ORIGINAL ARTICLE

# Improving Antimicrobial Stewardship: The Evolution of Programmatic Strategies and Barriers

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OBJECTIVE.   To describe the prevalence and characteristics of antimicrobial stewardship programs (ASPs) in hospitals across the United States and to describe financial support provided for these programs.

DESIGN.   Electronic and paper 14-question survey of infectious diseases physician members of the Infectious Diseases Society of America Emerging Infections Network (IDSA EIN).

PARTICIPANTS.   All 1,044 IDSA EIN members who care for adult patients were invited to participate.

RESULTS.   Five hundred twenty-two (50%) members responded. Seventy-three percent of respondents reported that their institutions had or were planning an ASP, compared with 50% reporting the same thing in an EIN survey 10 years before. A shift was noted from formulary restriction alone to use of a set of tailored strategies designed to provide information and feedback to prescribers, particularly in community hospitals. Lack of funding and lack of personnel were reported as major barriers to implementing a program. Fifty-two percent of respondents with an ASP reported that infectious diseases physicians do not receive direct compensation for their participation in the ASP, compared with 18% 10 years ago.

CONCLUSIONS.   The percentage of institutions reporting ASPs has increased over the last decade, although small community hospitals were least likely to have these programs. In addition, ASP strategies have shifted dramatically. Lack of funding remains a key barrier for ASPs, and administrators need additional cost savings data in order to support ASPs. Interestingly, while guidelines and editorials regard compensated participation by an infectious diseases physician in these programs as critical, we found that more than half of the respondents reported no direct compensation for ASP activities.

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Antimicrobial resistance among bacteria has increased dramatically over the past decades. Infections caused by resistant organisms increase patient morbidity, mortality, and the cost of health care.[1,2] The association between antimicrobial use and resistance[3] has stimulated interest in antimicrobial stewardship, a concept that emerged in the 1970s.[4,5] The Infectious Diseases Society of America (IDSA) and the Society of Healthcare Epidemiology of America (SHEA) published guidelines in 2007 for creating and maintaining antimicrobial stewardship programs (ASPs).[6] ASPs are designed to optimize clinical outcomes while minimizing unintended consequences of antimicrobial use, such as toxicity, the selection of pathogenic organisms, and the emergence of resistance. Antimicrobial stewardship is an important priority for the SHEA research agenda.[7] Understanding how stewardship guidelines have been incorporated into institutional practice as well as the barriers to their use can help improve antimicrobial use and decrease adverse events.

Current ASP guidelines recommend that the ASP team include an infectious diseases (ID) physician who is compensated for this service.[6] In a survey of ID physicians approximately 10 years ago, half of respondents reported that they were directly involved in the approval process for antimicrobials; only 18% reported remuneration for this participation.[8]

We surveyed IDSA Emerging Infections Network (EIN) members to determine the prevalence and characteristics of inpatient ASPs and to identify barriers to their success as well as suggestions for improvement. We also were interested in how the antimicrobial management role of the ID physician has changed in the last decade and how common is compensation for this role.

## METHODS

The IDSA EIN is a sentinel network of ID physicians who regularly engage in clinical activity and who volunteer to participate. The network has been funded by the Centers for Disease Control and Prevention since 1995.[9] The eligible study population consisted of all 1,044 EIN members who care for adult patients. A 14-question survey was e-mailed (for the electronic version) or faxed (for the paper version) to eligible members in September 2009. Two e-mail reminders were sent to nonresponders at 1-week intervals.

All members were asked to describe hospital characteristics and to rank reasons for clinician misuse of antimicrobials and barriers to ASPs. Members whose institutions had or were planning an ASP were asked to describe program characteristics, including core members, paid full-time equivalent (FTE) employees, and duration of existence. Members also were asked to select strategies used to decrease inappropriate antimicrobial prescription in their institutions.[6] Preauthorization was defined as "approval required before antimicrobial can be used," and postprescription review with feedback was defined as "use is reviewed after specified time period." Members were asked to identify criteria used to select cases for antimicrobial review. We asked whether ID physicians receive compensation for their ASP participation. Finally, 2 questions focused on administrator support of the ASP and data to help convince administrators and clinicians of the value of stewardship programs.

Data were analyzed using SAS, version 9.2 (SAS Institute, Cary, NC). The $\chi^2$ test or Fisher exact test was used, as appropriate, to compare proportions between categorical variables.

## RESULTS

### Characteristics of Respondents

Responses were received from 522 (50%) of the 1,044 EIN members from 46 states and the District of Columbia. Respondents were not different from the nonrespondent group, except that respondents were significantly more likely to be SHEA members ($P = .0001$) and have more than 14 years of infectious diseases experience ($P = .0001$). The 51 respondents who reported not caring for inpatients were excluded from further analysis.

### Characteristics of and Compensation for Antimicrobial Stewardship Programs

Sixty-one percent of respondents reported presence of an institutional ASP; 12% reported plans to start one. The type, size, and regional location of the respondents' primary hospitals all were significantly associated with whether the institution had an ASP (Table 1). Respondents reporting no ASP were significantly more likely to work in a private practice in the US Census Bureau East North Central region and in a community hospital with fewer than 200 beds.

Eighty-nine percent of ID physicians responding to the survey reported involvement in their institutional ASP; more than half were highly involved. Respondents who were highly involved in their ASPs had more years of experience than those who were peripherally or not involved ($P = .04$). Two-thirds (66%) of the programs had existed for at least 2 years; only 14% had existed for less than 1 year. Core members included ID physicians (95%) and pharmacists (91%). Infection control professionals (33%) and microbiologists (33%) were included less frequently.

Approximately one-quarter of current programs reported no physicians (infectious diseases or other background) or pharmacists as paid FTEs; 73% reported no paid data analyst positions (Table 2). Fifty-two percent of respondents with ASPs reported that ID physicians involved in the program receive no direct compensation for their participation. Although fewer respondents reported direct compensation than reported at least a partial physician FTE, significantly more of those reporting no direct compensation were employed by the Department of Veterans' Affairs or the military ($P < .0028$). Comments by respondents who reported at least a partial FTE but no direct compensation indicate that salary lines were not increased when more ASP responsibilities were added. Physicians working in Veterans' Affairs and Department of Defense hospitals were least likely to report paid positions and were least likely to report compensation for their involvement. University hospitals were most likely to report paid positions for pharmacists, physicians, and data analysts; they also were most likely to report direct compensation for ID physicians' involvement in ASPs. For respondents who reported compensation, the sources of the funds for current programs were 85% general hospital funds alone, 4% pharmacy savings alone, 4% both general hospital funds and pharmacy savings, and 7% other monies. For respondents planning ASPs, the proposed sources were 47% general hospital funds alone, 13% both general hospital funds and pharmacy savings, and 40% other monies.

### Strategies Used as Part of Antimicrobial Stewardship Programs

Most ASPs combined 1 or more primary strategies with 1 or more supplemental strategies (listed in Table 3). Specifically, 265 respondents reported using 164 different strategy combinations. Interestingly, use of preauthorization was indicated by significantly fewer respondents planning ASPs than by those with current ASPs (15 [37%] vs 166 [63%]; $P = .002$). Respondents reporting newly established ASPs (active for less than 1 year) were significantly less likely to select preauthorization as a primary strategy ($P = .04$). Use of postprescription review with feedback did not vary by program longevity; overall, 67% of current programs used postprescription review with feedback as a primary strategy.

Formulary restriction was most likely to be used by facilities with well-established programs (88% of those reporting pro-

gram duration of more than 10 years) and least likely to be used by those with programs existing for less than 2 years ($P = .009$). Veterans' Affairs and Department of Defense hospitals were most likely to use formulary restriction and preauthorization and were least likely of all hospital types to use postprescription review and feedback. Conversely, community hospitals were least likely to use formulary restriction and preauthorization and were most likely to use postprescription review and feedback. The use of formulary restriction as the sole primary strategy or use of supplemental strategies alone was reported significantly more often by respondents planning ASPs ($P < .05$).

The most commonly used supplemental strategies were education and development of guidelines or clinical pathways. Recommendations aimed at modification of current therapies were common, with almost half using conversion from par-

enteral to oral formulations protocols, dose optimization, and de-escalation of therapy. Antimicrobial cycling was rare.

### Antibiotic Management in the Hospital

All respondents were asked to rank order the main barriers to a functional and effective ASP (Table 4). Respondents who worked in a city or county hospital were most likely to rank lack of funding or personnel as the most important, whereas respondents working in Veterans' Affairs or Department of Defense hospitals ranked this barrier as less important.

### Criteria Used to Select Antimicrobial Therapy for Review

The most common reason for selecting specific antimicrobial therapies for review was high cost (Table 5). Other factors that are indirectly related to cost, including novel and high-

TABLE 1. Respondent and Facility Characteristics for Emerging Infections Network Respondents, Sorted by Presence of an Antimicrobial Stewardship Program (ASP)

| Characteristic | No ASP | Planned ASP | Current ASP |
|---|---|---|---|
| No. of respondents | 127 (27) | 58 (12) | 286 (61) |
| Years of experience since infectious diseases fellowship | | | |
| &lt;5 years (includes fellows-in-training) | 36 (32) | 11 (10) | 65 (58) |
| 5–14 years | 33 (32) | 12 (12) | 58 (56) |
| 15–24 years | 32 (24) | 21 (15) | 83 (61) |
| ≥25 years | 18 (21) | 9 (11) | 57 (68) |
| Type of hospital*** | | | |
| Community | 59 (42) | 25 (18) | 55 (40) |
| Nonuniversity teaching | 32 (23) | 17 (12) | 91 (65) |
| University | 18 (14) | 10 (8) | 104 (79) |
| City or county | 8 (35) | 2 (9) | 13 (66) |
| Veterans' Affairs or military | 9 (26) | 3 (9) | 22 (65) |
| Other (cancer, long-term acute care) | 1 (33) | 1 (33) | 1 (33) |
| Computerized prescription order entry* | 35 (24) | 15 (10) | 96 (66) |
| Total no. of beds* | | | |
| &lt;200 beds | 26 (42) | 9 (14) | 27 (44) |
| 200–350 beds | 45 (30) | 23 (16) | 79 (54) |
| 351–450 beds | 21 (27) | 8 (10) | 50 (63) |
| 451–600 beds | 17 (21) | 7 (9) | 55 (70) |
| &gt;600 beds | 18 (17) | 11 (11) | 75 (72) |
| US Census Bureau region* | | | |
| New England | 7 (21) | 2 (6) | 25 (73) |
| Middle Atlantic | 13 (18) | 6 (8) | 55 (74) |
| East North Central | 27 (37) | 9 (12) | 38 (51) |
| West North Central | 11 (31) | 3 (9) | 21 (60) |
| South Atlantic | 28 (35) | 10 (12) | 42 (53) |
| East South Central | 6 (26) | 7 (30) | 10 (44) |
| West South Central | 9 (24) | 4 (10) | 25 (66) |
| Mountain | 6 (24) | 5 (20) | 14 (56) |
| Pacific | 17 (21) | 11 (14) | 51 (65) |
| Puerto Rico | 2 (100) | 0 | 0 |
| Canada | 1 (14) | 1 (14) | 5 (71) |

NOTE.   Data are no. (row %) of respondents, unless indicated otherwise. Not all respondents replied to each question in the survey.
* $P < .05$.
*** $P < .0001$.

TABLE 2. Dedicated Paid Full-Time Equivalent Employees (FTEs) for Antimicrobial Stewardship Programs (ASPs)

| Position | 0 FTEs | <0.5 FTE | 0.5–1 FTE | >1 FTE |
|---|---|---|---|---|
| Current ASP | | | | |
| Pharmacist | 59 (24) | 60 (24) | 99 (39) | 33 (13) |
| Physician | 70 (28) | 102 (41) | 51 (20) | 27 (11) |
| Data analyst | 148 (73) | 38 (19) | 16 (8) | 2 (1) |
| Planned ASP | | | | |
| Pharmacist | 12 (31) | 13 (33) | 12 (31) | 2 (5) |
| Physician | 17 (44) | 15 (38) | 7 (18) | 0 |
| Data analyst | 31 (86) | 5 (14) | 0 | 0 |

No. (row %) of respondents

use agents, were used as selection criteria by about half of current ASPs. Similarly, half of planned ASPs intended to target commonly used antimicrobials for review, and only a quarter intended to target novel antimicrobials. Criteria related to the infecting organism (e.g., resistance profile) or site of infection were more often reported by established ASPs as reasons for review of antimicrobials ($P < .01$).

**Support for Antimicrobial Stewardship Programs**

Most respondents with current ASPs believed that new data are needed to convince administrators to support these programs and to influence clinicians to follow ASP recommendations (Figure 1). Those planning ASPs were more likely to report that administrators needed data showing a cost decrease (93%). When compared with all other respondents (A), the subset of respondents consulting in community facilities with fewer than 200 beds (B) were less likely to report that any type of outcomes data would help convince administrators to support ASPs: reduction in *Clostridium difficile* (15% B vs 29% A, $P = .08$), reduction in adverse events (18% B vs 32% A, $P = .09$), reduction in resistance (9% B vs 30% A, $P = .009$), and decrease in costs (35% B vs 57% A, $P = .01$).

The level of support by senior hospital management for ASPs was rated as very high or good by 56% of those with current programs and by 31% of those planning programs. Only 3% of those with current programs believed management support was very poor, compared with 11% of those planning ASPs. Forty-five percent of respondents working in university hospitals reported management support as good to very high, compared with 24% of respondents working in community hospitals ($P = .04$).

**DISCUSSION**

Our survey of ID physicians documents a shift over the past decade in antimicrobial stewardship strategies from formulary restriction[8,10,11] to use of a set of tailored methods designed to provide information and feedback to prescribers. Almost three-quarters of respondents reported that their institutions had or were planning ASPs. Lack of funding and/or personnel was identified as the primary barrier to effective

TABLE 3. Primary and Supplemental Strategies Used by Antimicrobial Stewardship Programs (ASPs)

| Strategies | Current ASP | Planned ASP |
|---|---|---|
| Primary strategies | 265 (100) | 41 (100) |
| Single primary strategy alone | 63 (24) | 14 (34) |
| Formulary restriction | 17 (6) | 8 (19) |
| Preauthorization | 5 (2) | 0 |
| Postprescription review and feedback | 41 (16) | 6 (15) |
| Combination primary strategies | 194 (73) | 23 (56) |
| Formulary restriction and preauthorization | 57 (22) | 3 (7) |
| Formulary restriction and postprescription review | 33 (12) | 8 (19) |
| Preauthorization and postprescription review | 21 (8) | 0 |
| All 3 primary strategies | 83 (31) | 12 (29) |
| No primary strategies (supplemental alone) | 8 (3) | 4 (10) |
| Supplemental strategies[a] | | |
| None | 11 (4) | 3 (7) |
| Any (but no primary) strategy | 8 (3) | 4 (10) |
| Education | 212 (80) | 34 (83) |
| Guidelines and clinical pathways | 187 (71) | 34 (83) |
| Parenteral to oral conversion protocol | 161 (61) | 220 (49) |
| Dose optimization/automatic dose adjustment | 147 (55) | 15 (37) |
| Streamlining/de-escalation of therapy | 132 (50) | 17 (41) |
| Time-sensitive automatic stop orders | 110 (42) | 14 (34) |
| Antimicrobial order forms | 75 (28) | 10 (23) |
| Antimicrobial cycling | 6 (2) | 2 (5) |

No. (column %) of respondents

[a] Respondents checked all that applied (total more than 100%).

TABLE 4. Rank Order of Barriers to a Functional and Effective Antimicrobial Stewardship Program (ASP)

| Barrier | No ASP | | Planned ASP | | Current ASP | |
|---|---|---|---|---|---|---|
| | Median | Mean ± SD | Median | Mean ± SD | Median | Mean ± SD |
| Lack of funding or personnel | 2 | 2.2 ± 1.6 | 1 | 1.4 ± 1.0 | 1 | 2.3 ± 1.7 |
| Other higher-priority clinical initiatives | 3 | 3.1 ± 1.7 | 3 | 3.0 ± 1.6 | 3 | 3.1 ± 1.5 |
| Administration not aware of value of ASP | 3 | 3.0 ± 1.7 | 3.5 | 3.5 ± 1.8 | 4 | 4.0 ± 1.8 |
| Opposition from prescribers | 4 | 3.6 ± 1.7 | 4 | 3.8 ± 1.7 | 3 | 3.3 ± 1.8 |
| Lack of informaton technology support and/or inability to get data | 4 | 4.4 ± 1.9 | 3 | 3.7 ± 1.8 | 4 | 4.0 ± 1.9 |
| Other specialties antagonized by ASP | 4 | 4.0 ± 1.6 | 5 | 4.7 ± 1.7 | 4 | 4.1 ± 1.8 |
| Multiple infectious disease groups within facility | 7 | 5.3 ± 2.3 | 7 | 6.2 ± 1.4 | 7 | 5.9 ± 1.9 |

NOTE. No barriers were reported by 3 respondents with a planned ASP (5%) and by 38 respondents with a current ASP (13%). Rank: 1, most common; 7, least common.

ASPs. The importance of program cost and financing[12] was underscored, with most respondents reporting that administrators need evidence of additional cost savings in order to support ASPs. Interestingly, whereas guidelines and editorials regard compensated ASP program participation by an ID physician as vital,[6,13,14] we found that more than half of respondents reported no direct compensation for these activities.

In a decade-old survey of antimicrobial management practices,[8] 50% of respondents reported presence of an ASP as indicated by the requirement for approval by ID consultants for use of some antimicrobials. This rate now has increased to 73%. Our findings are consistent with other published reports, which have ranged from 55% of general hospitals in 2001[15] to 74% in 2006[16] and again in 2008,[17] and 51% of pediatric hospitals in 2009.[18]

Guidelines recommend that ASPs should be customized to adapt to local antimicrobial use and resistance patterns and to accommodate institutional needs and resources.[6,19,20] Our results suggest that adaptation is occurring, using several strategies. Formulary restriction, used either alone or in combination with other primary strategies, was the most common primary strategy for ASPs. However, programs in planning were less likely to incorporate preauthorization, perhaps as a reflection of a series of recent studies showing that postprescription review with feedback was associated with decreased and improved antimicrobial use.[21-23] This approach does not create a barrier to initiating therapy, which may be more acceptable to prescribers.[18,24]

Physicians in our survey and as reported by others believe that their colleagues' lack of knowledge is a primary reason for antimicrobial misuse.[25] Willingness of prescribers to accept the association between overuse or misuse of antibiotics with antimicrobial resistance was viewed by our respondents to be important for decreasing inappropriate use. These findings suggest that education and training should be a major component of ASPs and may help explain why the strategy of postprescription review with feedback has been shown to improve antimicrobial use.

Interestingly, opposition from prescribers and the potential for antagonizing colleagues in other specialties were not identified by respondents as major barriers to ASPs. These findings compare favorably with data from 1999 that suggested 45% of ID physicians judged that their participation in the approval process would antagonize colleagues in other specialties.[8] Our 2009 findings document a shift away from concern that practicing physicians consider efforts to control drug resistance as an unwarranted intrusion on their independence.[13] A recent Australian survey also found that few clinicians (19%) believed that ASPs infringed on their autonomy.[26]

A 2004 editorial suggested that compensation for ID consultants' involvement in antimicrobial management should be routine and should come from general funds rather than from pharmacy savings.[13] This editorial accompanied an article reporting that only 18% of physician survey respondents to received direct remuneration in 1999 for their antimicrobial management efforts.[8] Nonetheless, fewer than half of our respondents planning ASPs reported that anticipated funding sources were general funds alone. A 2006 survey of SHEA members determined that most respondents provided expertise in antimicrobial management and related areas, but less than 25% were specifically compensated for these activities.[27] A recent review reiterated the benefits of ID specialist-directed antimicrobial management programs.[14] Nonetheless, we found that less than half of respondents with current programs and about one-third of those planning programs reported direct compensation for stewardship duties, although indirect compensation may have occurred with other activities. The largest hospitals (with more than 600 beds) were most likely to provide compensation for ID physician time, and the smallest hospitals (with fewer than 200 beds) were least likely to provide direct compensation.

Lack of program funding was underscored as the most important barrier to effective ASPs. Cost was the primary criterion used in selecting cases for review by almost 9 of 10 hospitals, with the potential for misuse (ie, patient safety) a distant second. The majority believed that additional data associating cost savings with stewardship represented the most effective approach to convince administrators to sup-

port ASPs. Those who identified cost savings as important were twice as likely to report poor or very poor support by senior hospital management. The important role played by administration was further reinforced by respondents' selection of "Hospital leadership not aware of the potential value of ASPs" as 1 of the top 4 barriers to effective ASPs. Although the primary goal of stewardship is to optimize clinical outcomes and improve patient safety,[6] we think these composite data suggest that, in practice, the unstated goal of most programs is to save money. Since cost savings resulting from ASPs have been extensively studied mostly at larger academic centers,[14,24,25,28-31] future studies should identify the types of cost studies that would be most compelling for smaller and community hospitals. In addition, developing standardized performance measures with a focus on patient safety may assist with better aligning administrator support for ASPs with guideline goals.[6]

Finally, small community hospitals still represent the "frontier" for new stewardship programs. They are the least likely to have ASPs, the least likely to provide compensation to physicians, and the least likely to believe that any outcomes data might convince administrators to support ASPs. Small rural hospitals were found to have 40% higher rates of antimicrobial use than a large academic center.[32] As hospitals with fewer than 200 beds comprise the majority of U.S. hospitals, more data from nonacademic medical centers are needed to determine how to implement and disseminate the core elements of antimicrobial stewardship effectively. Computerized decision support and use of electronic tools could assist small community hospitals with stewardship efforts.[24,33]

This study has several limitations. Although our response rate was high for a physician survey and results represent physician responses from 46 states, the results may not be generalizable to all hospitals. Because respondents were significantly more likely to be interested in infection control than nonrespondents, our findings likely overestimate the
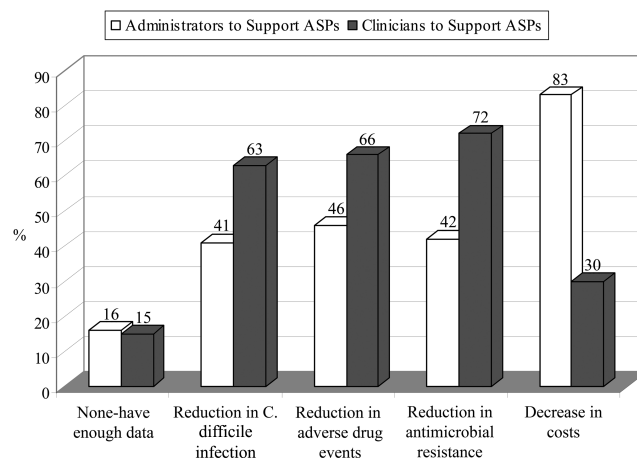


FIGURE 1. Outcomes data that would be most useful in convincing clinicians and administrators to support antimicrobial stewardship programs.

dissemination of ASPs. Clinicians with or planning ASPs might have been more interested in responding to this survey, further overestimating the frequency of ASPs. We used the individual respondent as the unit of analysis and not the institution, so multiple respondents from a single institution could have biased our results. We estimate that 34 hospitals were represented more than once, and 1 hospital had 4 respondents. Analyses without repeat responses were almost identical to analyses using the entire data set.

Antimicrobial stewardship programs continue to proliferate, although their use is far from universal and they are absent in many smaller hospitals. During the past decade, there has been a shift away from formulary restriction alone toward a set of strategies that is tailored to local needs and includes information and feedback for the prescribers. Costs remain a significant implementation barrier. Thus, programs

TABLE 5. Criteria for Review of Antimicrobial Therapy Used by Antimicrobial Stewardship Programs (ASPs)

| | No. (column %) of respondents | |
| --- | --- | --- |
| Criterion | Current ASP (N = 248) | Planned ASP (N = 35) |
| High-cost agents | 215 (87) | 24 (69) |
| Agents with high potential for misuse | 166 (67) | 15 (43) |
| Broad spectrum agents | 141 (57) | 13 (37) |
| Agents with potential for parenteral to oral conversion | 130 (52) | 20 (57) |
| Resistance profile of organism (eg, MRSA) | 130 (52) | 8 (23) |
| Novel agents | 128 (52) | 9 (26) |
| High-use agents | 114 (46) | 19 (54) |
| Agents with high risk of adverse events | 98 (40) | 10 (20) |
| Potential overlapping spectra (duplicative therapy) | 70 (28) | 11 (31) |
| Site of infection (eg, bloodstream) | 44 (18) | 0 |

NOTE. MRSA, methicillin-resistant *Staphylococcus aureus.*

that can demonstrate cost savings may be better positioned to manage institutional antimicrobial use effectively. Whereas compensation for ID physician involvement in ASPs has increased over the last decade, lack of compensation remains a significant barrier to optimal antimicrobial use. Finally, since the smallest community hospitals are least likely to have ASPs, future research should examine the unique needs of these institutions.

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