Development of a Pediatric Trigger Tool to Identify Adverse Drug Events

Pediatric Safety Surveillance Workshop
Critical Path Institute
September 13, 2010

Glenn Takata, MD, MS
Childrens Hospital Los Angeles
Abbreviations

ADE = Adverse Drug Event
CHAI = Child Health Accountability Initiative
CHCA = Child Health Corporation of America
IHI = Institute for Healthcare Improvement
ME = Medication Error
Outline

1. Why Measure?
2. ADE Trigger Tool Origins
3. Development of a Pediatric ADE Trigger Tool
4. Is the Outcome the Trigger Tool?
5. ADE Trigger Tool Challenges
Why Measure?

Accountability versus Improvement?

↓

For the Child Health Accountability Initiative

Improvement = Measurement Purpose!
ADE Trigger Tool Origins

A trigger is defined as an “occurrence, prompt, or flag found on review of the medical chart that ‘triggers’ further investigation to determine the presence or absence of an adverse event.

Classen, 1991
ADE Trigger Tool Origins

Trigger Example:

• **Naloxone (Narcan) Trigger:**
  “This is a powerful narcotic antagonist. If it has been used, overdosage of narcotics is a frequent finding. If it was used and the patient's condition didn't change, doubt excessive narcotic administration.”

Review medical record for naloxone use.

• If found, e.g. morphine order, review medical record for ADE associated with naloxone use, e.g. respiratory arrest in child who received morphine.
## ADE Trigger Tool Origins

<table>
<thead>
<tr>
<th>Classen’s (1991) Trigger Tool</th>
<th>IHI ADE Trigger Tool (Rozich, 2003)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Computerized monitor</td>
<td>Chart Review monitor</td>
</tr>
<tr>
<td>✓ Sudden medication order</td>
<td>Sudden medication order stops</td>
</tr>
<tr>
<td>✓ Antidote ordering</td>
<td>Antidote ordering</td>
</tr>
<tr>
<td>✓ Abnormal laboratory values</td>
<td>Abnormal laboratory values</td>
</tr>
<tr>
<td>- Computer identified trigger</td>
<td>- Oversedation, rash, transfer</td>
</tr>
<tr>
<td>- Pharmacist identified ADE</td>
<td>- Customized to individual institution</td>
</tr>
<tr>
<td></td>
<td>- Reviewer identified trigger</td>
</tr>
<tr>
<td></td>
<td>- Reviewer identified identified ADE</td>
</tr>
</tbody>
</table>
ADE Trigger Tool Origins

Classen’s (1991) Trigger Tool
36,653 Primarily Adult Patients over 18 months
Trigger Tool → 631 ADEs
Voluntary Report → 92 ADEs
IHI ADE Trigger Tool (2003)
Total: 2,837 Patients in 86 hospitals
Trigger Tool → 720 ADEs
Subset: 1,040 Patients in 9 hospitals
Trigger Tool → 274 ADEs
Voluntary Report → 5 ADEs
CHAI/CHCA Pediatric ADE Trigger Tool

Purpose:

• Develop and test a pediatric-focused trigger tool.

• Determine the rate of adverse drug events (ADEs) in hospitalized children at 12 freestanding children’s hospitals in the United States.

• Identify characteristics of ADEs in children’s hospitals to provide the basis for developing a strategy to prevent drug-related harm in hospitalized children.
### CHAI/CHCA Pediatric ADE Trigger Tool: Phase 1

#### Antidote Use
- Diphenhydramine
- Vitamin K
- Flumazenil
- Antiemetic
- Naloxone
- Sodium polystyrene
- Droperidol
- Anti-diarrheals

#### Abnormal Lab Value
- PTT > 100 seconds
- Rising Serum Creatinine
  - Hypoglycemia
  - C. difficile (+) stool
  - INR > 6
  - Leukopenia
  - Thrombocytopenia
  - ↑ Digoxin
  - ↑ Lidocaine
  - ↑ Gentamicin or Tobramycin
  - ↑ Amikacin
  - ↑ Vancomycin level

#### Other
- Oversedation/lethargy/fall/hypotension
- Rash
- Abrupt medication stop
- Transfer to higher level of care
CHAI/CHCA Pediatric ADE Trigger Tool: Phase 2

**Antidote Use**
- Diphenhydramine
- Vitamin K
- Flumazenil
- Antiemetic
- Naloxone
- Sodium polystyrene

+ Laxative or stool softener

**Abnormal Lab Value**
- PTT > 100 seconds
- Rising Serum Creatinine

+ Hyperglycemia
+ Hyperkalemia

**Other**
- Oversedation/lethargy/fall/hypotension
- Rash

+ Abrupt medication stop
+ Called codes
CHAI/CHCA Pediatric ADE Trigger Tool: Phase 2

- 12 Free-Standing Children’s Hospitals
- Training
- Random Chart Selection
  - 4 consecutive two-week periods
  - 20 charts randomly selected each two-week period at each hospital

Exclusion Criteria
- Hospital stay <2 days
- Newborn nursery stay
- Obstetrics service
- Day hospital or observation unit
CHAI/CHCA Pediatric ADE Trigger Tool: Phase 2

960 Patients in 12 Children’s Hospitals

Trigger Tool ➔ 89 ADEs
Voluntary Report* ➔ 4 ADEs
Total† ➔ 107 ADEs

*All 4 voluntary report ADEs were identified by the Trigger Tool.
†14 additional ADEs not associated with a trigger were identified while using the Trigger Tool.

7.29% of all patients experienced an ADE.

Trigger Tool ➔ 13.1 ADEs/1000 pt-days
Voluntary Report ➔ 0.59 ADEs/1000 pt-days
Total ➔ 15.7 ADEs/1000 pt-days
Medication-Related Harm in US Children’s Hospitals

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>ADE Detection Method</th>
<th>ADEs per 100 admissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaushal (2001)</td>
<td>1999</td>
<td>Chart Review &amp; Incident Reports</td>
<td>2.3</td>
</tr>
<tr>
<td>Holdsworth (2003)</td>
<td>2000-2001</td>
<td>Chart Review &amp; Staff Interviews</td>
<td>6.4</td>
</tr>
</tbody>
</table>

The rate of adverse drug events experienced by hospitalized children is higher than previously reported.
CHAI/CHCA Pediatric ADE Trigger Tool: Phase 2

Trigger Positive Predictive Values

All Triggers $\rightarrow$ 3.73%

<table>
<thead>
<tr>
<th>Trigger</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polystyrene</td>
<td>20.0%</td>
</tr>
<tr>
<td>Medication stop</td>
<td>19.7%</td>
</tr>
<tr>
<td>PTT</td>
<td>16.7%</td>
</tr>
<tr>
<td>Oversedation</td>
<td>14.9%</td>
</tr>
<tr>
<td>Codes</td>
<td>14.3%</td>
</tr>
<tr>
<td>Rash</td>
<td>12.7%</td>
</tr>
<tr>
<td>Naloxone</td>
<td>12.1%</td>
</tr>
<tr>
<td>Diphenhydramine</td>
<td>8.4%</td>
</tr>
<tr>
<td>Serum creatinine</td>
<td>3.8%</td>
</tr>
<tr>
<td>Hyperkalemia</td>
<td>3.6%</td>
</tr>
<tr>
<td>Laxative</td>
<td>2.8%</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>1.8%</td>
</tr>
<tr>
<td>Antiemetic</td>
<td>1.5%</td>
</tr>
<tr>
<td>Hyperglycemia</td>
<td>0.6%</td>
</tr>
<tr>
<td>Flumazenil</td>
<td>0.0%</td>
</tr>
</tbody>
</table>


CHAI/CHCA Pediatric ADE Trigger Tool: Phase 2

**Patient-Level Characteristics**

- Chronic Diagnoses
- Principle Diagnosis
- Admission Date
- Discharge Date
- Gestational Age
- Date of Birth
- Initial Unit
- Communication Barrier
- Total Transfers between Units

In addition:
- Number of Triggers
- Number of ADEs
- Total Medications
- Total Doses
- Time to Review Chart
- Chart Reviewer Type
<table>
<thead>
<tr>
<th>ADE Characteristics</th>
<th>ADE Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trigger</td>
<td>ADE Severity</td>
</tr>
<tr>
<td>ADE Date</td>
<td>Preventable?</td>
</tr>
<tr>
<td>How ADE Identified</td>
<td>Identified Earlier?</td>
</tr>
<tr>
<td>Unit of ADE Occurrence</td>
<td>Mitigated Better?</td>
</tr>
<tr>
<td>ADE Outcome</td>
<td>ADE Process</td>
</tr>
<tr>
<td>Medication Involved</td>
<td>Medication Error Type</td>
</tr>
<tr>
<td>Intervention</td>
<td></td>
</tr>
</tbody>
</table>

CHAI/CHCA Pediatric ADE Trigger Tool: Phase 2
Conclusions

The Pediatric ADE Trigger Tool identified more ADEs than voluntary reporting → 22 times more.

1 of 15 hospitalized children experienced an ADE.

1 of 5 ADEs were preventable.

Opportunities for Improvement:

- Narcotics & antibiotic usage
- Monitoring & prescribing/ordering
Is the Outcome the Trigger Tool? No!

An Intervention to Decrease Narcotic-Related Adverse Drug Events in Children’s Hospitals (Sharek, 2008):

Interventions Narcotic-related ADE rates 67%

Based on Narcotic-Related ADE Trigger Tool

- Antiemetic use
- Naloxone use
- Oversedation, lethargy, falls
- Abrupt cessation of narcotic
- Administration of laxatives or enemas
- Administration of diphenhydramine
- Intubation/respiratory arrest
- Combination of $\geq 3$ narcotics ordered
ADE Trigger Tool Challenges

Measurement Challenges
What is the gold standard for ADE detection?  Sensitivity?  Specificity?
Optimal thresholds?
Are positive predictive values enough?  (Handler, 2007)
Cost-effectiveness?

How dependent are ADE trigger tools on the operator?
Phansalkar (2007): 0.23 ADEs identified/admit by pharmacists versus 0.12 ADEs identified/admit by non-pharmacists

Resources to utilize ADE Triggers
Ferranti (2008): 2 dedicated clinical pharmacists to follow-up 57 automated ADE triggers at an academic medical center
Jha (1998): voluntary report 5 h/wk → 23 ADEs; chart review 55 h/wk → 398 ADEs; computer monitoring 11 h/wk → 275 ADEs
ADE Trigger Tool Challenges

How do we automate triggers, in particular those not related to medication use or laboratory values? Will natural language triggers work?

- Melton (2005): sensitivity 25% and specificity 99.96%
- Cantor (2007): sensitivity 31% and specificity 98%
- CHLA (2010): testing prohibited abbreviation triggers in EMR

Real-time trigger intervention

- Raschke (1998): Physicians notified for increased ADE risk situations 53% true positive 44% unrecognized by MD
- Jha (2008): High-priority ADE alerts 38% true positive 11.3% MDs contacted & all unaware of event.
- Duncan (2006): PEWS (Pediatric Early Warning System) triggers Rapid Response Team
# Pediatric ADE Trigger Tool: Postlude

## Automated ADE Trigger

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Manual or Automated</th>
<th>ADEs per 100 admissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Takata</td>
<td>2002</td>
<td>Manual Pediatric ADE Trigger &amp; Incident Reports</td>
<td>11.1</td>
</tr>
<tr>
<td>(2008)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ferranti*</td>
<td>2004-2006</td>
<td>Automated ADE Trigger &amp; Incident Reports</td>
<td>3.5</td>
</tr>
<tr>
<td>(2008)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Takata†</td>
<td>2003-2004</td>
<td>Automated Pediatric ADE Trigger</td>
<td>11.2</td>
</tr>
<tr>
<td>(2008)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Ferranti, Horvath, Cozart, et al., 2008: Duke Children’s Hospital

†Takata, Taketomo, Waite, 2008: California Pediatric Patient Safety Initiative
CaPSSI Findings, Takata (AJHP 2008): Postlude

5 California Children’s Hospitals (CHCF): Pediatric Patient Safety Surveillance System

Automated ADE Triggers: antidote and lab values

Patients with Trigger: 53.9%

Trigger Rate: 2.3 triggers/patients

Patients with ADE: 9.1%

Trigger ADE Rate: 11.2 ADEs/100 patients

11 times higher than voluntary ADE rate

Positive Predictive Value (all triggers):

Trigger level: 4.7%

Patient level: 16.8%
Patient safe practices are the right thing to do.
References


Stockwell DC, Kane-Gill SL. Developing a patient safety surveillance system to identify adverse events in the intensive care unit. Crit Care Med 2010;38[Suppl.]:S117-S125.


## Phase 1: Trigger Selection

<table>
<thead>
<tr>
<th>Group</th>
<th>Trigger level</th>
<th>Patient level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group 1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Most Active</strong></td>
<td>&gt;300 triggers</td>
<td>&gt;100 patients</td>
</tr>
<tr>
<td>T1 (Diphenhydramine)</td>
<td>T4 (Antiemetics)</td>
<td>T1 (Diphenhydramine)</td>
</tr>
<tr>
<td>T4 (Antiemetics)</td>
<td></td>
<td>T4 (Antiemetics)</td>
</tr>
<tr>
<td><strong>Group 2</strong></td>
<td>50 - 100 triggers</td>
<td>50-100 patients</td>
</tr>
<tr>
<td>Moderately Active</td>
<td>T12 (WBC &lt; 3000)</td>
<td>T22 (Rash)</td>
</tr>
<tr>
<td>T22 (Rash)</td>
<td></td>
<td>T23 (Abrupt mediation stop)</td>
</tr>
<tr>
<td>T23 (Abrupt mediation stop)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group 3</strong></td>
<td>20 - 50 triggers</td>
<td>20-49 patients</td>
</tr>
<tr>
<td>Somewhat Active</td>
<td>T2 (Vitamin K)</td>
<td>T2 (Vitamin K)</td>
</tr>
<tr>
<td>T5 (Naloxone)</td>
<td></td>
<td>T12 (WBC &lt; 3000)</td>
</tr>
<tr>
<td>T6 (Antidiarrheals)</td>
<td>T8 (Serum glucose &lt;50)</td>
<td>T13 (Platelet count &lt; 50,000)</td>
</tr>
<tr>
<td>T13 (Platelet count &lt; 50,000)</td>
<td>T16 (Rising serum creatinine)</td>
<td>T16 (Rising serum creatinine)</td>
</tr>
<tr>
<td>T17 (Gentamicin or Tobramycin levels)</td>
<td>T21 (Oversedation, lethargy, fall, hypotension)</td>
<td>T21 (Oversedation, lethargy, fall, hypotension)</td>
</tr>
<tr>
<td>T21 (Oversedation, lethargy, fall, hypotension)</td>
<td>T24 (Transferred to a higher level of care)</td>
<td>T24 (Transferred to a higher level of care)</td>
</tr>
<tr>
<td><strong>Group 4</strong></td>
<td>1-19 triggers</td>
<td>1-19 patients</td>
</tr>
<tr>
<td>Least Active</td>
<td>T7 (Sodium Polystyrene)</td>
<td>T5 (Naloxone)</td>
</tr>
<tr>
<td>T9 (C difficile positive)</td>
<td>T10 (PTT &gt;100 seconds)</td>
<td>T6 (Antidiarrheals)</td>
</tr>
<tr>
<td>T10 (PTT &gt;100 seconds)</td>
<td>T11 (INR &gt; 6)</td>
<td>T7 (Sodium Polystyrene)</td>
</tr>
<tr>
<td>T11 (INR &gt; 6)</td>
<td></td>
<td>T8 (Serum glucose &lt;50)</td>
</tr>
<tr>
<td>T14 (Digoxin levels &gt;2)</td>
<td>T18 (Amikacin levels peak &gt; 30 or trough &gt; 10)</td>
<td>T9 (C difficile positive)</td>
</tr>
<tr>
<td>T18 (Amikacin levels peak &gt; 30 or trough &gt; 10)</td>
<td>T19 (Vancomycin trough &gt;15)</td>
<td>T10 (PTT &gt;100 seconds)</td>
</tr>
<tr>
<td>T19 (Vancomycin trough &gt;15)</td>
<td></td>
<td>T11 (INR &gt; 6)</td>
</tr>
<tr>
<td><strong>Group 5</strong></td>
<td>0 triggers</td>
<td>0 patients</td>
</tr>
<tr>
<td>Truly Inactive</td>
<td>T3 (Flumazenil)</td>
<td>T3 (Flumazenil)</td>
</tr>
<tr>
<td>T15 (Lidocaine level &gt; 5)</td>
<td>T20 (Theophylline level &gt; 20)</td>
<td>T15 (Lidocaine level &gt; 5)</td>
</tr>
<tr>
<td>T20 (Theophylline level &gt; 20)</td>
<td></td>
<td>T20 (Theophylline level &gt; 20)</td>
</tr>
</tbody>
</table>
Trigger Level Summary:

>300 triggers (Most Active)
  T1 (Diphenhydramine)
  T4 (Antiemetics)

50 - 100 triggers (Moderately Active)
  T12 (WBC < 3000)
  T22 (Rash)
  T23 (Abrupt medication stop)

20 - 49 triggers (Somewhat Active)
  T2 (Vitamin K)
  T5 (Naloxone)
  T6 (Antidiarrheals)
  T8 (Serum glucose <50)
  T13 (Platelet count < 50,000)
  T16 (Rising serum creatinine)
  T17 (Gentamicin or Tobramycin levels)
  T21 (Oversedation, lethargy, fall, hypotension)
  T24 (Transferred to a higher level of care)

1-19 triggers (Least Active)
  ✓ T7 (Sodium Polystyrene)
  ✓ T9 (C difficile positive)

  T10 (PTT >100 seconds)
  T11 (INR > 6)
  T14 (Digoxin levels >2)
  T18 (Amikacin levels peak > 30 or trough > 10)
  T19 (Vancomycin trough >15)

0 triggers (Truly Inactive)
  ✓ T3 (Flumazenil)
  T15 (Lidocaine level > 5)
  T20 (Theophylline level > 20)
Patient Level Summary:

>100 patients (Most Active)
  T1 (Diphenhydramine)
  T4 (Antiemetics)

50-100 patients (Moderately Active)
  T22 (Rash)
  T23 (Abrupt medication stop)

20-49 patients (Somewhat Active)
  T2 (Vitamin K)
  T12 (WBC < 3000)
  T13 (Platelet count < 50,000)
  T16 (Rising serum creatinine)
  T21 (Oversedation, lethargy, fall, hypotension)
  T24 (Transferred to a higher level of care)

1-19 patients (Least Active)
  T5 (Naloxone)
  T6 (Antidiarrheals)
  T7 (Sodium Polystyrene)
  T8 (Serum glucose <50)
  T9 (C difficile positive)
  T10 (PTT >100 seconds)
  T11 (INR > 6)
  T14 (Digoxin levels >2)
  T17 (Gentamicin or Tobramycin levels)
  T18 (Amikacin levels peak > 30 or trough > 10)
  T19 (Vancomycin trough >15)

0 patients (Truly Inactive)
  T3 (Flumazenil)
  T15 (Lidocaine level > 5)
  T20 (Theophylline level > 20)
The triggers with the combination of being most active and having the highest yield for all ADEs at patient level (proportionately leading to the identification of a high number of ADEs) were:

- T5 (Narcan) – 55.6%
- T18 (Rising serum creatinine) – 50%
- T21 (Oversedation, lethargy, fall, hypotension) – 40.1%
- T7 (Sodium Polystyrene) – 33.3%
- T23 (Abrupt mediation stop) – 29%
- T1 (Diphenhydramine) – 26.6%
- T10 (Ptt > 100 seconds) – 22.2%

Although T1 & T4 were in the “most active” group, they did not have a high yield for ADE identification at the patient level.
Phase 1: Trigger Selection

Trigger Efficacy for Preventable ADEs

The triggers with the combination of being most active and having the highest yield for all ADEs at patient level (proportionately leading to the identification of a high number of ADEs) were:

- T5 (Naloxone) – 44.4%
- T21 (Oversedation/lethargy/fall/hypotension) – 18.8%
- T10 (PTT >100 seconds) – 11.1%

For the 91 total ADEs, 26 ADEs (29%) were categorized as preventable ADEs for the study (based on slide 47)
Pediatric ADE Trigger Tool

ADE Characteristics

97% → mild, temporary harm
22% → preventable
18% → possible to identify earlier
17% → possible to mitigate better
Pediatric ADE Trigger Tool

**ADE Characteristics**

**ADE Type** → pruritis (18%)  
nausea (11%)

**Medication Type** → narcotics (51%)  
antibiotics (12%)

**Error Type** → monitoring (63%)  
ordering (50%)

**Location** → Heme/Onc (18%)
Medication-Related Harm in US Children’s Hospitals

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>ADE Detection Method</th>
<th>ADEs per 100 admissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaushal (2001)</td>
<td>1999</td>
<td>Chart Review &amp; Incident Reports</td>
<td>2.3</td>
</tr>
<tr>
<td>Holdsworth (2003)</td>
<td>2000-2001</td>
<td>Chart Review &amp; Staff Interviews</td>
<td>6.4</td>
</tr>
</tbody>
</table>

The rate of adverse drug events experienced by hospitalized children is higher than previously reported.
# Pediatric ADE Trigger Tool: Progeny & Relatives

## Automated ADE Trigger

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Manual or Automated</th>
<th>ADEs per 100 admissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Takata† (2008)</td>
<td>2003-2004</td>
<td>Automated Pediatric ADE Trigger</td>
<td>11.2</td>
</tr>
</tbody>
</table>

*Ferranti, Horvath, Cozart, et al., 2008: Duke Children’s Hospital

†Takata, Taketomo, Waite, 2008: California Pediatric Patient Safety Initiative
Pediatric ADE Trigger Tool: Progeny & Relatives

Neonatal Intensive Care Unit Trigger Tool: Vermont Oxford Network and CHCA (Sharek, 2006)

Pediatric Critical Care Unit Trigger Tool: Primary Children’s Medical Center, Salt Lake City, Utah (Larsen, 2007)

Pediatric Emergency Department Trigger Tool: Newfoundland and Labrador, Canada (Sikdar, 2010)

Canadian Paediatric Trigger Tool: The Canadian Association of Paediatric Health Centres (Matlow, 2005)
Neonatal Intensive Care Unit Trigger Tool: (Sharek, 2006)

15 Vermont Oxford Network and CHCA NICUs, n=749 NICU patient charts over 3 months

- Adverse Events 0.74 per patient
- Preventable 56%
- Event Type: nosocomial infections, infiltrates, abnormal cranial imaging
Pediatric ADE Trigger Tool: Progeny & Relatives

- Pediatric Critical Care Unit Trigger Tool:
  
  (Larsen, 2007)
  
  ✓ Primary Children’s Medical Center, Salt Lake City, Utah, n=259 PICU cases of 1,826 over 1 year
  
  ▪ Preventable adverse events 0.19 per pt-day
  
  ▪ Severity 78% minor, 19% moderate, 3% serious
  
  ▪ Type sedation 22%, skin 16%, medical device 14%, pulmonary 13%, cardiovascular 11%
Pediatric ADE Trigger Tool: Progeny & Relatives

- Canadian Paediatric Global Trigger Tool: (Matlow, 2005)
  - Canadian Adverse Events Study
  - Pediatric ADE Trigger Tool
  - IHI Global Trigger Tool
  - NICU Trigger Tool
  - Calgary Trigger Tool
Pediatric ADE Trigger Tool: Future Directions?

• Triggers to Prevent Harm in Real-Time

✓ Raschke (1998): targeted 37 drug-specific ADEs
  ▪ Physicians notified by hospital information system for increased ADE risk situations, n=13,521 adult admissions over 6 months.
  ▪ 1,116 alerts → 596 true positive
    53% positive-predictive value
  ▪ 44% unrecognized by physician
Pediatric ADE Trigger Tool: Future Directions?

• Triggers to Prevent Harm in Real-Time

✓ Jha (2008): targeted ADEs

  ▪ Pharmacist or physician review of specialized information system module high-priority ADE alerts, n=2,407 adult admissions over 4 months.
  ▪ 516 alerts → 23% ADE & 15% potential ADE
  ▪ 266 alerts reviewed real-time → 11.3% MD contacted
  ▪ All 15 MDs contacted were unaware of the event.
Pediatric ADE Trigger Tool: Future Directions?

• Natural Language Triggers


■ Event level: 1,000 charts with 65 events
  
sensitivity $\rightarrow$ 25%  \((+)-pred$ value $\rightarrow$ 44%
  
specificity $\rightarrow$ 99.96%  \((-)-pred$ value $\rightarrow$ 99.89%
Pediatric ADE Trigger Tool: Future Directions?

- Natural Language Triggers

✓ Cantor (2007): targeted outpatient medicine clinic notes at Bellevue Hospital, New York, for phrases related to discontinuation of or non-compliance with a medication.

  - Event level: 1,250 notes → 54 with ADRs
    - sensitivity → 31%  (+)-pred value → 45%
    - specificity → 98%
  - Processing time: 1250 notes → 3 seconds
Pediatric ADE Trigger Tool: Challenges

- Human Resources: Jha (1998), n= 21,964 patient days over 9 months

<table>
<thead>
<tr>
<th>Method</th>
<th>person-hrs</th>
<th>ADEs per week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voluntary reports</td>
<td>5</td>
<td>23</td>
</tr>
<tr>
<td>Chart review</td>
<td>55</td>
<td>398</td>
</tr>
<tr>
<td>Computer Monitor</td>
<td>11</td>
<td>275</td>
</tr>
</tbody>
</table>

2620 computer alerts
Pediatric ADE Trigger Tool: Challenges

• **Meta-analysis of Adverse Drug Events Rates Detected by Pharmacist versus non-Pharmacist Chart Reviewers:** Phansalkar (2007), n=23 studies

  - **Pharmacist Reviewer** → 0.23 per admit
    - (IQR: 0.18-0.44)
  - **non-Pharmacist Reviewer** → 0.12 per admit
    - (IQR: 0.02-0.49)