**EARLY DETECTION AND TIMELY MANAGEMENT OF PEDIATRIC SEPSIS**  
**CHILDREN’S HOSPITAL OF MICHIGAN**

**Publication Year:** 2014

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**SUMMARY:**  
We developed a simple, parsimonious, pragmatic, age-specific and evidence-based algorithm for early detection and timely management of pediatric sepsis.

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**SUBMISSION CATEGORY:**  
- Safety & Quality  
- Flow & Efficiency  
- Care Coordination

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**HOSPITAL:**  
Children’s Hospital of Michigan  
**LOCATION:**  
Detroit, MI

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**CATEGORY:**  
- A: Arrival  
- C: Clinician Initial Evaluation

**KEY WORDS:**  
- Care Transitions  
- Care in the ED  
- Care on Inpatient Unit  
- Early Recognition of Sepsis  
- Lean Methodology & Six Sigma

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**HOSPITAL METRICS:**  
- Annual ED Volume: 90,000  
- Hospital Beds: 220  
- Ownership: Private  
- Trauma Level: 1  
- Teaching Status: Yes, Wayne State University School of Medicine

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**TOOLS PROVIDED:**  
- Attachment 1: Early Recognition and Timely Management Algorithm – ED  
- Attachment 2: Early Recognition and Timely Management Algorithm – Inpatient  
- Attachment 3: Sepsis Project Charter  
- Attachment 4: List of Stakeholders  
- Attachment 5: Case Studies for Education  
- Attachment 6: Barriers and Facilitators – Stakeholder Feedback  
- Attachment 7: DMAIC Plan  
- Attachment 8: Badge for PEWS and Age-specific Vitals  
- Attachment 9: PAS presentation  
- Attachment 10: PEWS feasibility  
- Attachment 11: Pre-Intervention Halo Effect on PEWS in Inpatient Units  
- Attachment 12: Post Intervention Data

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**CLINICAL AREAS AFFECTED:**  
- ED  
- Fast Track  
- Inpatient Units  
- Respiratory Therapy  
- Surgery  
- Triage  
- Hematology Oncology

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**STAFF INVOLVED:**  
- Social Workers/Case Managers  
- Toxicologists  
- Hospitalists  
- Infectious Disease  
- Intensive Care  
- Neonatal Intensive Care  
- Pediatrician-in-Chief  
- Surgeon-in-Chief  
- System CMO

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This tool (a) leverages electronic medical record, (b) incorporates PEWS (Pediatric Early Warning Scores) which increases sensitivity and specificity, (c) empowers residents and nurses to identify children with early sepsis and those who are at risk for severe sepsis/septic shock, and (d) provides management guidance at patient bedside that allows them to rapidly escalate care commensurate with illness severity. Most importantly, this algorithm can be easily translated to other ERs and inpatient settings irrespective of size, location and nature of the healthcare institution.

**Innovation**

Pediatric sepsis is an important cause of death worldwide and it is estimated that 42,000 children will die annually in the US alone. It is proven that (a) there are signs of early sepsis and (b) if recognized early, much of this mortality and morbidity can be prevented. However, signs of early sepsis (SIRS - or Systemic Inflammatory Response Syndrome) such as rapid heart rate and fever can mimic many non-fatal conditions. Furthermore, many clinicians, especially ER providers, who work under significant time-constraints, can misdiagnose these children. Indeed the unfortunate case of Rory Staunton (NY Times July 11, 2014) is one such example. Many such similar instances have led to mortality in my institution as well. However, there is a simultaneous risk for "over-diagnosis" of sepsis thus potentially subjecting children to unnecessary and harmful therapies. Indeed, most early sepsis detection clinical decision tools have high numbers of false positives which increases resource burden and leads to alert fatigue which is an important safety issue in healthcare.

**Challenge:** To develop a sensible, simple, pragmatic and parsimonious clinical algorithm that has high sensitivity and high specificity in identifying children with early sepsis in the ER setting that can potentially be extrapolated in non-ER settings such as inpatient units. Furthermore, can this be achieved by leveraging existing technology without significant incremental costs?

**Project:** We created an evidence-based, age-specific, EMR algorithm that fires an alert when a patient meets SIRS criteria based on vital signs. This alert then triggers an automatic page to the Charge Nurse responsible for that area (either ER pod or inpatient unit). Charge nurse then performs a PEWS score, records it in the EMR which directs the nurse to escalate care based on the PEWS score which includes repeating the score, alerting the resident and staff attending and in cases of very high PEWS scores (6-9) activating the rapid response team, thus bringing appropriate resources to patient bedside. By adding a simple pre-checked sepsis order set, we have been able to take out the variation in management plan and patients receive the essential components of early goal directed therapy in a very timely manner. Performance of PEWS by an experienced Charge Nurse improves sensitivity and specificity. Use of PEWS score to trigger rapid response team empowers junior residents/nurses to take the right step without waiting for approval from senior faculty. Activating sepsis order set ensures delivery of the right care to the right patient at the right time. Finally, since all these components are time stamped on EMR, this allows for data acquisition and reporting in real-time to ensure sustainability.

**Background**

**Why Pediatric Sepsis:** Although it was well recognized that early goal directed therapies (mainly parenteral normal saline boluses and broad spectrum antibiotics followed by aggressive use of vasopressors) has been effective in reducing the morbidity and mortality of septic shock - a comprehensive multi-disciplinary peer review of 8 deaths in the immediate past calendar year across the hospital system revealed that 7 of the 8 patients demonstrated signs of early sepsis (SIRS) yet, were unrecognized. In some instances patients had signs of SIRS for 12 hours before they deteriorated. Separately, institutional review of many cases of septic shock revealed that most patients did not receive appropriate interventions as suggested by experts in early goal directed therapy in a timely manner. In most instances there was either a failure of recognition, or a knowledge gap, that was most evident in those instances where patients went into septic shock during after-hours on the inpatient floor or during busy times in the ER. We also recognized that there was a fear of escalation by junior residents and nurses due to institutional culture that did not allow empowerment. These were the reasons why we chose pediatric sepsis specifically focusing on early recognition and timely management. Since this issue was prevalent in the ER and on the inpatient units, we felt it was efficient to expand the scope of this intervention beyond the ER to ensure continuity of care.
How Innovation Works: The sepsis alert (shape of a bug) is triggered when any patient meets the age-specific SIRS criteria (see algorithm). Not all patients who are SIRS positive will develop sepsis. So reliance of this criteria alone will lead to false positives, resource over-utilization and alert fatigue. To mitigate that issue, we developed a cloud based rule that triggers a page to the Charge Nurse in that ER pod or in that inpatient unit. The pager alerts reveals the age and location of the patient, reveals the type of SIRS criteria that were met (early sepsis or septic shock - Temperature or WBC count and Heart Rate or Respiratory Rate) along with the patient identification number. The Charge Nurse (often a very experienced provider) arrives promptly at patient bedside and quantifies the clinical severity of illness by performing Pediatric Early Warning Score (PEWS). This process takes less than a minute and has already brought needed resources at patient bedside. This PEWS score is then automatically calculated in the EMR as its components are checked and based on the score, the algorithm directs the nurse to either repeat PEWS score in 30 minutes (for low scores of 0-2), call the resident/senior staff (mid-level scores of 3-5) or call the rapid response team (high scores of 6-9). This reduces the false positives from SIRS and also empowers the nurse to take action for those who are in septic shock. Furthermore, we created a simple pre-checked sepsis order set as a part of the algorithm (please see sepsis order set) that allows the resident/nurse to place orders for provision of saline blouses over 20 minutes, antibiotics and collection of a blood gas with calcium, glucose and lactate as point-of-care labs. This ensures rapid treatment and collection of lactate that can be used to monitor progress. By activating the sepsis order set, the entire bundle of the early goal directed therapy is delivered to the patient even before arrival of the senior faculty. We have been able to deliver saline boluses and antibiotics within one hour of recognition of early sepsis.

Innovation Implementation

How was the Innovation implemented: We used a combination of Lean methodology, Six-sigma, Model for Improvement principles for accomplishing this project. We had two green-belt and one black-belt six-sigma experts in our stakeholder group

**Step 1:** Identification of problem - pediatric early sepsis recognition and timely intervention was identified as the main aim. The vision was to reduce mortality and morbidity due to pediatric sepsis in the ED and the entire hospital

**Step 2:** Gathering of stakeholders: We recognized that the lack of recognition was prevalent in the ED and on the inpatient units. Thus, despite being ED focused as most patients came via the ED a significant number of missed patients were on the inpatient units. So we developed a core committee of the following stakeholders:

- Lead: Director, Center for Quality and Innovation
- Physicians - including ED and hospitalists - as content experts and site lead
- Resident representatives: Chief Residents - as lead for all residents
- Infectious Disease experts - Pediatric ID Chief - content expert
- Nursing: Included ED and floor charge nurses, nurse educators - process experts and unit leads
- Intensive care units - physicians and nurse leaders from PICU and NICU - content experts
- Pharmacy - for antibiotics recommendations and availability in all units
- IT - Clinical transformation, EMR experts and system CMIO for order sets and power forms, cloud based rules and pager alerts
- Respiratory Therapists - Lead RT director for point-of-care blood gas, lactate, glucose and calcium
- System CIO - for cloud based alerts
- QI experts - for use of Lean process design, Six-sigma, Model for Improvement and DMAIC methodology to optimize resources
- Administration leadership: VPMA, Hospital CEO, Pediatrician-in-Chief and Surgeon-in-Chief
- Research: Grants manager, biostatistician with expertise in statistical process control analysis and run charts
- Faculty Development: We created a database of patient visits that was opened up to faculty for manuscripts, abstracts, QI work for faculty development
- Data analysts: We added a data analyst for ongoing data analysis
Step 3: Created an implementation time-line which included weekly meetings, monitoring of interventions, education roll out to faculty, residents, nursing, pharmacy and respiratory therapy. We also developed the algorithm, studied barriers and facilitators for implementation and resources required. We demonstrated feasibility of performing PEWS in the ED setting to obtain data on reliability and impact on ED care.

Dissemination: This was done via weekly meetings of leaders that trickled down to individual constituencies via the chief residents, nurse educators, physician leads and was implemented and disseminated by conducting grand rounds, resident lectures, face-to-face meetings, newsletter. Furthermore, early successes, lessons learned, failures, barriers etc were disseminated on a regular basis along with data summaries in easy to read format. We deployed our successes as screen savers along with the algorithm. Finally - abstracts, manuscripts and grants submitted were also circulated among all stakeholders.

Resources needed: Apart from the time spent on the implementation, we used no other formal resources. The only resource that was used was IT time - but that was achieved by applying for an EMR award that prioritizes IT improvement suggestions that arise from stakeholders - the early recognition of pediatric sepsis award was rated as the highest and resources were allocated almost immediately.

What will be need to sustain this: We will need an ongoing education of the impact of our intervention and we believe that our weekly meetings with monthly data summaries will help sustain this. We also believe that hospital and department commitment to sepsis will ensure success. Finally, dissemination of post-intervention impact on actual use of resources, morbidity averted, early or "great" catches due to this algorithm will sustain this effort.

Please see attachments # 1 - 12 regarding the algorithm, stakeholder list, project charter, case studies etc.

Timeline
The entire process has taken 18 months

Step 1 - time zero

Step 2 - Identification of all stakeholders - 1 month

Step 3 - Creation of algorithm - this took 6 months. Here time was spent in gathering available evidence from literature and other institutions, identifying barriers and facilitators at our institution, collecting data on local extent of the problem (i.e. scope of intervention), cleaning up the algorithm so that it is simple, parsimonious, pragmatic and easy to understand and implement. This also included using DMAIC/Lean and Six-sigma methods along with Model for Improvement to create a charter with specific timeline for deliverables.

Converting it into an EMR based algorithm: This was the most challenging part. Because there was a pre-existing sepsis algorithm in the EMR - it took an inordinately long time to convince everybody that (a) pediatrics is different from adults, (b) SIRS criteria and septic shock criteria and management is different in children and (c) it is important that we do not extrapolate experience from adult implementation of sepsis to pediatrics. This took a year.

In the meantime there were children in early sepsis who were being missed in the ER and on the inpatient units - so we implemented a paper-based version of the algorithm, gave out pocket cards for SIRS criteria and PEWS and pushed forward with the non-EMR based implementation and dissemination. The advantage was that as soon as the EMR algorithm was available, we could deploy it immediately.

Results
Please note that although we developed the algorithm very early, the EMR portion took a very long time. Thus there was a period where we intentionally chose to deploy the algorithm as a paper based process to address pediatric sepsis as
we could not ethically wait once the algorithm was developed. The advantage of EMR based algorithm is that every event is time stamped and data on thousands of visits can be collected in real time. The EMR based algorithm was initiated on July 1st, 2014. The run-in period ended on July 15th, 2014. Thus we have data from July 16th to July 20th, 2014 at the time of this submission.

1. Attachment #1 - The algorithm that has the age specific vitals, definition of pediatric SIRS, PEWS criteria, the flow-diagram regarding events subsequent to PEWS score and finally the sepsis order set. The second page (on the back side) is the evidence supporting the algorithm in peer literature and is the flow diagram for the early goal directed therapy.

2. Attachment # 2 - is the same algorithm but for inpatient use - slightly different as following the PEWS score, the nurses are asked to page the resident/attending on call rather than inform the attending which is what happens in the ER

1. Please note that attachments # 1 and 2 can be used in institutions that do not have EMR capabilities

2. Attachment # 3 - is the charter for the entire project with project time line and responsibilities

3. Attachment # 4 - is the excel file with a list of stakeholders - this describes the truly multi-disciplinary nature of our group

4. Attachment # 5 - these are case studies of patients who were missed because of various reasons. We used real cases to underscore the importance and imperativeness to address pediatric sepsis. Please note that in parenthesis are areas where individual patients could have been identified earlier in their disease course if we had a pediatric sepsis algorithm. These cases were before we initiated the algorithm.

5. Attachment # 6 - While we were in the process of defining the algorithm, we performed a detailed analysis of barriers and facilitators for successful implementation of this algorithm. Attachment # 6 lists the details of this process

6. Attachment # 7 - is an example of the DMAIC (six-sigma) process

7. Attachment # 8 - is a pdf of the sepsis badge that we circulated when we realized that there will be a delay in the implementation of the EMR based algorithm. We used this along with attachments # 1 and 2 to disseminate information about the algorithm in the ER and inpatient units.

8. Attachment # 9 - is the detailed analysis of the pre-intervention state - i.e. details regarding the work burden and describe the sensitivity/specificity of SIRS criteria. This was done to demonstrate that ~ 14% of patient visits will trigger SIRS alerts but SIRS by itself is not optimal as a screening tool. This laid the basis for PEWS to be incorporated in the algorithm to reduce the false positives and false negatives. These results were also presented at PAS meeting in May 2014 - please note that this allowed me to provide scholarship opportunities to my team members - the "carrot"

9. Attachment # 10 - This is the results of a study we performed to convince the stakeholders that it is indeed feasible to perform PEWS in the ED (takes less than a minute) and the scores are reliable - this study allowed us to get buy-in from nursing and as a "carrot" it allowed us to present it at PAS meeting with nurses as co-investigators

10. Attachment # 11 - describes the "halo-effect" - the dissemination of PEWS was successful that it now is a standard practice to perform PEWS by nursing on all inpatient admits regardless of suspicion of sepsis. Thus the...
numbers of PEWS can be higher than numbers of patients with SIRS. This is very important as there is robust
data that use of PEWS on the inpatient units has reduced the number of code activations and averted fatal
cardio-respiratory events.

11. Attachment # 12 - These are results of post-intervention on the inpatient units. Please note that the EMR issue
finally got resolved in July 2014. We have provided results post-intervention from July 16th to 20th as these are
the most updated. The ER results are presented there as well. We fully expect our results to remain robust and
will be happy to present them if selected.

Cost/Benefit Analysis
We did not perform a formal cost analysis and we recognize that time spent on this project is time taken away from
others which has true costs. However, this project was identified by every stakeholder as being of importance and we
submitted this for an EMR award within the institution so that IT could prioritize EMR enhancements. This project
moved high up and was rated as being most important thus we were able to secure IT support.
This project should be considered as any QI process improvement project and the only costs were the time spent in the
project implementation by the stakeholders. We did not incur any additional costs except costs of printing the posters
and badges - ~ $100 per year

Advice and Lessons Learned
1. The most important lesson learned was that what appears to be an area/issue that needs to be addressed is a
matter of perspective - although there were seen out of 8 deaths due to sepsis who could have been identified
this algorithm (see case studies attachment), there were a lot of false positives - i.e. patients who satisfy the SIRS
criteria but do not develop sepsis. So, we had to pull data over a period of two years (we analyzed ~200,000 ED
visits) to describe the extent of the problem - we demonstrated that although ~14% of all our ED visits will
trigger the alert, if PEWS were to be added - and an experienced resource such as the charge nurse were to
perform a PEWS then we will correctly identify those who need treatment/intervention immediately and
separate the false positives from true negatives

2. We need to demonstrate that integration of PEWS by the in the patient evaluation which was over and above
the current scope of work for the nurses did not adversely affect patient care - i.e. balancing measure. We
performed a inter- and intra-rater reliability study by involving the front line nurses and demonstrated that it
took less than a minute to perform PEWS and PEWS scores on same patient by two providers remained
consistent. This study and its findings were very important and it is because of this that we got nurse buy-in
across the institution. Indeed, we are pleased to say that PEWS has now become a part of the entire institutional
culture and this halo effect has spread to even assessments of non-septic patients. Most importantly - this
allowed us to reach a tipping point and nurses from the ED and other units would communicate with each other
to support and educate the units that were low on performing PEWS and following the algorithm

3. If EMR does not happen - have a plan B - It was taking a long time for the EMR portion of this project while the
entire ER and the institution was ready to implement this. Moreover, we got quite a few anecdotal
communications that we should forge ahead without waiting for EMR. I was hesitant because EMR would allow
for immediate data acquisition, however patient care was being compromised. So we modified the process,
created hand-outs, badges and posters about the algorithm - and residents, nurses and faculty started using this
algorithm despite lack of IT support

4. Data - It is important to provide data that is local (extent of the problem), relevant (case studies), timely and
transparent so that buy in is sustained. The case studies demonstrated that if the algorithm had existed then
potentially most of the morbidity and mortality could have been avoided
5. Chose the appropriate stakeholders - we chose the relevant stakeholders including experts in QI methodology and senior administration leaders including hospital CEO, VPMA, CIO, Pediatrician-in-Chief and Surgeon-in-Chief to get their buy in

6. Create - innovative carrots - avoid the stick! - We made sure that we appreciated and advertised that effort adequately. We developed innovative carrots - for instance - data from this project was made available for nurses to present it at nursing research meetings and also used for evaluation and promotion. Indeed, 6 nurses from my institution are co-authors on the PEWS feasibility and reliability manuscript. For physicians, submitted two manuscripts (one on PEWS feasibility and other of the epidemiology of SIRS), two abstracts that were accepted at international research meetings (PAS) and provided authorship opportunities.

Sustainability
We have identified pediatric sepsis management as the number one priority
Through the Center for Quality and Innovation which I direct, we will be monitoring all outcomes including change in morbidity and mortality, length of stay, use of resources (cost-effectiveness) on an ongoing basis. We have established a data repository that we can query in real time as the amount of data to be monitored is massive - we have ~90,000 ER visits and ~12-15,000 inpatient admissions. An estimated 14% will have SIRS criteria and will trigger the alerts but only 2% will have sepsis - thus the burden and the balancing measures - which is the unintended consequences of initiating this process will need to be monitored. We will be monitoring on going education and watch out for "alert fatigues".

Next steps:
1. We will be publishing our results on reliability and feasibility of performing PEWS in the ER - manuscript being submitted to Pediatric Emergency Care
2. We will be submitting our manuscript on the ER SIRS alerts to JAMA Pediatrics
3. We have been approached by the Quality Committee of our institution to share our algorithm with ~ 70 other institutions that are under the common ownership - we have been in discussions with them to modify the process to adapt to local conditions - for instance, not all of the participating hospitals have EMR, thus our experience with the non-EMR based algorithm will be very useful
4. The official start date of the EMR based algorithm was July 2014. I have shared the results under results section. We will be happy to share even more robust data. Because the EMR based algorithm allows for immediate data retrieval - we are happy to share that since July 16th, 1058 patients presented to ER, 12.5% (133) had SIRS. The EMR algorithm successfully identified 100% of them and 133 page alerts were sent to the Charge Nurse. 131 PEWS were performed with a success rate of 98%. The numbers of inpatient units post-intervention are given in attachment # 12.

Tools to Download
- Attachment 1: Early Recognition and Timely Management Algorithm – ED
- Attachment 2: Early Recognition and Timely Management Algorithm – Inpatient
- Attachment 3: Sepsis Project Charter
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- Attachment 10: PEWS feasibility
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- Attachment 12: Post Intervention Data
**Score PEWS** - Add 1 to PEWS if: Nursing concern OR Parental concern OR Pre-disposing conditions (immune-compromised)

<table>
<thead>
<tr>
<th>Modified PEWS</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Behavior</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Playing/appropriate OR</td>
<td>Playing/appropriate OR</td>
<td>Fussy, but consolable</td>
<td>Irritable, difficult to console</td>
<td>Lethargic/confused</td>
</tr>
<tr>
<td>Sleeping but arousable</td>
<td></td>
<td></td>
<td></td>
<td>Reduced response to pain</td>
</tr>
<tr>
<td><strong>Cardiovascular</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pink OR Capillary refill 1-2 sec</td>
<td>Pale OR Capillary refill 3 seconds</td>
<td>Gray/cyanotic OR Capillary refill 4 sec OR Tachycardia at or above normal HR for age</td>
<td>Gray/cyanotic OR Mottled or Capillary refill 5 sec OR Tachycardia &gt;10 above normal HR for age OR HR&lt;60 for ages 4 &amp; older</td>
<td></td>
</tr>
<tr>
<td><strong>Respiratory</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within normal parameters No accessory muscle use No retraction</td>
<td>RR at or above normal RR for age OR Accessory muscle use OR Any supplemental O2</td>
<td>RR &gt;10 above normal RR for age OR Retractions OR 40% FiO2 OR Breathing treatment Q2</td>
<td>RR&lt;20 for infants &amp; toddlers, &lt;10 for ages 4 &amp; older with retraction or grunting OR 50% FiO2/High-Flow ≥ 4 l/m OR Continuous Albuterol</td>
<td></td>
</tr>
</tbody>
</table>

### PEWS in the ED

#### 0 – 2
1. Repeat PEWS in 30 minutes
2. Stop scoring if PEWS remains between 0 – 2

#### 3 – 5
1. Consider CBG with lactate
2. Consider Peds Sepsis Order Set
3. Repeat PEWS in 30 minutes

#### 6 – 9
1. Initiate Peds Sepsis Order Set
2. Move patient to trauma bay
3. Repeat PEWS in 30 minutes

### PEDS SEPSIS ORDER SET:
1. IV bolus 20ml/kg NS over 20 minutes or as fast as possible (can give up to 60 ml/kg of NS in 1st hour).
2. Stat CBG with lactate, electrolytes, calcium and glucose.
3. Order stat IV broad-spectrum antibiotics.
4. Reevaluate patient between IV boluses.
5. Strongly consider additional resources to bedside (Attendings, Seniors, PICU/NICU and RRT).

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**SIRS definition:** Temperature >38.5°C or < 36°C and/or abnormal WBC AND abnormal HR and/or abnormal RR for age (see table below).

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Heart rate (beats/min)</th>
<th>Respiratory rate (breaths/min)</th>
<th>Systolic Blood Pressure mm/Hg</th>
<th>WBC x 1000/mm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 1 wk</td>
<td>&gt; 180</td>
<td>&gt; 50</td>
<td>&lt; 65</td>
<td>&gt; 34 or &lt; 5</td>
</tr>
<tr>
<td>1 wk to 1 mo</td>
<td>&gt; 180</td>
<td>&gt; 40</td>
<td>&lt; 75</td>
<td>&gt; 19.5 or &lt; 5</td>
</tr>
<tr>
<td>1 mo to 1 yr</td>
<td>&gt; 180</td>
<td>&gt; 34</td>
<td>&lt; 100</td>
<td>&gt; 17.5 or &lt; 5</td>
</tr>
<tr>
<td>1 - 5 yrs</td>
<td>&gt; 140</td>
<td>&gt; 22</td>
<td>&lt; 94</td>
<td>&gt; 15.5 or &lt; 6</td>
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<tr>
<td>6 - 12 yrs</td>
<td>&gt; 130</td>
<td>&gt; 18</td>
<td>&lt; 105</td>
<td>&gt; 13.5 or &lt; 4.5</td>
</tr>
<tr>
<td>13 - 18 yrs</td>
<td>&gt; 110</td>
<td>&gt; 14</td>
<td>&lt; 117</td>
<td>&gt; 11.5 or &lt; 4.5</td>
</tr>
</tbody>
</table>

**PEWS in the ED**

0 – 2
1. Repeat PEWS in 30 minutes
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6 – 9
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2. Move patient to trauma bay
3. Repeat PEWS in 30 minutes

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**PEWS in the ED**

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1. Consider CBG with lactate
2. Consider Peds Sepsis Order Set
3. Repeat PEWS in 30 minutes

6 – 9
1. Initiate Peds Sepsis Order Set
2. Move patient to trauma bay
3. Repeat PEWS in 30 minutes
0 min
- Recognize decreased mental status and perfusion. Begin high flow O₂. Establish IV/IO access.

5 min
- **Initial resuscitation**: Push boluses of 20 cc/kg isotonic saline or colloid up to & over 60 cc/kg until perfusion improves or unless rales or hepatomegaly develop. Correct hypoglycemia & hypocalcemia. Begin antibiotics.
- **shock not reversed?**

15 min
- **Fluid refractory shock**: Begin inotrope IV/IO. use atropine/ketamine IV/IO/IM to obtain central access & airway if needed. Reverse cold shock by titrating central dopamine or, if resistant, titrate central epinephrine. Reverse warm shock by titrating central norepinephrine.
- **shock not reversed?**

60 min
- **Catecholamine resistant shock**: Begin hydrocortisone if at risk for absolute adrenal insufficiency

Monitor CVP in PICU, attain normal MAP-CVP & ScvO₂ > 70%

- **Cold shock with normal blood pressure**:
  1. Titrate fluid & epinephrine, ScvO₂ > 70%, Hgb > 10 g/dL
  2. If ScvO₂ still < 70%
     - Add vasodilator with volume loading (nitrovasodilators, milrinonine, imrinone, & others)
     - Consider levosimendan
- **Cold shock with low blood pressure**:
  1. Titrate fluid & epinephrine, ScvO₂ > 70%, Hgb > 10 g/dL
  2. If still hypotensive consider norepinephrine
  3. If ScvO₂ still < 70% consider dobutamine, milrinone, enoximone or levosimendan
- **Warm shock with low blood pressure**:
  1. Titrate fluid & norepinephrine, ScvO₂ > 70%
  2. If still hypotensive consider vasopressin, terlipressin or angiotensin
  3. If ScvO₂ still < 70% consider low dose epinephrine

- **Persistent catecholamine resistant shock**: Rule out and correct pericardial effusion, pneumothorax, & intra-abdominal pressure >12 mm/Hg.
  - Consider pulmonary artery, PICCO, or FAD catheter, &/or doppler ultrasound to guide fluid, inotrope, vasopressor, vasodilator and hormonal therapies.
  - Goal C.I. > 3.3 & < 6.0 L/min/m²
- **shock not reversed?**

- **Refractory shock**: ECMO
SIRS definition: Temperature >38.5°C or < 36°C and/or abnormal WBC AND abnormal HR and/or abnormal RR for age (see table below).

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Heart rate (beats/min)</th>
<th>Respiratory rate (breaths/min)</th>
<th>Systolic Blood Pressure mm/Hg</th>
<th>WBC x 1000/mm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 1 wk</td>
<td>&gt; 180</td>
<td>&lt; 100</td>
<td>&gt; 50</td>
<td>&gt; 34 or &lt; 5</td>
</tr>
<tr>
<td>1 wk to 1 mo</td>
<td>&gt; 180</td>
<td>&lt; 100</td>
<td>&gt; 40</td>
<td>&gt; 19.5 or &lt; 5</td>
</tr>
<tr>
<td>1 mo to 1 yr</td>
<td>&gt; 180</td>
<td>&lt; 90</td>
<td>&gt; 34</td>
<td>&gt; 17.5 or &lt; 5</td>
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<tr>
<td>1 - 5 yrs</td>
<td>&gt; 140</td>
<td>N/A</td>
<td>&gt; 22</td>
<td>&gt; 15.5 or &lt; 6</td>
</tr>
<tr>
<td>6 - 12 yrs</td>
<td>&gt; 130</td>
<td>N/A</td>
<td>&gt; 18</td>
<td>&gt; 105 or &lt; 4.5</td>
</tr>
<tr>
<td>13 - 18 yrs</td>
<td>&gt; 110</td>
<td>N/A</td>
<td>&gt; 14</td>
<td>&gt; 117 or &lt; 4.5</td>
</tr>
</tbody>
</table>

Score PEWS - Add 1 to PEWS if: Nursing concern OR Parental concern OR Pre-disposing conditions (immune-compromised)

<table>
<thead>
<tr>
<th>Modified PEWS</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavior</td>
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<tr>
<td>Cardiovascular</td>
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<tr>
<td>Respiratory</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PEWS for In-Patient

0 – 2
1. Repeat PEWS in 30 minutes
2. Stop scoring if PEWS remains between 0 – 2
3. Notify resident PEWS has been performed

3 – 5
1. Inform Floor Senior/Attending to assess the patient
2. Consider CBG with lactate
3. Consider Peds Sepsis Order Set
4. Repeat PEWS in 30 minutes

6 – 9
1. Inform Floor Senior/Attending to assess the patient
2. Initiate Peds Sepsis Order Set
3. Activate RRT
4. Repeat PEWS in 30 minutes

PEDS SEPSIS ORDER SET
1. IV bolus 20ml/kg NS over 20 minutes or as fast as possible (can give up to 60 ml/kg of NS in 1st hour).
2. Stat CBG with lactate, electrolytes, calcium and glucose.
3. Order stat IV broad-spectrum antibiotics.
4. Reevaluate patient between IV boluses.
5. Strongly consider additional resources to bedside (Attendings, Seniors, PICU/NICU and RRT).
Recognize decreased mental status and perfusion. Begin high flow O₂. Establish IV/IO access.

**Initial resuscitation:** Push boluses of 20 cc/kg isotonic saline or colloid up to & over 60 cc/kg until perfusion improves or unless rales or hepatomegaly develop. Correct hypoglycemia & hypocalcemia. Begin antibiotics.

**shock not reversed?**

**Fluid refractory shock:** Begin inotrope IV/IO. use atropine/ketamine IV/IO/IM to obtain central access & airway if needed. 
Reverse cold shock by titrating central dopamine 
or, if resistant, titrate central epinephrine

Reverse warm shock by titrating central norepinephrine.

**shock not reversed?**

**Catecholamine resistant shock:** Begin hydrocortisone if at risk for absolute adrenal insufficiency

Monitor CVP in PICU, attain normal MAP-CVP & ScvO₂ > 70%

---

**Cold shock with normal blood pressure:**
1. Titrate fluid & epinephrine, ScvO₂ > 70%, Hgb > 10g/dL
2. If ScvO₂ still < 70%
   Add vasodilator with volume loading (nitrovasodilators, milrinone, imriline, & others)
   Consider levosimendan

**Cold shock with low blood pressure:**
1. Titrate fluid & epinephrine, ScvO₂ > 70%, Hgb > 10g/dL
2. If still hypotensive consider norepinephrine
3. If ScvO₂ still < 70% consider dobutamine, milrinone, enoximone or levosimendan

**Warm shock with low blood pressure:**
1. Titrate fluid & norepinephrine, ScvO₂ > 70%
2. If still hypotensive consider vasopressin, terlipressin or angiotensin
3. If ScvO₂ still < 70% consider low dose epinephrine

**Persistent catecholamine resistant shock:** Rule out and correct pericardial effusion, pneumothorax, & intra-abdominal pressure > 12 mm/Hg.
Consider pulmonary artery, PICCO, or FATD catheter, &/or doppler ultrasound to guide fluid, inotrope, vasopressor, vasodilator and hormonal therapies.
Goal C.I. > 3.3 & < 6.0 L/min/m²

**shock not reversed?**

**Refractory shock:** ECMO
Kick-Off Meeting
Sepsis Work Group
**Project Charter**

**Business Case:** Early identification and implementation of the sepsis protocol/pathway, will provide positive outcomes for patients cared for at CHM. The quality of care rendered will be positively affected by having a standard protocol/pathway.

**Problem Statement:**
Late identification and diagnosis of sepsis, creates more challenging medical management and potentially poor outcomes.

Standardized protocol/pathway not in place.

How often is the problem occurring?
Where is the problem occurring?
Who is it impacting?

Current defect rate: If unknown may put in XX’s

**Goal Statement**
Develop and implement a sepsis pathway, to standardize the care and treatment of this population of patients, to provide for better outcomes, as evidenced by:

- ____% decrease in deaths related to sepsis
- ____% decrease # of SRM related to sepsis

Implementation will provide a collaborative multi-disciplinary approach to the care and treatment of septic patients (Physicians, nurses, respiratory therapy).

When do you want to have the improvement in place?
What measurable business impact will the improvement have? Type? Magnitude?

For example: Deliver an improved process to reduce cycle time in a business process by 50% by 12/31/11

**Scope (In and Out):** In scope, early identification of septic patients at the time of presentation. Activation of a standardized protocol/pathway for all septic patients, except those in the NICU.

**Process (Start and End Point):**
Process Start Point:
Process End Point:

**Estimated Financial Benefit:**
Unit cost reduction, Cost cut
Productivity /scale Calculation used

<table>
<thead>
<tr>
<th>PHASE</th>
<th>Completion Date</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEFINE</td>
<td>1 month Mar-April</td>
<td>GREEN</td>
</tr>
<tr>
<td>MEASURE</td>
<td>1 month April-May</td>
<td>YELLOW</td>
</tr>
<tr>
<td>ANALYZE</td>
<td>1 month June</td>
<td>RED</td>
</tr>
<tr>
<td>IMPROVE</td>
<td>2 month June/July</td>
<td>GREEN</td>
</tr>
<tr>
<td>CONTROL</td>
<td>August/Sept.</td>
<td>GREEN</td>
</tr>
</tbody>
</table>

**STATUS Legend**
- Green: On Track
- Yellow: 5 days – 2 weeks behind
- Red: > 2 weeks behind
Roles & Responsibilities

- Champions
- Sponsors
- Projects
- Clinical Biostatistician
- Project Team Members (SMEs)
- Green Belts
- Part-Time Project Leaders
- Selected Employees

Project “Owners”
Roles & Responsibilities
Green Belt Team Leaders

- Facilitate workflow of project
- Meets weekly or as needed with project sponsor, Biostatistician and with project team
- With the project sponsor, be accountable for results through disciplined project management and good team facilitation
- Provide “just-in-time” skills training to team members as needed
- Accountable for reporting project progress and coordinating communication to project stakeholders
- Ensure documentation of project maintained, prepares and submits deliverables, including executive presentations
- Acts as a change agent
- Raises conflicts or major issues in a timely manner to the project sponsor and makes recommendations for how to move forward
Roles & Responsibilities
Team Members

- Commitment of time project
- Meets with other team members; embraces the ground rules established by the team
- Actively supports project goals and communicates about project with unit, area where they work
- Supports data collection, process mapping and analysis as requested by team leader
- Helps in the preparation of project deliverables and may also participate in executive presentations
- Helps develop the appropriate solutions/improvements and actively supports the implementation
- Acts as a change agent
Roles & Responsibilities
Biostatistician/Data Analyst

• With the support of the project sponsor, provides strategic direction and leadership for project team

• With the project sponsor, accountable for results through disciplined project management and use of appropriate tools

• Provides “just-in-time” skills training to team members with Green Belt

• Accountable for reporting project progress and coordinating communication to project stakeholders

• Maintains all documentation from project, prepares and submits deliverables, including executive presentations

• Manages implementation of solutions, ensures transition of improved process to the business

• Acts as a change agent
Team Ground
Rules/Expectations

• Attendance
  – Crucial to project success
  – Time commitment

• Meeting determination?
  – Biweekly?

• Minutes will be sent out the following day with any assignments and deliverable dates.

• No idea is a dumb idea

• Be willing to trial new things
DMAIC Methodology

DEFINE
“Identify process issues and customer requirements”

ANALYZE
“Identify causes for performance shortfalls”

IMPROVE
“Identify and implement solutions”

CONTROL
“Monitor new process and develop procedures”

MEASURE
“Measure current performance”
1.0 - Define Opportunities

Objectives
- Identify and/or validate the improvement opportunity
- Develop the business processes
- Define critical to quality customer requirements (CTQ’s)
- Build an effective project team

Main Activities
- Validate/Identify Business Opportunity
- Validate/Develop Project Charter
- Identify and Map Processes
- Identify "Quick Win" and Refine Process
- Translate VOC into CCRs
- Develop Team Guidelines & Ground Rules

Potential Tools and Techniques
- Project Charter
- Action Plan
- Process Maps
- Voice of Customer

Key Deliverables
- Project Charter
- Action Plan
- Process Maps
- "Quick-Win" Opportunities
- Voice of Customer
- Critical Customer Requirements
- Prepared Team

Tasks Activities Responsible Start Due Status & Actions
- Plan Quality Data Collection Guide Objective: Develop guide to provide thorough and consistent feedback, and reporting of data
  Lead: Bob
  10/17 Gerry to incorporate comments on:
  - Format readability
  - Available space for recording data
  10/5 Information cannot be found:
  10/7 Patrick located materials. 10/11 GS identified materials as correct.
  10/10 Complete Develop Objective & Outline
  Gather Existing Materials
  Develop Guide & Formats
  Initial Review
  Gerry
  10-2-89
  Gerry
  Penny
  Patrick
  Gerry
  Penny
  10-10-89
  10-16-89
  10-4-89
  10-16-89

10/11 CPI Dept. AH

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Children’s Hospital of Michigan
# 2.0 - Measure Performance

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Main Activities</th>
<th>Potential Tools and Techniques</th>
<th>Key Deliverables</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Identify critical measures needed to meet the CTQ's &lt;br&gt; - Develop a methodology to effectively collect data to measure process performance &lt;br&gt; - Understand the elements of the six sigma calculation &lt;br&gt; - Establish baseline sigma for the process</td>
<td>- Identify Input, Process and Output Indicators &lt;br&gt; - Develop Operational Definition &amp; Measurement Plan &lt;br&gt; - Plot and Analyze Data &lt;br&gt; - Determine if Special Cause Exists &lt;br&gt; - Determine Sigma Performance &lt;br&gt; - Collect Other Baseline Performance Data</td>
<td>- Check Sheets &lt;br&gt; - Histograms &lt;br&gt; - Sigma Calculations</td>
<td>- Input, Process and Output Indicators &lt;br&gt; - Operational Definitions &lt;br&gt; - Data Collection Formats and Plans &lt;br&gt; - Baseline Performance &lt;br&gt; - Productive Team Atmosphere</td>
</tr>
</tbody>
</table>

### Sigma Calculations

$$DPMO = \frac{Defects}{Units \times Opportunities \ per \ Unit} \times 1,000,000$$

$$DPMO = \frac{.496 + 246}{2020} \times 1,000,000$$

$$= 184.158$$

$$\text{Process Sigma} = 2.4$$
3.0 - Analyze Opportunity

Objectives
- Stratify and analyze the opportunity to identify a specific problem
- Define a problem statement
- Identify and validate the “real” root causes

Main Activities
- Stratify Process
- Stratify Data & Identify Specific Problem
- Develop Problem Statement
- Identify Root Causes
- Design Root Cause Verification Analysis
- Validate Root Causes
- Enhance Team Creativity & Prevent Group-Think

Potential Tools and Techniques
- Cause & Effect Analysis (Fishbone Diagram)
- Process Analysis

Key Deliverables
- Data Analysis
- Process Maps
- Validated Root Causes
- Problem Statement

<table>
<thead>
<tr>
<th>Process Step</th>
<th>Value Added</th>
<th>Non-Value Added</th>
<th>Operational Value Added</th>
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<tbody>
<tr>
<td>Login Application</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Prioritize Application</td>
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<tr>
<td>Review Application</td>
<td>★</td>
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</tr>
<tr>
<td>Approve Application</td>
<td>★</td>
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<tr>
<td>Print Policy</td>
<td>★</td>
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<tr>
<td>Application Quality Control</td>
<td>★</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mail Policy</td>
<td>★</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.0 - Improve Performance

Objectives

- Identify, evaluate, and select the right improvement solutions
- Develop a change management approach

Main Activities

- Generate Solution Ideas
- Determine Solution Impacts: Benefits
- Evaluate and Select Solutions
- Develop Process Maps & High Level Plan
- Develop and Present Storyboard
- Communicate Solutions to all Stakeholders

Potential Tools and Techniques

Sources of Solutions

Cost Benefit Analysis

Key Deliverables

- Process Maps & Documentation
- Implementation Milestones
- Improvement Impacts & Benefits
- Storyboard
- Change Maps
5.0 - Control Performance

Objectives
- The importance of planning
- Executing against a plan
- Determine the approach to achieve the results
- Capture lessons learned
- Solidify the changes for continued improvement

Main Activities
- Develop Pilot Plan & Pilot Solution
- Verify Reduction in Root Cause Sigma Improvement
- Develop Implementation Work plan activities
- Pilot Process Control Systems
- Do the Work plan activities
- Integrate Lessons Learned
- Identify Next Steps & Plan for Remaining Opportunities

Potential Tools and Techniques
- Process Control Systems
- Standards and Procedures
- Training
- Team Evaluation
- Change Implementation Plans
- Potential Problem Analysis
- Pilot and Solution Results
- Success Stories
- Replication Opportunities
- Standardization Opportunities

Key Deliverables
- Process Control Systems
- Standards and Procedures
- Training
- Team Evaluation
- Change Implementation Plans
- Potential Problem Analysis
- Pilot and Solution Results
- Success Stories
- Replication Opportunities
- Standardization Opportunities

Implementation Workplan
Target Timeline for GB Projects

Define
- Project is scoped and team identified, end to end “as-is” process is documented, customer needs and requirements are identified.

Measure
- Input, process, and output measures are identified, data is collected, and current process performance is displayed.

Analyze
- Process and data are analyzed, value add and non-value add activities are identified, causes of poor performance are understood.

Improve
- Process solutions are determined, “to-be” process map is developed, solutions are implemented into the organization.

Control
- Process monitoring plan is developed, dashboard is implemented, and procedures are implemented to ensure highest levels of performance.

~1-3 Weeks
- Define

~3-5 Weeks
- Measure

~1-2 Weeks
- Analyze

~3-5 Weeks
- Improve

~1-2 Weeks
- Control

Projects targeted to be in “Control” by date
Green Belt Deliverables

Each phase’s deliverables needs to be completed before moving to the next phase; the Green Belt will receive support from DCG to deliver these tools.

**Define**
- Project Charter
- SIPOC
- As-Is Process Map
- Voice of Customer
- Customer Requirements

**Measure**
- Input, Process, Output Measures
- Measure Collection Plan
- Display Process Performance
- Quick Wins

**Analyze**
- Process Value Analysis
- Cause and Effect Analysis
- Documented Root Causes

**Improve**
- Solution Selection Matrix
- Cost/Benefit Analysis
- To-Be Process Map
- Implementation Plan

**Control**
- Process Monitoring Plan
- Dashboard
- Standardized Procedures
SIPOC: Elements Common to All Processes

Who PROVIDES the input?

What is provided to START the process?

What STEPS are Included in the Process today? (high level)

WHAT does the customer receive? (Think of their CCR’s)

WHO are the customers of the process?

Supplier
(Who)

Input
(Use Nouns)

Process
(Verbs)

Output
(Use Nouns)

Customer
(Who)

List Supplier
List Supplier
List Supplier
List Supplier
List Input
List Input
List Input
List Outputs
List Outputs
List Outputs
List Outputs
List Customer
List Customer
List Customer
List Customer

Step 1:
Step 2:
Step 3:
Step 4:
Step 5:
Step 6:
Step 7:
SEPSIS COLLABORATIVE POINT PEOPLE

Project Lead: Dr Prashant Mahajan
EMR: Dr. Srivasan Suresh, Kathy Dodds, Deborah Hutcherson
Rapid Response Team: Dr Brad Tilford
Respiratory Therapy: Rita Peterson
Lab: Janet Poulik
Physician Leadership: Dr.Rudolph Valentini, Dr.Tonya Touchstone, Dr. Ashok Sarniak, Dr. Lynn Smitherman
Nursing Leadership: Damita Williams, Brenda Vanwallaghen
Intensivists: Dr.Jeff Clark, Dr. Kevin Valentine, Dr. Lilia Dejesus
Surgical Service: Dr.R.Gonzalez
Infectious Disease Service: Dr. Basim Asmar
Quality: Marlene Ercolani
Data: William Rumao, Hanadi Dorra, Elizabeth Duffy
Pharmacy: Leah Steinke
Nursing Education: Naomi Compton, Beth Page
Nursing Practice: Mindi Johnson, Deb Ryan, Janel Kooienga, Tina Kaunelis
Six Sigma Greenbelt support: Sharon Joseph, Annette Hartner
Case Studies

**Case #1**
GR, 2 yr old with hx of illness X 5 days
10:53 ER presentation: 39.5 (T), 150, 28 (PEWS trigger to charge nurse)
Labs drawn, .9NS bolus over 60min ordered, + strep culture
12:30 WBC: 3.2
1340 IV D%.3 @ 75cc/hr, Hematology consult
18:24 Adm order, dx Strep pharyngitis with thrombocytopenia, started IV Amp
1953 Transferred to inpt unit, eating a popsicle
On inpt unit: unable to obtain BP, O2 sat 78%
2047 Pt found not breathing, code called

**Case #2**
EA, 23month old with eczema herpeticum, failed outpt treatment
ER: 39.5 (T), 140, 36 (PEWS trigger to charge nurse)
Cultures; wound, blood and HSV, started on IV Acylovir and Clindamycin
8/5-8/6 T-37.9-40.0, tachycardia and tachypneic (continued trigger/alert)
8/7-2300 Ill appearing, 80/44.112, 60, 36.7(ax)
8/8- 0300 94/63, 180, 60, 38.7(ax) PICU contacted
0700 code called
Case #3
AB, 2 yr old with lymphoma, s/p bone marrow transplant, GVHD
4/1 VS: 38.5 ax, 168, 78 (PEWS trigger to charge nurse)
4/2 Tachypnea, nasal flaring, abdominal distention, chest nodular treating with anti fungals, mental status changes
4/3 Requiring O2 at 1-2 liter to maintain sats, 39.8, 184, 52-60
4/4 Hypoxia, re-breather mask applied, Attending and fellow informed, mom refusing intervention
  2100 36.7, 152, 106/57,68, 91% on 5 liters
  2300 apnea episode with mental status changes, mom refused CBG’s
  4/5 0114 Gases 7.29/61/39/28.7/5.9
  0226 Code called

Case #4
MA, 13 year old adm to ER with abdm pain, ruptured appendix suspected, WBC 23
ER VS: 37.8, 108,20, 118/82. IV bolus. Surgical consult: NPO, triple antibiotics
Repeat VS 38, 128, 24, 106/40, WBC 20 (PEWS trigger to charge nurse)
ED attending suspicious of sepsis, contacted surgery for possible ICU placement,
sent to general surgical floor, 38.6, 128, 106/54 (Trigger to charge nurse), OR, in AM
  0600 rounds Surgery informed of pt VS, per surgery, OR that am. OR bumped until pm.
  RRT called at 1410
  Taken to OR, found to have a ruptured appendix, peritonitis and abscess formation.
  Pt required an extended hospital stay and home TPN
| PEOPLE |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Knowledge deficit | Not focused on Sepsis, not aware of early S/S, no knowledge of SIRS, staff too busy to in-service | Practice in silo only doing a small piece, i.e. VS, may not recognize septic pt | May not know when to escalate up so delay in patient being seen by physician | Delay in treatment |
| Availability of physician staff | Competing priorities, Delay in pt assessment | Multiple care issues, delay in diagnosis | Coverage spread thin, delay in treatment implementation |
| Lack of compliance with hand off communication | Incomplete handoff, SBAR used ineffective or inefficient, RN not always reporting off | Lack of time, knowledge, commitment, physicians and RN handoff inadequate, Delay in communication to MD | Poor culture, short staffed, delay in treatment |
| Short staffing (all services) | Lack of staff to evaluate patients | Delay in orders being placed | Delay in treatment |
| Lack of empowerment | Poor culture, RN may not be confident to alert MD, RN’s not experienced with this emergent situation, Leadership not aware of poor culture |

| PROCESS/METHOD |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Variation in taking vital sign, specifically temperature | Varied standard of practice and technique | Training not put into practice, misinformation | Retraining needs to occur, standards not always clear, delay in data in EMR | Complex pts delay in treatment |
| Variation for frequency of vital signs | Variation in standard of care | Missed information | Delay in treatment | Delay in diagnosis |
| Patient transfer during shift change | Adm order placed at end of ER shift | Completing work-up | Doesn’t want new patients | Increased RN/MD workload |
| Charge nurse competing priorities | Delay seeing patient because of other job duties | Delay communicating to MD | Delay in diagnosis | Delay in treatment |

| TECHNOLOGY |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Physician not aware of abnormal vitals | Not always looking in EMR | Delay in diagnosis | Delay in treatment |
| Lack of ability to monitor patients (telemetry) | No visual prompt to alert staff | Delay in communication | Delay in diagnosis | Delay in treatment |
| Delay of VS in EMR | Staff batching VS due to lack of WOW’s | Delay in recognizing abnormal labs | Delay in communication with Charge nurse | Delay in notification to physicians | Delay in Diagnosis and treatment |

| MEASUREMENT |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| No measurable criteria |

<p>| ENVIRONMENT |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| ED volume | Large patient volume | Delay in triage | Delay in VS | Delay in physician notification | Delay in Diagnosis and treatment |
| No designated area in ED | No designated area identified | Patients mixed in with less acute pt | Delay in VS | Delay in physician notification | Delay in Diagnosis and treatment |</p>
<table>
<thead>
<tr>
<th>Phase II Sepsis Pathway</th>
<th>Comments: Answer the question. WHY is this a barrier?</th>
<th>Comments: Answer the question. WHY is this a barrier?</th>
<th>Comments: Answer the question. WHY is this a barrier?</th>
<th>Comments: Answer the question. WHY is this a barrier?</th>
<th>Comments: Answer the question. WHY is this a barrier?</th>
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</thead>
<tbody>
<tr>
<td><strong>PEOPLE</strong></td>
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<tr>
<td>Knowledge deficit</td>
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<tr>
<td>Variation in practice</td>
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<tr>
<td>IV team availability</td>
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<td>Staff availability to start IV or IO</td>
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<td>Personal bias</td>
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<td>Fear of negative data</td>
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</tr>
<tr>
<td>Lack of personnel</td>
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<tr>
<td>Lack of buy in</td>
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<tr>
<td><strong>PROCESS</strong></td>
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<tr>
<td>No IV access</td>
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<td>Rapid response team nursed pulled away from assignment</td>
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<tr>
<td>Competing resource utilization</td>
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<tr>
<td><strong>TECHNOLOGY</strong></td>
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</tr>
<tr>
<td>EMR inputting data i.e. PEWS score</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td><strong>MEASUREMENT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative data</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>ENVIRONMENT</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Lack of resources in clinic</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Room assignments on the acute care units</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SUMMARY of BARRIERS**

<table>
<thead>
<tr>
<th>PEOPLE</th>
<th>知能的丧失</th>
<th>Staffing all service lines (IV team, physicians, RRT, PEWS, pathway)</th>
<th>Lack of buy in (triggers, PEWS, pathway)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROCESS</td>
<td>变异的实践,VS,Temp Taking,PEWS,IV starts</td>
<td>Competing resource utilization, physicians, RRT, Charge nurse</td>
<td></td>
</tr>
<tr>
<td>TECHNOLOGY</td>
<td>延迟在输入数据在EMR,VS,PEWS</td>
<td>Physicians not aware of abnormal VS</td>
<td>Lack of telemetry</td>
</tr>
<tr>
<td>MEASUREMENT</td>
<td>无可衡量的准则</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENVIRONMENT</td>
<td>ED volume</td>
<td>Room assignment on acute care units</td>
<td></td>
</tr>
</tbody>
</table>
Sepsis Workgroup Plan

1. What are we trying to accomplish (Model for Improvement) – D of DMAIC
A. Increase awareness and recognition of SIRS, early sepsis
B. Increase appropriate recognition, evaluation and management of sepsis and septic shock

2. Definitions: D of DMAIC
   a. SIRS
      Is there an entity such as early sepsis that we can feasibly define to intervene?
      Step wise triggers – fever with adjusted heart rate – table?
      - Same for respiratory rate
      - Lactate trigger
   b. Sepsis
   c. Severe sepsis
   d. Septic shock
   e. Multiple Organ Dysfunction Syndrome
To do:
   a. Literature review
   b. Definitions and usable table

3. Burden of illness – how often is the problem occurring? – M of DMAIC
   a. Anecdotal cases
      repository
      RCA/IA
   To do: Collect patients – all docs/nurses
      Marlene RCA/IA sepsis
   b. PHNS
      how many years of data
      which ICD-9 codes – see at end
      Marshall Rennick
      ED based studies
      how do we identify the SIRS
      based on bolus/antibiotics/febrile neutropenics?
      Transfers to PICU from ED or floor?
      Is it even worth identifying?
      Should we do this prospectively?
      Predisposed to sepsis
      Immune compromised
      What defines immune compromised status
      Numbers of immune compromised diagnosis for burden
Remember we need these to define outcomes or measures that we will identify pre and post intervention
   Number of cases per site
   Number of cases by spectrum of sepsis – SIRS, severe sepsis etc
   Number of transfers – appropriate/inappropriate
Number who required boluses
Time to first, second, third bolus
Total fluid volume
Time to IV access
Time to pathway triggering
Time to antibiotics
Total LOS – subdivided by ICU and inpatient
Burden of morbidity – intubation, pressors etc

To do: Pull numbers from PHNS
Define Outcomes
4. Scope of impact – D and M of DMAIC
   a. ED
   b. Inpatient floors
   c. Outpatient clinics
   d. ICUs – PI and NI

---------------------   Pre-intervention data   ----------------
Straddle pre and post intervention

5. What is out there - assessment of resources – Help define the intervention (I – idea in Model for Improvement – what changes can we make that will result in improvement)
   a. CHCA collaborative
   b. Sepsis pathways – mainly for severe sepsis/septic shock
   c. Tools/HER alerts etc

6. Create pathway – I – idea in Model for Improvement
   a. Early sepsis/SIRS
   b. Septic shock
   c. Common pathway

7. Outline each step – nursing and physician perspective including
   a. Triggers for initiating pathway – need age based vital signs
      need to make sure that they are accessible and easily understood
   b. Clear entry rules into the pathway – outcome measurement
   c. Clear rules for non-qualification of pathway
   d. Clear order sets for nursing/physicians/labs
      start IV – IO
      Call subspecialists (ICU)
      Bed triggers
      Pharmacy triggers
      Lab order sets (part of the main order set)
      RT triggers
      Intervention triggers – intubation, pressors

I – idea for Model for intervention also P – Plan of PDSA, also Improve of DMAIC

8. Implement pathway – D – Do of PDSA
   a. Education
   b. Dissemination plan

When do you define post-intervention of pathway for measurement?

9. Measure improvement (or lack thereof)
   A – Analyze of DMAIC, S – Study of PDSA
   Consider a run-in period
For next meeting
1. identify groups
2. Identify leaders
3. Define timelines
4. Place the above plan in the context of DMAIC
5. Frequency of meetings
   separate meetings with one common meeting a month
   who should attend
6. CHCA collaborative
7. PEWS
8. Suresh HER links
9. Suzzanne White’s input
10. ICD-9 Codes
11. List of participants
12. Surgery?
<table>
<thead>
<tr>
<th>Age Group</th>
<th>Heart rate (beats/min) Tachycardia</th>
<th>Bradycardia</th>
<th>Respiratory rate (breaths/min)</th>
<th>Systolic Blood Pressure mm/Hg</th>
<th>WBC x 1000/mm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 1 wk</td>
<td>&gt;180</td>
<td>&lt;100</td>
<td>&gt;50</td>
<td>&lt;65</td>
<td>&gt;34 or &lt; 5</td>
</tr>
<tr>
<td>1 wk to 1 mo</td>
<td>&gt;180</td>
<td>&lt;100</td>
<td>&gt;40</td>
<td>&lt;75</td>
<td>&gt;19.5 or &lt;5</td>
</tr>
<tr>
<td>1 mo to 1 yr</td>
<td>&gt;180</td>
<td>&lt;90</td>
<td>&gt;34</td>
<td>&lt;100</td>
<td>&gt;17.5 or &lt;5</td>
</tr>
<tr>
<td>1 - 5 yrs</td>
<td>&gt;140</td>
<td>NA</td>
<td>&gt;22</td>
<td>&lt;94</td>
<td>&gt;15.5 or &lt;6</td>
</tr>
<tr>
<td>6 - 12 yrs</td>
<td>&gt;130</td>
<td>NA</td>
<td>&gt;18</td>
<td>&lt;105</td>
<td>&gt;13.5 or &lt;4.5</td>
</tr>
<tr>
<td>13 - 18 yrs</td>
<td>&gt;110</td>
<td>NA</td>
<td>&gt;14</td>
<td>&lt;117</td>
<td>&gt;11.5 or &lt;4.5</td>
</tr>
</tbody>
</table>

**SIRS criteria Met or High Clinical Suspicion for Sepsis**

PERFORM PEWS

---

**MODIFIED PEDIATRIC EARLY WARNING SIGNS (PEWS)**

<table>
<thead>
<tr>
<th>Modified PEWS</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavior</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Playing/appropriate OR</td>
<td>• Fussy, but consolable</td>
<td>• Irritable, difficult to console</td>
<td>• Lethargic/confused</td>
<td>• Reduced response to pain</td>
</tr>
<tr>
<td>• Sleeping but arousable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiovascular</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Pink OR</td>
<td>• Pale OR</td>
<td>• Gray/cyanotic OR</td>
<td>• Gray/cyanotic AND mottled OR</td>
<td>• Capillary refill 5 sec or longer OR</td>
</tr>
<tr>
<td>• Capillary refill 1-2 sec</td>
<td>• Capillary refill 4 sec OR</td>
<td>• Capillary refill 3 seconds OR</td>
<td>• Capillary refill 1-2 sec OR</td>
<td>• Tachycardia &gt;30 above normal HR for age OR</td>
</tr>
<tr>
<td>Respiratory</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Within normal parameters</td>
<td>• RR at or above normal RR for age OR</td>
<td>• RR &gt;10 above normal RR for age OR</td>
<td>• RR &gt;20 for infants &amp; toddlers, &lt;10 for ages 4 &amp; older with retractions or grunting OR</td>
<td>• Respiratory rate Q2 OR</td>
</tr>
<tr>
<td>• No accessory muscle use</td>
<td>• Accessory muscle use OR</td>
<td>• Accessory muscle use OR</td>
<td>• 50% FiO₂ High-Flow ≥ 4 l/m OR</td>
<td>• Breathing treatment Q2 OR</td>
</tr>
<tr>
<td>• No retractions</td>
<td>• Any supplemental O₂</td>
<td>• Continuous Albuterol</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Does presence of SIRS in the ED identify children with sepsis syndromes?

P Mahajan, X Niu, B Tilford, J Clark, U Sethuraman
Department of Pediatrics
Wayne State University SOM
Center for Quality & Innovation
Children’s Hospital of Michigan
Affiliations & Financial Disclosures

- Financial disclosures - none
• Sepsis is the most cause of death in children
• ~100,000 pediatric ED visits for severe sepsis
• Sepsis is a clinical syndrome with a range of severity
  o SIRS – Systemic Inflammatory Response Syndrome
  o Sepsis – SIRS in presence of proven or suspected infection
  o Severe sepsis, septic shock – Sepsis with cardiovascular dysfunction
  o MODS – multiple organ dysfunction
• Early recognition and timely management important
• Management of severe sepsis/septic shock – well recognized
• Many institutions have incorporated algorithmic approach
• Driver for early recognition has been
  o scientific
  o lay press
Background

• SIRS - early recognition for sepsis
• Issues with SIRS
  o Non-specific – burns, trauma,
  o Overly sensitive
  o Epidemiology unknown
  o Definition different between adults and children
Sepsis Syndromes

- BACTERIA
- FUNGI
- PARASITES
- VIRUSES
- OTHER

INFECTION

SEPSIS

SIRS

- OTHER
- TRAUMA
- BURNS
- PANCREATITIS

BLOOD BORN INFECTION

**Sepsis Syndromes**
• Adult - SIRS
• Any two and any combination
  o Temperature, Heart Rate, Respiratory Rate and WBC count
• Pediatric – SIRS – Age specific criteria
  o Need one of the two – Abnormal Temperature AND/OR Abnormal WBC
  AND
  o Need one of the two – Abnormal Heart Rate AND/OR Abnormal Respiratory Rate
## Background

Temperature > 38.5 °C or < 36 °C

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Heart rate (beats/min)</th>
<th>Respiratory rate (breaths/min)</th>
<th>WBC x 1000/mm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 1 wk</td>
<td>&gt; 180</td>
<td>&lt; 100</td>
<td>&gt; 50</td>
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<tr>
<td></td>
<td></td>
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<tr>
<td>1 mo to 1 yr</td>
<td>&gt; 180</td>
<td>&lt; 90</td>
<td>&gt; 34</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; 17.5 or &lt; 5</td>
</tr>
<tr>
<td>1 - 5 yrs</td>
<td>&gt; 140</td>
<td>N/A</td>
<td>&gt; 22</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; 15.5 or &lt; 6</td>
</tr>
<tr>
<td>6 - 12 yrs</td>
<td>&gt; 130</td>
<td>N/A</td>
<td>&gt; 18</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; 13.5 or &lt; 4.5</td>
</tr>
<tr>
<td>13 - 18 yrs</td>
<td>&gt; 110</td>
<td>N/A</td>
<td>&gt; 14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt; 11.5 or &lt; 4.5</td>
</tr>
</tbody>
</table>
Objective(s)

• Describe the epidemiology of Pediatric SIRS at ED presentation

• To determine if SIRS in the emergency department (ED) is a predictor for pediatric sepsis syndromes.
Methods

• **Setting:** Inner-city, level 1 trauma, pediatric ED
  o Annual census - ~ 95,000

• **Population:** < 18 years of age included for analysis

• **Study design:** Retrospective analysis of EMR database along with selective chart review

• **Duration of study:** 2012 and 2013

• **Definitions**
  o SIRS – ± 1 hour from qualifying temperature
  o ICD-9 codes for sepsis diagnosis
• **Analysis**
  
  o The contingency tables were analyzed by Pearson chi-squared test.
  o Student t test was used to compare patients’ age and length of stay across different SIRS/sepsis groups.
  o All the analyses were performed in SPSS v22.
181,747 Unique Visits

4,219 excluded (LWBS, Registration Errors)

177,528 (97.7%) Visits

SIRS
24,523 (13.8%)

No SIRS
153,005 (86.2%)

Sepsis
1,864 (7.6%)

No Sepsis
22,659 (92.4%)

Sepsis
1,045 (0.7%)

No Sepsis
151,960 (99.3%)
Results – SIRS Etiology

- Infectious Disease: 62.58%
- Other: 36.58%
- Trauma: 0.21%
- Burns: 0.51%
- Pancreatitis: 0.12%
Results

- Age (day, median[Q1, Q3])
  - SIRS vs Non-SIRS: 3.02 yrs [1.23, 7.04] vs. 4.72 yrs [1.60, 10.16], P<0.001

<table>
<thead>
<tr>
<th>Age group</th>
<th>SIRS (# 24,523)</th>
<th>Non-SIRS (# 153,005)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1 week</td>
<td>7 (0.03%)</td>
<td>537 (0.4%)</td>
</tr>
<tr>
<td>1 week – 1 month</td>
<td>138 (0.6%)</td>
<td>3,567 (2.3%)</td>
</tr>
<tr>
<td>1 month – 1 year</td>
<td>4,571 (18.6%)</td>
<td>23,243 (15.2%)</td>
</tr>
<tr>
<td>1 year – 5 years</td>
<td>11,037 (45.0%)</td>
<td>52,605 (34.4%)</td>
</tr>
<tr>
<td>6 years – 12 years</td>
<td>5,665 (23.1%)</td>
<td>45,159 (29.5%)</td>
</tr>
<tr>
<td>12 years – 18 years</td>
<td>3,105 (12.7%)</td>
<td>27,860 (18.2%)</td>
</tr>
</tbody>
</table>
## Results

<table>
<thead>
<tr>
<th>Race group</th>
<th>SIRS (N= 24,523)</th>
<th>Non-SIRS (N= 153,005)</th>
</tr>
</thead>
<tbody>
<tr>
<td>African American</td>
<td>N=16,643 (12.7%)</td>
<td>N=114,822 (87.3%)</td>
</tr>
<tr>
<td>White</td>
<td>N=3,197 (18.1%)</td>
<td>N=14,425 (81.9%)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>N=1,761 (16.2%)</td>
<td>N=9,137 (83.8%)</td>
</tr>
<tr>
<td>Other</td>
<td>N=2,922 (16.7%)</td>
<td>N=14,621 (83.3%)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>N=12,925 (52.7%)</td>
<td>N=80,947 (52.9%)</td>
</tr>
<tr>
<td>Female</td>
<td>N=11,598 (47.3%)</td>
<td>72,057 (47.1%)</td>
</tr>
</tbody>
</table>
## Results SIRS vs. Non-SIRS

<table>
<thead>
<tr>
<th></th>
<th>SIRS (N=24,523)</th>
<th>Non-SIRS (N=153,005)</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>At least one test among urinalysis, urine culture analysis and blood culture</td>
<td>N= 9,862 (40.2%)</td>
<td>N=17,767 (11.6%)</td>
<td>5.1 (5.0, 5.3) *</td>
</tr>
<tr>
<td>Receive a saline bolus</td>
<td>N=9,596 (39.1%)</td>
<td>N=11,330 (7.4%)</td>
<td>8.0 (7.8, 8.3) *</td>
</tr>
<tr>
<td>Receive antibiotics</td>
<td>N=5,831 (23.8%)</td>
<td>N=6,029 (3.9%)</td>
<td>7.6 [7.3, 7.9] *</td>
</tr>
<tr>
<td>Vasopressors</td>
<td>N=498 (2.0%)</td>
<td>N=964 (0.6%)</td>
<td>3.3 [2.9, 3.6] *</td>
</tr>
<tr>
<td>Admitted</td>
<td>N=9,860 (40.2%)</td>
<td>N=13,902 (9.1%)</td>
<td>7.0 (6.8, 7.2)*</td>
</tr>
<tr>
<td>Transferred to ICU (from ED or inpatient unit)</td>
<td>N=1,285 (13.0% among admitted, 1,285/9,860)</td>
<td>N=1,369 (9.8% among admitted, 1,369/13,902)</td>
<td>1.4 (1.3, 1.5)*</td>
</tr>
<tr>
<td>LOS (median [Q1, Q3])</td>
<td>5.9 hr [2.9, 50.1]</td>
<td>2.4 hr [1.5, 3.9] *</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* Indicates $P<0.001$;
### Results

<table>
<thead>
<tr>
<th></th>
<th>SIRS with Sepsis (TP, N=1,864)</th>
<th>Non-SIRS with Sepsis (FN, N=1,045)</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>At least one test among urinalysis, urine culture analysis and blood culture</td>
<td>N=1,759 (94.4%)</td>
<td>N=788 (75.4%)</td>
<td>5.5 (4.3, 7.0)*</td>
</tr>
<tr>
<td>Receive a saline bolus</td>
<td>N=1,331 (71.4%)</td>
<td>N=305 (29.2%)</td>
<td>6.1 (5.1, 7.2)*</td>
</tr>
<tr>
<td>Receive antibiotics</td>
<td>N=1,326 (71.1%)</td>
<td>N=578 (55.3%)</td>
<td>2.0 (1.7, 2.3)*</td>
</tr>
<tr>
<td>Vasopressors</td>
<td>N=165 (8.9%)</td>
<td>N=43 (4.1%)</td>
<td>2.3 (1.6, 3.2)*</td>
</tr>
<tr>
<td>Admitted</td>
<td>N=1,655 (88.8%)</td>
<td>N=644 (61.6%)</td>
<td>5.1 (4.2, 6.2)*</td>
</tr>
<tr>
<td>Transferred to ICU (from ED or inpatient unit)</td>
<td>N=400 (24.2% among admitted)</td>
<td>N=149 (23.1% among admitted)</td>
<td>1.1 (0.9, 1.3)</td>
</tr>
<tr>
<td>LOS (median [Q1, Q3])</td>
<td>78.6 hr [52.8, 158.8]</td>
<td>48.5 hr [4.3, 80.0]*</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* Indicates $P<0.001$
## Results

<table>
<thead>
<tr>
<th></th>
<th>SIRS without sepsis (FP# 22,659)</th>
<th>Non-SIRS without Sepsis (TN# 151,960)</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>At least one test among urinalysis, urine culture analysis and blood culture</td>
<td>N=11,404 (%)</td>
<td>N=20,724 (%)</td>
<td>6.4 (6.2, 6.6)*</td>
</tr>
<tr>
<td>Receive a saline bolus</td>
<td>8,265 (36.5%)</td>
<td>11,025 (7.3%)</td>
<td>7.3 (7.1, 7.6)*</td>
</tr>
<tr>
<td>Receive antibiotics</td>
<td>4,505 (19.9%)</td>
<td>5,451 (3.6%)</td>
<td>6.7 (6.4, 7.0)*</td>
</tr>
<tr>
<td>Vasopressors</td>
<td>333 (1.5%)</td>
<td>921 (0.6%)</td>
<td>2.4 (2.2, 2.8)*</td>
</tr>
<tr>
<td>Admitted</td>
<td>8,205 (36.2%)</td>
<td>13,258 (8.7%)</td>
<td>6.1 (5.9, 6.3)*</td>
</tr>
<tr>
<td>Transferred to ICU (from ED or inpatient unit)</td>
<td>885 (10.8% among admitted)</td>
<td>1,220 (9.2% among admitted)</td>
<td>1.2 (1.1, 1.5)*</td>
</tr>
<tr>
<td>LOS (median [Q1, Q3])</td>
<td>5.1 hr [2.8, 43.9]</td>
<td>2.4 hr [1.5, 3.9] *</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* Indicates \( P<0.001 \)
### SIRS Test Characteristics

<table>
<thead>
<tr>
<th>SIRS (n)</th>
<th>Prevalence (%; 95% CI)</th>
<th>Sensitivity (%; 95% CI)</th>
<th>Specificity (%; 95% CI)</th>
<th>PPV (%; 95% CI)</th>
<th>NPV (%; 95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24,523</td>
<td>1.6 (1.6-1.7)</td>
<td>64.0 (62.3 – 65.8)</td>
<td>87.0 (86.9 – 87.2)</td>
<td>7.6 (7.3 – 8.0)</td>
<td>99.3 (99.3 – 99.4)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SIRS (n)</th>
<th>LR + (%; 95% CI)</th>
<th>LR -(%; 95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24,523</td>
<td>4.9 (4.8 – 5.1)</td>
<td>0.41 (0.39 – 0.43)</td>
</tr>
</tbody>
</table>
Conclusions

• Children who satisfy SIRS criteria in the ED are more likely to develop sepsis syndromes.
• Children with SIRS are more likely to need resources and have high morbidity.
• SIRS – sub-optimal test characteristics as a screening test
Limitations

- Early recognition – amelioration of symptoms
- Not every severe sepsis will have SIRS
- Charting/EMR issues
  - Dependent on charting of vitals
  - Errors in recording of vitals
  - Timing – intent vs. charting vs. actual administration
- Sepsis Codes chosen for analysis
  - Removed ICD9 Code 682
Future Direction

• Analysis – ongoing
  o Lactate
  o CBC
  o Acute phase reactants

• Predictors for sepsis

• PEWS – marginal value of PEWS in early identification and management
• Elizabeth Duffy
• Ezra Brooks
• Eklund Fisher
• William Rumao
• Hitomi Kobayashi
Back-up Slides
Results (I)

177,528 (97.7%) Visits

SIRS
24,523 (13.8%)

- Admitted 9,860 (40.2%)
  - ICU 1,031 (10.5%)
  - Never been to ICU 8,575 (97.1%)

- Discharged 13,331 (54.4%)
  - ICUs 254 (2.9%)
  - Never been to ICUs 8,575 (97.1%)

Non-SIRS
153,005 (86.2%)

- Admitted 13,902 (9.1%)
  - ICU 1,238 (8.9%)
  - Never been to ICU 12,664 (91.1%)

- Discharged 130,188 (85.1%)
  - ICU 131 (1.0%)
  - Never been to ICU 12,533 (99.0%)
Results (II)

Sepsis
2,909 Visits

- SIRS with Sepsis (TP, N=1,864, 64.1%)
  - Admitted: 1,655 (88.8%)
    - ICU: 313 (18.9%)
      - ICU: 87 (6.5%)
    - Inpatient: 1,342 (81.9%)
      - Never been to ICU: 1,255 (93.5%)
  - Discharged: 197 (10.6%)

- Non-SIRS with Sepsis (FN, N=1,045, 35.9%)
  - Admitted: 644 (61.6%)
    - ICU: 136 (21.1%)
      - ICU: 13 (2.6%)
    - Inpatient: 508 (78.9%)
      - Never been to ICU: 495 (97.4%)
  - Discharged: 389 (37.2%)

Results (III)

Non-Sepsis
174,619 Visits

SIRS without sepsis (FP# 22,659, 13.0%)

- Admitted 8,205 (36.2%)
  - ICU 718 (8.8%)
  - Inpatient 7,487 (91.2%)
  - ICU 167 (2.2%)

- Discharged 13,134 (58.0%)

Non-SIRS without Sepsis (TN# 151,960, 87.0%)

- Admitted 13,258 (8.7%)
  - ICU 1,102 (8.3)
  - Inpatient 12,156 (91.7%)
  - ICU 118 (1.0%)

- Discharged 129,799 (85.4%)
  - Never been to ICU 12,038 (99.0%)
## ED-Revisit

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Total (N)</th>
<th>Followed by another visit (N)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>(SIRS+ sepsis)</td>
<td>1,864</td>
<td>42</td>
<td>2.2%</td>
</tr>
<tr>
<td>Group 2</td>
<td>22,659</td>
<td>1041</td>
<td>4.6%</td>
</tr>
<tr>
<td>(SIRS+ non-sepsis)</td>
<td>22,659</td>
<td>1041</td>
<td>4.6%</td>
</tr>
<tr>
<td>Group 3</td>
<td>1,045</td>
<td>49</td>
<td>4.7%</td>
</tr>
<tr>
<td>(Non-SIRS + sepsis)</td>
<td>1,045</td>
<td>49</td>
<td>4.7%</td>
</tr>
<tr>
<td>Group 4</td>
<td>151,960</td>
<td>4,599</td>
<td>3.0%</td>
</tr>
<tr>
<td>(Non-SIRS + non-sepsis)</td>
<td>151,960</td>
<td>4,599</td>
<td>3.0%</td>
</tr>
</tbody>
</table>
SIRS Patients Diagnoses

- Infectious Disease: 62.58%
- Other: 36.58%
- Trauma: 0.21%
- Burns: 0.51%
- Pancreatitis: 0.12%
Top “Other” Diagnoses

- Fever: 28.90%
- Other Diagnoses: 45.17%
- Other and Unspecified Noninfectious Gastroenteritis and Colitis: 4.71%
- Asthma: 12.01%
- Diabetes: 2.29%
- Headache: 1.36%
- Abdominal Pain: 2.93%
- Epilepsy: 2.63%
Infectious Disease Diagnoses

- Acute Infection: 37.01%
- Viral Infection: 17.83%
- Pneumonia: 9.30%
- Otitis Media: 9.24%
- Influenza: 6.82%
- Other Infection: 10.20%
- UTI: 2.47%
- Strep: 5.54%
- Abscess and or Cellulitis: 1.59%
- Other Infection: 10.20%
### Final Diagnosis ICD9 Codes used to determine “Sepsis” group

<table>
<thead>
<tr>
<th>Code Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>038.0 - 038.9</td>
<td>Septicemia related illness</td>
</tr>
<tr>
<td>040.0 - 041.9</td>
<td>Other specified bacterial diseases, Streptococcus, Staphylococcus, etc.</td>
</tr>
<tr>
<td>54.5</td>
<td>Herpetic Septicemia</td>
</tr>
<tr>
<td>286.6 - 286.9</td>
<td>Defibrination Syndrome</td>
</tr>
<tr>
<td>785.52 &amp; 785.59</td>
<td>Septic Shock, Other Shock Without Mention Of Trauma</td>
</tr>
<tr>
<td>790.7</td>
<td>Unspecified Bacteremia</td>
</tr>
<tr>
<td>995.90 - 995.94</td>
<td>Systemic Inflammatory Response Syndrome, Sepsis</td>
</tr>
<tr>
<td>996.60 - 996.69</td>
<td>Infection And Inflammatory Reaction</td>
</tr>
<tr>
<td>999.3 – 999.32</td>
<td>Bloodstream Infection Due To Central Venous Catheter</td>
</tr>
</tbody>
</table>
## Results---Backup slides

<table>
<thead>
<tr>
<th></th>
<th>SIRS (N=24,523)</th>
<th>Non-SIRS (N=153,005)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>within 1-hr of SIRS</strong></td>
<td>N=1,177 (4.8% among all SIRS, and 12.3% (1,177/9,596) among patients who received bolus)</td>
<td>N=11,330 (7.4%)</td>
</tr>
<tr>
<td><strong>Receive a saline bolus within 1-hr of SIRS</strong></td>
<td>N=420 (1.7% among all SIRS, and 7.2% (420/5,831) among all patients who received antibiotics)</td>
<td>N=6,029 (3.9%)</td>
</tr>
</tbody>
</table>

* Indicates $P<0.001$;
## Results---Backup slides

<table>
<thead>
<tr>
<th></th>
<th>SIRS with Sepsis (TP, N=1,864)</th>
<th>Non-SIRS with Sepsis (FN, N= 1,045)</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>within 1-hr of SIRS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Receive a saline bolus</strong></td>
<td>N=164 (8.8% among all SIRS, and 12.3% (164/1331) among patients who received bolus)</td>
<td>N=305 (29.2%)</td>
<td>6.1 (5.1, 7.2) *</td>
</tr>
<tr>
<td><strong>Receive antibiotics</strong></td>
<td>N=100 (5.4% among all SIRS, and 7.5% (100/1326) among patients who received bolus)</td>
<td>N=578 (55.3%)</td>
<td>2.0 (1.7, 2.3) *</td>
</tr>
</tbody>
</table>

* Indicates $P<0.001$
<table>
<thead>
<tr>
<th></th>
<th>SIRS without sepsis (FP# 22,659)</th>
<th>Non-SIRS without Sepsis (TN# 151,960)</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>within 1-hr of SIRS</td>
<td>Anytime after arrival</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receive a saline bolus</td>
<td>N=1,013 (4.5% among all SIRS, and 12.3% (1,013/8,265) among patients who received bolus)</td>
<td>11,025 (7.3%)</td>
<td>6.1 (5.1, 7.2) *</td>
</tr>
<tr>
<td>Receive antibiotics</td>
<td>N=320 (1.4% among all SIRS, and 7.1% (320/4,505) among patients who received bolus)</td>
<td>5,451 (3.6%)</td>
<td>2.0 (1.7, 2.3) *</td>
</tr>
</tbody>
</table>

* Indicates $P<0.001$
Validity of Pediatric Early Warning Score in Emergency Department Setting
X Niu PhD, H Kobayashi PhD, RN, Tilford B MD, K Ryan MSN, RN, M Johnson MSN, RN, B Page MSN, RN, C Martin MSN, RN, R Caldwell, BSN, RN, P Mahajan, MD
Children’s Hospital of Michigan, Detroit MI

Background:
- Pediatric Early Warning Score (PEWS) has been successfully utilized to identify clinical deterioration and institute timely intervention.
- Despite the increasing use in the pediatric emergency department (ED) setting, reliability of PEWS in this setting has not been substantiated.

Objective
- To investigate (a) the inter- and intra-rater reliability of PEWS in ED among nurses with varying levels of experience, and (b) the feasibility of performing PEWS as part of standard patient evaluation.

Method (I)
- Nurses in a busy (annual ED census ~95,000) inner-city pediatric ED received a standardized training in PEWS.
- Inter-rater reliability (degree of agreement among raters): three registered nurses performed PEWS on 47 patients; each patient was evaluated independently by three nurses within 5 minute (min) of each other.

Method (II)
- Intra-rater reliability (degree of agreement among multiple repetitions of PEWS performed by a single nurse): 52 nurses performed PEWS on 52 different patients; each patient was only evaluated by one nurse for three times in 60 min.
- Nursing education level and experience were recorded.
- Patients < 18 years were eligible
- We excluded patients with life threatening emergencies
- Intra-class correlation coefficient (ICC, absolute agreement, single measure) was to evaluate the intra- and inter-rater reliability of PEWS, e.g., ICC≥0.90, very good as ICC≥0.85, and good as ICC≥0.75.

Results (I)
- Nursing education (degree): associate (41.3%), bachelor (47.8%) and master (10.9%)
- Nursing experience: Range 2 months – 38 yrs, (M=4.0 yrs; Q2-Q3: 2.4-11 yrs).
- ~66% of nurses had prior experience in performing PEWS.
- PEWS range from 0 to 7: 59.6% (0-2; mild illness; 59/99), 32.3% (3-5; moderate severity; 32/99) and 8.1% (6-7; severe; 8/99).
- Time spent on PEWS scoring on inter- and intra-rater reliability was 2.0±0.1 min, and 2.5±0.2 min (mean ± SE).

Results (II)
- Inter-rater reliability: excellent with ICC=0.91 (0.87, 0.95).
- Intra-rater reliability: excellent with ICC=0.90 (0.85, 0.94).
- 31 patients received PEWS scores higher than 2 from at least one nurse.

Table 1. Comparison between patients with PEWS≤2 and those with ≥3

<table>
<thead>
<tr>
<th>PEWS</th>
<th>Admitted ICU Antibiotics Bolus Lab test*</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤2</td>
<td>N=59</td>
</tr>
<tr>
<td></td>
<td>(N=59) (22.0%) (0.0%) (11.9%) (13.6%)</td>
</tr>
<tr>
<td>≥3</td>
<td>N=40</td>
</tr>
<tr>
<td></td>
<td>(N=40) (52.5%) (7.5%) (22.5%) (22.5%)</td>
</tr>
<tr>
<td>OR</td>
<td>3.9</td>
</tr>
<tr>
<td>(95% CI)</td>
<td>(1.6, 9.4)</td>
</tr>
<tr>
<td>P-value</td>
<td>0.002</td>
</tr>
<tr>
<td>N/A</td>
<td>0.158</td>
</tr>
<tr>
<td>0.247</td>
<td>0.001</td>
</tr>
</tbody>
</table>

* Lab test means patient received at least one test among urinalysis, urine culture analysis, and blood culture analysis.

Conclusions
- PEWS demonstrates high inter- and intra-rater reliability.
- PEWS can be performed rapidly in the busy ED setting and should be integrated in routine patient evaluation.
- PEWS can be used in the ED for prompt assessment of illness severity to guide appropriate resource allocation and subsequent management.
Please note that PEWS was performed on non-SIRS patients. Suggesting the halo effect and acceptance across the hospital.
ER results – post-intervention
(July 16th – 20th, 2014)

1058 patients presented in the ED

133 SIRS Alerts (12.57%) – please note that this number is fairly close to the “burden” in the pre-intervention numbers given on slide #12 on attachment #9

133 pages – 100% success rate for the EMR based algorithm

168 PEWS performed (131 patients) – 98% of the times PEWS performed
Post Intervention

Please note the convergence of all three lines suggesting success of appropriately performing PEWS on all patients with SIRS alerts.