Challenge sepsis.
Change lives.

Blood Culture Stewardship: Safe and Effective Application in the PICU

Bright STAR

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- No other financial disclosures
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Learning Objectives

1. Identify the importance of diagnostic stewardship related to blood culture practices in pediatric critical illness to prevent harmful overuse and improve patient outcomes
2. Describe the BrighT STAR consensus recommendations for blood culture practices in pediatric critical care
3. List key results of the collaborative related to blood culture stewardship in pediatric critical care
4. Discuss strategies for successful multidisciplinary team implementation of BrighT STAR consensus guidelines

Patient harm from *medical overuse*

Overuse: provision of health care for which net benefits do not exceed net harms

Overtreatment:

- Subjecting patients to treatment that, according to sound science and patients' preferences, does not benefit them
- A significant proportion of medical overuse
- Annual cost of $200 billion (Berwick, JAMA 2012)
- Associated with worse patient outcomes and even death

We are part of the problem: **clinicians overestimate benefits and underestimate harms** of interventions (Hoffman TC, JAMA Internal Medicine 2017)

Medical overuse in pediatrics

- Choosing Wisely campaign's original 5 pediatric topics → 140 recommendations
- "Bending the Value Curve" - Hospital Pediatrics journal
- National pediatric high-value care curriculum created
- 2017-2019 JAMA Pediatrics; 2021 Pediatrics reviews (ER Coon, et al)

What about **sepsis**?

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Pediatric Sepsis in the Context of Medical Overuse: Serious Challenges and Unique Opportunities

Sepsis is common, deadly, and costly

- Terminology:
  - Pediatric septic shock: severe infection leading to cardiovascular dysfunction (including hypotension, need for treatment with a vasoactive medication, or impaired perfusion)
  - Sepsis associated organ dysfunction: severe infection leading to cardiovascular and/or non-cardiovascular organ dysfunction

- **8%** prevalence in hospitalized children; **25%** mortality rate, even in developed countries

- $4-5 billion per year, or **16%** annually of money spent on pediatric hospitalizations

We are fighting sepsis by acting FAST

- Early recognition and appropriate antibiotic therapy shown to significantly impact outcomes
- Delayed start of appropriate antibiotics can increase morbidity and mortality
- Current guidelines ask clinicians to place urgent attention on rapid recognition and diagnosis
- High profile national collaboratives emphasize rapid diagnostic evaluation and administration of antibiotics for suspected sepsis as a marker of high quality care.
  - •Children's Hospital Association's Improving Pediatric Sepsis Outcomes project
  - •NY State Children's Hospital experience published in JAMA

Are we acting TOO fast?

- Adverse drug events from antibiotics
- Drug toxicity from antibiotics
- Increased length of stay and cost

- ***Antibiotic resistance***

Are we acting TOO fast?

Viewpoint

September 14, 2018

Antibiotics for Sepsis—Finding the Equilibrium

Michael Klompas, MD, MPH[1,2]; Thierry Calandra, MD, PhD[3]; Mervyn Singer, MD, FRCP[4]

Author Affiliations | Article Information

JAMA. Published online September 14, 2018. doi:10.1001/jama.2018.12179

Related Articles

Sepsis is medicine's last remaining preserve for unrestrained antibiotic prescribing. The Surviving Sepsis Campaign guidelines recommend empirical broad-spectrum therapy within one hour of triage for both sepsis and septic shock.[1] This recommendation, and mandates that compel it, encourage clinicians to adopt an approach of "treat first, ask questions later" for patients with any possibility of serious infection. This approach fails to account for the difficulties clinicians face with diagnosing infection, especially when patients initially present to care, and the high rate of overdiagnosis of sepsis, and thus risks promoting excess antibiotic use and causing unintended harm.

Are we acting TOO fast?

THE LANCET
Volume 394, Issue 10208, 26 October–1 November 2019, Pages 1513-1514

Correspondence

Sepsis hysteria: excess hype and unrealistic expectations

Mervyn Singer [a] ✉, Matt Inada-Kim [b, c], Manu Shankar-Hari [d, e]

A **balanced strategy** must be delivered in policy, public messaging, and frontline care, **to reduce excessive, inappropriate antibiotic use with concurrent risks of resistance and toxicity.**

Sepsis in children: finding the balance

Definitions of pediatric sepsis have important **implications on clinical care, accurate estimates of the burden of disease, quality improvement initiatives and benchmarking, and the design of research protocols**. The present definitions are inadequate to serve these goals because **identification of sepsis is prone to individual bias**; hence, the increased coding for sepsis seen in many countries remains difficult to interpret. Moreover, the considerable differences in pediatric intensive care unit resource use for pediatric sepsis, despite similar adjusted mortality, and the pediatric implications of the World Health Organization resolution lend urgency to the need for revised definitions. Sepsis-3 is widely recognized as providing robust end points to categorize sepsis with high specificity and to capture subgroups at substantially higher risk of mortality. At the same time, **clinicians must recognize and treat patients at risk for sepsis or septic shock ideally before the onset of advanced organ dysfunction**. Sepsis screening, awareness, and early intervention campaigns have been focusing on sensitive early clinical markers of patients at risk, given the rapid increase in poorer outcomes associated with delays in initiation of treatment. **Accurate early identification of those at risk is also important to avoid overtreatment** and for the inclusion of patients most likely to benefit from interventions in research trials.

Sepsis in children: finding the balance

- Key processes that reduce mortality for sepsis (IPSO):
  - Sepsis screening; Sepsis huddle; Order set utilization; Time to first fluid bolus; Time to first IV antibiotic

- Updated recommendations about timing of antibiotic administration (Surviving Sepsis Campaign update 2020)
  - **1 hour** for children with septic shock; **3 hours** for sepsis-associated organ dysfunction without shock

Sepsis in children: finding the balance

Is there an opportunity for diagnostic stewardship that concurrently facilitates timely treatment of sepsis AND safe reduction in tests/treatments ***when suspicion of sepsis is low***?

Exploring the Potential of Diagnostic Stewardship to Reduce Iatrogenic Harm and Overuse:

The BrighT STAR Collaborative

Testing STewardship to reduce Antibiotic use and Resistance

AHRQ Agency for Healthcare Research and Quality

Rainbow Babies & Children's Hospital

Bright STAR

JOHNS HOPKINS CHILDREN'S CENTER

Children's Hospital of Philadelphia

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The BrighT STAR Team

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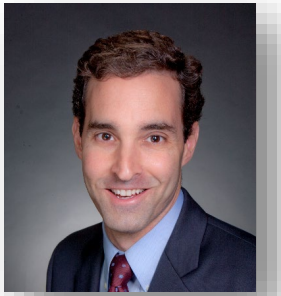
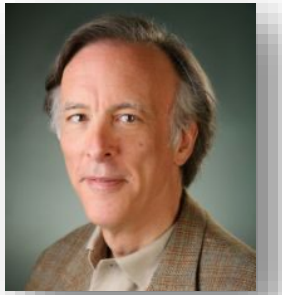


Aaron Milstone MD



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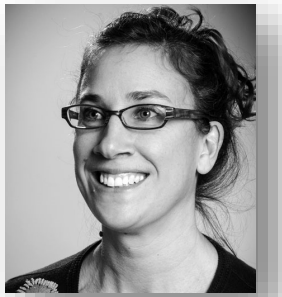

Elizabeth Colantuoni PhD

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Early work: a single center QI Initiative

A multidisciplinary team reviewed factors contributing to bloodstream infections in JHCC PICU

A focused collaboration between PICU & Infectious Diseases standardized clinical approach to BCx in critically ill children

Two documents were developed and implemented:

The Fever/Sepsis Checklist

Blood Culture Decision Algorithm

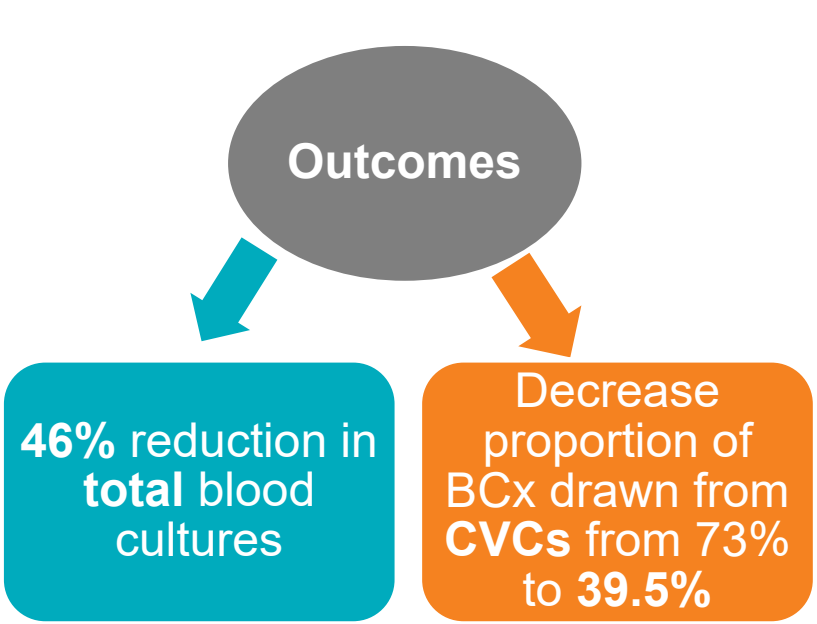
Blood cultures: Low yield (5-15%); High false positive rate

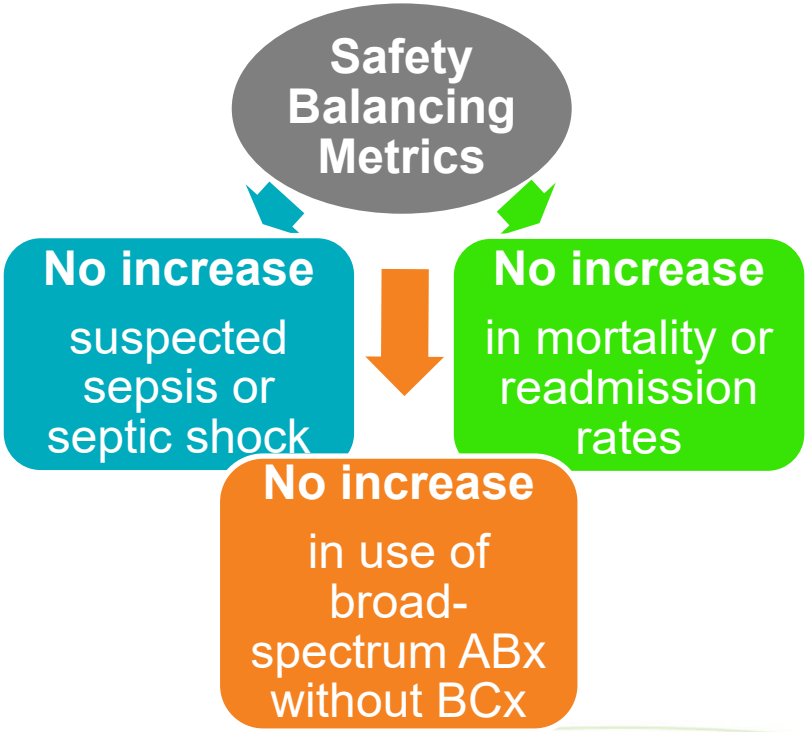
Our Initial Questions Were:

1) Is *diagnostic stewardship* for bloodstream infections in the PICU possible?

2) Is it safe?

JHH PICU Project Outcomes and Balancing Metrics





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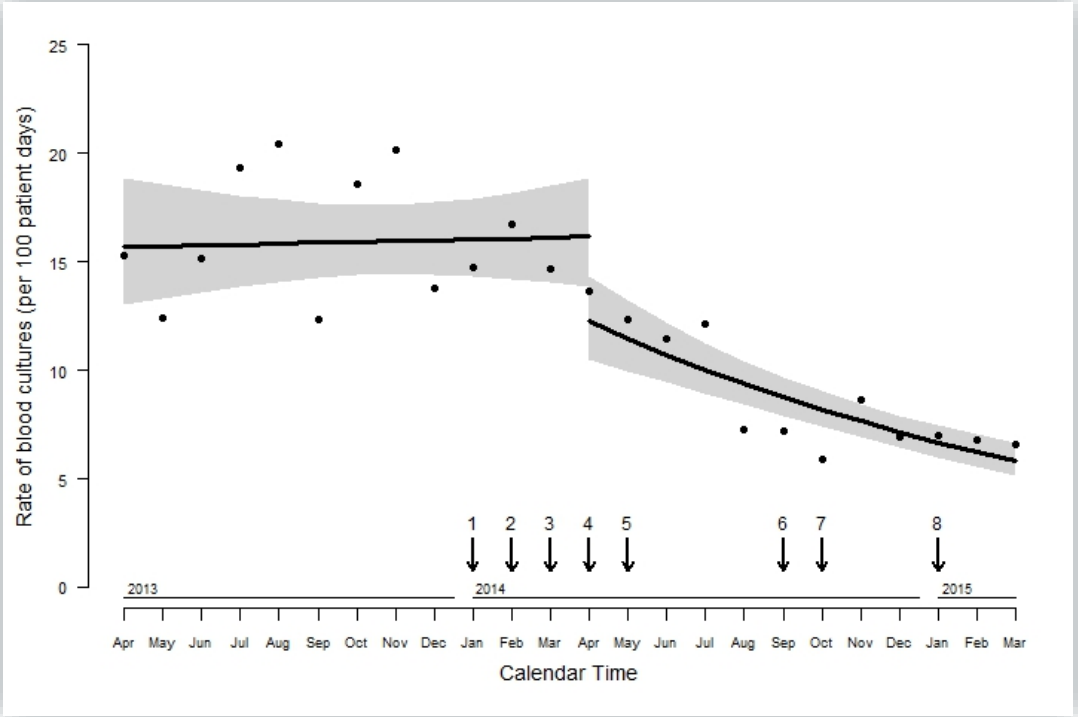
Step 1: JHH PICU Blood Culture Rates Before and After Quality Improvement Project



Woods-Hill CZ, et al. Association of a Clinical Practice Guideline With Blood Culture Use in Critically Ill Children. *JAMA Pediatr.* 2017;171(2):157-164.

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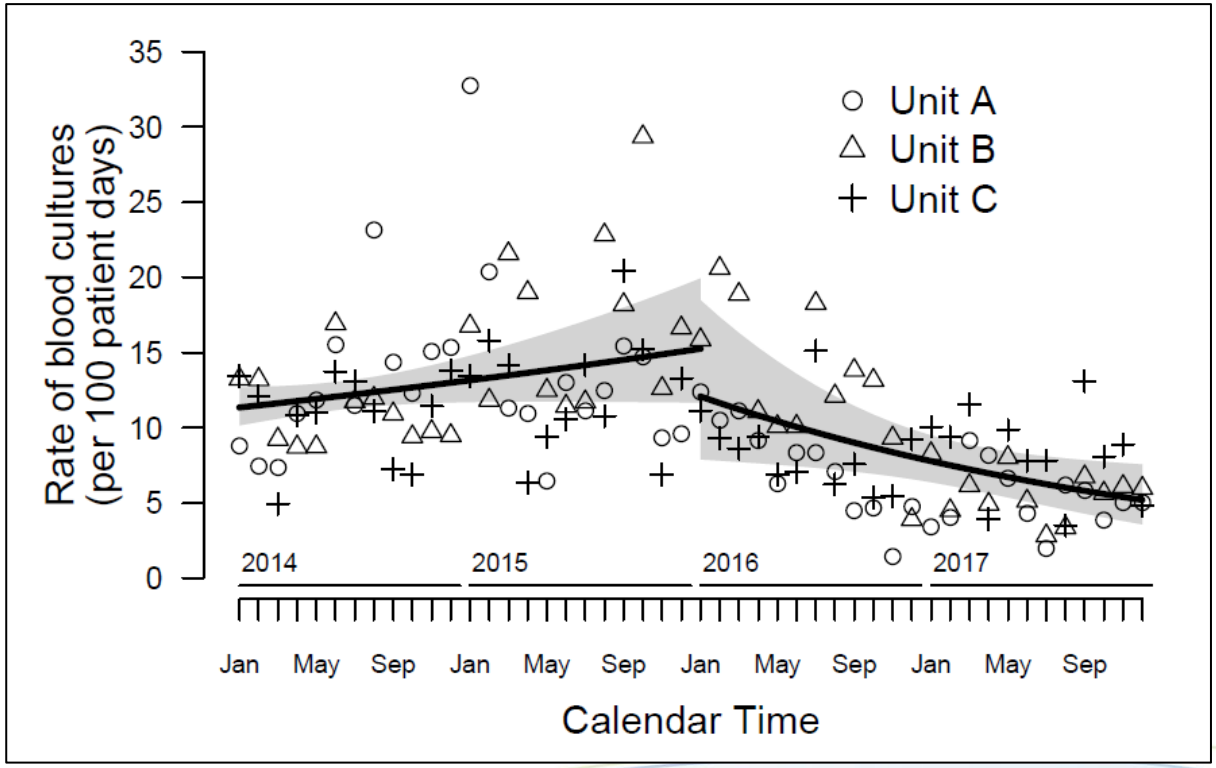
Step 2: Implementation of Similar Quality Improvement Project at 3 additional sites

Johns Hopkins All Children's Hospital (ACH) and University of Virginia Medical center (UVA) adopted similar programs

Overall results: 32% decrease across 3 units

Out of this implementation project came the 5-part framework for larger-scale dissemination



Woods-Hill CZ, et al. Dissemination of a novel framework to improve blood culture use in three pediatric intensive care units. Pediatric Quality and Safety 3(5): e112, September/October 2018.

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Step 3: The BrighT STAR Collaborative

Testing STewardship to reduce Antibiotic use and Resistance

An AHRQ-funded R18 to implement quality improvement work to ***reduce unnecessary blood cultures*** in PICUs across the country

Team with research coordinators, human factors engineers, QI experts, ICU and ID physicians

PI: Aaron Milstone, pediatric infectious diseases

The BrighT STAR Collaborative Sites

Primary Questions:

1. Is diagnostic stewardship for BCx **effective at reducing antibiotic use**?

2. **How can we scale up** our program?

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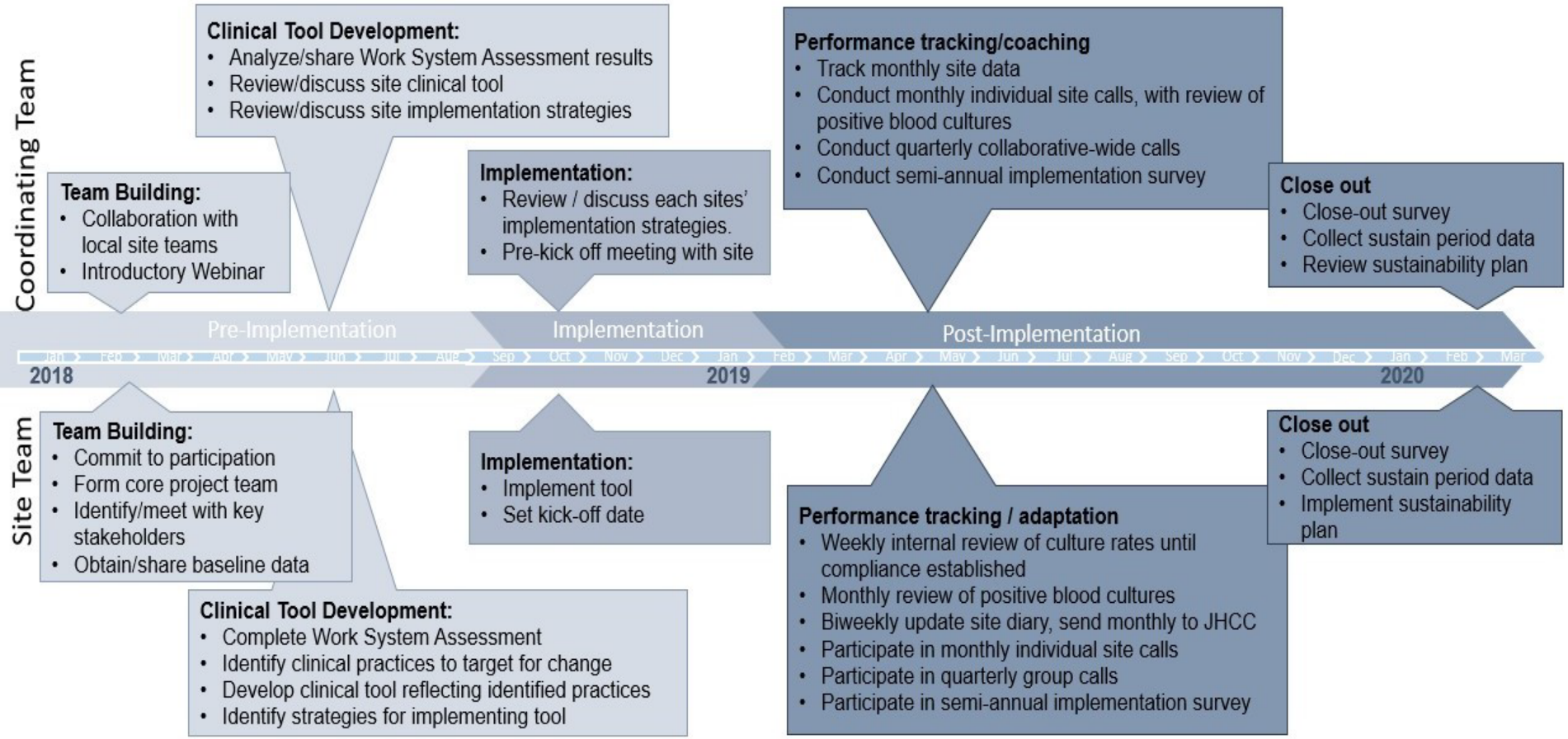
Coordinating Team
Clinical Tool Development:
• Analyze/share Work System Assessment results
• Review/discuss site clinical tool
• Review/discuss site implementation strategies
Team Building:
• Collaboration with local site teams
• Introductory Webinar
Implementation:
• Review / discuss each sites' implementation strategies.
• Pre-kick off meeting with site
Performance tracking/coaching
• Track monthly site data
• Conduct monthly individual site calls, with review of positive blood cultures
• Conduct quarterly collaborative-wide calls
• Conduct semi-annual implementation survey
Close out
• Close-out survey
• Collect sustain period data
• Review sustainability plan
Pre-Implementation
Implementation
Post-Implementation
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar
2018
2019
2020
Site Team
Team Building:
• Commit to participation
• Form core project team
• Identify/meet with key stakeholders
• Obtain/share baseline data
Clinical Tool Development:
• Complete Work System Assessment
• Identify clinical practices to target for change
• Develop clinical tool reflecting identified practices
• Identify strategies for implementing tool
Implementation:
• Implement tool
• Set kick-off date
Performance tracking / adaptation
• Weekly internal review of culture rates until compliance established
• Monthly review of positive blood cultures
• Biweekly update site diary, send monthly to JHCC
• Participate in monthly individual site calls
• Participate in quarterly group calls
• Participate in semi-annual implementation survey
Close out
• Close-out survey
• Collect sustain period data
• Implement sustainability plan

The Heart of the Collaborative

Facilitating ***behavior change*** *around*
diagnostic decision making in the PICU -
How do you change how a PICU clinician uses a test?

Human factors engineering, behavioral science, and **implementation science** can drive this kind of work forward

First steps, simultaneous to/within Bright STAR – examine how clinicians use the test

How goo round

likelihooc

PICU cli e results

96% neg

BMC Med Inform Decis Mak. 2020 Jul 2;20(1):144. doi: 10.1186/s12911-020-01165-3.

How good is our diagnostic intuition? Clinician prediction of bacteremia in critically ill children

Katherine E M Hoops [1], James C Fackler [2], Anne King [3], Elizabeth Colantuoni [4], Aaron M Milstone [3], Charlotte Woods-Hill [5]

Work system assessment of Bright STAR sites

Current

Cultures iation before testing

Variabi

Published in final edited form as:
Pediatr Crit Care Med. 2020 January ; 21(1): e23–e29. doi:10.1097/PCC.0000000000002176.

Practices, perceptions, and attitudes in the evaluation of critically ill children for bacteremia: a national survey

Charlotte Z Woods-Hill, MD[a,b], Danielle W Koontz, MA[c], Anne F King, RN[c], Annie Voskertchian, MPH[c], Elizabeth A Colantuoni, PhD[d], Marlene R Miller, MD MSc[e,f,g], James C Fackler, MD[h], Christopher P Bonafide, MD MSCE[i], Aaron M Milstone, MD MHS[c], Anping Xie, PhD[h,j], Bright Star authorship group

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The conclusion, and the follow-up question…

We don’t think we use this test particularly well, we admit we use it reflexively and without much pre-test evaluation, in highly variable ways, and we’re actually quite good at predicting when the test will be negative

Can we come to consensus about when we should send, and should not send, a blood culture in a PICU patient?

Delphi Consensus Work

- We have used the expertise within Bright STAR, plus experts from various societies (SHEA, SCCM, PIDS, and PALISI) to complete Delphi consensus work

- The end product is **consensus-based recommendations focusing on safe blood culture reduction in critically ill children**

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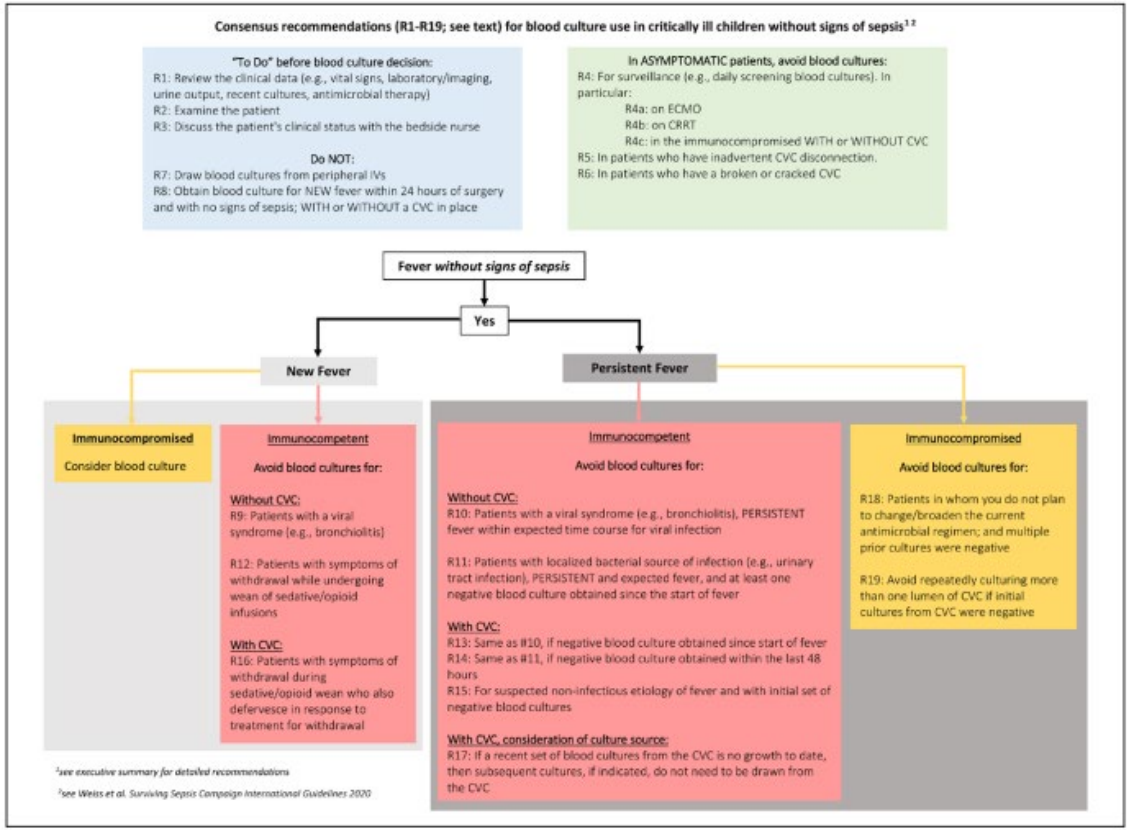
Delphi consensus recommendations



Woods-Hill CZ, et al. Consensus Recommendations for Blood Culture Use in Critically Ill Children Using a Modified Delphi Approach. Pediatr Crit Care Med. 2021 Apr 23.

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Results: general clinical practices

1	Clinicians should review a patient's clinical data (such as vital signs, existing laboratory/imaging data, urine output, recent cultures, current antimicrobial therapy) prior to making the decision to order or not order a blood culture.	97%	% Agreement
2	Clinicians should perform a physical exa[illegible]on to order or not order a blood culture.	89%	
3	Clinicians should discuss a patient's clinical status with the bedside nurse to inform the decision to order or not order a blood culture.	96%	
4	Avoid surveillance blood cultures (e.g. daily screening blood cultures) in all patients. 4a Avoid surveillance blood cultures (e.g. daily screening blood cultures) for patients on extracorporeal membrane oxygenation (ECMO). 4b Avoid surveillance blood cultures (e.g. daily screening blood cultures) for patients on continuous renal replacement therapy (CRRT). 4c Avoid surveillance blood cultures (e.g. daily screening blood cultures) in immunocompromised patients WITH or WITHOUT central venous catheters.	96%	
5	Avoid blood cultures in asymptomatic patients who experience an inadvertent central venous catheter disconnection.	89%	
6	Avoid blood cultures in asymptomatic patients who have a broken or cracked central venous catheter.	83%	
7	Avoid drawing blood cultures from peripheral IVs.	100%	
8	Avoid blood culture in patients with NEW fever within 24 hours after surgery, with no signs of sepsis, WITH or WITHOUT a central venous catheter in place.	96%	

SCREEN AND HUDDLE!

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Results: immunocompetent, no CVC

9	Avoid blood culture in patients with a viral syndrome (such as bronchiolitis), NEW fever, no signs of sepsis, and WITHOUT central venous catheter in place.	85%	% Agreement
10	Avoid blood culture in patients with a viral syndrome (such as bronchiolitis), PERSISTENT fever within expected time course for viral infection, no signs of sepsis, and WITHOUT central venous catheter in place.	89%	
11	Avoid blood culture in patients with a localized bacterial source of infection (e.g., urinary tract infection or focal pneumonia), PERSISTENT and expected fever, no signs of sepsis, at least one negative blood culture obtained since the start of fever, and WITHOUT a central venous catheter.	81%	
12	Avoid blood culture in patients with NEW fever, no signs of sepsis, and with symptoms of withdrawal while undergoing wean of sedative/opioid infusions, and WITHOUT a central venous catheter in place.	88%	

Results: immunocompetent, with CVC

13	Avoid repeat blood cultures in patients with a symptomatic viral infection (such as bronchiolitis), PERSISTENT fever within expected time course for this viral infection, no signs of sepsis, and who has already had at least one negative blood culture obtained since the start of fever, WITH central venous catheter in place.	100%	% Agreement
14	Avoid blood culture in patients with a documented localized bacterial infection (e.g., urinary tract infection or focal pneumonia), PERSISTENT and expected fever, no signs of sepsis, and who has a blood culture that is negative to date obtained within the last 48 hours, and WITH a central venous catheter.	100%	
15	For PERSISTENT fever in immunocompetent patients WITH a central venous catheter, suspected non-infectious etiology of fever and no documented source of infection, without signs of sepsis, and with initial set of negative blood cultures, avoid additional blood cultures.	78%	
16	Avoid blood culture in patients with NEW fever, no signs of sepsis, and with symptoms of withdrawal while undergoing wean of sedative/opioid infusions, WITH a central venous catheter in place, who defervesces in response to treatment for withdrawal.	100%	
17	For PERSISTENT fever in patients WITH central venous catheter and without signs of sepsis, if a recent set of blood cultures from the catheter is no growth to date, then subsequent cultures, if indicated, do not need to be drawn from the catheter.	96%	

Results: immunocompromised

18	After repeated negative-to-date blood cultures, avoid additional blood cultures in immunocompromised patients with PERSISTENT fever, but without signs of sepsis or infection, in whom you do not plan to change/broaden the current antimicrobial regimen.	89%	% Agreement
19	For PERSISTENT fever in immunocompromised patients without signs of sepsis, if initial set of blood cultures from all lumens of central venous catheters were negative, avoid repeatedly culturing more than one lumen of that central venous catheter.	85%	

Consensus recommendations: next steps?

- Larger-scale dissemination of the recommendations

- Is there important data to gather in that process? (Patient level, implementation level)

Questions so far?

BrighT STAR: Results

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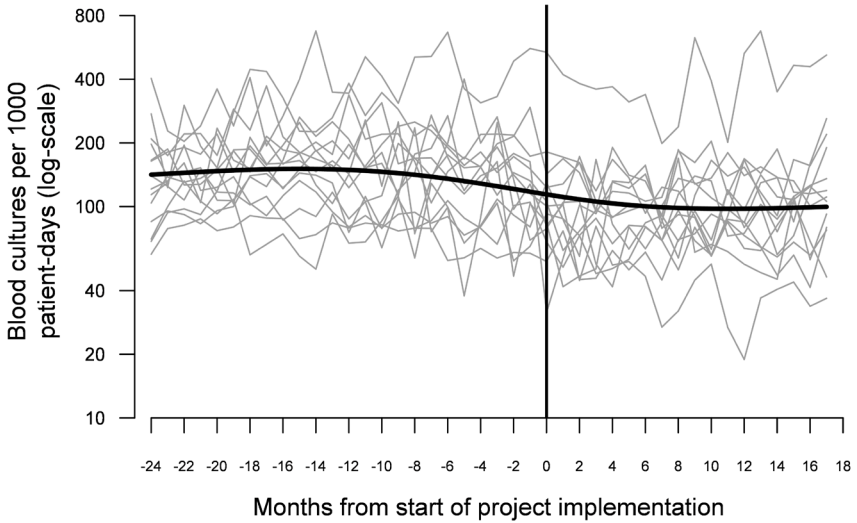
BrighT STAR results: blood cultures



33% relative reduction in blood culture rate, our primary outcome (95% CI: 26-39%)

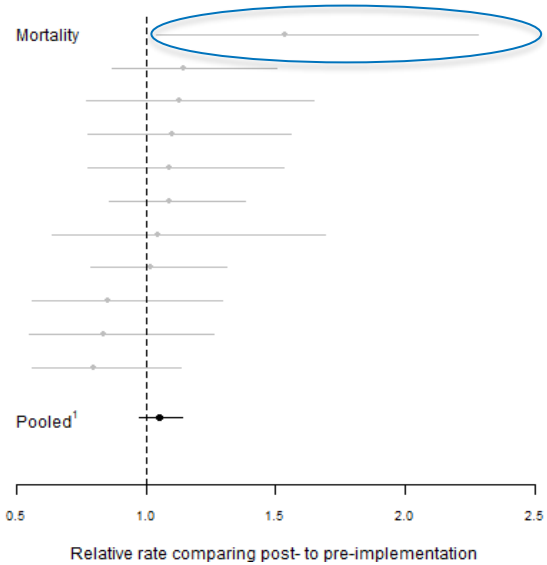
Woods-Hill CZ et al, JAMA Pediatrics 2022

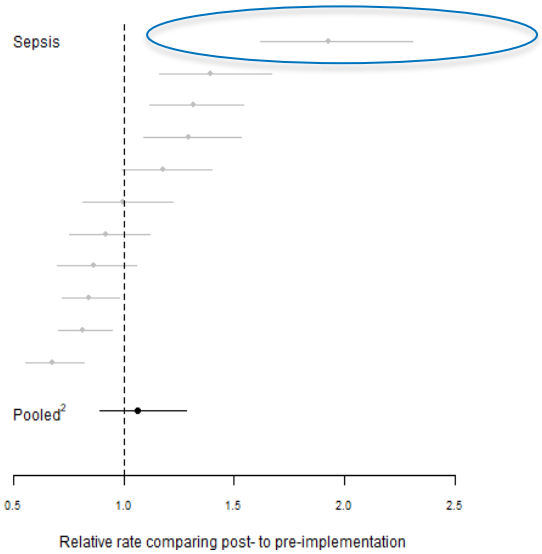
BrighT STAR results: safety/balancing metrics

	Relative rate: post- vs. pre-implementation (95% CI)	P-value
Mortality[1,2]	1.05 (0.97, 1.14)	0.25
PICU Length of stay in days[1,3]	1.02 (0.99, 1.04)	0.07
PICU readmission[1,2]	1.08 (0.99, 1.17)	0.07
Hospital readmission[1,2]	0.97 (0.89, 1.07)	0.56
Sepsis[1,2]	1.06 (0.89, 1.28)	0.50
Severe sepsis/septic shock[1,2]	1.04 (0.86, 1.27)	0.67

[1] Data from 11/14 sites that are Children's Hospital Association Pediatric Health Information System (PHIS) participating hospitals; [2] Rate per 100 PICU admissions; [3] Number of days in the PICU per number new PICU admissions per month

BrighT STAR results: safety/balancing metrics



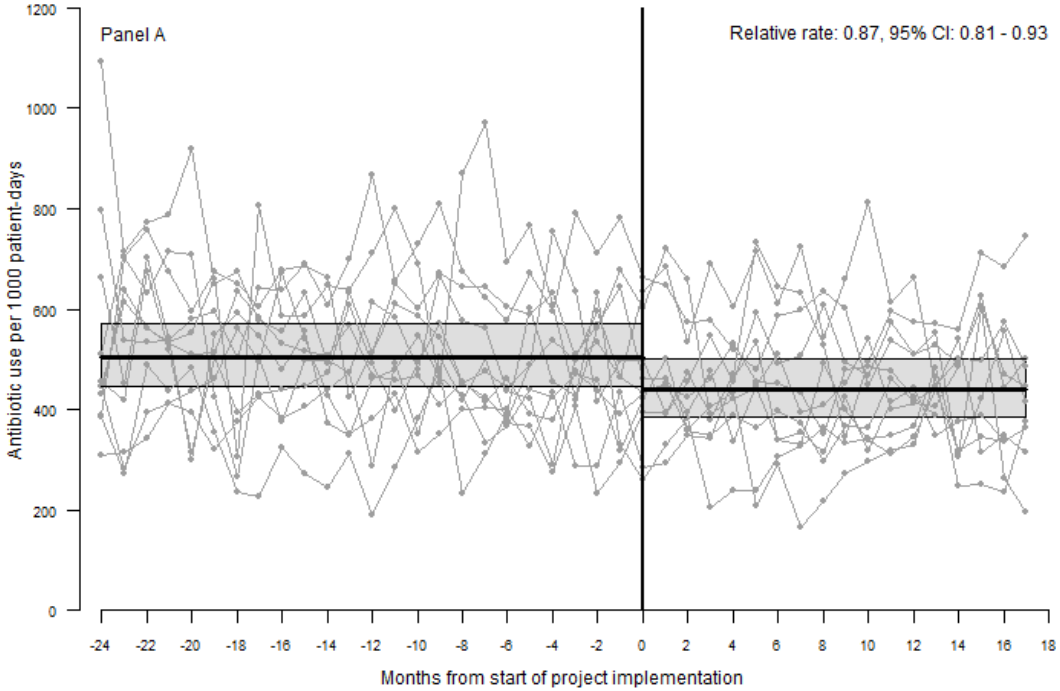


BrighT STAR results: safety/balancing metrics

- Site leads also examined 793 episodes of positive blood cultures for evidence of delay in obtaining the cultures as an additional safety metric

- 792 episodes (99%) with no evidence of delay

BrighT STAR results: antibiotic use

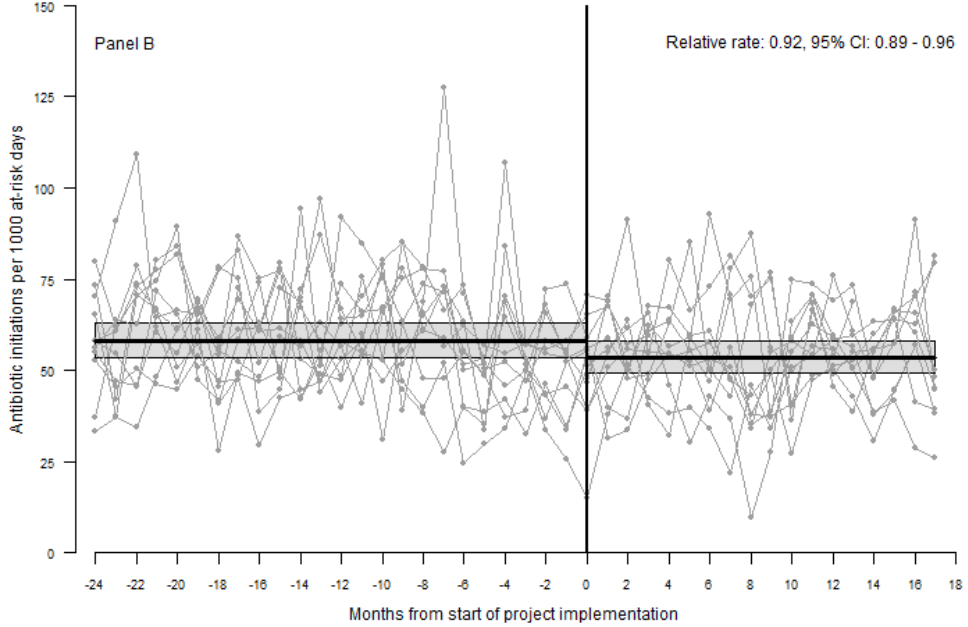


13% relative reduction in broad-spectrum antibiotic use*

*Days of broad-spectrum antibiotics for PICU days ≥ 3

Woods-Hill CZ et al, JAMA Pediatrics 2022

BrighT STAR results: antibiotic use



8% relative reduction in new initiations of broad-spectrum antibiotic use*

*for PICU days ≥ 3

Woods-Hill CZ et al, JAMA Pediatrics 2022

Strategies used for blood culture reduction

- Analysis underway now to try to understand which strategy, or combination of strategies, may be most effective for blood culture reduction in the PICU
- This will the focus of dedicated additional work
- Promising candidate strategies:

  -Formal leadership and stakeholder engagement
  -Formal contextual inquiry/assessment
  -Education and training for staff
  -Audit/feedback of results in real time
  -Workflow changes, such as adjustments to sepsis huddle or blood culture collection process
  -Performance benchmarking across sites

Conclusions

- Multi-site collaborative work can successfully implement diagnostic stewardship in the PICU, including for a clinical entity as challenging as sepsis

- The approach used here can likely be translated to ANY practice change you are interested in – not limited to blood cultures!

- Using a modified Delphi process, we created the first-ever consensus recommendations on when to avoid blood cultures and prevent overuse in the PICU. These recommendations are a critical step in disseminating diagnostic stewardship on a wider scale

Conclusions

- We also demonstrated the first-ever association between **blood culture stewardship and antibiotic reduction in the PICU setting**

- Future steps include determination of ideal strategies for the implementation of these recommendations, a larger-scale look at their impact, and creation of a **"toolkit" with the core components** necessary for reducing blood culture use in diverse, real-world practice settings

- **BrighT STAR 2.0** for respiratory cultures - underway now!

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Thank you!

- IPSO for the invitation to speak (Elise Buckwalter!)
- Aaron Milstone, Jim Fackler, Danielle Koontz, Judy Shea, entire BrighT STAR Team
- The BrighT STAR sites and site teams
- SHEA, PIDS, SCCM, and PALISI for consensus endorsement
- Dr. Robert Sutton and the CHOP Division of Critical Care Medicine

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References

Berwick, D. M., & Hackbarth, A. D. (2012). Eliminating waste in US health care. *Jama*, *307*(14), 1513-1516.

Coon, E. R., Quinonez, R. A., Moyer, V. A., & Schroeder, A. R. (2014). Overdiagnosis: how our compulsion for diagnosis may be harming children. *Pediatrics*, *134*(5), 1013-1023.

Evans, I. V., Phillips, G. S., Alpern, E. R., Angus, D. C., Friedrich, M. E., Kissoon, N., ... & Seymour, C. W. (2018). Association between the New York sepsis care mandate and in-hospital mortality for pediatric sepsis. *Jama*, *320*(4), 358-367.

Hartman ME, Linde-Zwirble WT, Angus DC, Watson RS. Trends in the epidemiology of pediatric severe sepsis. *Pediatr Crit Care Med.* 2013;14(7):686-693; Weiss SL, Fitzgerald JC, Balamuth F, et al. Delayed antimicrobial therapy increases mortality and organ dysfunction duration in pediatric sepsis. *Crit Care Med.* 2014;42(11):2409-2417.

Hoffmann, T. C., & Del Mar, C. (2017). Clinicians' expectations of the benefits and harms of treatments, screening, and tests: a systematic review. *JAMA internal medicine*, *177*(3), 407-419.

Hoops, K. E., Fackler, J. C., King, A., Colantuoni, E., Milstone, A. M., & Woods-Hill, C. (2020). How good is our diagnostic intuition? Clinician prediction of bacteremia in critically ill children. *BMC medical informatics and decision making*, *20*(1), 1-8.

Klompas, M., Calandra, T., & Singer, M. (2018). Antibiotics for sepsis—finding the equilibrium. *Jama*, *320*(14), 1433-1434.

Money, N. M., Schroeder, A. R., Quinonez, R. A., Ho, T., Marin, J. R., Morgan, D. J., ... & Coon, E. R. (2020). 2019 Update on Pediatric Medical Overuse: A Systematic Review. *JAMA pediatrics*, *174*(4), 375-382.

Schlapbach, L. J., & Kissoon, N. (2018). Defining pediatric sepsis. *JAMA pediatrics*, *172*(4), 313-314.

Singer, M., Deutschman, C. S., Seymour, C. W., Shankar-Hari, M., Annane, D., Bauer, M., ... & Angus, D. C. (2016). The third international consensus definitions for sepsis and septic shock (Sepsis-3). *Jama*, *315*(8), 801-810.

Singer, M., Inada-Kim, M., & Shankar-Hari, M. (2019). Sepsis hysteria: excess hype and unrealistic expectations. *The Lancet*, *394*(10208), 1513-1514.

Weiss, S. L., Fitzgerald, J. C., Balamuth, F., Alpern, E. R., Lavelle, J., Chilutti, M., ... & Thomas, N. J. (2014). Delayed antimicrobial therapy increases mortality and organ dysfunction duration in pediatric sepsis. *Critical care medicine*, *42*(11), 2409.

Weiss, S. L., Fitzgerald, J. C., Pappachan, J., Wheeler, D., Jaramillo-Bustamante, J. C., Salloo, A., ... & Thomas, N. J. (2015). Global epidemiology of pediatric severe sepsis: the sepsis prevalence, outcomes, and therapies study. *American journal of respiratory and critical care medicine*, *191*(10), 1147-1157.

Woods-Hill, C. Z., Koontz, D. W., King, A. F., Voskertchian, A., Colantuoni, E. A., Miller, M. R., ... & Xie, A. (2020). Practices, perceptions, and attitudes in the evaluation of critically ill children for bacteremia: a national survey. *Pediatric Critical Care Medicine*, *21*(1), e23-e29.

Woods-Hill, C. Z., Koontz, D. W., Voskertchian, A., Xie, A., Shea, J., Miller, M. R., ... & Milstone, A. M. (2021). Consensus Recommendations for Blood Culture Use in Critically Ill Children Using a Modified Delphi Approach. *Pediatric Critical Care Medicine: a Journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies*.

Woods-Hill, C. Z., Lee, L., Xie, A., King, A. F., Voskertchian, A., Klaus, S. A., ... & Milstone, A. M. (2018). Dissemination of a novel framework to improve blood culture use in pediatric critical care. *Pediatric quality & safety*, *3*(5).

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