

Detection and Reporting of Organisms Producing Extended-Spectrum β -Lactamases: Survey of Laboratories in Connecticut

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Extended-spectrum β -lactamases (ESBLs) are enzymes produced in some gram-negative bacilli that mediate resistance to extended-spectrum cephalosporins and aztreonam. They are most common in *Klebsiella* spp. and *Escherichia coli* but are present in a variety of *Enterobacteriaceae*. Resistance mediated by these enzymes can be difficult to detect depending on the antimicrobial agents tested. AmpC β -lactamases are related to the chromosomal enzymes of *Enterobacter* and *Citrobacter* spp. and also mediate resistance to extended-spectrum cephalosporins and aztreonam in addition to cephamycins, such as cefoxitin. Unlike ESBLs, however, AmpC β -lactamases are not inhibited by clavulanic acid or other similar compounds. To assess the abilities of various antimicrobial susceptibility testing methods to detect ESBLs, we sent three ESBL-producing organisms, one AmpC-producing organism, and a control strain that was susceptible to extended-spectrum cephalosporins to 38 laboratories in Connecticut for testing. Eight (21.0%) of 38 labs failed to detect extended-spectrum cephalosporin or aztreonam resistance in any of the ESBL- or AmpC-producing isolates. Errors were encountered with both automated and disk diffusion methods. Conversely, seven (18.4%) labs categorized at least some of the four resistant isolates as potential ESBL producers and reported the results with the extended-spectrum cephalosporins and aztreonam as resistant as suggested by current National Committee for Clinical Laboratory Standards (NCCLS) guidelines. The percentage of laboratories that failed to detect resistance in the ESBL or AmpC isolates ranged from 23.7 to 31.6% depending on the type of enzyme present in the test organism. This survey suggests that many laboratories have difficulty detecting resistance in ESBL and AmpC-producing organisms and may be unaware of the NCCLS guidelines on modifying susceptibility testing reports for ESBL-producing strains.

Extended-spectrum β -lactamases (ESBLs) are enzymes that mediate resistance to extended-spectrum cephalosporins, such as cefotaxime, ceftriaxone, and ceftazidime, and the monobactam aztreonam (10, 13, 15). Such enzymes are most commonly found in *Klebsiella pneumoniae* and *Escherichia coli*, but they have also been detected in *Klebsiella oxytoca*, *Proteus mirabilis*, *Salmonella* species, other members of the *Enterobacteriaceae*, and *Pseudomonas aeruginosa* (5, 6, 18, 23). Detection of organisms producing these enzymes can be difficult (6, 12, 31, 32), because the presence of ESBLs in a bacterial cell does not always produce a resistance phenotype when one is using the traditional MIC and disk diffusion interpretive criteria published by the National Committee for Clinical Laboratory Standards (NCCLS) (19, 20). Katsanis et al. (12) demonstrated that the MICs of cefotaxime and ceftriaxone for *E. coli* strains that produce ESBLs often do not exceed the numerical threshold for interpretation of a strain as resistant. Several other studies have shown that even the disk approximation test, first described by Jarlier and colleagues in 1988 (11), fails to detect some ESBL-producing strains (6, 31). In a similar fashion, AmpC β -lactamases, which are similar to the chromosomal β -lactamases of *Enterobacter* and *Citrobacter* species, can also produce resistance to extended-spectrum cephalosporins and aztreonam, in addition to the cephamycins, such as cefoxitin (2, 13). Strains producing AmpC β -lactamases are also emerging

in many areas (4, 24), yet little has been published about the detection of strains producing these enzymes. AmpC β -lactamases are not inhibited by clavulanic acid or other β -lactamase inhibitors. Thus, if an ESBL confirmation test using clavulanic acid is not performed, many AmpC-producing strains may be presumed to be ESBL-producing strains.

In 1998, in an effort to improve the detection of ESBL-producing strains, NCCLS described broth microdilution and disk diffusion screening tests that indicate possible ESBL production in isolates of *K. pneumoniae*, *K. oxytoca*, and *E. coli* (21). In 1999, NCCLS went a step further, adding confirmation tests for ESBL-producing strains and recommending that the interpretation of test results with extended-spectrum cephalosporins and aztreonam be changed to "resistant" for ESBL-positive strains (22).

The study reported herein was undertaken by the Centers for Disease Control and Prevention (CDC) in cooperation with the Connecticut Department of Public Health and the University of Connecticut in order to determine if laboratories in Connecticut were able to detect several common ESBL-producing organisms and an AmpC-producing strain of *E. coli*, and to determine if they could differentiate between the two mechanisms of resistance. Furthermore, we attempted to ascertain whether laboratories were modifying their susceptibility reports for extended-spectrum cephalosporins and aztreonam if an ESBL-producing organism was detected.

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MATERIALS AND METHODS

Bacterial strains. Five well-characterized isolates, coded as CT-6 to CT-10 (two isolates of *E. coli* and three isolates of *K. pneumoniae*), were selected from

TABLE 1. Characteristics of study isolates and susceptibility test results of participating laboratories listed by interpretive category^a

Antimicrobial agent tested	CT-6 (<i>E. coli</i> producing SHV-8)			CT-7 (<i>E. coli</i> producing AmpC)			CT-8 (<i>K. pneumoniae</i> producing SHV-4)			CT-9 (<i>K. pneumoniae</i> producing SHV-5)			CT-10 (<i>K. pneumoniae</i> susceptible control)							
	Ref MIC ^b	No. of laboratories obtaining a result of:			Ref MIC	No. of laboratories obtaining a result of:			Ref MIC	No. of laboratories obtaining a result of:			Ref MIC	No. of laboratories obtaining a result of:						
		S	I	R		S	I	R		S	I	R		S	I	R				
Ceftazidime	>128	0	1	22	128	0	0	23	128	0	7	16	>128	0	3	20	0.25	20	0	1
Cefotaxime	8	10	0	1	64	4	5	2	16	6	4	1	32	6	2	3	0.12	10	0	0
Ceftriaxone	16	13	4	0	128	7	6	4	16	4	9	3	32	1	11	4	0.12	15	0	0
Aztreonam	16	3	2	0	32	1	2	2	128	0	0	5	>128	0	0	6	0.12	5	0	0

^a S, susceptible; I, intermediate; R, resistant.

^b Ref MIC, reference MIC (in micrograms per milliliter) determined by the NCCLS broth microdilution method.

the strain collection of the CDC, subcultured, and sent through the Connecticut Department of Public Health and the University of Connecticut to the 38 laboratories (31 hospital-affiliated and 7 commercial clinical laboratories) that routinely send results for reportable diseases to the Connecticut Department of Public Health.

CT-6 was *E. coli* 2-76, which had previously been shown to produce the SHV-8 enzyme (28). CT-7 was an *E. coli* isolate that produced an AmpC β -lactamase. The isolate was resistant to the extended-spectrum cephalosporins, aztreonam, and the cephamycins by broth microdilution testing. The strain was shown by isoelectric focusing to produce a β -lactamase with a pI of >8.5, which is consistent with the presence of an AmpC β -lactamase (2). CT-8, a *K. pneumoniae* isolate that produces an SHV-4 enzyme, was obtained from L. B. Reller (Duke University, Raleigh, N.C.). CT-9, a *K. pneumoniae* isolate that produced an SHV-5 enzyme, was provided by M. P. Weinstein (Robert Wood Johnson Medical School, New Brunswick, N.J.). The identities of the enzymes produced by CT-8 and CT-9 were confirmed by isoelectric focusing, which is the reference method for monitoring β -lactamase activity in a bacterial cell. Briefly, the organisms were lysed by a freeze-thaw procedure (3) and the β -lactamases in the crude extracts were electrophoresed to equilibrium as described by Matthew et al. (14). CT-10 was *K. pneumoniae* ATCC 13883 (the *K. pneumoniae* type strain), which was susceptible to extended-spectrum cephalosporins and aztreonam. All organism identifications were confirmed at CDC by traditional biochemical methods (8). The antimicrobial susceptibility profiles of the isolates were confirmed by the NCCLS broth microdilution method (20). Quality control strains included *E. coli* ATCC 25922, *E. coli* ATCC 35218, *P. aeruginosa* ATCC 27853, and *K. pneumoniae* ATCC 700603 (the NCCLS ESBL-positive control strain).

Confirmation of phenotypes. Subcultures of all five isolates were sent back to CDC from the University of Connecticut at the conclusion of the study. The subcultures returned from the state, and subcultures of CT-6 through CT-10 from the CDC freezer, were again tested by broth microdilution using the NCCLS reference method (20), by Vitek (bioMérieux, Hazelwood, Mo.) using GNS-102 and NSF-29 cards, and by MicroScan WalkAway (Dade MicroScan, West Sacramento, Calif.) using Neg-urine MIC-7 panels. All of the isolates also were retested by isoelectric focusing to ensure that they still produced the appropriate TEM, SHV, or AmpC β -lactamase, all of which have distinct pI values. The results of the isoelectric focusing studies were identical for each pair

of isolates, and the MICs of ceftazidime, ceftriaxone, cefotaxime, aztreonam, or ceftioxin obtained for each organism pair differed by no more than a single twofold dilution.

Instructions to laboratory directors. The instructions to the laboratory director indicated that the five organisms (CT-6 to CT-10) were obtained from blood cultures and should be tested against the antimicrobial agents that the laboratory would routinely choose for isolates from patients with suspected cases of sepsis. (This was done in an attempt to ensure that laboratories would test extended-spectrum cephalosporins, which might be excluded from testing for isolates from the urinary tract.) A report form was provided, but it did not contain a list of antimicrobial agents to test. Rather, the laboratory director had to list the drugs that were tested. The laboratory director was further instructed to provide the following information: (i) test method, (ii) quantitative result (MIC or zone diameter), (iii) interpretation (susceptible, intermediate, or resistant), and (iv) the interpretation that would be reported on the patient's chart.

RESULTS

Characteristics of the study strains and test methods. The reference broth microdilution MICs of ceftazidime, cefotaxime, ceftriaxone, and aztreonam for the study strains and the β -lactamases produced by them are shown in Table 1. Strain CT-10 was included as a cephalosporin-susceptible control. The susceptibility testing methods used by the 38 laboratories participating in the survey are shown in Table 2. They included MicroScan WalkAway or AutoScan (15 laboratories, five different panel types), Vitek (13 laboratories, six different card types), disk diffusion (8 laboratories, including one that used a BioMIC reader [Giles Scientific, New York, N.Y.]), Sensititre broth microdilution (1 laboratory), and an in-house broth microdilution panel (1 laboratory). The various combinations of ceftazidime, cefotaxime, ceftriaxone, ceftizoxime,

TABLE 2. Abilities of antimicrobial susceptibility testing methods to detect decreased susceptibility to extended-spectrum cephalosporins and aztreonam

Method	No. of laboratories using the method	No. (%) of laboratories that reported at least one nonsusceptible result with an extended-spectrum cephalosporin or aztreonam ^a for:				
		CT-6	CT-7	CT-8	CT-9	CT-10
MicroScan	15 ^b	9	11	11	11	1 ^c
Vitek	13 ^d	9	9	10	10	0
Disk diffusion	8 ^e	6	6	5	6	0
Sensititre or in-house broth microdilution	2	2	2	2	2	0
All methods	38	26 (68.4)	28 (73.7)	28 (73.7)	29 (76.3)	1 (2.6)

^a Includes results of intermediate or resistant obtained with traditional (nonscreening) NCCLS breakpoints for ceftazidime, cefotaxime, ceftriaxone, or aztreonam.

^b Includes four laboratories that did not test any extended-spectrum cephalosporins or aztreonam.

^c One laboratory reported this organism as ceftazidime resistant.

^d Includes two laboratories that tested ceftizoxime as the only extended-spectrum cephalosporin and did not test aztreonam.

^e Includes two laboratories that did not test any extended-spectrum cephalosporins or aztreonam.

TABLE 3. Extended-spectrum beta-lactams tested by participating laboratories

Antimicrobial agent(s) tested	No. of laboratories
Ceftazidime, ceftriaxone	9
Ceftazidime only	4
Ceftazidime, ceftriaxone, cefotaxime	3
Ceftazidime, cefotaxime	3
Ceftazidime, aztreonam	2
Ceftizoxime only	2
Cefotaxime only	2
Ceftazidime, ceftriaxone, cefotaxime, aztreonam, ceftizoxime ..	1
Ceftazidime, ceftriaxone, cefotaxime, aztreonam	1
Ceftazidime, ceftriaxone, aztreonam	1
Ceftizoxime, ceftriaxone, cefotaxime	1
Ceftazidime, ceftizoxime	1
Ceftriaxone only	1
Aztreonam only	1
No extended-spectrum cephalosporins or aztreonam	6
Total	38

and aztreonam tested by the laboratories are shown in Table 3. Although ceftizoxime is not included in the NCCLS list of extended-spectrum cephalosporins recommended for ESBL detection, we included it because it was the only extended-spectrum cephalosporin tested by two of the participating laboratories. The most common combination of drugs tested was ceftazidime plus ceftriaxone (9 laboratories); 10 laboratories tested only a single extended-spectrum cephalosporin or aztreonam. Six laboratories (four MicroScan users and two disk diffusion users) failed to test any extended-spectrum cephalosporins or aztreonam. None of the laboratories in Connecticut tested cefpodoxime during this study.

Sensitivities of the various antimicrobial agents for detecting ESBLs. The susceptibility test results for the five study organisms by interpretive category (susceptible, intermediate, and resistant) reported by the 38 laboratories are shown by organism in Table 1 and by testing method in Table 2. All of the laboratories that tested ceftazidime (65.8%) reported a result of either intermediate or resistant for the four organisms producing an ESBL or AmpC β -lactamase. Cefotaxime, ceftriaxone, and aztreonam demonstrated variable sensitivities for detection of the three ESBL-producing strains or the AmpC-producing strain. Ceftizoxime showed the lowest sensitivity of the cephalosporins for detecting ESBL- or AmpC-producing organisms (data not shown). The two laboratories that tested ceftizoxime as their only extended-spectrum cephalosporin (both Vitek users) failed to report any of the four resistant organisms as intermediate or resistant to this drug. The percentage of laboratories that reported a result of intermediate or resistant with at least one extended-spectrum cephalosporin or aztreonam ranged from 68.4 to 76.3%, depending on the organism (Table 2). Resistance in the SHV-8 strain, which typically tests susceptible to cefotaxime and shows only intermediate levels of resistance to ceftriaxone and aztreonam by the broth microdilution reference method, was the most difficult to detect; 54.2% of test results with the extended-spectrum cephalosporins and aztreonam were reported as susceptible. Surprisingly, the next most difficult resistance mechanism to detect was that mediated by AmpC, which typically shows resistance to all extended-spectrum cephalosporins and aztreonam by broth microdilution testing (Table 1). The SHV-5-producing strain produced the lowest number of susceptible results. One laboratory (using a MicroScan Neg 8 MIC panel)

incorrectly identified the susceptible control strain (CT-10) as resistant to ceftazidime but susceptible to the other extended-spectrum cephalosporins (Table 2). Four laboratories using MicroScan breakpoint panels were among the six that failed to test any extended-spectrum cephalosporins or aztreonam. The other two laboratories failing to test these drugs reported using disk diffusion.

ESBL reporting. Seven (18.4%) of the 38 laboratories noted on their report forms that at least one of the five organisms contained a presumptive ESBL. For these organisms, the results of testing with the extended-spectrum cephalosporins and aztreonam to be reported on the "patient's chart" were recorded as resistant based on the suspected presence of the enzyme. An eighth laboratory noted on its report forms that all of the isolates except CT-10 were ESBL producers but still reported CT-6 and CT-8 susceptible to ceftriaxone, contrary to NCCLS guidelines (data not shown). No laboratory differentiated the AmpC-producing isolate (CT-7) from the other ESBL-producing isolates. Laboratories modifying reports for at least one organism included three Vitek users (two reported using the Vitek Expert system), one MicroScan user, two disk diffusion users, and the one laboratory using an in-house broth microdilution method. The results for all of the extended-spectrum cephalosporins and aztreonam tested by each of the seven laboratories are shown in Table 4, including the changes made to the reports. The Vitek Expert system used by laboratories A and B failed to recognize the ESBL phenotype in CT-6, although CT-8 and CT-9 were identified as ESBL producers. Laboratory C identified CT-8 as an ESBL producer and modified the reporting of ceftriaxone, cefotaxime, and ceftizoxime results, although the criteria they used for identification are unclear. Laboratory C did not recognize CT-9 as an ESBL producer, so the results for the three extended-spectrum cephalosporins were not modified. The changes reported by laboratories C through G were initiated by the microbiologists, while those in laboratories A and B were initiated by the Vitek Expert system.

DISCUSSION

Methods for detecting ESBL-producing bacteria have been evolving for more than a decade, beginning with the description of the disk approximation test by Jarlier and colleagues in 1988 (11). This test, also known as the "double disk" test, uses a clavulanic acid-containing disk placed in proximity to disks containing extended-spectrum cephalosporins and aztreonam to demonstrate that the test strain contains a β -lactamase whose activity is inhibited by clavulanic acid. This simple disk diffusion assay has served as the reference method for detecting ESBL-producing strains for a number of years (12, 30, 31). However, some studies have questioned its sensitivity, and several modifications, including changing the distance between the disks, have been recommended (5, 31). Vitek ESBL cards (30), special Etest strips (5, 32), and newer MicroScan panels (16) have also been evaluated for detecting these types of strains, and all have demonstrated >90% sensitivity.

The goal of our study, which included all of the laboratories in the state of Connecticut that routinely perform antimicrobial susceptibility testing, was to determine how well laboratories could detect ESBL-producing organisms and to determine if the laboratories could differentiate an AmpC-producing strain from an ESBL-producing strain. The purpose of the testing was blinded to the participating laboratories, i.e., detection of ESBL- and AmpC-producing isolates was not mentioned in the protocol. Ceftazidime, regardless of the testing method, proved to have adequate sensitivity to detect the

TABLE 4. Categorical interpretations for key antimicrobial agents, including changes, following recognition of a presumptive ESBL producer

Hospital	Method	Drug and NCCLS interpretation reported ^a (no. of changes) for the following test organism:			
		CT-6 (SHV-8)	CT-7 (AmpC)	CT-8 (SHV-4)	CT-9 (SHV-5)
A	Vitek with Expert system	Ceftazidime R, cefotaxime S (0)	Ceftazidime R, cefotaxime S (0)	Ceftazidime I→R, cefotaxime S→R (2)	Ceftazidime I→R, cefotaxime S→R (2)
B	Vitek with Expert system	Ceftazidime R, ceftriaxone S (0)	Ceftazidime R, ceftriaxone S (0)	Ceftazidime I→R, ceftriaxone S→R (2)	Ceftazidime I→R, ceftriaxone I→R (2)
C	Vitek	Ceftriaxone S, cefotaxime S, ceftizoxime S (0)	Ceftriaxone S, cefotaxime S, ceftizoxime S (0)	Ceftriaxone I→R, cefotaxime S→R, ceftizoxime S→R (3)	Ceftriaxone I, cefotaxime S, ceftizoxime S (0)
D	MicroScan	Ceftazidime R, aztreonam S→R (1)	Ceftazidime R, aztreonam S→R (1)	Ceftazidime R, aztreonam R (0)	Ceftazidime R, aztreonam R (0)
E	In-house broth microdilution	Ceftazidime R, cefotaxime S→R (1)	Ceftazidime R, cefotaxime I→R (1)	Ceftazidime R, cefotaxime S→R (1)	Ceftazidime R, cefotaxime S→R (1)
F	Disk diffusion	Ceftazidime R, cefotaxime S→R (1)	Ceftazidime R, cefotaxime R (0)	Ceftazidime R, cefotaxime S→R (1)	Ceftazidime R, cefotaxime R (0)
G	Disk diffusion	Ceftazidime R, ceftriaxone I→R, aztreonam I→R (2)	Ceftazidime R, ceftriaxone R, aztreonam I→R (1)	Ceftazidime R, ceftriaxone S→R, aztreonam R (1)	Ceftazidime R, ceftriaxone I→R, aztreonam R (1)

^a S, susceptible; I, intermediate; R, resistant. Arrows indicate changes made to the reports.

ESBL-producing isolates and the AmpC-producing isolate even when the traditional NCCLS breakpoints were used (19, 20); none of the laboratories testing ceftazidime failed to classify the four resistant strains as either intermediate or resistant. These results different from those of Moland et al. (16), who reported that ceftazidime had a sensitivity of only 78% for detection of ESBL-producing organisms when used in a broth microdilution format (although they included other enteric organisms besides *Klebsiella* species and *E. coli* in their study and selected a number of strains for which the ceftazidime MICs were ≤ 16 $\mu\text{g/ml}$). Our testing of three commercial antimicrobial susceptibility panels and cards confirmed that ceftazidime was sufficiently sensitive to detect strains that produce SHV-4, SHV-5, SHV-8, or AmpC. Thus, laboratories that include ceftazidime in their testing panels are more likely to detect ESBL-producing strains than those that do not. The utility of ceftazidime for detecting other β -lactamases, such as the TEM derivatives that are most active on cefotaxime (2, 13), remains unknown; however, data from CDC (unpublished observations) suggest that ceftazidime should be sufficiently sensitive to detect most of these strains, particularly if the new screening breakpoints are used (22). We chose SHV-4 and SHV-5 because they are common in ESBL-producing organisms that are reported to cause outbreaks of nosocomial disease (1, 9, 25, 26). The SHV-8-producing strain (28) was selected because it is usually more difficult to detect, as was the case in this study. The difficulty is primarily due to the low concentrations of cefotaxime and ceftriaxone required to inhibit growth of this *E. coli* strain, which, if ceftazidime is not tested, suggest a cephalosporin-susceptible isolate.

Although reports of ESBL-producing strains have been appearing for more than a decade (11, 17, 29), laboratories have been slow to embrace newer ESBL detection methods, in part because the clinical importance of identifying such strains remained unclear (7). However, there is now increasing clinical evidence that underscores the importance of detecting these strains (27, 33). While the Vitek Expert system can detect some

ESBLs, two different cards failed to identify the SHV-8-producing strain of *E. coli* (Table 4). These algorithms often incorporate the results of antimicrobial agents, such as ceftazidime and amoxicillin-clavulanic acid, which may not fit into classical ESBL definitions for all strains; therefore, it is important that microbiologists continue to review their susceptibility test results manually in order to identify presumptive ESBL producers, as was done by the other four laboratories that modified their results (Table 4).

In the most recent NCCLS document, M100-S9, both screening breakpoints to enhance the detection of potential ESBL-producing strains and confirmation tests using clavulanic acid in conjunction with ceftazidime and cefotaxime are described (22); however, there is no mention of testing or reporting results for AmpC-producing isolates. Although we assumed that AmpC-producing isolates would show resistance to all oxyiminocephalosporins and therefore would be easy to detect, our data suggest that this is not the case with many of the susceptibility testing methods being used in laboratories in the United States. NCCLS recommends modifying the extended-spectrum cephalosporin and aztreonam results only for ESBL-producing strains; however, the laboratory will not know whether the organism produces an ESBL or an AmpC β -lactamase if the confirmation tests with clavulanic acid are not performed. Thus, as was shown here, some AmpC-producing strains are likely to be classified as ESBL producers, and the interpretation of their susceptibility results for the extended-spectrum cephalosporins and aztreonam is likely to be changed to reflect resistance. Given the likelihood that AmpC-producing strains would not respond to extended-spectrum cephalosporins or aztreonam (4, 24), we believe that modifying the interpretations to reflect resistance to extended-spectrum cephalosporins and aztreonam for AmpC-producing strains is reasonable. While reporting a mechanism of resistance, such as "presence of an ESBL-producing strain," on a laboratory report is unlikely to aid clinicians in the selection of effective antimicrobial agents, modification of cephalosporin results on

laboratory reports should increase the accuracy of the susceptibility test reporting.

In this study, which was conducted before the release of M100-S9, it was surprising that 6 of the 38 laboratories failed to test any extended-spectrum cephalosporins or aztreonam against isolates of gram-negative bacilli that were identified as blood culture isolates. Table 1 of both NCCLS documents M2 and M7 (19, 20) recommends testing extended-spectrum cephalosporins routinely, although the laboratory has the opinion of not reporting the results of these drugs for organisms that are susceptible to first-generation cephalosporins. In this case, the six laboratories did not test the drugs. Given the rising incidence of ESBL-producing strains in the United States (6, 17, 27, 33), we believe that this provides false economy for the laboratory, as does testing of drugs, such as ceftizoxime, that are ineffective detectors of ESBL production.

In summary, the results of this study suggest that detection of ESBL-producing strains remains a problem in the United States and that strains of *Klebsiella* and *E. coli* that produce ESBLs and AmpC β -lactamases are likely to be overlooked in some hospitals. These data also show that ceftazidime is a sensitive indicator of ESBL- and AmpC-producing strains. While cefpodoxime may work well, none of the laboratories tested this agent during this study, perhaps because at the time of testing it was not available on most Vitek or MicroScan panels. We believe strongly that extended-spectrum cephalosporins, perhaps in parallel with aztreonam, should be tested routinely in the laboratory against gram-negative agents of sepsis, particularly if resistance to first-generation cephalosporins is evident. Although Emery and Weymouth (7) suggested that ESBL screening using additional tests is not cost-effective, our results show that with careful selection of panels, cards, and disks, routine testing strategies may detect many ESBLs without additional expense.

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