specific order sets (powerplans). Additional evaluation is needed to determine whether to expand the non-CAS triggers (eg, the free text scanning triggers) to all 13 UPMC EDs.

While we recognize that neither the CHP study nor the UPMC Hamot/Mercy study showed effectiveness in changing compliance with AAP guidelines, and that each design had limitations, we believe it is important to recognize that the CA-CDSS had positive effects that are more difficult to measure. Perhaps most importantly, this award allowed us to start to develop a culture of awareness and recognition of child abuse, particularly at the general EDs, which is a prerequisite to changing practice. Prior to the start of this award, providers in the general EDs rarely thought about child abuse as a potential cause or contributor to a child’s injury or presentation. Since the start of this award, the number of calls to the CPT from physicians at the UPMC general EDs asking for advice about possible child abuse cases has increased from virtually none to several a week. In some cases, providers are checking to be sure they have done everything they need to do; in other cases, they are asking for
advice about whether they should report to CPS; and sometimes, they are interested in whether a child would benefit from an evaluation by the CPT at CHP. In addition, the research team regularly receives emails from nurses throughout the UPMC system asking how we would recommend they address certain issues and/or asking whether they should file a report with CPS. This type of awareness could not be captured in our data. Culture change takes years to occur, and our hope is that what was started with this award is just the beginning.

As discussed previously, a significant barrier appears to be convincing physicians and advanced practice providers, particularly those without specific pediatric training, to follow the recommendations made by the CA-CDSS. We are currently addressing this issue in multiple ways, including increased and easy access to child abuse–related education for physicians, development of “cheat sheets” for writing statements of concern for CPS reports, and continuous feedback to clinicians on the evaluation of patients with potentially abusive injuries as well as when they should and should not file reports with CPS.

It is important to consider whether we did not see an effect of the rate of compliance at UPMC Hamot and Mercy partly because more time is needed to observe change given the large number of different providers seeing a relatively small number of patients, a limitation that we discussed above. As we describe in detail below, we have been able obtain institutional funding to continue to educate and engage all 13 general UPMC EDs over the next 2 years. We will continue to evaluate whether changes in compliance occur over this longer period. We are also assessing whether changes in culture regarding child abuse can be objectively measured.

Our inability to see a difference in compliance at CHP was related to the opposite issue—too high of a baseline rate of compliance. Even though we did not see a difference in this outcome, the CA-CDSS was transitioned to clinical practice as described above. As with the UPMC Hamot and Mercy sites, we achieved some positive, less measurable outcomes. For example, while the general EDs are engaging the CPT more, we have concurrently seen that the number of overnight calls to the on-call CPT physician has markedly decreased; many of the calls prior to the CA-CDSS were to ask the physician which tests needed to be done. With the child abuse–specific powerplans in place, this type of call rarely, if ever, occurs. Another unforeseen outcome has been that because the evaluation for abuse is
completed properly in the ED, infants and young children can sometimes be discharged from the ED to a safe location rather than requiring hospital admission so that the CPT physician can ensure that the proper evaluation has been conducted. In addition, because all the bloodwork that is needed for an evaluation is performed in the ED, the children do not need to undergo another blood draw. Future studies should assess whether these other outcomes can be measured.

We believe that the CAS portion of the award has promising findings, and this is what led to the transition of this CAS to clinical care. Continued engagement of the sites and continued measurement of outcomes as described below will be important moving forward.

Although we did not show the efficacy of our CA-CDSS, the overall project has been a success in our hospital system. Also, multiple other hospital systems have contacted us about integrating some or all of our CA-CDSS, which shows that EDs recognize that missed child abuse is a significant issue and are looking for ways to address it.

Next Steps/Future Research
To make our findings more generalizable, several steps need to occur. Sustained clinical use and continued evaluation of the CA-CDSS at CHP and throughout UPMC is important to identify barriers that may occur when the system becomes a standard part of clinical practice rather than a research study. Dissemination and implementation of the CA-CDSS in EMRs other than Cerner and/or expansion to other hospitals with Cerner are also important. We have recently received a grant from a local foundation (The Beckwith Foundation) to expand the CA-CDSS at CHP to other children’s hospitals with Cerner. There are currently 12 such hospitals; our goal is to implement it into half of these hospitals within 18 months. Enhancement of the triggers themselves could also be considered. For example, the current trigger clinical decision support system incorporates data from only the current ED visit, but the ability to pull in data from prior encounters, including prior injury-related visits, could enhance the sensitivity of the CA-CDSS. Enhanced use of free text scanning and/or incorporation of data from other systems such as the child welfare system could also be explored. Finally, expansion beyond the ED to in-patient or out-patient settings (eg, urgent care or primary care clinics) is another potential avenue for future research. Given our experience, we would plan to calculate a baseline compliance rate prior
to proceeding with any evaluation of the effect of the CA-CDSS at other institutions. We would also seek to measure some of the less quantifiable outcomes discussed earlier.

Our hospital recognizes the importance of CA-CDSS and we have been able to start a 2-year, systemwide UPMC Child Abuse Initiative, which is being funded by the Department of Pediatrics at CHP. Changing practice is difficult and slow; data are being collected about whether these interventions improve compliance rates and, if so, how long it takes for these changes to occur. Our data will also allow us to better understand the difficulties related to acceptance in the adult EDs and to design solutions to identified barriers. Our experience at UPMC can be used to anticipate and quickly respond to similar issues during any subsequent dissemination of the CA-CDSS.

We believe there is strong potential for large-scale dissemination owing to multiple incentives. Perhaps most importantly, Centers for Medicare & Medicaid Services now mandates that hospitals screen all children for child maltreatment, a mandate that substantially increases the likelihood of rapid, widespread dissemination of our CA-CDSS. The rapid spread of EMRs such that 96% of hospitals now use them strongly supports the widespread dissemination of EMR-based CDS. From an insurance perspective, early identification of child abuse saves money. A study by Fang and colleagues estimated the lifetime cost of child abuse to be $210,012 per victim of nonfatal abuse and $1,272,900 per victim of fatal child abuse.14

Scalability is a limitation given the different EMRs in different hospital systems as well as the differences among Cerner builds within the same hospital system. However, this is a limitation of the approach of using the EMR rather than a limitation of the CA-CDSS. One of the advantages of the EMR is that every hospital can tailor it to its own needs. However, this tailoring also means that once a CA-CDSS is established in an EMR in one hospital, it cannot easily be moved to another. For example, the list of chief complaints that is used as a trigger for the CHP CA-CDSS is developed by CHP. Another hospital may have a different list of chief complaints that may not include the ones that were used as triggers. We have recently been awarded a grant from the Beckwith Foundation to develop a toolkit for the CA-CDSS that was developed at CHP so that other children’s hospitals that use Cerner can more easily integrate this CA-CDSS into their EMR.
CONCLUSIONS

The primary result of specific aim 1 is that the CA-CDSS, including a trigger system, provider alerts, and an ED physical abuse–specific order set, could be integrated into the Cerner EMR at a children’s hospital with a trauma center. The CA-CDSS accurately detected physical abuse in children less than 2 years old. As discussed previously, we recognize that the calculated sensitivity of the trigger system is likely overestimated because the CPT systematically evaluated a subset of children who did not trigger the alert system. We did not show any differences in compliance owing to a combination of an unexpectedly high baseline compliance rate and a study design that resulted in contamination between groups. Contrary to published literature, we did not see racial disparities in the rate of compliance with AAP guidelines. Provider characteristics such as pediatric ED fellowship training made it more likely that physicians would be compliant.

Specific aim 2 demonstrated that a CA-CDSS can be embedded in general EDs, but that physicians did not consistently respond to the request of the alert to use the child abuse–specific order set. However, when the recommendation to use a child abuse–specific order set was accepted, very high (86%) compliance with AAP guidelines was achieved, demonstrating that once the physicians were shown a list of all the required tests, they completed them and did not choose to complete only a subset for the required evaluation.

Specific aim 3 demonstrated that the use of a universal 5-item CAS was associated with an increase in detection of child maltreatment in rural and urban, teaching and nonteaching hospitals. We also demonstrated clinical acceptability of the screen by nurses—close to 70% of screens were completed, with an increase during the second 13 weeks of the 25-week study.
REFERENCES


51. Louwers E CFM. *Systematic Screening for Child Abuse at Emergency Departments* [thesis]. Rotterdam, the Netherlands: Erasmus MC University Medical Centre; 2013.


Appendix A: Stakeholders

Rachel Berger, MD MPH, Professor of Pediatrics and Clinical and Translational Science, University of Pittsburgh; Child Advocacy Center Division Chief, Children’s Hospital of Pittsburgh of UPMC

Patrick Donohue, JD MBA, Caregiver of a child who was a victim of physical abuse and founder of an advocacy organization (The Sarah Jane Brain Foundation). The story of Patrick and his daughter can be found at https://thebrainproject.org/.

Janet Fogle, MSW Supervisor, Clinical Social Work, Children’s Hospital of Pittsburgh of UPMC (retired during the award period)

Sean Frederick, MD, Assistant Chief Medical Information Officer and Neonatologist, Children’s Hospital of Pittsburgh of UPMC

Richard Kidwell, JD, Vice President of Risk Management, UPMC

Deborah Lesniak, RN Clinical Director, Emergency and Acute Care Services, Children’s Hospital of Pittsburgh of UPMC (retired during the award period)

Lisa Meyer RN, Cerner Medical Informatics Nurse, Children’s Hospital of Pittsburgh of UPMC

Thomas McGinn, MD MPH, Chair, Department of Medicine; Center Head for Health Outcomes Research, Feinstein Institute for Medical Research, Northwell Health

Teresa Olsen, Director of the Suspected Child Abuse and Neglect Program, American Academy of Pediatrics, Pennsylvania State Chapter

Cathleen Palm, BS, Survivor of abuse and founder of an advocacy organization (Center for Children’s Justice)

Michele Poole, Caregiver and grandmother of a child who is a victim of abusive head trauma The story of Michele and her granddaughter can be found at http://nsbaz.org/a-grandmothers-story/

Cassandra Rennick RN, Clinical Education Specialist, Children’s Hospital of Pittsburgh of UPMC

Bruce Rosenthal, MD, Emergency Department Physician, UPMC Mercy

Richard Saladino, MD, Director of the Division of Emergency Medicine, Children’s Hospital of Pittsburgh of UPMC

Kathleen Schenkel RN, Programmatic Nurse Specialist, Children’s Hospital of Pittsburgh of UPMC (replaced Ms. Lesniak)
Janet Skrbin, DO, Emergency Department Physician and Medical Director of the Forensic Nursing Program, UPMC Hamot

Srinivasan Suresh, MD, MBA, FAAP, Chief Medical Information Officer and Emergency Medicine Physician, Children's Hospital of Pittsburgh of UPMC

Jamie Zaremski, MSW, Clinical Social Work, Children’s Hospital of Pittsburgh of UPMC (replaced Ms. Fogle)
## Appendix B: Triggers

The list of triggers at CHP

<table>
<thead>
<tr>
<th>Discrete field which results in a trigger/position of professional who enters data in this field</th>
<th>Name and value of discrete field which results in a trigger when combined with patient age</th>
<th>Patient Age (in years) which results in a trigger when present with discrete field</th>
<th>Criteria which prevents activation of the child abuse trigger system</th>
<th>Number of instances in which this was the first trigger (% of all first triggers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-arrival documentation /nurse</td>
<td>Is there concern for abuse or neglect—‘yes’ response OR Has a ChildLine* been filed—‘yes’ response</td>
<td>&lt;2</td>
<td>NA</td>
<td>38 (16.8)</td>
</tr>
<tr>
<td>Chief complaint/nurse</td>
<td>Assault OR SCAN</td>
<td>&lt; 2</td>
<td>NA</td>
<td>36 (15.9)</td>
</tr>
<tr>
<td>Chief Complaint/nurse</td>
<td>Bruising OR Burn OR Petechiae OR Fracture</td>
<td>&lt; 1</td>
<td>NA</td>
<td>19 (8.4)</td>
</tr>
<tr>
<td>Mechanism of injury (completed when patient assessed to be a trauma patient)/nurse</td>
<td>Assault OR SCAN OR Burn</td>
<td>&lt;2 for Assault or SCAN; &lt;1 for Burn</td>
<td>If ‘Mechanism of Injury’ response to ‘MVC’ = Yes</td>
<td>2 (0.9)</td>
</tr>
<tr>
<td>Documentation of ‘skin characteristic’ OR ‘head and neck assessment’/nurse</td>
<td>Burn OR bruise OR petechiae on ‘skin characteristic’; subconjunctival hemorrhage on ‘head and neck assessment’</td>
<td>&lt;1</td>
<td>If ‘bruise’ and patient age 6-11.99 months and response to ‘Is child able to cruise or walk’=Yes &amp;</td>
<td>15 (6.7)</td>
</tr>
<tr>
<td>Documentation of ‘head and neck assessment’/nurse</td>
<td>Left ear condition – bruising OR Right ear condition – bruising</td>
<td>&lt;2</td>
<td>NA</td>
<td>1 (0.4)</td>
</tr>
<tr>
<td>Social work screen/nurse</td>
<td>Reason for consult = SCAN</td>
<td>&lt;2</td>
<td>If ‘Mechanism of Injury’ response to ‘MVC’ = Yes</td>
<td>7 (3.1)</td>
</tr>
<tr>
<td>Orders placed/physician or APP</td>
<td>Orthopedic consult for fracture AND/OR Neurosurgery consult for skull fracture AND/OR Neurosurgery consult for intracranial hemorrhage</td>
<td>&lt;1</td>
<td>If ‘Mechanism of Injury’ response to ‘MVC’ = Yes</td>
<td>6 (2.7)</td>
</tr>
<tr>
<td>Orders placed</td>
<td>X-ray^ AND medication order for fentanyl, midazolam, ketorolac, naloxone, or flumazenil</td>
<td>&lt;1</td>
<td>NA</td>
<td>0*</td>
</tr>
<tr>
<td>Order placed/physician or APP</td>
<td>Skeletal survey</td>
<td>&lt;2</td>
<td>NA</td>
<td>72 (31.9)</td>
</tr>
<tr>
<td>Order placed/physician or APP</td>
<td>Consult social work reason ‘SCAN’</td>
<td>&lt;2</td>
<td>NA</td>
<td>9 (3.9)</td>
</tr>
<tr>
<td>Social work documentation/social worker</td>
<td>Type of referral ‘SCAN’ OR action ‘ChildLine-physical abuse’</td>
<td>&lt;2</td>
<td>If ‘Mechanism of Injury’ response to ‘MVC’ = Yes</td>
<td>6 (2.7)</td>
</tr>
<tr>
<td>Discharge instruction/physician or APP</td>
<td>Burn – first degree, burn – second degree OR Fracture-Clavicle, Fracture- Humerus Fracture (cast care), hand fracture</td>
<td>&lt;1</td>
<td>If ‘Mechanism of Injury’ response to ‘MVC’ = Yes</td>
<td>9 (3.9)</td>
</tr>
<tr>
<td>Discharge instruction/physician or APP</td>
<td>Contusion OR shoulder dislocation</td>
<td>&lt;1</td>
<td>If response to ‘Is child able to cruise or walk’ = Yes &amp;</td>
<td>6 (2.7)</td>
</tr>
</tbody>
</table>

Abbreviations: APP; advanced practice provider, SCAN; suspected child abuse and neglect, MVC, Motor vehicle crash

Notes:
^X-rays included in the trigger: Clavicle left; Clavicle right; Foot 3 views minimum left; Foot 3 views minimum right; Fingers 2 views minimum left; Fingers 2 views minimum right; Knee 3 views left; Knee 3 views right; Shoulder minimum 2 view left; Shoulder minimum 2 view right; Femur 2 views left; Femur 2 views right; Humerus 2 views minimum left; Humerus 2 views minimum right; Skull 4 views minimum; Ankle 2 view left; Ankle 2 view right; Ankle 3 view minimum left; Ankle 3 view minimum right; Elbow 2 views left; Elbow 2 views right; Elbow 3 views minimum left; Elbow 3 views minimum right; Tibia & fibula 2 view left; Tibia & fibula 2 view right; Wrist 2 view left; Wrist 2 view right; Wrist 3 views minimum left; Wrist 3 views minimum right; Foot 2 views left; Foot 2 views right; Hand 2 views minimum left; Hand 2 views minimum right; Knee 1 or 2 views left; Knee 1 or 2 views right; Knee Lt Comp 4 or more views; Knee Rt Comp 4 or more views; Knees bilateral AP standing
*ChildLine is the report to Child Protective Services in Pennsylvania
## The list of triggers at UPMC Hamot and Mercy

<table>
<thead>
<tr>
<th>Form name/ who completes the form</th>
<th>Name and value of field which results in a trigger when combined with patient age</th>
<th>Age requirement for triggering</th>
<th>Criteria which prevents activation of the child abuse trigger system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child abuse screening form/ RN</td>
<td>&quot;Are any of the following findings present on physical examination?&quot; with &quot;yes&quot; response (Q3)</td>
<td>&lt;2 yr</td>
<td>NA</td>
</tr>
<tr>
<td>Child abuse screening form/ RN</td>
<td>&quot;Are you concerned that the history may not be consistent with the extent of the injury or illness&quot; with a &quot;yes&quot; response (Q2)</td>
<td>&lt;2 yr</td>
<td>NA</td>
</tr>
<tr>
<td>ED Assessment Form v2: Focused assessment of complaint; Chief complaint/ RN</td>
<td>Any of the following words in a CC or focused assessment for a child &lt; 12 months of age: &quot;assault&quot;, &quot;abuse&quot;, &quot;bruise&quot;, &quot;burn&quot;, &quot;not moving&quot;, &quot;fracture&quot;, &quot;fx&quot;, &quot;broke&quot;, &quot;injury&quot;, &quot;sprain&quot;, &quot;deformity&quot;, &quot;subconjunctival hemorrhage&quot;, &quot;petechiae&quot;, &quot;arrest&quot;, &quot;hematomi&quot;, &quot;echy&quot;, &quot;echy&quot;, OR &quot;contus&quot;</td>
<td>&lt;1 yr (&lt;6m for &quot;injury&quot;)</td>
<td>Do not trigger if trigger word is preceded by &quot;DENIE&quot;, &quot;NO&quot; or &quot;NOT&quot;, if Burn is preceded by &quot;DR&quot;, if &quot;CORD&quot; precedes &quot;FALL&quot; or &quot;FELL&quot;, if &quot;BROKE&quot; is followed by &quot;OUT&quot;, &quot;ENGLISH&quot; or &quot;-ENGLISH&quot;, or if &quot;FEVER&quot; precedes &quot;BROKE&quot;</td>
</tr>
<tr>
<td>ED Assessment Form v2: Chief complaint ; focused assessment/ RN</td>
<td>Any of the following words in a child &lt; 6 months of age: &quot;fall&quot;, &quot;fell&quot;</td>
<td>&lt;6 mo</td>
<td>Do not trigger if Fall or Fell is followed by &quot;ASLEEP&quot;, do not trigger on &quot;FALLOT&quot;</td>
</tr>
<tr>
<td>Orders/ MD</td>
<td>Order for bone survey infant x-ray, bone survey limited x-ray or bone survey x-ray</td>
<td>&lt;2 year</td>
<td>NA</td>
</tr>
<tr>
<td>Orders/ MD</td>
<td>Order for x-ray of clavicle, foot, finger, hand, knee, femur, tibia, fibula, wrist, ankle, skull, elbow, humerus, shoulder, skeletal, or extremity</td>
<td>&lt;1 year</td>
<td>NA</td>
</tr>
<tr>
<td>Discharge/ MD</td>
<td>DC instruction title of abuse, fracture, injury, injuries, burn, cast, contusion, clavicle, dislocation, subluxation, hematoma, hyphema, nursemaid, hemorrhage, or bruise</td>
<td>&lt;1 year</td>
<td>Do not trigger is if 'inj' is preceded by 'head'</td>
</tr>
<tr>
<td>Discharge/ MD</td>
<td>DC diagnosis of 'contus'</td>
<td>&lt;1 year</td>
<td>NA</td>
</tr>
<tr>
<td>Discharge/ MD</td>
<td>DC instruction of child abuse, abuse and neglect, jaw fracture, nose fracture, sternum fracture, or rib fracture</td>
<td>&lt;2 year</td>
<td>NA</td>
</tr>
<tr>
<td>Discharge/ MD</td>
<td>Follow up in depart with clinic or office that has ortho, plastic, burn trauma (to pick up Burn Trauma Center-UPMC Mercy; Children's Hospital Orthopedic Clinic; CHP Orthopedics; CHP Plastics Department; Hamot Orthopedic Clinic; Hamot Orthopedic Hand; Hamot Orthopedics)</td>
<td>&lt; 1yr</td>
<td>NA</td>
</tr>
</tbody>
</table>
Appendix C: End-user feedback

1) CHP: We administered 3 groups of end-user surveys at CHP for the CA-CDSS. Group 1 was providers who received a pop-up alert for the CA-CDSS during the RCT at CHP. Group 2 was providers who did not receive a pop-up alert for the CA-CDSS but did order a powerplan during the RCT at CHP. Group 3 was all CHP ED providers (anonymous) during the RCT timeframe at CHP. We had very little feedback from groups 1 & 2. Data below is from group 3 (all CHP ED providers).

Current level of clinical training

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Attending</td>
<td>16</td>
<td>29%</td>
</tr>
<tr>
<td>2</td>
<td>Fellow</td>
<td>3</td>
<td>5%</td>
</tr>
<tr>
<td>3</td>
<td>CRNP/PA</td>
<td>4</td>
<td>7%</td>
</tr>
<tr>
<td>4</td>
<td>PGY1</td>
<td>3</td>
<td>5%</td>
</tr>
<tr>
<td>5</td>
<td>PGY2</td>
<td>14</td>
<td>25%</td>
</tr>
<tr>
<td>6</td>
<td>PGY3</td>
<td>12</td>
<td>21%</td>
</tr>
<tr>
<td>7</td>
<td>MA</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>8</td>
<td>Other</td>
<td>4</td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>56</td>
<td>100%</td>
</tr>
</tbody>
</table>

Other = PGY4 (n=3), chief resident = 1

Have you ever received a pop up [for the CA-CDSS]?

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>33</td>
<td>60%</td>
</tr>
<tr>
<td>2</td>
<td>No</td>
<td>21</td>
<td>38%</td>
</tr>
<tr>
<td>3</td>
<td>Don't remember</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>55</td>
<td>100%</td>
</tr>
</tbody>
</table>

Did getting the [CA-CDSS] pop-up alert alter your clinical decision-making process?

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>9</td>
<td>28%</td>
</tr>
<tr>
<td>2</td>
<td>No</td>
<td>19</td>
<td>59%</td>
</tr>
<tr>
<td>3</td>
<td>Don't remember</td>
<td>4</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>32</td>
<td>100%</td>
</tr>
</tbody>
</table>

Are you aware that you can access the ED Physical Abuse powerplan in the order catalog?

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>32</td>
<td>59%</td>
</tr>
<tr>
<td>2</td>
<td>No</td>
<td>22</td>
<td>41%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>54</td>
<td>100%</td>
</tr>
</tbody>
</table>
Have you ever used or accessed the ED Physical Abuse powerplan?

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>7</td>
<td>18%</td>
</tr>
<tr>
<td>2</td>
<td>No</td>
<td>30</td>
<td>77%</td>
</tr>
<tr>
<td>3</td>
<td>Don't remember</td>
<td>2</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>39</td>
<td>100%</td>
</tr>
</tbody>
</table>

Did you ever "uncheck" any of the pre-checked labs or tests on the ED Physical Abuse powerplan?

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>11</td>
<td>50%</td>
</tr>
<tr>
<td>2</td>
<td>No</td>
<td>8</td>
<td>36%</td>
</tr>
<tr>
<td>3</td>
<td>Don't remember</td>
<td>3</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>22</td>
<td>100%</td>
</tr>
</tbody>
</table>

Did you experience any difficulties or confusion using any part of the system (lightbulb icon on the tracking board, [CA-CDSS] pop-up alerts, ED Physical Abuse powerplan)? If so, please describe.

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>12</td>
<td>22%</td>
</tr>
<tr>
<td>2</td>
<td>No</td>
<td>42</td>
<td>78%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>54</td>
<td>100%</td>
</tr>
</tbody>
</table>

Comments

Once the system locked up so that we couldn't put any orders in at all and the CA-CDS needed to be deactivated.

Nurses, residents, APP's, and other medical team - many are unaware of meaning

I was not fully aware of it. But currently am on my CAC [Child Advocacy Center] rotation and have greater awareness for this feature

I tried to find it to activate it after the fact (on a patient that didn't trigger it) and couldn't find it.

If I ordered child abuse imaging or labs outside of the order set, the [CA-CDS] alert kept popping up and there was no option for "I've already seen the orderset or ordered the appropriate test."

I wasn't aware of the [CA-CDS] system

lack of awareness for users

Going through the different subphases [of the ED child physical abuse powerplan]

Seem like a lot of options

Didn't know what it was.

Was not sure what to do next/how to address the [lightbulb icon for the CA-CDS] icon
Do you think that any of the following parts of the [CA-CDS] system require further training or education?

<table>
<thead>
<tr>
<th>#</th>
<th>Question</th>
<th>Training needed</th>
<th>Training adequate</th>
<th>Total Responses</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lightbulb icon on the tracking board</td>
<td>24</td>
<td>25</td>
<td>49</td>
<td>1.51</td>
</tr>
<tr>
<td>2</td>
<td>[CA-CDS] Pop-up alerts</td>
<td>21</td>
<td>28</td>
<td>49</td>
<td>1.57</td>
</tr>
<tr>
<td>3</td>
<td>ED Physical Abuse powerplan</td>
<td>34</td>
<td>15</td>
<td>49</td>
<td>1.31</td>
</tr>
</tbody>
</table>

Do you have any suggestions for training or ideas for improving the [CA-CDS] system (lightbulb icon on the tracking board, [CA-CDS] pop-up alerts, ED Physical Abuse powerplan)?

<table>
<thead>
<tr>
<th>Text Responses:</th>
</tr>
</thead>
<tbody>
<tr>
<td>I just think we forget about it. It would be great to have an reminder maybe twice per year for residents at house staff lunch. And somehow getting the ED attending [physicians] to remind/encourage us to use it.</td>
</tr>
<tr>
<td>I think that we need a better ED orientation in general. There are several icons that come up on the [ED] tracking board that we are not trained about. It would be helpful to review all of these and our responsibilities regarding them.</td>
</tr>
<tr>
<td>A short video demonstrating how to use the [ED physical abuse] power plan, how to find it etc.</td>
</tr>
<tr>
<td>We have a lot of providers in ED - visiting residents, new nurses, pediatric residents - (inexperienced), PCT's [patient care technicians]. It's difficult for them to keep up with all the new icons, protocols. Definitely starts with Attendings, and charge nurses. We have monthly division meetings but we should send out updates, etc to the ED division as a whole so that cast as wide a net as possible.</td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>This survey alone was useful to help make me more aware. The nurses generally are helpful guides in the ED as to icons as well and I believe they are familiar with role of the lightbulb [icon] and the presence of the [ED physical abuse] power plan.</td>
</tr>
<tr>
<td>1/2 hour refresher session before/after staff meeting?</td>
</tr>
<tr>
<td>It would be great to have the [CA-CDS] pop-up go away if the tests were already ordered, or to have that as an option for justification when you click &quot;no, never&quot;</td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>This is an awesome and useful tool, thanks</td>
</tr>
<tr>
<td>Send an e-mail to residents letting them know this [CA-CDS] system exists? Announce it at residency housestaff lunch, and add into the video training that residents are required to watch prior to starting ED if it hasn't been added.</td>
</tr>
<tr>
<td>I wish I knew exactly what had triggered the [CA-CDS] pop - up.  <em>SCAN</em> PT, vs burn, vs fx in an infant. What else gets a trigger outside of the current complaint that we look for? I worry</td>
</tr>
</tbody>
</table>
that this might just be clicked out of because one thinks it irrelevant like a drug alert if the reason isn't available (like a miss fire or over call)

I never knew this was a new thing!

Maybe a different symbol? The light bulb does not connote physical abuse. Like the suicide risk symbol is a Ying and yang which suggests imbalance. Sepsis is lightning bolt which suggests action needed. Maybe a spider net like a safety net. Or flame to suggest danger. Or umbrella to suggest protecting. Some ideas....

I haven't been in the ED since this started so that's probably why I'm not familiar with it

2) All UPMC sites: A Qualtrics survey was administered to 2 groups of end-users regarding the CAS form experience and knowledge. This survey was emailed to a) every 20th nurse who completed the CAS, and b) physicians/APPs who saw a patient who had a positive CAS.

43/219 (20%) RN [nurse] responses - 50% have answered ‘Yes’ to at least 1 item on the CAS, 46% report completing the CAS >20 times

98% report the CAS taking <5 minutes to complete

50% report that completing this form affected the way they assessed the patient and/or changed their thoughts about the presenting injury/illness

Comments from nurses about the CAS:
- ‘The [CAS] form caused me to re-evaluate patient (pediatric) injuries and how to look for clues that could be specific to child abuse.’
- ‘This [CAS] form helped guide me through an exam’
- ‘It gives you an opportunity to address concerns, allowing staff to further determine if it needs to be reported. It is helpful for the triage RN who has limited time, so that the assigned RN and MD can further assess if needed. It also helps RN to consider possible signs of abuse, that may otherwise be overlooked.’
- ‘It reminded me to look closer for signs of abuse/neglect instead of just focusing only on the chief complaint’

99% answered that the CAS tool helps improve the recognition and treatment of children with suspected child abuse

29/169 (17%) MD/APP responses - 42% Attending, 24% CRNP/PA

71% report that they know that there is an ED Child Abuse Screening [CAS] in the EMR
24% report that the [CA-CDS] pop-up influenced their clinical decision-making process; 67% did not*

Comments from MD/APPs about the CAS:
- ‘it made me aware that the nurse had a concern before I even examined the patient’
‘Yes, I have case manager talk with every patient this [CA-CDS] pop-up appears on.’
‘Already considering child abuse and [CA-CDS] pop up did not raise my suspicions any additional amount.’
‘Was brought in for concerns for abuse/neglect by CYF, this was superfluous box and once again, as most Cerner boxes, useless.’

80% of MD/APPs responded that, overall, the CAS helps improve recognition and treatment of children with suspected child abuse
- ‘In this case I was aware, but I can easily envision scenarios in which this could be inadvertently overlooked. I'd rather be redundant than potentially miss an opportunity for intervention.’
- ‘Honestly, it’s another pop-up in a sea of pop-ups that we get and adds more clicks to my day.’

18% of MD/APPs report that they knew about the CARF and that it was located in the ad hoc folder [in the EMR]

3) UPMC Hamot and Mercy: There were 2 groups of end-users that were administered Qualtrics surveys about the CA-CDSS at the UPMC Hamot and Mercy locations. Survey A was administered to MD/APPs who received a CA-CDSS pop-up; survey B was anonymously administered to all ED providers (MD/APPs) at these 2 sites.

UPMC Hamot and Mercy Qualtrics summary: Survey A- only providers who received pop ups: 8/20 respondents
6 Hamot (75%), 2 Mercy (25%)
Level of providers: 4 Attending (50%)
3 CRNP/PA (38%)
1 resident (13%)
Do you remember EVER receiving the [CA-CDSS] alert? 6/8 (75%) said YES
Did getting the alert EVER alter your clinical decision-making? 3/6 (50%) said yes
Do you recall EVER seeing the [CA-CDSS] lightbulb icon? 2/8 (25%) said YES
Did you know that there is a CAS? 7/8 (88%) said YES
Did you know that you can see the results of the CAS in GenView [in the EMR]? 2/8 (25%) said YES
Did you know that there is a CARF? 2/8 (25%) said YES
Did you know that the physician should write/review statement of concern on CL [report to CPS]? 2/8 (25%) said YES
Do you feel you need more education on how to document concerns for abuse [for the report to CPS]? 3/8 (43%) said YES

UPMC Hamot and Mercy provider comments:
- ‘A quick PowerPoint with images of [CA-CDSS] forms that should be completed and how to complete would be beneficial’
- ‘Yes, aside from reviewing that [CAS] form, do we need to have any other specific documentation aside from our notes?’
- ‘Yes. I was never formally taught about the whole child abuse process, from screening to documentation and when to contact case management/OCY [CPS]’

Have you ever used or accessed the ED Child Physical Abuse powerplan? 0/8 said YES

Responses that the following CA-CDSS components require further training:
  - CAS 2/8 (25%)
  - CARF 5/8 (63%)
  - Lightbulb icon 2/8 (25%)
  - ED Child Physical Abuse powerplan 3/8 (38%)

Feedback/suggestions for training:
  - ‘Have the [ED Child Physical Abuse] power plan available from the ED orders home page’
  - ‘Triage nurse is mostly the person who screens for child abuse- not primary nurse. I feel they jump the gun with suspicion for possible child abuse. They are screening children as positive for child abuse for normal childhood injuries. In the cases where I am not concerned for abuse, but triage nurse screened positive for abuse, I am unsure if I should still contact case management.’
UPMC Hamot and Mercy Qualtrics summary: Survey B- All providers
40/139 respondents (respondents can select all that apply)
25 UPMC Hamot, 13 UPMC Mercy, 8 Other UPMC locations

Level of providers responding to the survey:
- 20 Attending (48%)
- 6 CRNP/PA (14%)
- 5 PGY1 (12%)
- 5 PGY3 (12%)
- 3 PGY4 (7%)
- 3 PGY2 (7%)
- 0 Fellow, Other

Do you remember EVER receiving the [CA-CDSS] alert? 31/39 (80%) said YES (6 said no, 2 don’t remember)

Did getting the [CA-CDS] alert EVER alter your clinical decision-making? 16/31 (52%) said yes
Do you recall EVER seeing the lightbulb icon? 8/39 (21%) said yes
Did you know that there is a CAS? 20/39 (51%) said YES, 19 (49%) said NO
Did you know that you can see the results of the CAS in GenView [in the EMR]? 4/39 (10%) said YES
Did you know that the primary nurse completes the CAS? 25/39 (64%) said YES
Did you know that there is a CARF? 6/39 (15%) said YES
Did you know that the physician should write/review statement of concern on CL [report to CPS]? 12/39 (31%) said YES
Do you feel you need more education on how to document concerns for abuse [for the report to CPS]? 22/39 (69%) said YES.

Comments from providers:
- ‘I think that it would beneficial for the residents to have an overview of this information, at least the interns, because it is very important and it is something that shouldn't be missed or done incorrectly’
- ‘Not sure if I am supposed to be opening childline reports [to CPS] or if case management should be doing it. Still feel uncomfortable with the whole process involving suspected child abuse- I feel like I need a class’
- ‘I’m still not certain where to find these folders [in the EMR]’
- ‘I would like a run through of how to access everything in cerner [EMR]’
- ‘I feel like I don’t know how to document child abuse charts well [in the EMR] - it would be nice to have a lecture on key points of documentation.’
- ‘more education and reminders are always welcome, especially since we do not see many children.’
- ‘I am unfamiliar with almost everything mentioned in this survey.’
- ‘I don’t remember ever getting any formal training on this, and believe it is important to document concerns for abuse.’
- ‘more info on suspicious patterns of injury’
- ‘Review of where to find the results of the child abuse screening form [in the EMR] and where / how to complete the reporting form would be helpful.’
- ‘Did not realize that we had to go into the ad hoc folder [in the EMR] to document. I always document as thoroughly as possible in my notes, but would not have known where to find us.’

Have you ever used or accessed the ED Child Physical Abuse powerplan? 32/38 (84%) said NO
- 3/6 (50%) said that it was clear that they had to select a subphase [in the ED Child Physical Abuse powerplan]

Providers responded that they think the following components of the CA-CDSS require further training:
  - CAS 12/33 (36%)
  - CARF 27/36 (75%)
  - Lightbulb 10/33 (30%)
  - ED Child Physical Abuse powerplan 25/36 (69%)

UPMC Hamot and UPMC Mercy provider feedback/suggestions for training:
- ‘Chart template that includes the [CARF] reporting form.’
- ‘I think a class would be beneficial as we were never formally taught the process [to report to CPS].’
- ‘I tried to use the [ED Child Physical Abuse] powerplan at UPMC Northwest and was unable to locate it. Ensuring this is available would be helpful.’
- ‘Remove it. Does not help. Only additional alarm fatigue.’
- ‘Continue education and awareness about available forms, tools and power plans available.’
Appendix D: ESCAPE form questionnaire

From Louwers E CFM. *Systematic Screening for Child Abuse at Emergency Departments* [thesis]. Rotterdam, the Netherlands: Erasmus MC University Medical Centre; 2013.

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the history consistent?</td>
<td>Yes</td>
<td>No*</td>
</tr>
<tr>
<td>Was there unnecessary delay in seeking medical help?</td>
<td>Yes*</td>
<td>No</td>
</tr>
<tr>
<td>Does the onset of the injury fit with the developmental level of the child?</td>
<td>Yes/NA</td>
<td>No*</td>
</tr>
<tr>
<td>Is the behavior of the child/the carers and the interaction appropriate?</td>
<td>Yes</td>
<td>No*</td>
</tr>
<tr>
<td>Are the findings of the top-to-toe examination in accordance with the history?</td>
<td>Yes</td>
<td>No*</td>
</tr>
<tr>
<td>Are there any other signals that make you doubt the safety of the child or other family members?</td>
<td>Yes*</td>
<td>No</td>
</tr>
</tbody>
</table>

*If ‘Yes’ describe the signals in the box ‘Other comments’ below.

**Other comments**

NA, not applicable.

* If one of these answers is selected, the risks of child abuse could be increased and additional action is recommended.
PILOT Child Abuse Screen

Disclaimer: "A positive child abuse screen will initiate an electronic physician notification and does not necessarily mean that sufficient suspicion exists to warrant mandated child abuse reporting."

Are there potential safety concerns for the child related to any of the following?

1. Was there a possible delay in seeking medical attention given the severity of illness or injury?  
   - Yes  
   - No

2. Are you concerned that the history may not be consistent with the injury or illness?  
   - Yes  
   - No

3. Are any of the following findings present on physical examination?
   a. Any bruise, scalp or extremity swelling in a non-mobile child.
      (If you can't cause, you can't bruise)
   b. Any burn, facial or mouth injury in a non-mobile child
      (includes subconjunctival hemorrhage, frenulum or palate injuries)
   c. Multiple bruises or any bruising in a location other than the forehead, posterior regions or over other bony prominences
      (e.g. cheeks, ears, neck, torso, genitale, upper arms, hands)
   d. Bare or bruise in the shape of an object

4. Are there findings that might reflect poor supervision, care, nourishment or hygiene?  
   - Yes  
   - No

5. Are there any additional comments or concerns?  

*ALL CHILDREN < 4 YRS AGE MUST BE UNDRESSED COMPLETELY*
Appendix E: UPMC hospitals site information

Urban/rural classification is based on the classification status of the county that the hospital is located (determined by US 2010 Census data), and is the standard method for classification by CDC and in research.

Teaching Hospital Status was determined by using the CMS established list of teaching hospitals (hospitals that received payment for Medicare direct graduate medical education (GME), inpatient prospective payment system (IPPS) indirect medical education (IME), or psychiatric hospital IME programs during the last calendar year for which such information is available) for the purposes of Open Payments; this was based on 2015 data.

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Number of beds</th>
<th>County</th>
<th>Urban/Rural Classification</th>
<th>Teaching Hospital Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altoona</td>
<td>380</td>
<td>Blair</td>
<td>Rural</td>
<td>Yes</td>
</tr>
<tr>
<td>Bedford</td>
<td>49</td>
<td>Bedford</td>
<td>Rural</td>
<td>No</td>
</tr>
<tr>
<td>East</td>
<td>156</td>
<td>Allegheny</td>
<td>Urban</td>
<td>No</td>
</tr>
<tr>
<td>Hamot</td>
<td>446</td>
<td>Erie</td>
<td>Urban</td>
<td>Yes</td>
</tr>
<tr>
<td>Horizon</td>
<td>196</td>
<td>Mercer</td>
<td>Rural</td>
<td>Yes</td>
</tr>
<tr>
<td>McKeesport</td>
<td>216</td>
<td>Allegheny</td>
<td>Urban</td>
<td>Yes</td>
</tr>
<tr>
<td>Mercy</td>
<td>489</td>
<td>Allegheny</td>
<td>Urban</td>
<td>Yes</td>
</tr>
<tr>
<td>Northwest</td>
<td>126</td>
<td>Venango</td>
<td>Rural</td>
<td>No</td>
</tr>
<tr>
<td>Passavant</td>
<td>401</td>
<td>Allegheny</td>
<td>Urban</td>
<td>No</td>
</tr>
<tr>
<td>Presby/Montefiore</td>
<td>762</td>
<td>Allegheny</td>
<td>Urban</td>
<td>Yes</td>
</tr>
<tr>
<td>Shadyside</td>
<td>520</td>
<td>Allegheny</td>
<td>Urban</td>
<td>Yes</td>
</tr>
<tr>
<td>St. Margaret</td>
<td>249</td>
<td>Allegheny</td>
<td>Urban</td>
<td>Yes</td>
</tr>
<tr>
<td>Magee</td>
<td>363</td>
<td>Allegheny</td>
<td>Urban</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Source: [http://www.rural.palegislature.us/rural_urban.html#maps](http://www.rural.palegislature.us/rural_urban.html#maps)
Appendix F: Development of the provider interface

The pop-up alerts, physical abuse–specific order set, and other parts of the provider interface described below were developed during the ‘silent mode’.

When the CA-CDSS is triggered, a light bulb appears on the EMR tracking board (Figure F1), a ‘positive physical abuse screen’ communication order appears, the nurse receives orders to undress the patient and measure the head circumference (Figure F2) and the provider (physician or advanced practice provider) receives a pop-up alert (Figure F3).

Figure F1. Screenshot of the lightbulb icon on the CHP ED tracking board
Figure F2. Screenshot from the CHP EMR of the physician and nursing orders once the CA-CDSS is activated.

As part of the this award, we were able to make the light bulb icon the universal sign for ‘think abuse’ at CHP and the 13 general EDs have the same icon on their tracking board when their CA-CDSS is activated.

Figure F3. A screenshot of the pop-up alert received by providers at the CHP site.

There are three times during a patient encounter when the pop-up can appear: at the time the chart is opened by the provider, at the time an order is placed by the provider or at the time of discharge (e.g. when the discharge diagnosis is the trigger or when the chart had not been opened prior to the discharge). The pop-up requires that providers select one of three options in response to the question about whether they want to be linked to the physical abuse–specific order set (referred to as a
‘powerplan’ in Cerner). If they select ‘yes’, they are directly linked to the child abuse order set (Figure F4). If they select ‘not now’, the same alert appears the next time they or another provider opens the chart. If the provider clicks ‘no, never,’ the alert is extinguished for all providers for the remainder of the ED visit. Providers used clinical judgment to decide which selection was appropriate.

Figure F4. Screenshot of the main screen of the child physical abuse–specific order set at CHP.

Within the order set, there are multiple subphases representing different clinical scenarios (Figure F5). All testing recommended in the AAP guidelines is pre-checked so that a physician can order all the recommended testing simply by clicking a single button. The orders for tests which are only needed in certain scenarios (e.g. head or abdominal CT) are each preceded by a note which describes the circumstance under which it is needed.
Figure F5. Screenshot of one of the subphases within the physical abuse–specific order set for a ‘child who is not yet cruising’ who needs to be evaluated for a bruise

The AAP guidelines used to develop the order sets and to assess compliance were developed by the AAP Committee on Child Abuse and Neglect and published in 2007 as a Clinical Report in *Pediatrics*, the official journal of the AAP. Since the time of the original PCORI application, the AAP has published updated guidelines as well as an additional clinical report related to evaluation of young children with fractures. The recommendations in these updated reports are also incorporated into the order sets. For each subject who met one of the five clinical scenarios being evaluated (Table 2), the PI assessed whether the provider was compliant with AAP recommendations.
Figure F6. A screenshot of the pop up alert received by providers at UPMC Hamot and Mercy
Figure F7. Child Abuse Reporting Form (CARF)
Figure F8. Pop-up alert for a positive CAS at the 11 UPMC Hospitals where the ED Child Physical abuse-specific order set was not available.

Figure F9. A screenshot of the 5-item CAS