The Neonatal Sepsis Risk Calculator: Development and Implementation

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November 17, 2017
DISCLOSURE STATEMENT

Karen M. Puopolo MD, PhD

• I have no relevant financial relationships with the manufacturer(s) of any commercial product(s) and/or provider(s) of commercial services discussed in this CME activity

• I do not intend to discuss an unapproved/investigative use of a commercial product/device in my presentation
Learning Objectives

(1) To review the epidemiology and microbiology of early-onset sepsis (EOS) among term and late preterm newborns

(2) To discuss the development of the Sepsis Risk Calculator for EOS risk assessment

(3) To describe implementation and outcomes of using the Sepsis Risk Calculator for EOS risk management
Definition of Neonatal EOS

- Culture-proven invasive infection (blood or CSF) that occurs from birth to 6 days of age
- Among term infants, perinatal practitioners are concerned about infection in first 24-48 hours of life
- Among VLBW infants, timing is restricted to <72 hours of life
- We will not be discussing “culture-negative sepsis” today
Does it Matter What We Do with Term Infants?

• 90% of 4 million annual births

• Among well-appearing newborns, EOS evaluation results in
  – 4-fold increase in late initiation of breastfeeding
  – 2-fold increase in non-medically indicated formula supplementation

• Multiple observational studies associate early-life antibiotics with impact on gut microbiome, wheezing, IBD, childhood obesity

Epidemiology of EOS Among Term Infants
Pathogenesis

- Bacterial (unlike viral) neonatal sepsis has an \textit{in utero} pathogenesis
- EOS due to ascending colonization and subsequent infection of uterine compartment with maternal GI/GU flora
- \textit{Listeria} is notable exception
- \textit{Preterm pathogenesis may be different}

# Risk Identified Factors for EOS

<table>
<thead>
<tr>
<th>Maternal</th>
<th>Neonatal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age and race</td>
<td>Birth Weight</td>
</tr>
<tr>
<td>Chorioamnionitis</td>
<td>Gestational age</td>
</tr>
<tr>
<td>Duration of ROM</td>
<td>Twin gestation</td>
</tr>
<tr>
<td>&quot;Foul-smelling&quot; fluid</td>
<td>Fetal tachycardia</td>
</tr>
<tr>
<td>GBS colonization</td>
<td>Clinical illness</td>
</tr>
<tr>
<td>Intrapartum antibiotics</td>
<td>Laboratory abnormalities</td>
</tr>
<tr>
<td>Intrapartum fever</td>
<td></td>
</tr>
<tr>
<td>Meconium-stained fluid</td>
<td></td>
</tr>
<tr>
<td>Obstetrical interventions</td>
<td></td>
</tr>
</tbody>
</table>

Impact of GBS Intrapartum Prophylaxis

FIGURE 1. Incidence of early- and late-onset invasive group B streptococcal (GBS) disease — Active Bacterial Core surveillance areas, 1990–2008, and activities for prevention of GBS disease


CDC 2015 Surveillance

EOS 0.21/1000 LB
LOS 0.32/1000 LB
Incidence of EOS Unchanged Over 10 years

Overall: 0.77 cases per 1000 live births
GBS: 0.22 cases per 1000 live births
E. coli: 0.18 cases per 1000 live births

Schrag, et al. (2016) Pediatrics
EOS Incidence ~20-fold Higher Among Preterm and VLBW Infants

Overall:
- 0.5 cases/1000 live births → 1/2000

GBS:
- 11 cases/1000 live births → 1/90

E.coli:
- ≥37 weeks
- <37 weeks
- < 1500 g

Rate for 1000 Live Births

Schrag, et al. (2016) Pediatrics
Microbiology of Neonatal EOS

- **GBS**: 38%
- **E. coli**: 24%
- **Other GP**: 22%
- **Other GN**: 16%

*E. coli* most common among VLBW infants

Overall Mortality
11%

BW <1500 g
37%

BW ≥1500 g
3.5%

82% of deaths occurred among those born < 34 weeks gestation

Schrag, et al. (2016) Pediatrics
Identifying Term Infants at Risk for EOS: It Shouldn’t Be So Hard…
CDC 2010 Guidelines: Management of Newborns

- EOS evaluation and empiric treatment of:
  - all infants who are not well-appearing
  - all infants if born to a mother with chorioamnionitis

- In the event of inadequate indicated GBS prophylaxis
  - EOS evaluation of preterm infants
  - EOS evaluation of term infants if ROM > 18 hours

AAP Committee on the Fetus and Newborn

- Endorsed CDC 2010 recommendations
- Additional algorithms for term and preterm infants with goal of reducing empiric treatment of “culture-negative” EOS
Newborns Are Frequently Evaluated and Empirically Treated for Risk of EOS

<table>
<thead>
<tr>
<th>Site</th>
<th>Policy</th>
<th>Years</th>
<th>Births included</th>
<th>Blood culture and/or labs</th>
<th>Empiric Antibiotics</th>
<th>Rate of EOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boston</td>
<td>CDC    2010</td>
<td>2011-2012</td>
<td>≥ 36 weeks N = 6544</td>
<td>13%</td>
<td>12%</td>
<td>0.04%</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>AAP    2013</td>
<td>2013-2014</td>
<td>≥ 36 weeks N = 7943</td>
<td>24%</td>
<td>7%</td>
<td>0.03%</td>
</tr>
<tr>
<td>Northern California</td>
<td>CDC    2010</td>
<td>2010-2012</td>
<td>≥ 35 weeks N = 95,354</td>
<td>14%</td>
<td>5%</td>
<td>0.06%</td>
</tr>
</tbody>
</table>

Can We Do Better?

- Could we safely evaluate *fewer* infants and still identify the infected ones?
- Can we *discriminate* better between at-risk infants?
  - Potentially treat fewer infants by identifying those at highest risk
- Can we define risk without using the clinical diagnosis of *chorioamnionitis*?
Multivariate Approach to Identifying Infants at Risk for EOS (Maybe It Can Be Easier...)

Pennsylvania Hospital
Penn Medicine
Multivariate Models of EOS Risk

• Algorithms based on cutoff values can waste information
  • There is usually information below the cutoff, as well as differential information above the cut-off
• Univariate consideration of risk factors doesn’t account for interactions between predictors
Risk of EOS: The Bayesian Perspective

• Begin with the population risk (i.e., all you know is that it is a term baby born at 34 weeks or above)
  – Prior probability of EOS

• Add the information you get before you even look at the baby (i.e., maternal fever, duration of ROM, GBS status) and modify the population risk
  – Modified prior probability of EOS

• Add the baby’s clinical status (i.e., now you examine the baby)
  – Final posterior probability of EOS

• Make your decision to evaluate +/- empirically treat the baby for EOS
Study Design

- Nested case-control study with Case Infants
  - GA $\geq 34$ weeks with culture-confirmed bacterial infection in first 72 hrs of life
  - No major anomalies

- Control Infants
  - Same criteria without culture-proven infection, randomly selected from the total birth cohort
  - Matched for birth hospital and year of birth

- Data collection
  - Maternal/infant from hospital admission leading to birth
  - Basic demographic dataset collected for all births $\geq 34$ weeks gestation

Sepsis Study Population

Total Birth Cohort
≥ 34 weeks
608,014

Kaiser-Permanente
12 California sites
418,755 births

195 cases
684 controls
1995-2007

Brigham and Women’s
Boston, MA
127,239 births

131 Cases
305 Controls
1993-2007

Beth-Israel Deaconess
Boston, MA
62,020 births

24 Cases
74 Controls
1995-2007

Total 350 cases, 1063 controls
Cases: ~50% GBS, 20% E. coli
Controls: ~20% received intrapartum antibiotics
Overall EOS incidence 0.58 cases/1000 live births
Rate of EOS by Highest Maternal Temperature
### Components of Multivariate Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable Type</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>GBS status</td>
<td>Categorical</td>
<td>1.78 (1.11 – 2.85)</td>
</tr>
<tr>
<td>Gestational age</td>
<td>Continuous</td>
<td>0.001 (0.0001 – 0.014)</td>
</tr>
<tr>
<td>Duration of ROM</td>
<td>Continuous</td>
<td>3.41 (2.23 – 5.20)</td>
</tr>
<tr>
<td>Highest intrapartum maternal temperature</td>
<td>Continuous</td>
<td>2.38 (2.05 – 2.77)</td>
</tr>
</tbody>
</table>

- No intrapartum abx
- GBS IAP or any abx not given on time
- Broad-spectrum abx given on time
- Categorical
  - Reference
  - 0.35 (0.23 – 0.53)
  - 0.31 (0.13 – 0.71)
SRS Cutoffs Distinguish EOS Cases and Controls

<table>
<thead>
<tr>
<th>Sepsis Risk at Birth</th>
<th>&lt; 0.65</th>
<th>0.65-1.54</th>
<th>&gt; 1.54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>55.7%</td>
<td>23.1%</td>
<td>21.7%</td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>93.7%</td>
<td>5.08%</td>
<td>1.22%</td>
</tr>
</tbody>
</table>
Quantifying EOS Risk Due to Newborn Clinical Status

• Data collected for first 24 hours of life
  – delivery room condition and resuscitation
  – hourly vital signs (i.e., HR, temperature)
  – administered intensive care (i.e., mechanical ventilation, supplemental O2)
  – observed abnormalities such as seizure or grunting

Escobar, et al. (2014) *Pediatrics*
Infant Condition Categorized into Three States

• **Clinical Illness**
  – 5 minute Apgar < 5
  – Seizure
  – Vasopressor therapy
  – Mechanical ventilation or CPAP
  – Respiratory distress and need for supplemental O2 by 6 hours of life
Infant Condition Categorized into Three States

- **Equivocal Presentation**
  - In the first 12 hrs of life, infant had two instances of an individual abnormality, with “instance” defined as \( \geq 2 \) measurements, \( \geq 2 \) hours apart
    - Heart rate \( \geq 160 \)
    - Respiratory rate \( \geq 60 \)
    - Temperature \( \geq 100.4^\circ F \) or \( < 97.5^\circ F \)
    - Respiratory distress (grunting, flaring, or retracting)

- **Well-appearing**
  - Infant did not meet definition of Clinical illness or Equivocal Presentation
# Likelihood Ratios for Clinical Presentation

<table>
<thead>
<tr>
<th>Clinical Presentation</th>
<th>LR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well-appearing</td>
<td>0.36</td>
<td>0.31 – 0.41</td>
</tr>
<tr>
<td>Equivocal</td>
<td>3.75</td>
<td>2.83 – 5.00</td>
</tr>
<tr>
<td>Clinical Illness</td>
<td>14.5</td>
<td>10.2 – 21.2</td>
</tr>
</tbody>
</table>

Upper limits of CI for each clinical presentation used to calculate most conservative posterior probability of EOS.
**SRS at Birth + Clinical Status = Posterior Probability of Sepsis**

<table>
<thead>
<tr>
<th>Clinical Status</th>
<th>Sepsis Risk Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 0.65</td>
</tr>
<tr>
<td><strong>Clinical Illness</strong></td>
<td></td>
</tr>
<tr>
<td>PP</td>
<td>5.57 (3.73-8.53)</td>
</tr>
<tr>
<td>NNT</td>
<td>180 (117-268)</td>
</tr>
<tr>
<td><strong>Equivocal</strong></td>
<td></td>
</tr>
<tr>
<td>PP</td>
<td>1.31 (0.93-1.84)</td>
</tr>
<tr>
<td>NNT</td>
<td>763 (543-1,076)</td>
</tr>
<tr>
<td><strong>Well-Appearing</strong></td>
<td></td>
</tr>
<tr>
<td>PP</td>
<td>0.11 (0.08-0.13)</td>
</tr>
<tr>
<td>NNT</td>
<td>9,370 (7,418-12,073)</td>
</tr>
</tbody>
</table>
## Quantitative Risk Stratification: Recommended Care Algorithm

<table>
<thead>
<tr>
<th>Clinical Status in 1st 12 hours</th>
<th>Sepsis Risk Score</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 0.65</td>
<td>0.65-1.54</td>
<td>&gt; 1.54</td>
</tr>
<tr>
<td><strong>Clinical Illness</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Equivocal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observe and Evaluate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treat Empirically</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4% of Births</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NNT 118</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Well-Appearing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continued Observation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>85% of Births</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NNT 9370</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observe and Evaluate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11% of Births</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NNT 883</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Neonatal Sepsis Risk Calculator

- Clinical care algorithms updated to include implementation work done at KPNC since 2014 publication
- Threshold for blood culture: >1/1000
- Threshold for antibiotics: >3/1000

New website: http://neonatalsepsiscalculator.kaiserpermanente.org
Also reached at: http://kp.org/eoscalc

Credits for websites: Soora Wi, MPH; Allen Fischer, MD, Regional Director of Neonatology; Michael Kuzniewicz, MD, Director, Perinatal Research Unit Kaiser Permanente Northern California
SRS Implementation

(What Happens if You Really Use it…)

The Children’s Hospital of Philadelphia®
Kaiser-Permanente Northern California (KPNC)

• Integrated healthcare system with 14 birth hospitals
  – Common inpatient and outpatient electronic medical record
  – All caregivers employed by KPNC
  – Very high rate of prenatal care

• Infants born at a KPNC hospital covered for a minimum of 30 days, regardless of the infant’s insurance status
  – Can track outcomes post-birth hospital discharge
Implementation at KPNC

• **Baseline period**
  – EOS risk assessment based on CDC guidelines

• **Learning period**
  – SRC based only on sepsis risk at birth available to clinicians
  – no guidance was given on how to use it

• **EOS calculator period**
  – Newborn’s clinical condition incorporated into the final risk estimate
  – Care recommendations were provided with the calculator

Kuzniewicz, et al. (2017) JAMA Pediatr
Monthly Rate of EOS Evaluation

Figure 1. Monthly Early-Onset Sepsis (EOS) Evaluation Rate

Monthly percentage of infants born at 35 weeks’ gestation or later undergoing EOS evaluation with a blood culture performed in the first 24 hours of life.

Kuzniewicz, et al. (2017) JAMA Pediatrics
Monthly percentage of infants born at 35 weeks’ gestation or later receiving intravenous antibiotic therapy in the first 24 hours of life. EOS indicates early-onset sepsis.
### Sepsis Risk Calculator at KPNC

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Live Births</th>
<th>Blood Culture ≤ 24 hrs</th>
<th>Antibiotics ≤ 24 hrs</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDC guidelines (1/2010-11/2012)</td>
<td>95,343</td>
<td>13,797 (14.5%)</td>
<td>4741 (5.0%)</td>
<td>-</td>
</tr>
<tr>
<td>EOS Calculator (7/2014-10/2015)</td>
<td>56,261</td>
<td>2754 (4.9%)</td>
<td>1482 (2.6%)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
# Measures of Safety

<table>
<thead>
<tr>
<th>Time Period</th>
<th>CDC Guidelines Period</th>
<th>EOS Calculator Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cases</td>
<td>24 (0.03%)</td>
<td>12 (0.02%)</td>
</tr>
<tr>
<td>Symptomatic at Birth</td>
<td>12 (50%)</td>
<td>6 (50%)</td>
</tr>
<tr>
<td>Critically Ill</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Death</td>
<td>0</td>
<td>1*</td>
</tr>
<tr>
<td>Readmission ≤ 7 days of life with EOS</td>
<td>5.2/100,000</td>
<td>5.3/100,000</td>
</tr>
</tbody>
</table>

*Infant with severe HIE treated with antibiotics, ECMO and cooling from birth
KPNC Implementation Conclusions

- SRC can *safely* decrease the proportion of infants evaluated and empirically treated for risk of EOS compared to prior recommended approaches
- No evidence that infants presenting later in more advanced state of illness
- Rate of rehospitalization for EOS very low at baseline and not different with use of SRC
SRC Implementation at Pennsylvania Hospital

- Pennsylvania Hospital is the nation’s oldest hospital
  - Founded by Benjamin Franklin in 1751
- One of the oldest maternity services (1803)
- Currently delivers ~5200 infants annually
- EOS evaluations by local algorithm that combined recommendations of CDC 2010 and AAP 2013
Current EOS Evaluations Among ≥ 36 week Infants at Pennsylvania Hospital 2013-2014

- ~31% all infants born ≥ 36 weeks were evaluated for EOS
- ~24% well-appearing, and evaluated with CBC/CRP only
- ~7% were treated empirically with antibiotics
- Only 2/8607 or ~0.03% were actually infected

Mukhopadhyay and Puopolo, unpublished data
SRC Implementation Plan

• Interdisciplinary planning committee
• Link out to SRC website created within Labor and Delivery EMR
• Training period for L&D and Well Nursery staff
• Established as standard of care in July 2015
• Daily report generated from EMR with variables needed and calculated SRS
PAH SRS Implementation Results

- **Nurses call Neonatology if Sepsis Risk at birth ≥ 0.7**
  - If 0.7-1.49 and well-appearing → enhanced vital signs for 36 hours
  - If 0.7-1.49 and not well-appearing → transfer to NICU for period of observation and decision-making
  - If SRS ≥ 1.5 → blood culture done and empiric antibiotics regardless of status
## Delivery Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Pre-SRS (N = 5,692)</th>
<th>Post-SRS (N = 6,090)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Females, n (%)</strong></td>
<td>2,721 (47.8)</td>
<td>2,998 (49.2)</td>
<td>0.12</td>
</tr>
<tr>
<td><strong>GA at birth, mean (SD)</strong></td>
<td>39.4 (0.2)</td>
<td>39.3 (0.2)</td>
<td><strong>0.004</strong></td>
</tr>
<tr>
<td><strong>Low Birth Weight, n (%)</strong></td>
<td>210 (3.7)</td>
<td>257 (4.2)</td>
<td>0.14</td>
</tr>
<tr>
<td><strong>APGAR score at 5 minutes ≤ 5</strong></td>
<td>34 (0.6)</td>
<td>28 (0.5)</td>
<td>0.30</td>
</tr>
<tr>
<td><strong>Vaginal Delivery, n (%)</strong></td>
<td>3,819 (67.1)</td>
<td>4,263 (70.0)</td>
<td><strong>0.001</strong></td>
</tr>
<tr>
<td><strong>Multiple Gestation, n (%)</strong></td>
<td>158 (2.8)</td>
<td>184 (3.0)</td>
<td>0.43</td>
</tr>
<tr>
<td><strong>Race/Ethnicity, n (%)</strong></td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>▪ White</td>
<td>2,602 (45.7)</td>
<td>2,962 (48.6)</td>
<td></td>
</tr>
<tr>
<td>▪ Black</td>
<td>1,668 (29.3)</td>
<td>1,786 (29.3)</td>
<td></td>
</tr>
<tr>
<td>▪ Hispanic</td>
<td>616 (10.8)</td>
<td>674 (11.1)</td>
<td></td>
</tr>
<tr>
<td>▪ Other</td>
<td>806 (14.2)</td>
<td>668 (10.9)</td>
<td></td>
</tr>
</tbody>
</table>
Sepsis Risk Score Distribution

49.4% of SRS < 0.10
## Sepsis Risk Score Distribution

<table>
<thead>
<tr>
<th>SRS Category</th>
<th>N (% of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.70</td>
<td>5,807 (95.4)</td>
</tr>
<tr>
<td>0.70-1.49</td>
<td>173 (2.8)</td>
</tr>
<tr>
<td>≥ 1.50</td>
<td>96 (1.6)</td>
</tr>
</tbody>
</table>
Empiric Antibiotic Use for EOS

Implementation of SRC

# Overall Antibiotics for EOS

<table>
<thead>
<tr>
<th></th>
<th>Pre-SRS (n = 5692)</th>
<th>Post-SRS (n = 6090)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Antibiotics &lt;72 hrs, N (%)</strong></td>
<td>356 (6.3)</td>
<td>222 (3.7)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td><strong>Antibiotics &lt;7 days, N (%)</strong></td>
<td>361 (6.3)</td>
<td>224 (3.7)</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>
"Sepsis evaluation" includes any combination of blood culture plus CBC and/or CRP
No Antibiotics ≠ No Care

• Three cases of EOS during SRS implementation
  – Case #1: SRS 11.45 (E. coli)
  – Case #2: SRS 3.75 (E. coli)
  – Case #3: SRS 0.3 (GBS)
    • 37 weeks; Tm 98.9°F; ROM 14.8 hours; GBS negative
    • Lethargy, poor feeding, tachypnea at ~36 hours
• Case # 3 infant would not be flagged by any current approach
• No sepsis algorithm can function without excellent clinical care
Conclusions

• *Treatment algorithms using individual EOS multivariate risk estimates can result in more objective and efficient means of identifying infants at risk for EOS and safely decrease the number of infants exposed to empiric antibiotics*
Acknowledgements

- **Pennsylvania Hospital Neonatal Research Group**
  - Sagori Mukhopadhyay, MD, MMSc
  - Miren Dhudasia, MBBS, MPH
- All the nurses, advanced practice clinicians and physicians in the Pennsylvania Hospital Women’s Program
- **Sepsis and Critical Illness Study Group** led by Gabriel Escobar, MD
  - Michael Kuzniewicz, MD, MPH
  - Allen Fischer, MD, Regional Director of Neonatology KPNC
  - David Draper, PhD
  - Thomas Newman, MD, MPH
  - John Zupancic, ScD, MD, Ellice Lieberman, DrPH, MD
  - Soora Wi, MPH, Myesha Smith, BS, Benjamin Turk, BA, Eileen Walsh, RN, MPH
  - Funded by NIH grant R01-GM-80180-01-A2, “Sepsis and Critical Illness in Babies ≥ 34 Weeks Gestation,” Gabriel Escobar, PI
Extra Slides
Approach to EOS Care Improvement

- **Identify what you do NOW**
- **Who** does EOS risk assessment?
  - L&D nurses, neonatal staff, housestaff
- **How** do they do it?
  - Local algorithm posted on the wall?
  - Call local pediatrician?
- **Can you measure what you are doing currently?**
- **What are your local resources for change?**
Approach to EOS Care Improvement

• Gather your stakeholders
  – Obstetricians, L&D nurses, neonatal staff, pediatric housestaff

• Using sepsis risk calculator, determine levels of risk you find acceptable

• Develop a process that will work for your local setting
  – Education period

• Determine how you will measure change and monitor safety
Association Between Early Antibiotic Exposure and Childhood Disease


## Clinical Status Over 1st Day of Life

<table>
<thead>
<tr>
<th>Status at 6 hrs of age (%)</th>
<th>Controls (N = 1063)</th>
<th>Cases (N = 350)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical illness</td>
<td>1.8</td>
<td>24.0</td>
</tr>
<tr>
<td>Equivocal presentation</td>
<td>5.6</td>
<td>18.6</td>
</tr>
<tr>
<td>Well-appearing</td>
<td>92.7</td>
<td>57.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Status at 12 hrs of age (%)</th>
<th>Controls (N = 1063)</th>
<th>Cases (N = 350)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical illness</td>
<td>2.0</td>
<td>27.1</td>
</tr>
<tr>
<td>Equivocal presentation</td>
<td>2.5</td>
<td>17.4</td>
</tr>
<tr>
<td>Well-appearing</td>
<td>95.6</td>
<td>55.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Status at 24 hrs of age (%)</th>
<th>Controls (N = 1063)</th>
<th>Cases (N = 350)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical illness</td>
<td>2.2</td>
<td>29.4</td>
</tr>
<tr>
<td>Equivocal presentation</td>
<td>0.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Well-appearing</td>
<td>97.3</td>
<td>68.3</td>
</tr>
</tbody>
</table>