Dissemination of child abuse clinical decision support: Moving beyond a single electronic health record

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ABSTRACT

Background: Child maltreatment is a leading cause of pediatric morbidity and mortality. We previously reported on development and implementation of a child abuse clinical decision support system (CA-CDSS) in the Cerner electronic health record (EHR). Our objective was to develop a CA-CDSS in two different EHRs.

Methods: Using the CA-CDSS in Cerner as a template, CA-CDSSs were developed for use in four hospitals in the Northwell Health system who use Allscripts and two hospitals in the University of Wisconsin health system who use Epic. Each system had a combination of triggers, alerts and child abuse-specific order sets. Usability evaluation was done prior to launch of the CA-CDSS.

Results: Over an 18-month period, a CA-CDSS was embedded into Epic and Allscripts at two hospital systems. The CA-CDSSs vary significantly from each other in terms of the type of triggers which were able to be used, the type of alert, the ability of the alert to link directly to child abuse-specific order sets and the order sets themselves.

Conclusions: Dissemination of CA-CDSS from one EHR into the EHR in other health care systems is possible but time-consuming and needs to be adapted to the strengths and limitations of the specific EHR. Site-specific usability evaluation, buy-in of multiple stakeholder groups and significant information technology support are needed. These barriers limit scalability and widespread dissemination of CA-CDSS.

1. Background

Child maltreatment is a leading cause of morbidity and mortality in children [1,2]. Failure to recognize abuse in its milder forms may result in repeated abuse and increased morbidity and mortality [3-7]. Many children diagnosed with physical abuse had been previously evaluated by a physician who did not recognize the abuse [3-9].

We previously reported on the development and implementation of a child abuse clinical decision support system (CA-CDSS) embedded in Cerner at the University of Pittsburgh Medical Center (UPMC) hospital system [10-13]. This CA-CDSS has been part of clinical practice at our level I pediatric trauma center since late 2015 and at the UPMC general emergency departments (EDs) since early 2017. The publications cited above describe the feasibility of performing routine child abuse screening in a large health system, improvement in identification of potentially abusive injuries in young children, and increased compliance
Fig. 1. a) Screenshot of the child abuse screen (CAS) used in the Emergency Departments in participating EDs at Northwell Health. b) The screenshot for the CAS used in EDs at the University of Wisconsin when the nurse selects that the child can cruise. c) University of Wisconsin’s alternative questions for when the nurse selects that the child does not cruise.
with the American Academy of Pediatrics (AAP) guidelines for evaluation of suspected child physical abuse with use of CA-CDS. Feedback from nurses, physicians and advanced practice providers demonstrated overwhelming support for its role in improved identification of child maltreatment [Rachel Berger, unpublished data].

Improving identification and evaluation of child abuse using CA-CDS requires dissemination into multiple hospital systems. Since just 26% of hospitals use Cerner as their EHR [14], we sought to disseminate the UPMC CA-CDS to Epic, the most commonly used EHR [14] and Allscripts. Our hope was that availability of CA-CDS in three large EHRs would improve the likelihood of rapid, widespread dissemination.

2. Methods

Development of the CA-CDS was approved by the Institutional Review Boards at the University of Wisconsin (UW) which uses Epic (Epic, Verona, WI) and Northwell Health (NW) which uses Allscripts (Sunrise Clinical Manager, Allscripts, Chicago, IL).

2.1. Setting

There were two participating EDs at UW: UW Health BerbeeWalsh ED supporting the American Family Children’s Hospital (pediatric ED as part of a general academic ED with pediatric and adult level I trauma and burn center), and UW Health at The American Center (general ED). There were four participating EDs at NW: Cohen Children’s Medical Center (pediatric level I trauma center), North Shore University Hospital (adult level I trauma center), Long Island Jewish Forest Hills (general ED), and Staten Island University Hospital (pediatric level II and adult level I trauma center). While there are 13 hospitals using Allscripts within NW, we chose 4 hospitals including the pediatric hospital because of the significant time required to train nurses and educate providers and the time required to support each site once the system was live. The UPMC CA-CDS which is actually two systems due to the use of different Cerner platforms in the general vs. pediatric EDs was used as the template for the two other hospital systems. The general ED CA-CDS will be referred to as the UPMC CA-CDS and UPMC Children’s Hospital of Pittsburgh CA-CDS will be referred to as the CHP CA-CDS.

2.2. Selection of triggers, functioning of alerts and development of neglect and physical abuse order sets

Medical directors, physicians, advanced practice providers, and nurses were interviewed to determine workflows in the UW and NW EDs, assess institutional attitudes towards child abuse screening and evaluation, identify potential facilitators and barriers to implementing the CA-CDS and assure buy-in from key stakeholders. Flowcharts of current workflows were developed to guide the development team on how the CA-CDS could be most seamlessly incorporated. Each site selected triggers, determined the attributes of the alerts and developed physical abuse and neglect order sets based on the functionality of the respective EHRs.

2.3. Usability

Both UW and NW underwent two phases of usability testing with nurses, physicians, and advanced practice providers: ‘think-aloud’ and ‘near-live’. ‘Think-aloud’ assesses usability and participants verbalize their thought process as they interact with the CA-CDS to see how it fits into their workflow. ‘Near-live’ focuses on workflow using actors to simulate patient interactions; in this case, interacted with an actor who played the part of a parent presenting with a child with child abuse or accidental injury. Each usability testing session was audio recorded and lasted approximately 30 min; all screen shots were captured. At UW, nine providers completed the ‘think aloud’ and 11 completed the ‘near-live’. At NW, seven providers completed ‘think aloud’ and 5 completed ‘near-live.’

At both sites, the high risk of missing a potential case of abuse was a facilitator for nurses, advanced practice providers and physicians to use the CA-CDS. Facilitators for nurse completion of the child abuse screen CAS at NW included having clear definitions of each question and ease of use of the form; changes were made to incorporate these facilitators. For example, at NW, the initial CAS stated “ALL CHILDREN < 2 YEARS OF AGE MUST BE UNDRESSED COMPLETELY. Older children should be completely undressed if there is any concern for abuse or neglect.” During the ‘think aloud,’ a nurse stated “are they just telling me that all children under the age of 2 should be undressed?...but then it is saying all the children (with concern) should be undressed...like why is it highlighted for under two.” In response to this, the CAS was changed to state, “...you must completely undress all children <2 years of age. Older children should be....” The words “BEFORE you complete the Child Abuse Screen...” were also added in front of the above statement to make the workflow clear since children need to be undressed prior to answering question 3 of the CAS.

Another change related to visibility at NW was to move the disclaimer statement from the bottom to the top of the CAS to make it clear to nurses what the response to a positive screen would be. Finally, a change was made to enhance ease of use of question 3. The CAS should be done by observation, but one nurse noted in response to the question “Is the child developmentally cruising or walking?” that “the only question with this one is that you’re not actually going to be able to visualize this...if the patient comes in and sits on the stretcher, you’re not going to see that. So, you’re going to have to ask the parent that...it’s not just a strict observation.” In response to this concern, the phrase “Can ask parent or guardian” was added so that the screen states “Is the child developmentally ‘cruising or walking (CAN ASK PARENT OR GUARDIAN) ...’”.

One of the provider barriers related to that fact that the alert triggered upon chart opening, which was often before the provider had seen the patient and was ready to make decisions about whether the patient needed to be evaluated (e.g. “it’s hard because I’m just at the beginning.”) In response, the acknowledgement statement within the ED provider note was moved further down in the documentation at NW. Facilitators to providers using order sets included the fact that recommended testing was pre-checked at both sites. Providers also found the guidance on when to order certain tests useful.

3. Results

Dissemination of the CA-CDS into Epic and Allscripts was done as a collaborative process among the three sites (UPMC, UW, NW) in order to maximize the similarity between the systems while recognizing differences in workflow, EHR functionality, site-specific usability and acceptance of the integration of the CA-CDS by stakeholders in each hospital system. The difference in access to child abuse expertise also was a consideration; a Child Protection Team (CPT) was available for 24/7 consultation at UW, whereas NW had a single child abuse pediatrician at Staten Island University Hospital but not at any other site.

3.1. Selection of triggers

For both UW and NW, there were two main categories of triggers, the CAS and non-CAS triggers. The non-CAS triggers were divided into chief complaints, orders, and discharge diagnoses.

3.2. The CAS

The CAS developed in the Netherlands used in the general EDs at UPMC [12] was used by both sites with a few differences. Screening was done in UPMC and NW in children <13 years of age (Fig. 1a). UW screened children <10 years of age (Fig. 1b, c). The lower age cut-off at UW was used because other nurse-administered screening tools were...
increasing nursing workload; the small number of children in the 10
children at UPMC supported the change in the age cut-off [12]. At UPMC, all children <4 years of age are expected to be undressed to complete the

Abbreviation: SCAN; suspected child abuse and neglect.

* At Northwell Health, chief complaints included age within the text as shown.

required in children 10 and older and there was concern about increasing nursing workload; the small number of children in the 10–12 year age group with a positive screen in the initial CAS evaluation at UPMC supported the change in the age cut-off [12]. At UPMC, all children <4 years of age are expected to be undressed to complete the

3.3. Chief complaints (Table 1)

The chief complaint triggers at CHP were selected in 2013 based on review of the child abuse literature and comparison to the list of discrete chief complaints which were available in the CHP Cerner EHR. Since that time, the ability to use hospital-specific data to identify high-risk chief complaints has improved. UW developed their list of high-risk chief complaints based on data from their own institution; the initial ED chief complaints for all CPT consultations from January 2016 through April 2018 were reviewed and compared to the chief complaints for all ED patients in the same age groups. Chief complaints were chosen based on the number of occurrences among patients with a CPT consult compared with the number of all ED patient with that chief complaint in three age groups - <6 months, <1 year and <2 years - over 3 calendar years. Any chief complaint which resulted in a referral to the CPT more than 5 times a year and was referred to the CPT more than 10% of the time when it occurred was added to the list of chief complaints which would trigger in that age group. In addition, chief complaints which resulted in a CPT consult close to 100% of the time it occurred were also included even if there were fewer than 5 per year. For example, the chief complaint of ‘fall’ in a child under 1 year of age was included as a chief complaint trigger because it was the reason for a CPT consult in 18 children over the 3 calendar years and in 13% of the time when it was the chief complaint in the ED in that age group, a CPT consult was performed. The same chief complaint was not included as a trigger for older children because although many children referred to the CPT had ‘fall’ as a chief complaint, only a very small proportion of all ED patients in that age group with that chief complaint were referred to the CPT.

NW was unable to use the same approach as UW since NW did not have a CPT; NW, therefore, used a combined list of chief complaints used by UW and CHP. Novel chief complaints were added to the ED selections; these chief complaints incorporated age (e.g. ‘burn <6 months’) because of concern that system performance would be slowed if age and chief complaint were in separate fields. CHP, UW and NW all use discrete fields for their chief complaints although at NW, there is also an option for free-text chief complaints.

3.4. Orders

At CHP, multiple orders were used as triggers [11]. At UW, ordering of a skeletal survey (SS) in a child <5 years of age from outside the physical abuse order set was the only order-based trigger whereas at NW, ordering of a SS in a child <2 years of age from outside the physical abuse order set and any X-ray order except for a chest or abdomen in a child <1 year of age were used as triggers.

3.5. Discharge diagnoses

The UPMC CA-CDSS cannot use ICD-10 codes as triggers since these codes are not entered prior to discharge. Instead, the presence of discharge instructions for high-risk injuries specific for abuse were used as triggers. At UW, providers must enter a discharge diagnosis prior to discharging a patient, which allows discharge diagnoses to be used as a trigger. At the time the triggers were being developed, a comprehensive list of ICD-10 codes which were suggestive of abuse was not available. As a result, using previously published ICD-9 codes, [15] a list of almost 3500 ICD-10 codes suggestive of abuse was developed (Benjamin Eithun, manuscript in preparation) and these codes were used as triggers at UW. NW opted not to use discharge diagnoses as triggers since their workflow does not require discharge diagnoses to be placed prior to ED discharge. Free text was not used to trigger the CA-CDSS at either site.

Table 1

Chief Complaints used as triggers at the three sites.

<table>
<thead>
<tr>
<th>UPMC Children’s Hospital of Pittsburgh</th>
<th>University of Wisconsin</th>
<th>Northwell Health*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assault &lt;2 years of age</td>
<td>Arm problem &lt;1 year of age</td>
<td>'Abuse, Child'</td>
</tr>
<tr>
<td>Bruise &lt;1 year of age</td>
<td>Bruising &lt;2 years of age</td>
<td>'Ankle pain/injury &lt;1yr'</td>
</tr>
<tr>
<td>Burn &lt;1 year of age</td>
<td>Fracture &lt;2 years of age</td>
<td>'Arm pain/injury &lt;1yr'</td>
</tr>
<tr>
<td>Fracture &lt;1 year of age</td>
<td>Cardiac arrest &lt;5 years of age</td>
<td>'Assault &lt;2yr'</td>
</tr>
<tr>
<td>Peltechiae &lt;1 year of age</td>
<td>Drug/alcohol use &lt;2 years of age</td>
<td>'Bruise &lt;1yr'</td>
</tr>
<tr>
<td>Drug/alcohol use &lt;2 years of age</td>
<td>Burns &lt;1yr</td>
<td>'Cardiac arrest &lt;5yr'</td>
</tr>
<tr>
<td>Fall &lt;6 months</td>
<td>Head injury &lt;1 year of age</td>
<td>'Drug/alcohol use &lt;2yr'</td>
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<tr>
<td>Head injury &lt;1 year of age</td>
<td>Laceration &lt;6 months of age</td>
<td>'Fall &lt;6m'</td>
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<tr>
<td>Leg problem &lt;1 year of age</td>
<td>Fall down stairs &lt;6m'</td>
<td>'Fall from height &lt;6m'</td>
</tr>
<tr>
<td>Mouth problem &lt;1 year of age</td>
<td>'Feet pain/injury &lt;1yr'</td>
<td>'Foot pain/injury &lt;1yr'</td>
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<tr>
<td>Suspected abuse &lt;10 years of age</td>
<td>'Forearm pain/injury &lt;1yr'</td>
<td>'Forearm pain/injury &lt;1yr'</td>
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<td></td>
<td>'Fracture &lt;1yr'</td>
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<td>'Head injury &lt;1yr'</td>
<td>'Head trauma &lt;1yr'</td>
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<td>'Injury, ankle &lt;1yr'</td>
<td>'Injury, ankle &lt;1yr'</td>
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<td>'Injury, arm &lt;1yr'</td>
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<td>'Injury, dental &lt;1yr'</td>
<td>'Injury, dental &lt;1yr'</td>
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<td>'Injury, elbow &lt;1yr'</td>
<td>'Injury, elbow &lt;1yr'</td>
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<td>'Injury, finger &lt;1yr'</td>
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<td>'Injury, foot &lt;1yr'</td>
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<td>'Injury, forearm &lt;1yr'</td>
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<td>'Injury, hip &lt;1yr'</td>
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<td>'Injury, lip &lt;1yr'</td>
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<td>'Injury, lower leg &lt;1yr'</td>
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<td>'Injury, shoulder &lt;1yr'</td>
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<td>'Injury, thigh &lt;1yr'</td>
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<td>'Injury, upper leg &lt;1yr'</td>
<td>'Injury, upper leg &lt;1yr'</td>
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<td>'Injury, wrist &lt;1yr'</td>
<td>'Injury, wrist &lt;1yr'</td>
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<td></td>
<td>'Knee pain/injury &lt;1yr'</td>
<td>'Knee pain/injury &lt;1yr'</td>
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<td></td>
<td>'Lower leg pain/injury &lt;1yr'</td>
<td>'Lower leg pain/injury &lt;1yr'</td>
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<td>'Mouth pain &lt;1yr'</td>
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<td>'Pain, upper leg &lt;1yr'</td>
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<td>'Peltechiae &lt;1yr'</td>
<td>'Peltechiae &lt;1yr'</td>
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<td></td>
<td>'SCAN &lt;13yr'</td>
<td>'SCAN &lt;13yr'</td>
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<td>'Thigh pain/injury &lt;1yr'</td>
<td>'Thigh pain/injury &lt;1yr'</td>
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<td>'Trauma &lt;2yr'</td>
<td>'Trauma &lt;2yr'</td>
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<tr>
<td></td>
<td>'Upper leg pain/injury &lt;1yr'</td>
<td>'Upper leg pain/injury &lt;1yr'</td>
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<tr>
<td></td>
<td>'Wrist pain/injury &lt;1yr'</td>
<td>'Wrist pain/injury &lt;1yr'</td>
</tr>
</tbody>
</table>

3.5. Discharge diagnoses

The UPMC CA-CDSS cannot use ICD-10 codes as triggers since these codes are not entered prior to discharge. Instead, the presence of discharge instructions for high-risk injuries specific for abuse were used as triggers. At UW, providers must enter a discharge diagnosis prior to discharging a patient, which allows discharge diagnoses to be used as a trigger. At the time the triggers were being developed, a comprehensive list of ICD-10 codes which were suggestive of abuse was not available. As a result, using previously published ICD-9 codes, [15] a list of almost 3500 ICD-10 codes suggestive of abuse was developed (Benjamin Eithun, manuscript in preparation) and these codes were used as triggers at UW. NW opted not to use discharge diagnoses as triggers since their workflow does not require discharge diagnoses to be placed prior to ED discharge. Free text was not used to trigger the CA-CDSS at either site.
Fig. 2. a) Screenshot of Northwell Health acknowledgement/static alert within the ED provider note. b) Northwell Health’s status board alert color change and pop-up text when hovering on the status tracking board over a patient that triggered the clinical decision support system. c) Screenshot of the Best Practice Alert at University of Wisconsin if the chief complaint is the trigger. (For interpretation of the references to colour in this figure text, the reader is referred to the web version of this article.)
3.6. Alerts after the CA-CDSS is triggered

UPMC – At UPMC, an alert is displayed to ED providers when a patient chart is opened, or an order is placed. In the general EDs, there is a single alert which requires an acknowledgement which each provider receives once. Because of limitations of the Cerner platform, it is not possible to link directly from the alert to the order set. At CHP, the alert can show multiple times, has multiple options and a direct link to the order set [13].

3.7. NW

The decision was made not to use an interruptive alert due to system wide concerns about growing alert fatigue and ongoing initiatives to reduce the number of interruptive alerts. Instead, a static alert was included at the top of the ED provider note with a mandatory acknowledgement which includes the reason for the alert. (Fig. 2a) The provider cannot save their note without acknowledging the alert. A positive CAS or chief complaint trigger each require a separate acknowledgement and results in a color change of the chief complaint on the ED status tracking board to purple (Fig. 2b). The purple color transitions back to the background color when the attending acknowledges that the child may be at increased risk of abuse or neglect (Fig. 2a). The status tracking board color change alert is a way to alert all members of the care team to the concern for abuse, particularly the social workers. The order triggers for an X-ray or SS result in the color change on the ED tracking board, but not an acknowledgement. It was not possible to directly link either the provider note or status board change alert to the order set. This is a limitation of Allscripts and not specific to the child abuse acknowledgement. The alert in the provider note includes text in all capital letter with the name of the order set and recommends its use, if applicable. When the mouse hovers over a patient of interest’s chief complaint on the status tracking board, the provider can see the trigger for that patient (Fig. 2b).

3.8. UW

In Epic, Best Practice Alerts (BPAs) are displayed to ED providers when a patient chart is opened after the CA-CDSS is triggered. The BPA includes the reason why the BPA is triggered. As a result, four different BPAs were developed – if the CAS was positive, if a skeletal survey was ordered, if a chief complaint was the trigger (Fig. 2c) and if a discharge diagnosis was the trigger (Fig. 2d). Each BPA provides a direct link to multiple age-appropriate child abuse-specific order sets. If more than one trigger occurs before the chart is opened and one of the triggers is the CAS, the provider will only see the CAS BPA. Each provider receives only one BPA unless a positive CAS was completed after the provider received a BPA for a different trigger; in those cases, the provider still receives the CAS as a second BPA. If the provider does not select one of the order sets from the BPA, they can either “dismiss” and temporarily close the BPA, in which case it will display the next time they open the chart, or they can select a reason in order to silence the alert for that entire patient encounter. Choices include: “child not at risk”; “UW Child Protection Program already evaluating”; “Will evaluate as an inpatient”; and “Other reasons to silence alert.” The BPA is prompted by opening the chart, placing an order or entering a discharge diagnosis.

3.9. Order sets

The physical abuse order set in CHP Cerner was used as a template for Allscripts (Fig. 3a, b) and Epic (Fig. 3c, d). The order set was based on the AAP guidelines for evaluation of physical abuse. Both NW and UW used an order set with subphases specific to injury types (e.g. bruise, fracture). While there was a standard set of subphases for injuries such as bruises and fractures, each site added site-specific subphases - NW has subphases for infants exposed to intimate partner violence and another
for infants with sudden unexplained infant death, while UW has a sub-phase for a skull fracture/skull fracture with underlying extra-axial hemorrhage. The differences in the subphases represent clinical scenarios for which the AAP does not have specific guidelines; each site, therefore, had flexibility to develop subphases which represented current practice at their institution. CHP and UW also have the same neglect order set which focuses on deciding whether an event meets the threshold for reporting to CPS.

Order sets at both sites included pre-checked orders for tests that are part of the AAP recommendations based on patient age and injury. Other orders that are appropriate in some situations were unchecked for providers to determine appropriateness. CDS was included in the order sets to provide advice to provider about when certain tests or consultations should be ordered.

The flow of the UW and NW CA-CDSS is visualized in Fig. 4a and b. A comparison of the two CA-CDS systems at UW and NW is seen below in Table 2.

### 4. Discussion

This study demonstrates that it is possible to disseminate a CA-CDSS into different EHRs and different hospital systems, but that this process is time-consuming and cumbersome. Much of the work related to identification of triggers needed to be repeated in each hospital system and the limitations of each EHR affected the way in which providers could be alerted and the ease with which they could access child abuse-specific order sets. In addition, because of differences in workflow, usability evaluations needed to be done in each hospital system. While Fast Healthcare Interoperability Resources (FHIR) may solve the problem of one CA-CDSS communicating with multiple EHRs, most EHRs don’t currently support write functionality for FHIR-based applications which would preclude documentation of the results of the CAS or allow for the tool to trigger the opening of the order sets. Similarly, a web-based application could solve the issue of multiple EHRs, but at this time web-based applications are not able to interact directly with the EHR in-real time and therefore, cannot obtain data from the EHR or put data back into it. As a result, web-based applications are currently limited to simple calculator type applications in which users can input their own data into the application and then follow the recommendations.

The ability to trigger the CA-CDSS from an ICD-10 code is a novel addition to the CA-CDSS and it will be important to assess how this affects the ability to identify abuse. Based on our experience in UPMC, we hypothesize that if completed accurately in all patients, the CAS and chief complaints would be sufficient to identify most cases of abuse, but given the lack of completion of CAS in all patients and inaccurately coded chief complaints, the discharge diagnoses will offer a ‘back-up’ approach to identification of suspected abuse.

The ability of Epic and Allscripts to inform the provider of why the BPA is present - rather than just a notification that a given child has alerted the CA-CDSS which is what occurs in Cerner - is an advantage of these EHRs. Similarly, the ability to link directly to the order sets which can be done at CHP Cerner and Epic is an advantage of these EHRs. The lack of a direct link to the order set has been an ongoing concern at the general UPMC EDs where the use of order sets remains low after several years. Comparing the use of order sets in Epic and Allscripts when the systems go live will be important; it may be that this function is a critical aspect of one CA-CDSS communicating with multiple EHRs, most EHRs don’t currently support write functionality for FHIR-based applications which would preclude documentation of the results of the CAS or allow for the tool to trigger the opening of the order sets. Similarly, a web-based application could solve the issue of multiple EHRs, but at this time web-based applications are not able to interact directly with the EHR in-real time and therefore, cannot obtain data from the EHR or put data back into it. As a result, web-based applications are currently limited to simple calculator type applications in which users can input their own data into the application and then follow the recommendations.

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### Table 2

<table>
<thead>
<tr>
<th>CA-CDS components</th>
<th>University of Wisconsin</th>
<th>Northwell Health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trigger: Child abuse</td>
<td>See Table 1</td>
<td>See Table 1</td>
</tr>
<tr>
<td>Trigger: Child Abuse Screen (CAS)</td>
<td>Mandatory for age &lt;10 year</td>
<td>Mandatory for age &lt;13 year</td>
</tr>
<tr>
<td>Trigger: Order placed</td>
<td>Skeletal survey ordered on a patient &lt;5 years old</td>
<td>Plain X-ray (except chest or abdomen) order on a patient &lt;1 year old</td>
</tr>
<tr>
<td>Trigger: Discharge diagnosis</td>
<td>3500+ discharge diagnoses</td>
<td>None</td>
</tr>
<tr>
<td>Alerts</td>
<td>4 different interruptive</td>
<td>Static provider alerts if chief complaint or CAS - provider must acknowledge the positive CAS and/or chief complaint in note</td>
</tr>
<tr>
<td>Order sets</td>
<td>No alert for order trigger – order trigger results in chief complaint turning purple on tracking board</td>
<td></td>
</tr>
<tr>
<td>Link from Alert to</td>
<td>No action for order trigger</td>
<td></td>
</tr>
</tbody>
</table>

### Fig. 4

4a) Flow chart depicting the functioning of the CA-CDSS at UW. 4b) Flow chart depicting the functioning of the CA-CDSS at NW.
Summary points
What was already known on the topic:
- It is possible to embed child abuse clinical decision support (CA-CDS) into an electronic health record
- Improved health care outcomes including increased identification of abuse and improved compliance with published guidelines for physical abuse evaluation have been shown with use of CA-CDS

What this study added to our knowledge:
- Dissemination of CA-CDS into different electronic health records and different hospital systems is possible, but is laborious and requires significant adaptations
- The need for multi-disciplinary stakeholder engagement, significant IT infrastructure, and site-specific usability would likely limit widespread dissemination unless other approaches to dissemination are identified.

part of successful CA-CDS.
We intentionally included hospital systems with both pediatric and general EDs so that we could evaluate the effect of CA-CDS in both settings.
The next step will be to evaluate the functioning of the CA-CDS in clinical practice to determine if they improve identification of suspected child maltreatment, assist providers in appropriately evaluating children identified as being possible victims of abuse and improve reporting of suspected maltreatment to child protective services.

5. Conclusions
We have demonstrated that while it is possible to embed CA-CDS in multiple EHRs and multiple hospital systems, scalability is a significant limitation to widespread dissemination. An evaluation of the effect of using CA-CDS in Epic and Allscripts on identification of suspected abuse and compliance with AAP guidelines for evaluation of child physical abuse is currently underway.

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Authors’ contributions
RB: Substantial contributions to the conception or design of the work and drafting the work and final approval of the version to be published and in agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
EH: Acquisition, analysis and interpretation of data, revision for important intellectual content, final approval of the version, and in agreement with the accuracy and integrity of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
TM: Substantial contributions to the conception or design of the work, analysis and interpretation of data, revision for important intellectual content, final approval of the version to be published and in agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
DF: Substantial contributions to the conception or design of the work, acquisition, analysis and interpretation of data, revision for important intellectual content, final approval of the version, and in agreement with the accuracy and integrity of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

IB: Substantial contributions to the conception or design of the work, Acquisition of data, revision for important intellectual content, final approval of the version, and in agreement with the accuracy and integrity of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
JR: Acquisition of data, revision for important intellectual content, final approval of the version, and in agreement with the accuracy and integrity of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
DK: Acquisition of data, revision for important intellectual content, final approval of the version, and in agreement with the accuracy and integrity of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
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BK: Substantial contributions to the conception or design of the work, acquisition of data, revision for important intellectual content, final approval of the version, and in agreement with the accuracy and integrity of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
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Declaration of Competing Interest

The authors report no declarations of interest.

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Appendix A. Supplementary data

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References


