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Clinicians' Knowledge, Attitudes, and Practices Regarding Infections with Multidrug-Resistant Gram-Negative Bacilli in Intensive Care Units

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Abstract

Objective—To assess how healthcare professionals caring for patients in intensive care units (ICUs) understand and use antimicrobial susceptibility testing (AST) for multidrug-resistant gram-negative bacilli (MDR-GNB).

Design—A knowledge, attitude and practice survey assessed ICU clinicians knowledge of antimicrobial resistance, confidence interpreting susceptibility testing, and beliefs regarding the impact of susceptibility testing on patient outcomes.

Setting—16 ICUs affiliated with New York-Presbyterian Hospital.

Participants—Attending physicians and subspecialty residents with primary clinical responsibilities in adult or pediatric ICUs and infectious diseases (ID) subspecialists and clinical pharmacists.

Methods—Participants completed an anonymous electronic survey. Responses included 4-level Likert scales dichotomized for analysis. Multivariate analyses were performed using Generalized Estimating Equations logistic regression to account for correlation of respondents from the same ICU.

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Results—The response rate was 51% (178/349 eligible participants) of whom 120 (67%) were ICU physicians. Those caring for adult patients were more knowledgeable about antimicrobial activity and more familiar with MDR-GNB infections. Only 33% and 12% of ICU physicians were familiar with standardized and specialized AST methods, respectively, but >95% believed AST improved patient outcomes. When adjusted for demographic and healthcare provider characteristics, those familiar with treatment of MDR-GNB bloodstream infections, those aware of resistance mechanisms, and those aware of AST methods were more confident they could interpret AST and/or request additional *in vitro* testing.

Conclusions—Our study uncovered knowledge gaps and educational needs that could serve as the foundation for future interventions. Familiarity with MDR-GNB increased overall knowledge and familiarity with AST increased confidence interpreting these results.

INTRODUCTION

Infections caused by multidrug-resistant gram-negative bacilli (MDR-GNB) such as *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, and *Acinetobacter* species have increased, particularly in intensive care units (ICUs), due to numerous factors including antimicrobial selective pressure, horizontal acquisition of genes that encode for antimicrobial resistance, contamination of the healthcare environment with MDR-GNB with subsequent transmission to patients, and patient-to-patient transmission via the hands of healthcare workers. [1–4] Infections caused by MDR-GNB are associated with increased morbidity, mortality, length of stay, and healthcare costs.[5–9] Furthermore, successful treatment of MDR-GNB infections may be hampered by limited therapeutic options as well as the knowledge, attitudes, and practices of healthcare providers regarding optimal management of MDR-GNB infections.

Little is known about how healthcare professionals caring for patients in the ICU understand and use the results of antimicrobial susceptibility testing for MDR-GNB. The aims of this study were to assess the knowledge, attitudes, and practices of ICU healthcare professionals regarding the following: antimicrobial resistance, *in vitro* susceptibility testing for MDR-GNB, relevant transmission precautions, and the activity of specific antimicrobial agents. In doing so, we sought to identify knowledge gaps and educational opportunities that could ultimately be used to improve care for ICU patients infected with MDR-GNB.

MATERIALS AND METHODS

Study Sites

Eligible respondents worked in the adult and pediatric ICUs of New York-Presbyterian Hospital (NYP) which is affiliated with Weill Cornell (WC) Medical College and Columbia University Medical Center (CUMC). In all, NYP has 16 ICUs with 214 beds for adults, 170 beds for children and neonates, and approximately 14,814 annual admissions. Clinical microbiology laboratories are located on site at both the WC campus and the CUMC campus. The laboratories report antimicrobial susceptibility data in the electronic medical record as both minimal inhibitory concentrations (μg/ml) and their interpretation based on

relevant breakpoints (susceptible, intermediate, or resistant). The Institutional Review Boards of WC and CUMC approved this study with a waiver of written informed consent.

Study Design, Participants and Sites

From February 2009 to June 2009, eligible participants were asked to complete an anonymous, self-administered web-based survey that required 10–15 minutes to complete. Eligible healthcare professionals included: attending physicians and subspecialty residents with primary clinical responsibilities in ICUs caring for adult (e.g., medical, surgical, burn ICUs) or pediatric (e.g., pediatric, neonatal ICUs) patients as well as ID subspecialists and clinical pharmacists who consulted in these ICUs. Eligible participants were invited to participate by email and three reminder emails were sent. Participants received a $20 Starbucks gift card for completing the survey and could enter a $500 raffle intended for use to attend a professional meeting.

Knowledge, Attitudes, and Practices Survey

The knowledge, attitudes, and practices survey was developed by an interdisciplinary team of ID physicians, hospital epidemiologists, and a clinical pharmacist and used the paradigm developed by Cabana and colleagues to assess knowledge, attitude and practice barriers to adherence to treatment guidelines experienced by clinicians. [10–14] The survey assessed knowledge, awareness, and familiarity with treatment of infections caused by MDR-GNB and with relevant infection control policies (eTable 1). The survey assessed respondents' perceptions of the usefulness and impact of *in vitro* susceptibility testing on patient outcomes (outcome expectancy), respondents' confidence using susceptibility data (self-efficacy), and respondents' use of other clinical resources, e.g., ID consultations and electronic antimicrobial prescribing resources. The survey items incorporated forced choice format and Likert scales.

Statistical Analysis

Responses to the Likert scales were dichotomized as shown in eTable 1. For example, "strongly disagree and disagree" were combined. Mantel Haenszel chi square tests were used to examine the association between the independent variables (e. g., type of healthcare professional) and dependent variables (i.e., knowledge, attitudes, and practices). As the responses of the 8 clinical pharmacists were very similar to those of the ID physicians, responses were combined as "ID healthcare professionals".

To further improve our understanding of factors that may influence the use of susceptibility testing, we assessed the impact of familiarity with MDR-GNB infections and awareness of susceptibility testing methods on respondents' confidence interpreting susceptibility results or use of specialized susceptibility testing such as Etests® (bioMérieux Inc., Durham, NC). The multivariate models included age, gender, work site, type of healthcare professional, primary patient population served (pediatric vs. adult), and training status as independent variables. Multivariate analyses were performed using Generalized Estimating Equations logistic regression[15] to account for the correlation of respondents from the same ICU; 95% confidence intervals and p-values were adjusted for the possible increase in false positives due to multiple comparisons by setting the false discovery rate to be no more than 5%.

RESULTS

Respondent Characteristics

Of 349 eligible participants, 178 (51%) completed the survey and their characteristics are shown in Table 1. The response rate by adult and pediatric ICU physicians was similar at CUMC and WC (data not shown). However, compared with eligible participants working with adult populations, a larger proportion of pediatric healthcare providers responded to the survey (79/239, 33% vs. 76/110, 69%; $p<0.05$). The characteristics of respondents from WC and CUMC were generally similar, but a larger proportion of respondents from CUMC were pediatric healthcare professionals than respondents from WC (50/90, 56% vs. 23/61, 38%; $p<0.05$). Twenty nine (24%) respondents worked in more than one ICU.

Respondents' Knowledge, Attitude, and Practices

The majority of respondents agreed that infections caused by MDR-GNB were a serious problem in ICUs in the United States (97%) as well as at NYP (96%).

Agreement with Potential Strategies to Reduce MDR-GNB—The majority of respondents (96%) agreed that limiting broad spectrum antimicrobial agents could decrease resistance. More ID healthcare professionals (93%) than ICU healthcare professionals (74%) agreed that implementing *Contact Isolation* for patients colonized/infected with MDR-GNB could decrease antimicrobial resistance ($p< 0.05$). However, only 67% of ID and 56% of ICU healthcare professionals were aware of the NYP definition used to initiate *Contact Isolation* which had been in place since 2006. At the time of the survey, MDR-GNB were defined as strains susceptible to < 1 tested antimicrobial agent (excluding polymyxin or tigecycline) or those that were resistant to carbapenem agents or expressed extended spectrum β-lactamases.

Familiarity with MDR-GNB Infections—Compared with ID healthcare professionals, ICU physicians were less likely to be "extremely/ very familiar" with treatment of bloodstream infections (91% vs. 55%, respectively, $p<0.05$), pneumonia (86% vs. 43%, $p<0.05$), and urinary tract infections (84% vs. 50%, $p<0.05$) caused by MDR-GNB. Adult and pediatric ICU physicians were similarly familiar with treatment of bloodstream infections (56% vs. 52%) and urinary tract infections (56% vs. 45%) caused by MDR-GNB, but adult ICU physicians were more familiar with treatment of pneumonia caused by MDR-GNB (60% vs. 29%, $p<0.05$).

Knowledge of Antimicrobial Agents—Respondents' knowledge of the activity of antimicrobial agents is shown in Table 2. ID healthcare professionals had more correct answers than ICU physicians and the knowledge of ICU attendings and fellows was similar (data not shown). ICU physicians working with adult patients were more likely to know that tigecycline was inappropriate for pneumonia caused by *Pseudomonas aeruginosa* and that quinolone agents were inappropriate for treatment of carbapenem-resistant *Klebsiella* spp. Almost all (98%) ID healthcare professionals were aware of the resistance mechanisms expressed by MDR-GNB while only 50% of ICU physicians reported they were aware of these mechanisms ($p<0.05$).

Use of Susceptibility Testing—Most ID healthcare professionals (86%) were aware of both the standard, commercial antimicrobial susceptibility testing methods (i.e., MicroScan® [Siemens Healthcare Diagnostics Inc., Tarrytown, NY] and Vitek® assays [bioMérieux Inc., Durham, NC]) and specialized antimicrobial susceptibility testing methods (i.e., Etest assays for susceptibility to tigecycline and polymyxin B, and checkerboard synergy testing for selected agents) used at NYP. Far fewer ICU physicians were aware of either standard (33%) or specialized assays (12%). Consistent with these observations, when compared with ID healthcare professionals, ICU healthcare professionals rarely requested additional susceptibility testing (57% vs. 23%, respectively, $p<0.05$). A comparable proportion of ID and ICU healthcare professionals agreed that susceptibility testing was useful for managing MDR-GNB infections (91% and 95%, respectively), and reported that they "often or always" modified treatment based on susceptibility testing (93%). However, when compared with ID healthcare professionals, fewer ICU physicians were aware that commercial assays for susceptibility testing could be inaccurate, i.e., provide false negative or false positive results, (90% vs. 57%, respectively, $p< 0.05$).

Most ID healthcare professionals had confidence (self-efficacy) in their ability to use local resistance patterns, interpret susceptibility testing, and review the literature to determine treatment strategies (Table 3). In contrast, most ICU physicians lacked confidence they could perform these tasks, although those caring for adult patients were somewhat more confident. The confidence of ICU attending physicians vs. ICU fellows was similar (data not shown).

Respondents' Perceptions of External Prescribing Resources—Nearly all respondents believed that *in vitro* susceptibility testing could improve outcomes for patients with MDR-GNB infections (Table 4). Similarly, most believed that consults from ID healthcare professionals could improve patient outcomes, although compared with adult ICU physicians, pediatric ICU physicians were more likely to consider consults useful and to request them ($p< 0.05$).

Both groups of healthcare professionals considered the NYP web-based resources to be the most important resource to guide antimicrobial prescribing for treatment of MDR-GNB, although ID healthcare professionals were more likely to consider the literature important (Table 4). Compared with ICU attending physicians, ICU fellows were significantly more likely to consider literature searches, formal lectures, and electronic references important resources for managing MDR-GNB infections (data not shown, $p< 0.05$).

Factors Influencing Respondents' Confidence Interpreting Susceptibility Tests

When adjusted for demographic and healthcare provider characteristics, knowledge of MDR-GNB, of resistance mechanisms, and of antimicrobial susceptibility testing impacted respondents' confidence and practices (Table 5). For example, those familiar with treatment of bloodstream infections caused by MDR-GNB were more confident they could interpret both standard and specialized susceptibility tests. Those aware of resistance mechanisms were also more confident they could interpret susceptibility tests as well as request

specialized testing. In contrast, awareness of standardized or specialized susceptibility tests did not impact respondents' confidence they could interpret specialized test results. Furthermore, familiarity with treatment of bloodstream infections caused by MDR-GNB did not increase respondents' requests for specialized testing.

DISCUSSION

Antimicrobial prescribing practices are known to be influenced by sociodemographic characteristics, training, specialty, knowledge, attitudes, and judgment.[16] Studies have shown that selection of antimicrobials is more likely to reflect the prescriber's assessment of efficacy, ease of use, previous experience, toxicity, and cost considerations than the impact of selection for resistance.[17,18] In the outpatient setting, patient demands for antimicrobials are frequently cited as an important influence on prescribing practices.[17] However, in the inpatient setting, clinicians are largely free of such demands. Thus, improving prescribing in the acute care setting can preferentially focus on understanding prescribers' knowledge, attitudes, and practices to identify potential barriers to optimal care.[19] We sought to address these complex issues among healthcare professionals caring for adult and pediatric patients hospitalized in ICUs and focused on treatment of infections caused by MDR-GNB, including respondents' confidence using antimicrobial susceptibility data and their perceptions of the impact of antimicrobial susceptibility testing on patient outcomes. To our knowledge, only one previous study has been conducted among a similar group of Australian providers which found that 89% of ID and ICU healthcare providers believed that results of susceptibility testing were an important influence on their antimicrobial prescribing.[20]

Several surveys about antimicrobial resistance have been conducted with different types of healthcare workers, including medical students, residents, and attending physicians (Table 6).[21–25] These previous studies have found that 87% to 97% of respondents viewed resistance as a national problem while fewer (55% to 93%) viewed resistance as a local problem.[17,19,21–24] In contrast, we found that the vast majority of respondents at our institution agreed that MDR-GNB infections were a serious problem in ICUs both in the U.S. and at our medical center. Both ID and ICU healthcare professionals shared this attitude. These findings suggest that providers at our medical center were knowledgeable about this issue as MDR-GNBs, including strains that express carbapenemases, have been a major problem in New York City hospitals for over a decade.[26,27] Previous studies have found that respondents underestimated the prevalence of resistance, particularly at their own institution.[21,24,25] As noted in previous studies and our study, most healthcare providers believed that excess use of antimicrobials was a cause of resistance,[24,25] but fewer believed that antimicrobials were overused in the hospitals in which they worked.[22,23]

Our survey uncovered a substantial knowledge gap which may delay appropriate implementation of transmission precautions and thus facilitate transmission of multidrug-resistant organisms.[4] Among ICU providers, only 74% agreed that implementing *Contact Isolation* for patients harboring MDR-GNB could decrease resistance and even fewer respondents were aware of the MDR-GNB definition used to initiate such precautions.

ICU healthcare professionals working with adult populations were more knowledgeable about the activity of antimicrobial agents than those working with pediatric populations. This may reflect the relative infrequency with which infections caused by MDR-GNB are seen in pediatric populations; from 2007–2009, the prevalence of the most common MDR-GNB in the pediatric ICUs was 2.6% while in adult ICUs was 6.6% (unpublished observation, E Yoko Furuya). In addition, these findings suggest that clinical pharmacists play an important role in educating physicians in ICU settings as ICU providers working with adult populations had more contact with clinical pharmacists than those providers working with pediatric populations. Nonetheless, many ICU healthcare professionals lacked confidence they could use local resistance patterns to guide empiric therapy or interpret susceptibility testing results. However, those respondents who were more familiar with treatment of bloodstream infections caused by MDR-GNB, with resistance mechanisms, and with susceptibility testing methods were more confident they could interpret and request susceptibility testing. Of note, the vast majority of respondents perceived that such results would improve patient outcomes.

These observations suggest possible educational strategies. Case vignettes of MDR-GNB infections could be used to supplement the lack of knowledge and familiarity experienced by some providers.[28] To be effective, the educational strategy should address general principles such as mechanisms of resistance expressed by MDR-GNB, pharmacokinetic principles for different types of infections, and methods of susceptibility testing. Content should also include locally relevant information such as the institutional antibiogram, pathogen distribution, relevant empiric therapy and targeted therapy, and interpretation of relevant microbiology reports. As ICU fellows considered literature searches, formal lectures, and electronic references as important resources for managing MDR-GNB infections, mastering these strategies could be integrated into educational efforts. Previous studies have also explored the educational needs of healthcare professionals regarding antimicrobial use and resistance (Table 6).[21–25] Many respondents desired educational sessions on antimicrobial use, prescribing guidelines, and feedback on their prescribing practices.[22,23,25] As we and others have noted, interactive education appears to be generally preferred to didactic sessions or handouts as reflected in providers' desire for feedback or preference for the advice of local experts and local resources.[21,25] As further evidence of the effectiveness of prescriber audit and feedback, this evidence-based strategy is recommended to improve antimicrobial stewardship.[29]

This study had several limitations. While this multicenter study was conducted on 4 different campuses, all the ICUs are part of a single academic medical center with both infectious disease physicians and clinical pharmacists with ICU and ID expertise. Thus our study may lack generalizability. The components of the survey reflected the institutional biases of the interdisciplinary team that created the survey. Despite reminders and incentives, only 51% of eligible respondents completed the survey. We could not compare the responses of medical ICU physicians with those of surgical ICU physicians as many of the respondents provided service in both types of ICUs. Our study may have lacked some internal validity as adult and pediatric providers may have experienced different patterns of resistance, different access to clinical pharmacists, and different patterns of usage of agents

such as tigecycline. Finally, self-reported adherence to practices may not reflect true practices.

CONCLUSION

This study uncovered knowledge gaps and educational needs that could serve as the foundation for future interventions to improve antimicrobial treatment and use of susceptibility testing for MDR-GNB. Familiarity with infections caused by MDR-GNB increased overall knowledge and familiarity with susceptibility testing methods and increased confidence interpreting these results. Our findings and the findings of others suggest that an interactive educational strategy should include case vignettes, the input of local experts, particularly to interpret specialized susceptibility testing, and prescriber feedback.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Characteristics of Respondents (N=178)

Characteristics		Respondents (n, %)
Demographic		
Age (years)	≤ 30	23 (13)
	31–40	80 (45)
	≥ 41	58 (32)
	Unknown	17 (10)
Sex	Female	83 (47)
	Male	76 (43)
	Unknown	19 (10)
Race	Black	2 (1)
	White	113 (64)
	Asian	28 (16)
	Other	6 (3)
	Unknown	29 (16)
Ethnicity (Hispanic)		8 (1)
Type of Healthcare Professional		
Intensive Care Unit Physician[a]		120 (67)
Infectious Diseases Physician[b]		35 (20)
Clinical Pharmacist[c]		8 (5)
Unknown		15 (8)
Primary Patient Population Served		
Pediatric		76 (43)
Adult		79 (44)
Unknown		23 (13)
Work Site		
Weill Cornell Medical College		61 (34)[d]
Columbia University Medical Center		90 (51)[e]
Both		4 (2) [f]
Unknown		23 (13)

[a] 74 attending physicians and 46 fellows

[b] 27 attending physicians and 8 fellows

[c] 2 clinical pharmacists worked with pediatric populations

[d] 44% of 138 eligible participants

[e] 43% of 211 eligible participants

[f] 7% of 349 eligible participants work at both sites

Table 2

Healthcare Professionals' Knowledge of the Activity of Antimicrobial Agents

Questions (*Correct answer*)	**ID HCP n=43**	**ICU HCP n=120**	**Adult ICU n= 55**	**Pediatric ICU n=65**
	Participants with Correct Response (%)			
Carbapenem agents are ineffective for GNB expressing extended spectrum β-lactamases. (*False*)	98[a]	64	64	65
Tigecycline is an option for hospital-associated pneumonia caused by MDR- *Pseudomonas aeruginosa* (*False*)	83[a]	25	36[b]	15
Carbapenem-resistant *Klebsiella* spp. are usually susceptible to quinolone agents. (*False*)	86[a]	37	58[b]	19
Quinolone agents exhibit concentration-dependent killing. (*True*)	60[a]	28	33	25
Correct answers per respondent (mean)	3.3	1.5	1.9	1.2

Abbreviations used in Table: ID, infectious diseases; HCP, healthcare professional; ICU, intensive care unit; MDR, multidrug-resistant; GNB, gram-negative bacilli.

[a] $p<0.05$ when comparing responses of ID HCP vs. ICU HCPs.

[b] $p<0.05$ when comparing responses of adult vs. pediatric ICU HCPs.

Table 3

Healthcare Professionals Confidence (Self-Efficacy) in Their Ability to Use Antimicrobial Susceptibility Testing

Questions	ID HCP n=43	ICU HCP n=120	Adult ICU n= 55	Pediatric ICU n=65
	Participants 'very/extremely confident' (%)			
Use antimicrobial resistance patterns in the ICU to guide empiric antibiotic therapy.	67	46	56[b]	37
Interpret standard, commercial antimicrobial susceptibility testing results for MDR-GNB.	65	41	47	35
Interpret additional, specialized antimicrobial susceptibility testing results for MDR-GNB.	61[a]	18	28[b]	9
Use literature to determine optimal treatment strategies for MDR-GNB infections.	63[a]	33	31	34

Abbreviations used in Table: ID, infectious diseases; HCP, health care professional; ICU, intensive care unit; MDR, multidrug-resistant; GNB, gram-negative bacilli.

[a] $p<0.05$ when comparing responses of ID vs. ICU HCPs.

[b] $p<0.05$ when comparing responses of adult vs. pediatric ICU HCPs.

Table 4

Healthcare Professionals Perceptions of Importance of External Factors on Patient Outcomes and Management of MDR-GNB Infections

Importance of Factors	ID HCP n=43	ICU HCP n=120	Adult ICU n= 55	Pediatric ICU n=65
	Responding 'moderately/ extremely important' (%)			
To improve patient outcomes				
• Susceptibility testing results	100	95	96	94
• Pre-approval for restricted antibiotics	83	83	78	88
• Infectious diseases consult	N/A	92	83[b]	99
• Clinical pharmacist consults	N/A	76	80	72
To guide antimicrobial prescribing				
• Literature searches	91[a]	71	69	72
• Formal lectures	86	79	75	83
• Pocket guides or PDA-based references	57	66	75[b]	57
• NYP web-based resources	95	90	93	88
• Other web-based resources available through NYPH (e.g., *Up-to-date*)	80	83	83	83
• Outside web-based resources (e.g., Johns Hopkins guide, MD consult)	58	64	64	64

Abbreviations used in Table: ID, infectious diseases; HCP, health care professional; ICU, intensive care unit; MDR, multidrug-resistant; GNB, gram-negative bacilli; N/A, not applicable; NYP, NewYork-Presbyterian Hospital.

[a] $p<0.05$ when comparing responses of ID vs. ICU HCPs.

[b] $p<0.05$ when comparing responses of adult vs. pediatric ICU HCPs.

Table 5

Impact of Knowledge of MDR-GNB Infections, Resistance Mechanisms, and Susceptibility Testing on Interpretation and Use of Specialized Susceptibility Testing

Knowledge variables	Confident interpreting standard AST	Confident interpreting specialized AST	Request specialized AST
	AOR (CI_{95})		
Familiarity with BSI caused by MDR-GNB	1.32 (1.05–1.67)	1.23 (1.08–1.40)	NS
Awareness of MDR-GNB resistance mechanisms	1.49 (1.33–1.67)	1.27 (1.20–1.35)	1.23 (1.03–1.48)
Awareness of standard AST	1.39 (1.25–1.55)	NS	1.36 (1.14–1.63)
Awareness of specialized AST	1.29 (1.10–1.52)	NS	1.69 (1.29–2.22)

Abbreviations used in Table: BSI, blood stream infection; MDR-GNB, multidrug-resistant gram-negative bacilli; AST, antimicrobial susceptibility testing; AOR, adjusted odds ratio; CI, confidence interval; NS, not significant;

Table 6

Surveys of Healthcare Professionals' Knowledge, Beliefs, and Educational Needs regarding Antimicrobial Treatment and Resistance in Acute Care Settings

Country	Respondents	Major findings		
	Response rate n/N (%)	Knowledge	Attitudes/ Beliefs	Educational Needs
France & Scotland[25]	Residents 139/190 (73%)	Underestimated national prevalence of resistance	Too many antimicrobials used (including broad spectrum agents) and sub-therapeutic antimicrobials important causes of resistance	Prescribing guidelines Educational sessions on antimicrobial selection Advice from infectious diseases specialists
USA [23]	Medical Students 304/999 (34%)	Not reported	92% agreed hospitals face serious problem with resistance 53% believed antimicrobials overused in their hospital	More education about antimicrobial use (78%)
Brazil [21]	Preceptors & medical residents 277/369 (75%)	Underestimated own institution's prevalence of resistance	87% believed physicians prescribed more antimicrobials than necessary. 86% agreed physicians lack knowledge about antimicrobial use and resistance	Education (44%) and knowing pathogen and susceptibility results (30%) rated as most important strategies to prevent resistance
USA [22]	Residents 179/269 (67%)	Low (28%) overall knowledge score	72% believed antimicrobials overused in their hospitals 25% felt very confident using antimicrobials optimally in ICU	More antimicrobial education (90%) More feedback on antimicrobial decisions (67%)
USA [24]	Medicine attendings & residents 424/490 (87%)	Underestimated own institution's prevalence of resistance	97% believed overuse of antimicrobials increased resistance 60% favored antimicrobial control	Current antibiograms Institution-specific prescribing guidelines Grand rounds on antimicrobial prescribing