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ORIGINAL ARTICLE

Diagnosing and Reporting of Central Line–Associated Bloodstream Infections

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BACKGROUND. The diagnosis of central line–associated bloodstream infections (CLABSIs) is often controversial, and existing guidelines differ in important ways.

OBJECTIVE. To determine both the range of practices involved in obtaining blood culture samples and how central line–associated infections are diagnosed and to obtain members' opinions regarding the process of designating bloodstream infections as publicly reportable CLABSIs.

DESIGN. Electronic and paper 11-question survey of infectious-diseases physician members of the Infectious Diseases Society of America Emerging Infections Network (IDSA EIN).

PARTICIPANTS. All 1,364 IDSA EIN members were invited to participate.

RESULTS. 692 (51%) members responded; 52% of respondents with adult practices reported that more than half of the blood culture samples for intensive care unit (ICU) patients with central lines were drawn through existing lines. A sizable majority of respondents used time to positivity, differential time to positivity when paired blood cultures are used, and quantitative culture of catheter tips when diagnosing CLABSI or determining the source of that bacteremia. When determining whether a bacteremia met the reportable CLABSI definition, a majority used a decision method that involved clinical judgment.

CONCLUSIONS. Our survey documents a strong preference for drawing 1 set of blood culture samples from a peripheral line and 1 from the central line when evaluating fever in an ICU patient, as recommended by IDSA guidelines and in contrast to current Centers for Disease Control and Prevention recommendations. Our data show substantial variability when infectious-diseases physicians were asked to determine whether bloodstream infections were primary bacteremias, and therefore subject to public reporting by National Healthcare Safety Network guidelines, or secondary bacteremias, which are not reportable.

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Bloodstream infections (BSIs) in hospitalized patients are associated with significant morbidity[1] and associated mortality that ranges from 16% to 40%.[2] Intravenous catheters are the most common source of these infections.[3,4] Umscheid and colleagues[5] recently estimated that as many as 65%–70% of catheter-associated BSIs were preventable, representing approximately 44,762–164,127 avoidable infections in the United States per year.

In 2009, the Infectious Diseases Society of America (IDSA) released updated guidelines to help clinicians diagnose and manage catheter-related BSIs (CRBSIs).[6] The Centers for Disease Control and Prevention's (CDC) National Healthcare Safety Network (NHSN) has published a surveillance definition for central line–associated BSIs (CLABSIs) to allow these infections to be identified consistently so that infection prevention programs can assess whether their rates are changing over time and so that facilities can compare their rates with national benchmarks.[7] The NHSN definitions were not intended to facilitate clinical management.[8]

Since 2011, the Centers for Medicare and Medicaid Services (CMS) has required hospitals that receive reimbursements from Medicare to report CLABSIs acquired in their intensive care units (ICUs) to NHSN. Thus, hospitals must use the NHSN CLABSI definition when doing surveillance for these infections. In addition, at least 31 states and the District of Columbia mandate hospital reporting of CLABSIs to NHSN.[9] The NHSN CLABSI surveillance definition is agreed to be highly sensitive but, as with many surveillance definitions,

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may lack specificity.[10,11] The low specificity has become particularly problematic because CMS is using CLABSI rates to qualify hospitals for their annual payment update.

We surveyed members of the IDSA Emerging Infections Network (EIN) to determine both the range of practices hospitals use when obtaining blood samples for culture and how infectious-diseases clinicians diagnose CLABSIs. We also asked members about the process used to determine whether a BSI meets the NHSN definition of CLABSI and thus would be publicly reportable.

METHODS

The IDSA EIN is a voluntary sentinel network of 1,364 infectious-diseases physicians who currently care for adult or pediatric patients and who represent approximately 20% of the infectious-diseases subspecialists in the United States certified by the American Board of Internal Medicine.[12,13] The survey was developed with input from numerous persons who have content expertise.[13] We sent an 11-question survey via e-mail link (for the electronic version) or fax (for the paper version) to members in July 2011, and we sent 2 reminders to nonresponders at approximately 2-week intervals.

We asked all members whether the blood sample site could be identified and the proportion of blood samples drawn through existing lines at their facilities. We also asked members to rank the approaches used in their facilities to obtain the first 2 sets of blood culture samples during fever evaluations of ICU patients with central lines and to select the diagnostic tools used to diagnose CLABSIs and/or to determine the source of a bacteremia. We presented a brief clinical vignette (Table 3) and asked respondents to indicate the most likely source of a patient's BSI, given that it was caused by a specific organism. We asked about involvement in decisions regarding whether a BSI meets the reportable NHSN definition of CLABSI. Respondents who were involved in these decisions were asked to read a second vignette (Table 4) and then specify whether they and the infection preventionists would assess the bacteremia as primary (CLABSI) or as secondary.

We analyzed the data in SAS, version 9.2 (SAS Institute). A χ^2 or Fisher exact test was used to compare proportions between categorical variables, as appropriate.

RESULTS

Characteristics of Respondents

Of the 1,364 EIN members, 692 (51%) responded, from 49 states, the District of Columbia, Puerto Rico, and 4 Canadian provinces. Respondents were not different from the nonrespondent group with respect to region of practice, type of hospital or employment, or size of hospital (number of beds). Respondents were significantly more likely than nonrespondents to have a pediatric practice ($P = .03$), to have more than 14 years of infectious-diseases experience ($P < .0001$), or to be a hospital epidemiologist or a member of an institutional infection control committee ($P < .0001$). Responses from 84 respondents who reported that they did not diagnosis CLABSIs were excluded from further analysis. See Table 1 for more detail.

Site from Which Blood Specimens for Culture Are Drawn

Seventy-two percent of respondents with an adult practice reported always or usually being able to identify the site from which blood culture samples are drawn, compared to 93% of pediatric respondents. Respondents from hospitals with more than 450 beds were least likely to report always knowing the blood sample draw site ($P = .027$).

Fifty-two percent of respondents with adult practices reported that more than half of the blood culture samples obtained from ICU patients with central lines were drawn through existing lines (Figure 1), compared with 96% of respondents who had pediatric practices ($P < .0001$). A similar pattern was seen with hematology-oncology and bone marrow transplant patients: 64% of respondents with adult practices reported that more than half of the blood culture samples obtained from patients with central lines were drawn through existing lines, compared with 98% of respondents with pediatric practices ($P < .0001$).

Diagnosis of BSIs in Patients with Existing Central Lines

Respondents overwhelmingly reported that the usual practice at their hospitals was to obtain one set of blood culture samples from a peripheral vein and a second set from the central line when evaluating febrile ICU patients with central lines (Figure 2). The second most commonly reported approach was drawing both sets of blood culture samples from different peripheral veins. Most respondents (85%) reported that a third set of blood culture samples was not obtained routinely during initial fever evaluation.

Use of a variety of diagnostic tools recommended in the literature varied widely among respondents (Table 2). About 60% of respondents reported that they used time to positivity, differential time to positivity when paired blood cultures were used, or quantitative culture of catheter tips when diagnosing CLABSIs or determining the source of that bacteremia. A minority of respondents reported that they used quantitative blood cultures (12%) or the endoluminal-brush method (1%) or that these tests were available but not used (13% and 5%, respectively).

Clinical Judgments Regarding the Source of BSIs

Respondents were given a clinical vignette (Table 3) and asked to identify the most likely source of the patient's BSI for 8 different causative organisms. Most respondents believed that a coagulase-negative staphylococcal BSI was attributable to a central line and that BSIs caused by either anaerobes (eg, *Bacteroides* species) or Enterobacteriaceae were likely attributable to another source. Pediatric and adult infectious-

TABLE 1. Respondent and Facility Characteristics for All EIN Respondents, Shown by Those Who Report Adjudicating CLABSIs and Those Who Report Not Adjudicating CLABSIs

Characteristic	All respondents	Report adjudication	Report no adjudication	*P*
Total	692 (100)	373 (65)	202 (35)	
Practice				.0018
Adult ID	534 (77)	300 (80)	139 (69)	
Pediatric ID	158 (23)	73 (20)	63 (31)	
Experience since ID fellowship, years				.0009
<5 (includes fellows-in-training)	110 (16)	49 (13)	48 (24)	
5–14	191 (28)	97 (26)	63 (31)	
15–24	197 (28)	111 (30)	49 (24)	
≥25	194 (28)	116 (31)	42 (21)	
Type of hospital				.0001
Community	157 (23)	100 (27)	32 (16)	
Nonuniversity teaching	200 (29)	123 (33)	52 (26)	
University	260 (38)	114 (31)	103 (51)	
City/county	22 (3)	9 (2)	6 (3)	
VA or military	45 (6)	26 (7)	9 (4)	
Other (cancer, LTAC)	8 (1)	1 (0.3)	0	
No. of beds[a]				.054
<200	61 (9)	39 (16)	10 (8)	
200–350	159 (23)	94 (38)	48 (37)	
351–450	69 (10)	35 (11)	22 (17)	
451–600	74 (11)	43 (17)	17 (13)	
>600	89 (13)	39 (16)	32 (25)	
Involvement in infection prevention/infection control[b]				.0001
Hospital epidemiologist	197 (28)	145 (39)	18 (9)	
Infection control committee	134 (19)	85 (23)	29 (14)	
Interested and/or SHEA member	66 (10)	31 (8)	26 (13)	
Not involved and not SHEA member	295 (43)	112 (30)	129 (64)	

NOTE. Data are presented as number (%) of respondents; except for the first row, percentages are column percentages. CLABSI, central line–associated bloodstream infection; EIN, Emerging Infections Network; ID, infectious diseases; LTAC, long-term acute care; SHEA, Society for Healthcare Epidemiology of America.

[a] Data not available for 240 respondents.

[b] Data not available for 117 respondents. Note that 241 respondents who are not SHEA members reported involvement in adjudicating CLABSIs.

diseases physicians responded similarly, except when viridans-group streptococci were the etiological agent. Pediatric practitioners were more likely to believe that a viridans streptococcus bacteremia originated with the central line, while adult-practice infectious-diseases specialists were more likely to believe either that the source was not the central line or that the source was equally likely to be the central line or another source ($P = .0004$).

Adjudication of CLABSI Data

Sixty percent of respondents (373) reported that they had at least some role in deciding whether a blood culture isolate met the NHSN definition of a CLABSI. These respondents were asked to read a vignette (Table 4) and state whether they thought that the source of a BSI caused by vancomycin-resistant enterococci (VRE), *Klebsiella*, or methicillin-resistant *Staphylococcus aureus* (MRSA) was a primary or a secondary BSI. They were also asked to state whether the infection preventionists at their hospital would categorize the BSI as primary or secondary. The hypothetical bacteremias in this vignette would all meet the NHSN definition of a primary BSI, which should be classified as a CLABSI, given the patient's peripherally inserted central catheter (PICC) line. Eighty-three percent of respondents designated MRSA bacteremias as primary BSIs, compared with 45% for VRE bacteremias and 36% for *Klebsiella* bacteremias. Respondents were only somewhat more likely to indicate that infection preventionists would designate VRE and *Klebsiella* bacteremias as primary BSIs, and they believed that infection preventionists would be less likely to designate MRSA bacteremias as primary BSIs.

These 373 respondents were asked to indicate approaches used in their institutions to adjudicate difficult or controversial cases. Sixty-six percent of respondents reported that a consensus method was used, 25% reported that a single "decider" made the final determination; 13% reported that there was "no adjudication method; original call will stand,"

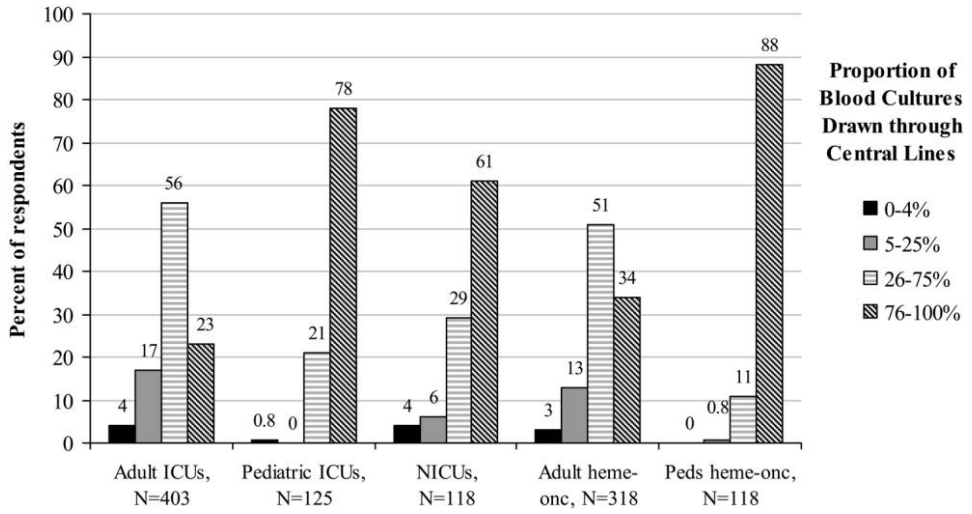

FIGURE 1. Proportion of blood culture samples obtained during evaluation of patients with central lines that respondents estimated were drawn through existing lines, by type of patient care unit. ICU, intensive care unit; NICU, neonatal ICU; heme-onc, hematology-oncology; peds, pediatric.

and 13% reported that the "clinician is allowed a veto (clinical judgment)." Seventy percent of these respondents reported that their infection prevention programs incorporated clinical judgment (either clinician veto or a consensus method) into assessments of whether a patient had a CLABSI.

These 373 respondents were asked whether a public reporting system should define CLABSI using objective criteria only (which may be less valid clinically but would minimize interobserver and interinstitutional variability), subjective clinical judgment only (which may be more clinically valid for individual patients but would increase population-level, interobserver, and interinstitutional variability), or a combination of objective and subjective measures. Fifty-seven percent of respondents indicated that the CLABSI definition should be based exclusively or mostly on objective measures. However, 33% indicated that the CLABSI definition should be based equally on objective measures and subjective clinical judgment, and 11% indicated that the definition should be

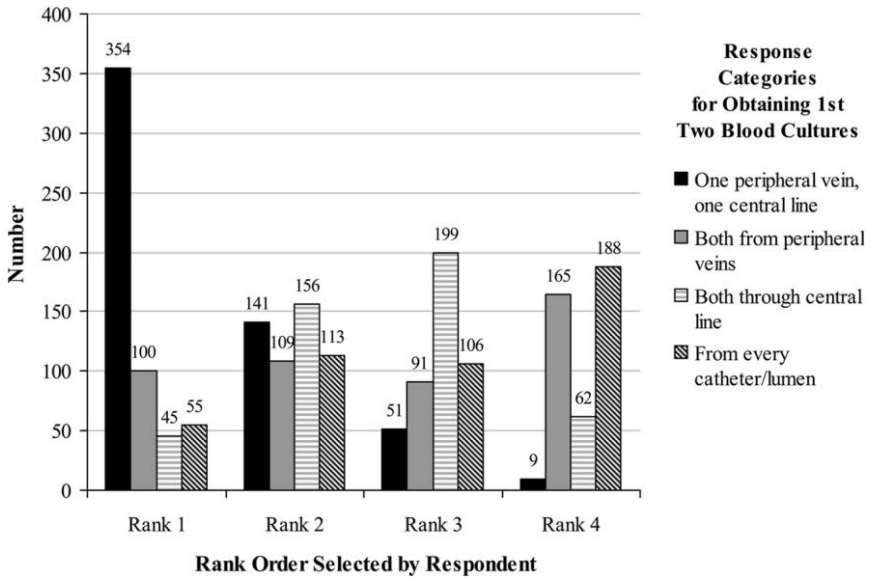

FIGURE 2. Respondents' rankings of the approaches used in their hospitals when obtaining the first 2 sets of blood culture samples for evaluating fever in an intensive care unit patient with a central line. A rank of 1 indicates the most frequent approach; a rank of 4 indicates the approach that occurs least often.

TABLE 2. Diagnostic Tools Used to Diagnose CLABSI and/or to Determine the Source of a Bacteremia

Test	Not available in my institution	Yes, I use this	Available, but I do not use
Time to positivity	98 (18)	341 (62)	109 (20)
Differential time to positivity when paired BC[a] are drawn	110 (20)	334 (60)	109 (20)
Quantitative BC (eg, isolators)	405 (75)	63 (12)	73 (13)
Cultures from all lumens of a central line	82 (15)	239 (44)	219 (41)
Endoluminal-brush method	485 (94)	5 (1)	25 (5)
Quantitative culture of catheter tips (sonication or roll plate)	129 (24)	337 (61)	82 (15)

NOTE. Data are presented as number (row %) of respondents. BC, blood cultures; CLABSI, central line–associated bloodstream infection.

[a] One from central line, one from peripheral vein.

based mostly or entirely on subjective clinical judgment. Overall, 75% of 240 respondents to this question wanted at least some subjectivity in the definition.

DISCUSSION

Our survey of infectious-diseases physicians documents that a two-thirds majority usually evaluate fever in an ICU patient by obtaining one set of blood culture samples from a peripheral vein and one set from a central line, as recommended by IDSA clinical guidelines[6] and in contrast to current CDC NHSN epidemiologic definitions.[14] Our data also show that infectious-diseases physicians frequently disagree about whether BSIs should be categorized as primary BSIs, and therefore subject to public reporting by NHSN guidelines, or secondary BSIs, which are not reportable. In addition, the survey indicated that infectious-diseases clinicians do not agree on the components of a CLABSI surveillance definition. While a majority (57%) of respondents indicated that the CLABSI definition should be based entirely or mostly on objective criteria, a substantial minority (43%) believed that subjective clinical judgment was equally or more important.

Our respondents' preference for drawing blood culture samples both peripherally and through a central line mirrors IDSA's "best practice" clinical recommendations.[6] NHSN currently recommends collecting two or more blood culture samples from separate venipuncture sites and not through vascular catheters.[14] NHSN definitions are intended for epidemiologic purposes and are designed to limit misclassification of central-line colonization as a true BSI.[8]

About two-thirds of respondents reported that they used differential time to positivity as a diagnostic technique when evaluating the source of fever and bacteremia in patients with central lines. This technique is based on the premise that patients with CLABSI have a greater burden of bacteria in blood drawn through the catheter than in blood drawn peripherally, and it is fairly accurate and more cost-effective than other methods.[6,15,16] However, clinicians can use it only when at least 1 blood culture sample was drawn through the catheter and when the site from which the blood was drawn was identified clearly. In fact, only 15% of our survey respondents reported always being able to identify the site. If more clinical laboratories report differential time to positivity and if process issues, such as identifying the site from which blood was drawn, are corrected, NHSN definitions could be

TABLE 3. Determining the Source of Bloodstream Infections in Patients with Existing Central Lines: Members' Opinions about the Most Likely Source of a Patient's Bloodstream Infection, by Organism

	Most likely central line	Most likely not central line (either gut or mucosa)	Equally likely to be either central line or other source
Staphylococcus aureus	427 (75)	10 (2)	132 (23)
Coagulase-negative staphylococci	538 (93)	5 (0.9)	33 (6)
Candida parapsilosis	261 (46)	79 (14)	229 (40)
Candida spp. (not *C. parapsilosis*)	165 (29)	95 (17)	310 (54)
Enterococcus spp.	55 (10)	239 (42)	277 (48)
Viridans-group streptococci	71 (13)	315 (55)	183 (32)
Enterobacteriaceae	17 (3)	375 (66)	178 (31)
Anaerobes (eg, *Bacteroides*)	5 (0.9)	531 (93)	32 (6)

VIGNETTE: A patient develops fever on day 8 status post hematopoietic stem cell transplant. He is neutropenic, has mucositis and diarrhea, and has a central venous catheter. Two blood cultures are positive (one obtained from the central line, one from a peripheral vein); all other cultures are negative. His empiric therapy for neutropenic fever is modified according to the culture growth from the blood. He remains hemodynamically stable, and immediately clears his blood cultures.

NOTE. Data are presented as number (row %) of respondents.

TABLE 4. CLABSI Adjudication: Members' Opinions as to How a Bacteremia Would Be Designated, by Organism

	CLABSI (primary)	Secondary to gastroenteritis	Not sure
VRE			
By you	110 (45)	68 (28)	63 (26)
By the infection preventionist	134 (55)	43 (18)	64 (27)
Klebsiella			
By you	86 (36)	89 (37)	65 (27)
By the infection preventionist	120 (50)	51 (21)	69 (29)
MRSA			
By you	200 (83)	11 (5)	30 (12)
By the infection preventionist	176 (73)	16 (7)	49 (20)

VIGNETTE: A patient has a central venous catheter (PICC) and a PEG tube. He develops fever and 2 blood cultures (peripheral + PICC line) are positive. No other cultures (urine, sputum) are positive. He also has "gastroenteritis" with coincident diarrhea and is stool fecal leukocyte positive. Upon hospital admission he had a screening rectal swab obtained, which grew both VRE and MRSA.

NOTE. Data are presented as number (row %) of respondents. CLABSI, central line–associated bloodstream infection; MRSA, methicillin-resistant *Staphylococcus aureus*; PEG, percutaneous endoscopic gastrostomy; PICC, peripherally inserted central catheter; VRE, vancomycin-resistant enterococci.

altered to include differential time to positivity as a diagnostic technique, and a difference between the IDSA guidelines and NHSN definitions could be reduced. This process could be improved if practices for drawing and identifying blood culture samples were standardized.[6,10]

Respondents used other potentially useful diagnostic techniques even less often than they used differential time to positivity. For example, Safdar and her colleagues[16] determined that paired quantitative blood cultures were the most accurate test for diagnosing intravascular device–related BSIs, but 75% of our respondents reported that this technique was not available in their institutions, and only 12% of respondents used it. The labor-intensive nature of this technique, as well as the increased likelihood of contamination, may explain why so few centers use it. Similarly, the endoluminal-brush method was 100% sensitive for the diagnosis of CLABSI,[17] but 94% of respondents indicated that it was not available in their institutions, and only 1% used this technique.

Clinicians' responses to the questions about the source of BSIs caused by various organisms suggested that they strongly associated specific organisms with specific sources. Respondents agreed on the sources for coagulase-negative staphylococci and anaerobes. A smaller majority agreed that the source of an Enterobacteriaceae BSI was most likely either the gut or a mucosal surface, even if BSI met the NHSN definition of a CLABSI. Fewer than half of the respondents who were involved in CLABSI adjudication correctly categorized *Klebsiella* or VRE BSIs as primary CLABSIs. Respondents believed that infection preventionists would be somewhat more likely to designate the infections as primary CLABSIs. Furthermore, the respondents' answers indicated that different infection prevention programs use different approaches to adjudicating difficult or controversial cases, and 13% reported that clinicians could "veto" the infection preventionists' assessments on the basis of their clinical judgment.

Thus, our results suggest that many infectious-diseases consultants use subjective criteria for both clinical and epidemiologic purposes. Several other investigators have noted substantial subjective variability in reported CLABSI rates.[18-20] Backman and her colleagues[18] performed a blinded retrospective chart review of "septic events" in Connecticut. Only 48% of the events that met the CLABSI definition had been reported to NHSN; 45% of the underreporting was related to misinterpretation of the NHSN definition of primary and secondary BSIs. Lin et al[19] developed a computer algorithm that approximated the CDC surveillance definition and correlated results using this algorithm with CLABSI rates in 20 ICUs at 4 hospitals. They concluded that the way infection preventionists apply the standard CLABSI definitions varies substantially across hospitals. Niedner and colleagues[20] surveyed staff in 16 pediatric ICUs and found substantial variation in surveillance practices for CLABSI. They also found a significant correlation between a surveillance-aggressiveness score, which quantified practices likely to increase identification of BSIs, and CLABSI rates.[20] Surveillance for CLABSI is also problematic outside of the United States. For example, McBryde and colleagues[21] compared CLABSI rates from routine surveillance in Australian hospitals with rates calculated by staff of their state system for reporting healthcare-associated infections and found that routine surveillance had a low predictive positive value (59%) and sensitivity (~35%).

Despite these limitations in the accuracy and validity of CLABSI rates, researchers, public health officials, and others often use these data when comparing rates over time or com-

paring rates among hospitals. For example, CDC recently reported that CLABSI rates in US ICUs decreased 58% from 2001 to 2009.[1] These rates also are publicly reported in 14 states by mandate[22] and are used by CMS to qualify hospitals for their annual payment update. In addition, healthcare-associated-infections data are now available on the CMS Hospital Compare website (http://www.hospitalcompare.hhs.gov/), effectively reporting NHSN ICU CLABSI rates for all hospitals that receive reimbursements from Medicare. Clinicians and epidemiologists often criticize CDC and CMS for using definitions that are subjective and can be "gamed" for such high-stakes purposes. Nevertheless, our survey demonstrated that many infectious-diseases clinicians who play a substantial role in hospital epidemiology and infection prevention programs resist using a strictly objective definition for CLABSI because these definitions do not always match the clinicians' views on the pathogenesis of specific infections.

A possible solution to this dilemma might be to include results of diagnostic tools such as time to positivity and differential time to positivity into the surveillance definition, thereby incorporating objective data that address the source of the BSI. Even so, our data suggest that as many as 1 in 5 infectious-diseases clinicians do not have access to these tools. Computer surveillance algorithms remove some subjectivity from surveillance, but many hospitals still do not have comprehensive electronic medical records, and existing systems vary so much that considerable work would be needed for information technology staff at each hospital to implement the algorithm. Another solution might be to modify the epidemiological definition of CLABSI such that, for reporting purposes, infection preventionists review the results of blood cultures from samples obtained from peripheral veins but not the results of those from samples drawn through central lines, given the contamination rate of the latter.[23-25]

This survey-based study has several limitations. Although our response rate was high for a physician survey and respondents were from 49 states, the results are based on physician self-report and may not be generalizable to all infectious-diseases physicians or all hospitals. Because respondents were significantly more likely to be interested in infection control issues than nonrespondents, our findings likely overestimate the average infectious-diseases consultant's knowledge about surveillance for CLABSIs. In addition, we did not design our survey to determine whether clinicians did not understand the different intents for the NHSN's surveillance definitions and IDSA's practice guidelines or whether they understood the differences and chose to not apply current definitions or guidelines as they were intended to be used. In addition, we did not design the survey to address all controversial or problematic aspects of diagnosing CLABSIs and of doing surveillance for these infections.[23-28]

In conclusion, EIN members' practices for diagnosing BSIs and for applying the NHSN definition of CLABSI vary substantially. Furthermore, infectious-diseases consultants often use subjective clinical judgment when interpreting existing CLABSI definitions. These findings indicate that CLABSI, as currently defined, is not an optimal measure for high-stakes purposes such as public reporting, pay for performance, and interhospital comparisons. Nonetheless, clinicians, including infectious-diseases consultants, are likely to criticize or reject CLABSI rates based on a definition that is less subjective and more amenable to electronic reporting because they believe that the definition ignores the pathogenesis of the infections. Moreover, many hospitals lack the resources to implement a strictly objective definition. NHSN staff need to consider these factors as the CLABSI definitions are revised.

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