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## Neonatologists' Perceptions of Antimicrobial Resistance and Stewardship in the Neonatal Intensive Care Unit

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In 2002, the Centers for Disease Control and Prevention (CDC) launched the Campaign to Prevent Antimicrobial Resistance in Health Care Settings.<sup>1</sup> Designed to facilitate practice improvements for healthcare providers, the campaign consisted of 4 major strategies: prevent acquisition of potential pathogens, diagnose and treat infections effectively, use antimicrobials wisely, and prevent transmission. Although the campaign was not tailored to patients hospitalized in neonatal intensive care units (NICUs), its principles can be adapted for this patient population (Table 1). We developed a 43- question, anonymous, self-administered survey for neonatologists to assess barriers to knowledge, attitudes, and practices with regard to antimicrobial resistance, antimicrobial stewardship, and the CDC campaign principles by means of a paradigm created by Cabana et al.<sup>2</sup> The survey used a 3-point or 5-point Likert format as well as forced choices. The survey was administered to neonatal medicine attendings and fellows practicing in tertiary care NICUs in the United States who were attending research conferences on June 1, 2007, or October 6, 2008.

In all, 53 neonatologists from 31 medical centers participated in this study. All respondents worked in level III NICUs affiliated with academic institutions. Because the survey was anonymous, the academic affiliation of each respondent was unknown, although no more than 2 attendees from the same institution were at each of the research conferences. Resources available to assist antimicrobial prescribing differed among respondents. The majority (49 [92%] of 53) had access to an infectious diseases subspecialty consult service, fewer had access to a clinical pharmacist (36 [71%] of 51) or required preapproval for antibiotics (25 [48%] of 52), and only a minority (8 [15%] of 53) had access to an

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Potential Conflicts of Interest

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antimicrobial stewardship program (ASP). Nearly all (46 [88%] of 52) agreed or strongly agreed that antimicrobial resistance is a serious problem among infants hospitalized in NICUs in the United States, but only 35 (67%) of 52 believed antimicrobial resistance was a serious problem in their NICU.

Among the respondents, only 32 (65%) of 49 agreed that adherence to contact precautions would decrease the burden of antimicrobial resistance. Most (48 [91%] of 53) agreed that limiting the use of third-generation cephalosporin agents would decrease antimicrobial resistance. However, fewer agreed that limiting the duration of postoperative surgical prophylaxis to 48 hours (20 [40%] of 50), obtaining 2 blood cultures for evaluation of late-onset sepsis (29 [56%] of 52), or discontinuing empirical vancomycin after 72 hours if blood culture results were negative (18 [36%] of 50) could improve patient outcomes. A minority (19 [37%] of 51) of respondents were very or extremely confident that, given a positive culture result, they could distinguish infection from colonization and/or contamination. In addition, a minority (17 [34%] of 50) were confident that they could use local epidemiology and resistance patterns to guide antibiotic use in their NICU.

Only 12 (23%) of 52 respondents regularly obtained 2 blood cultures for sepsis evaluations, and 7 (14%) of 50 reported that they never obtained more than 1 blood culture. Although 40 (83%) of 48 respondents reported that they regularly avoided the use of meropenem for empirical treatment of late-onset sepsis, only 37 (70%) of 53 avoided vancomycin to treat methicillin-susceptible *Staphylococcus aureus* after antibiotic susceptibilities were known.

The most commonly reported influences on antimicrobial prescribing were colleagues (44 [96%] of 46), infectious diseases consultations (43 [93%] of 46), and peer-reviewed literature (43 [93%] of 46). Professional society guidelines (41 [87%] of 47) and clinical pharmacists (31 [66%] of 47) were also influential, and most (36 [71%] of 51) reported that they were influenced by 3 or more sources. Didactic lectures and small group discussions were the most preferred means of education for antimicrobial resistance and stewardship, and printed materials and computer-based order entry were least preferred.

As has been shown with internal medicine physicians, the neonatologists in our survey considered antimicrobial resistance to be a more significant health issue nationally than locally.<sup>3</sup> Particularly noteworthy was respondents' relative lack of confidence that they could accurately diagnose infections in this population. This response is understandable, because neonates exhibit nonspecific symptoms of sepsis, and adequate blood culture volumes can be difficult to obtain. Another important finding was a lack of familiarity with optimum therapy for methicillin-susceptible *S. aureus* infection, even after antibiotic susceptibilities are known. Despite the range of electronic and print resources available to prescribers, respondents preferred traditional face-to-face education, in the form of lectures, small-group discussions, or formal infectious diseases consultation.

The barriers to knowledge, attitudes, and practices identified in our study may inform the development of NICU specific ASPs. ASPs use multifaceted interventions (eg, prescriber feedback and computer-assisted decision support) and consist of an interdisciplinary team of physicians, nurses, pharmacists, hospital epidemiologists, and bioinformatics specialists.

Direct education supplemented with computerized decision support may help prescribers to choose empirical therapy appropriate for site of infection and history of previous drug-resistant organisms. As noted above, our respondents had low self-reported adherence to obtaining 2 blood cultures for sepsis evaluations. Prescriber feedback on blood culturing practices may improve diagnostic strategies. Review of antibiotics at 48–78 hours after initiation by an infectious diseases physician or clinical pharmacist may help prescribers to interpret culture results and to narrow or to discontinue antibiotic coverage, if warranted. Finally, readily available NICU-specific antibiograms can familiarize prescribers with local epidemiology, can guide empirical therapy, and can demonstrate a link between antimicrobial resistance and antibiotic prescribing.

Because respondents were attending research conferences, there may have been selection bias toward individuals from university-affiliated, tertiary care institutions. Although anonymous, the respondents may have provided socially desirable answers to the survey questions. However, any acquiescence bias likely would underestimate barriers.

Formal ASPs in pediatrics are not common. In a national survey of pediatric infectious diseases consultants, the prevalence of ASPs was low (33%).<sup>4</sup> The Infectious Diseases Society of America has issued guidelines for institutional development of ASPs.<sup>5</sup> However, these recommendations do not address the specific needs of neonatal populations. Our survey provides insight into developing NICU-specific ASPs. By addressing barriers to implementation and focusing on areas of consensus, we can safely and sustainably improve antibiotic use, even in medically complex NICU populations.

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## REFERENCES

1. Centers for Disease Control and Prevention. [Accessed Dec. 2009] 12-Step Program to Prevent Antimicrobial Resistance in Health Care Settings. 2002. Available at: <http://www.cdc.gov/drugresistance/healthcare/>
2. Cabana MD, Rand CS, Powe NR, Wu AW, Wilson MH, Abboud PA et al. Why don't physicians follow clinical practice guidelines? A framework for improvement. *JAMA*. 1999; 28:1458–1465. [PubMed: 10535437]
3. Wester C, Durairaj L, Evans AT, Schwartz DN, Husain S, Martinez E. Antibiotic resistance: survey of physician perceptions. *Arch Intern Med*. 2002; 162:2210–2216. [PubMed: 12390064]
4. Hersh AL, Beekmann SE, Polgreen PM, Zaoutis TE, Newland JG. Antimicrobial Stewardship Programs in Pediatrics. *Infect Control Hosp Epidemiol*. 2009; 30:1211–1217. [PubMed: 19852666]
5. Dellit TH, Owens RC, McGowan JE Jr, Gernding DN, Weinstein RA, Burke JP, et al. Infectious Diseases Society of America, Society for Healthcare Epidemiology of America. Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. *Clin Infect Dis*. 2007; 44:159–177. [PubMed: 17173212]

**Table 1**

Application in the Neonatal Intensive Care Unit (NICU) of the Strategies of the Centers for Disease Control and Prevention Campaign to Prevent Antimicrobial Resistance in Health Care Settings

General Strategies	Campaign Principles	Example(s) of Violation of Specific Principle
Prevent acquisition	<ol style="list-style-type: none"> <li>1. Vaccinate</li> <li>2. Get the catheter out</li> </ol>	<ol style="list-style-type: none"> <li>1. Failing to vaccinate NICU staff (e.g., against influenza).</li> <li>2. Continued central venous catheter use when feeds &gt; 100 ml/kg/day.</li> </ol>
Diagnose and Treat Infection Effectively	<ol style="list-style-type: none"> <li>3. Use appropriate methods for diagnosis</li> <li>4. Target the pathogen</li> <li>5. Access the experts</li> </ol>	<ol style="list-style-type: none"> <li>3. Obtaining central catheter blood culture without simultaneous peripheral culture.</li> <li>4. Continuing vancomycin for MSSA infection rather than oxacillin.</li> <li>5. Using cefotaxime rather than ceftazidime; clinicians interpreting susceptibility reports incorrectly.</li> </ol>
Use Antimicrobials Wisely	<ol style="list-style-type: none"> <li>6. Practice antimicrobial control</li> <li>7. Use local data</li> <li>8. Treat infection, not contamination or colonization</li> <li>9. Know when to say 'no' to antibiotics, (e.g., vancomycin)</li> <li>10. Stop treatment when infection is cured or unlikely</li> </ol>	<ol style="list-style-type: none"> <li>6. Continuing post-operative prophylaxis for &gt; 48 hours.</li> <li>7. Antimicrobial stewardship program not guided by local epidemiology.</li> <li>8. Treating when only 1 of 2 coagulase-negative staphylococci blood cultures is positive. Treating when tracheal culture is positive for <i>Pseudomonas aeruginosa</i> without signs of ventilator-associated pneumonia.</li> <li>9. Using carbapenem for empiric treatment of late onset sepsis</li> <li>10. Treating <i>Staphylococcus epidermidis</i> bloodstream infection for &gt;10 days</li> </ol>
Prevent Transmission	<ol style="list-style-type: none"> <li>11. Practice infection control</li> <li>12. Practice hand hygiene</li> </ol>	<ol style="list-style-type: none"> <li>11. Failing to institute appropriate transmission precautions.</li> <li>12. Missing opportunities for hand hygiene</li> </ol>

MSSA, methicillin-susceptible *Staphylococcus aureus*.