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A Survey of Antimicrobial Stewardship Practices in the Western United States: Successes and Challenges

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A SURVEY OF ANTIMICROBIAL STEWARDSHIP PRACTICES

IN THE WESTERN UNITED STATES:

SUCCESSES AND CHALLENGES

By

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<u>Abstract</u>

Antibiotics are one of the most important developments in medicine, and their ability to prevent and control infections has had a major impact in clinical medicine. However, the past three decades have shown an increase in multidrug-resistant organisms (MDROs) in both hospital patients and in the community, decreasing our ability to successfully control infection. Complicating the depletion of effective antimicrobials is the fact that, in the last 10 years, there has also been a decrease in the development of new antibacterial agents. Resistant infections have resulted in increased morbidity and mortality, with a consequential increase in healthcare costs. The utilization of antimicrobial stewardship strategies in hospitals has been shown to decrease antimicrobial use, decrease antimicrobial resistance patterns, decrease the development of secondary infections, reduce adverse medication effects, and consequently decrease healthcare costs. In 2007, the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America published the *Guidelines for Developing an Institutional Program to Enhance Antimicrobial Stewardship*, encouraging hospitals to implement antimicrobial stewardship programs and presenting a blueprint for their development. After the *Guidelines* were published, several surveys of current antimicrobial stewardship practices ensued, including ones specific to certain states, ones geared towards the members of certain infectious disease professional societies, and even one attempting to assess antimicrobial stewardship practices nationally. For the most part, these surveys have found fairly widespread implementation of antimicrobial stewardship strategies, even in the absence of formal antimicrobial stewardship programs. However, these surveys have also found that barriers to implementation of stewardship

programs are common. Because the Western United States has been relatively under-represented in these surveys, this project aimed to determine to what degree hospitals in western states are engaging in stewardship strategies. Additional aims were to further elucidate the barriers to antimicrobial stewardship, and to identify factors associated with the number of antimicrobial stewardship strategies in use in a facility. A web-based antimicrobial stewardship survey was disseminated via email to pharmacy directors, medical directors, infection control professionals, and other healthcare professionals at general acute care and critical access hospitals in 19 states. Responses (n=105) were summarized using descriptive statistics and univariate analyses of associations between survey respondents and hospital characteristics and the reported usage of the various antimicrobial stewardship strategies.   Results demonstrated the widespread use of antimicrobial stewardship strategies, even in spite of simultaneous reports of barriers to the establishment of formal antimicrobial stewardship programs. A multivariate model was developed via multiple linear regression, which identified six predictors of the number of antimicrobial stewardship strategies in use at a hospital. This model can be utilized to guide the further development of antimicrobial stewardship in facilities that are struggling with MDROs.

<u>Acknowledgements</u>

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Introduction

Antibiotics are one of the most important developments in medicine, and their ability to prevent and control infections has had a major impact in surgery, transplant medicine, oncology, and intensive care medicine (Society for Healthcare Epidemiology of America [SHEA] et al., 2012). The use of antimicrobials began in the 1930s and 1940s with the introduction of sulfonamides, penicillin, and streptomycin (SHEA et al., 2012). From the 1950s onward, a large number of natural and synthetic antimicrobial agents became available (SHEA et al., 2012). However, gradually, bacteria evolved strategies of resistance to these antimicrobials, and the antibiotics became less effective (SHEA et al., 2012). The past three decades have witnessed an increase in multidrug-resistant organisms (MDROs) in patients admitted to hospitals and in the community. Examples include the spread of methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE) among patients in healthcare settings, as well as carbapenemase-producing *Klebsiella pneumoniae* and other carbapenem-resistant Enterobacteriaceae spp. (CRE) (SHEA et al., 2012). In fact, the term "panresistant" is unfortunately not too strong of a description for some of the most recent pathogens that have been isolated (SHEA et al., 2012). As the SHEA, the Infectious Diseases Society of America (IDSA), and the Pediatric Infectious Diseases Society (PIDS) state in their joint *Policy Statement*, "It is ironic that in the twenty-first century we are encountering bacterial infections for which we have no treatment" (2012).

Complicating the depletion of effective antimicrobials is the fact that, in the last 10 years, there has also been a decrease in the development of new antibacterial agents (Boucher et al., 2009), compromising our ability to treat infectious diseases (SHEA et al., 2012). Resistant infections have resulted in increased morbidity and mortality, with a

consequential increase in healthcare costs (Cosgrove et al., 2002; Cosgrove et al., 2003a&b; DiazGranados et al., 2005). The major professional infectious disease societies have advocated a multifaceted approach to prevent and control the emergence of antimicrobial-resistant organisms (SHEA et al., 2012). This recommended approach includes ensuring that proper therapeutic agents are available, that rapid and reliable diagnostics are available to detect specific pathogens and to determine their antimicrobial susceptibilities, and that antimicrobial stewardship programs are promoted robustly (SHEA et al., 2012).

Although each professional society and healthcare facility often has its own definition of antimicrobial stewardship, the *Policy Statement* authored by SHEA, IDSA, and PIDS defines antimicrobial stewardship as the "coordinated interventions designed to improve and measure the appropriate use of antimicrobial agents by promoting the selection of the optimal antimicrobial drug regimen including dosing, duration of therapy, and route of administration" (2012). The justification for antimicrobial stewardship programs rests on numerous studies that have demonstrated that antimicrobial therapy increases the risk of acquiring resistant organisms (Lautenbach et al., 2002; Paterson et al., 2004; Weber et al., 2003). This is especially troubling, given the fact that the overuse and inappropriate use of antimicrobials has also been reported in the literature (Dellit et al., 2007). Optimizing antimicrobial use should minimize antimicrobial resistance (Drew et al., 2009), as well as achieve the best clinical outcome and minimize adverse events (SHEA et al., 2012). Indeed, it has been reported that the implementation of antimicrobial stewardship strategies in acute care hospitals decreases antimicrobial use (by 22-36%), antimicrobial resistance patterns, development of secondary infections, and

adverse medication effects, consequently decreasing healthcare costs in hospital settings by $200,000 to $900,000 annually (Bal et al., 2011; Drew et al., 2009; Goff et al., 2011; Ohl et al., 2011; Pope et al., 2009).

The goals of antimicrobial stewardship are to improve clinical outcomes, minimize unintended consequences of antimicrobial use (such as adverse events and the emergence of resistance), and reduce healthcare costs (Dellit et al., 2007; Drew et al., 2009). In 2007, the IDSA and SHEA published guidelines on the development of antimicrobial stewardship programs (Dellit et al., 2007). These guidelines recommend combining effective antimicrobial stewardship with a comprehensive infection control program to limit the emergence and transmission of antimicrobial-resistant bacteria (Dellit et al., 2007). The *Guidelines for Developing an Institutional Program to Enhance Antimicrobial Stewardship* encourage hospitals to implement antimicrobial stewardship programs and present a blueprint for their development (Dellit et al., 2007).

As far as the antimicrobial stewardship team and administrative support are concerned, the *Guidelines* recommend that core members of the multidisciplinary antimicrobial stewardship team include an infectious diseases (ID) physician and a clinical pharmacist with infectious diseases (ID) training, with the inclusion of a clinical microbiologist, an information systems specialist, an infection control professional, and hospital epidemiologist being optimal. The *Guidelines* also recommend collaboration between the antimicrobial stewardship team, hospital infection control, and pharmacy and therapeutics committees. The support and collaboration of hospital administration, medical staff leadership, and local providers in the development and maintenance of antimicrobial stewardship programs is also stressed by the *Guidelines*, and the

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antimicrobial stewardship team leaders should negotiate with hospital administration to obtain adequate authority, compensation, and expected outcomes for the program.

As for the elements or strategies recommended by the *Guidelines*, they include both active and supplemental antimicrobial stewardship strategies. The active antimicrobial stewardship strategies include prospective audit with intervention and feedback, and formulary restriction/ preauthorization requirements for specific antimicrobial agents. Recommended supplemental antimicrobial stewardship strategies include education of prescribers, evidence-based guidelines and clinical pathways, antimicrobial cycling with scheduled antimicrobial switch, antimicrobial order forms, combination therapy, streamlining or de-escalation of therapy, dose optimization, and conversion from parenteral to oral therapy as soon as possible. Other supports that are recommended by the *Guidelines* include information technologies, such as electronic medical records (EMRs), computerized physician order entry (CPOE), clinical decision support, and computer-based surveillance, as well as microbiology laboratory assistance, such as patient-specific culture and susceptibility data, surveillance of resistant organisms, and molecular epidemiologic investigation of outbreaks.

To measure the degree of success of antimicrobial stewardship efforts, the *Guidelines* recommend monitoring process and outcome variables, where the process variables would include the degree to which antimicrobial use changed, and the outcome variables would include reduction in resistance, decreased infection rates, and lowered costs as a result of the process change.

The 2012 *Policy Statement on Antimicrobial Stewardship* by SHEA, IDSA, and PIDS strongly encourages the Centers for Medicare and Medicaid Services (CMS) to

require healthcare institutions to develop stewardship programs (SHEA et al., 2012).

Public reporting on healthcare-associated infections (HAIs) in healthcare settings is

increasingly being mandated by accrediting organizations, insurance companies, and

legislative entities (Drew et al., 2009; Trivedi et al., 2013). For example, California

Senate Bill (SB) 739 (Health and Safety Code §§ 1288.5–1288.9, 2006) established the

California Department of Public Health HAI program to conduct surveillance,

prevention, and public reporting of HAIs in general acute care hospitals in California. In

2008, SB 739 mandated that all general acute care hospitals develop processes for

evaluating the judicious use of antibiotics and monitor results using appropriate quality

improvement committees, thus providing an incentive for hospital administrators to

establish and direct resources toward active antimicrobial stewardship programs (Drew et

al., 2009; Trivedi et al., 2013). Currently, California is the only U.S. state with this type

of legislation. Perhaps of greatest concern for hospital administrators are recent payment

rules from CMS, where hospitals will lose a portion of their reimbursement when certain

preventable healthcare-associated infections occur (Drew et al., 2009).

After the *Guidelines* were published, surveys of antimicrobial stewardship

practices ensued by researchers in the United States, including two surveys specific to a

particular state (Abbo et al., 2013; Trivedi et al., 2013), one survey geared towards the

members of certain professional societies (Pope et al., 2009), and even an attempt to

capture the prevalence of antimicrobial stewardship practices nationally (Doron et al.,

2013). Response rates from these surveys ranged from 7% to 53%, yielding sample sizes

from 82 to 406 respondents (Abbo, et al., 2013; Doron, et al., 2013; Pope, et al., 2009;

Trivedi et al., 2013). The percentage of respondents that reported having an

antimicrobial stewardship program at their facility averaged around 50%, but 75%-96% of respondents reported the use of at least one antimicrobial stewardship strategy, with or without having a formal program in place (Doron, et al., 2013; Pope, et al., 2009; Trivedi et al., 2013).

The most commonly utilized antimicrobial stewardship strategies included prospective monitoring of antimicrobial prescribing, formulary restriction, antibiograms (i.e., the measurement and tracking of antimicrobial resistance), and automatic antibiotic stop orders (Pope et al., 2009). Factors that have been found to be significantly associated with the presence of an antimicrobial stewardship program include having an infectious disease consultation service (Doron, et al., 2013) and having an infectious disease pharmacist (Doron, et al., 2013). Barriers to antimicrobial stewardship have included staffing issues (Pope et al., 2009; Trivedi et al., 2013), lack of funding (Trivedi et al., 2013), higher-priority clinical initiatives (Pope et al., 2009), opposition from prescribers (Pope, et al., 2009), and resistance from hospital administration (Pope, et al., 2009). The Western U.S. has been relatively under-represented in these previous antimicrobial stewardship practice surveys.

The aims of the present study were to assess both the current antimicrobial stewardship practices and the barriers to antimicrobial stewardship in general acute care and critical access hospitals in an under-represented portion of the United States. This study also determined what percentage of hospitals are engaging in stewardship strategies, elucidated the barriers faced by antimicrobial stewardship programs, and identified factors associated with the number of antimicrobial stewardship strategies in

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use at a facility. In addition, the following research questions and hypotheses were addressed.

Research questions

1. What percentage of hospitals in the surveyed states/regions are engaging in antimicrobial stewardship strategies?

2. Which strategies and techniques are being employed in antimicrobial stewardship efforts in hospitals in the surveyed states/regions?

3. What are the barriers to the overall success of antimicrobial stewardship efforts in hospitals in the surveyed states/regions?

4. What factors are associated with the number of antimicrobial strategies implemented in hospitals in the surveyed states/regions?

Hypothesis #1

H_o: The percentage of hospitals engaging in at least one antimicrobial stewardship strategy is equal among the surveyed states/regions.

H_a: The percentage of hospitals engaging in at least one antimicrobial stewardship strategy differs between the surveyed states/regions.

This hypothesis was tested using univariate analysis of variance (ANOVA) to determine if the proportion of hospitals engaging in at least one stewardship strategy (continuous outcome variable) differed by surveyed state or region (categorical predictor variable). Mean differences were compared between the states/regions, and post-hoc analyses were conducted when statistically significant differences between states/regions occurred.

Hypothesis #2

> **H$_o$:** The strategies being employed in antimicrobial stewardship efforts are the same across the surveyed states/regions.

> **H$_a$:** The strategies being employed in antimicrobial stewardship efforts differ between the surveyed states/regions.

This hypothesis was analyzed using univariate analysis of variance to determine if the frequency of use of each antimicrobial stewardship strategy (continuous outcome variable) is associated with the surveyed state/region (categorical predictor variable). Mean differences were compared between the states/regions, and post-hoc analyses were conducted when statistically significant differences between states/regions occurred.

Hypothesis #3

> **H$_o$:** The barriers to the success of antimicrobial stewardship efforts are the same across the surveyed states/regions.

> **H$_a$:** The barriers to the success of antimicrobial stewardship efforts differ between the surveyed states/regions.

This hypothesis was tested using univariate analysis of variance to compare the frequency of each barrier (continuous outcome variable) and surveyed state/region (categorical predictor variable). Mean differences were compared between the states/regions, and post-hoc analyses were conducted when statistically significant differences between states/regions occurred.

Hypothesis #4

H_o**:** No factors are associated with the number of antimicrobial stewardship strategies implemented.

H_a**:** There is at least one factor associated with the number of antimicrobial stewardship strategies implemented.

This hypothesis was tested using multiple linear regression analysis to determine how much variance in the number of stewardship strategies implemented (continuous outcome variable) were accounted for by the linear combination of various continuous and dichotomous predictor variables (e.g., surveyed state/region, hospital type, hospital size, presence/absence of infectious disease consultation service, etc.).

Methods

Survey development

The present survey (Appendix A) was modeled after that created by Doron et al., 2013, for the national assessment of the prevalence of antimicrobial stewardship practices (Appendix B). The revised survey for the present study collected information on hospital characteristics such as size, classification, and rurality, the presence of information technologies and microbiology laboratory support, the presence of a formal antimicrobial stewardship program, which personnel are on the antimicrobial stewardship team, the presence of an infectious disease consultation service and/or fellowship program, utilization of various antimicrobial strategies, barriers to implementation, and the process and outcome measures used. Perceived degree of success from the use of antimicrobial stewardship strategies was also ascertained, as well as the identification of the most

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concerning resistant organisms for each facility. Unlike the previous surveys in the literature (Pope et al., 2009; Abbo et al., 2013; Doron et al., 2013; Trivedi et al., 2013), definitions of each antimicrobial stewardship strategy and "antimicrobial stewardship program" were provided in the present survey. This study qualified for exempt status from the University of Nevada, Las Vegas (UNLV) Institutional Review Board, as had been the case for previous surveys of this nature in the literature (Doron et al., 2013; Trivedi et al., 2013).

Survey distribution

A link to the survey was created using Qualtrics (www.qualtrics.com), and the survey link was disseminated through multiple waves of emails, with responses collected over a period of 7 weeks (from January 16, 2014, through March 7, 2014). Several strategies were utilized to disseminate the survey link to relevant audiences. One initial strategy was the involvement of the HAI (Healthcare Associated Infection) staff members of the CMS Quality Improvement Organizations (QIOs) in Alaska, Colorado, Hawaii, Kansas, Montana, Nebraska, New Mexico, Nevada, South Dakota, Utah, and Wyoming (Appendix C), to disseminate the survey link via their email lists of acute care and critical access hospitals in their particular state. Another strategy was to target and message relevant SHEA and Association for Professionals in Infection Control and Epidemiology (APIC) members via membership directories (Appendix D), and the representation of the additional western states of Arizona, California, Idaho, North Dakota, Oklahoma, Oregon, Texas, and Washington were added to the sample with this strategy.

Participation was voluntary, and various communications, such as reminders via email and during a webinar presentation by a Centers for Disease Control and Prevention

(CDC) representative, were utilized to encourage participation. Additionally, it was announced in the initial messages to potential respondents that those who completed the survey would receive a compilation of potentially useful antimicrobial stewardship literature, as well as aggregated survey results, if they gave their contact information, which was optional. Survey instructions specified that a single survey should be filled out by one professional (e.g., pharmacy director, medical director, infectious diseases professional, or other professional with knowledge of antimicrobial use) at each hospital.

Data analysis

Facilities were de-identified, and results were aggregated by state. Respondent personal identifiers were only used for response clarification and the distribution of promised antimicrobial stewardship literature and survey results. Responses were summarized using descriptive statistics. Univariate analyses of associations between hospital characteristics and the reported number of antimicrobial stewardship strategies used were determined using t-tests, analyses of variance (ANOVAs), and Pearson/Spearman correlations. Factors that were significant, with a p-value of less than 0.1, in the univariate analyses were included in the process of building the multivariate model, which was analyzed using multiple linear regression (forward method). All statistical analyses were performed using SPSS (v. 22).

Results

Description of sample

Of approximately 1000 to 1200 hospital representatives contacted (it is uncertain of the number contacted via each QIO's emailing efforts), there were 110 total hospitals represented in the survey responses, an estimated response rate of about 9 to 11%. Five

responses were from non-Western states and were excluded from analyses, leaving a total number of 105 responses. Respondents represented 17 out of the 19 states targeted for this project; only Kansas and New Mexico were not represented. The HAI QIO staff member for Kansas had requested that Kansas hospitals not be approached for this survey, because the Kansas QIO was concurrently conducting its own antimicrobial stewardship survey. California, Nevada, and Wyoming were the most represented states in the sample at 21.9%, 18.1%, and 11.4%, respectively. The representativeness of the sample was determined via comparison of the number of hospitals per state in the sample (n=105) to the number of total hospitals per state in the population (n=1639), which was obtained from the CMS Hospital Compare website (https://data.medicare.gov/data/hospital-compare; last updated 2/26/14). The sample represented 6.4% of the overall number of hospitals in the surveyed states. Further details regarding the states represented are included in Table 1 and Figure 1.

Table 1. Number/percent/representativeness of survey respondents, by state.

	Sample (n=105)		Population (n=1639)	
State	**# Hospitals**	**% of Sample**	**# Hospitals**	**% Represented in Sample**
CA	23	21.9%	348	6.6%
NV	19	18.1%	36	52.8%
WY	12	11.4%	29	41.4%
TX	9	8.6%	380	2.4%
NE	8	7.6%	91	8.8%
UT	6	5.7%	45	13.3%
CO	5	4.8%	75	6.7%
AZ	3	2.9%	78	3.8%
MT	3	2.9%	58	5.2%
ND	3	2.9%	45	6.7%
OK	3	2.9%	127	2.4%
OR	3	2.9%	60	5.0%
WA	3	2.9%	91	3.3%
SD	2	1.9%	55	3.6%
AK	1	1.0%	21	4.8%
HI	1	1.0%	17	5.9%
ID	1	1.0%	41	2.4%
NM	0	0.0%	42	0.0%
TOTALS	**105**	**100.0%**	**1639**	**6.4%**

Figure 1. Geographic distribution of survey respondents, by state.

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Since multiple states had low numbers of respondents, it was deemed necessary to group the states into larger units for statistical testing, and the standard U.S. Federal Regions were used for this purpose (http://en/wikipedia.org/wiki/File:USFederalRegions.svg). Table 2 and Figure 2 provide information similar to Table 1 and Figure 1, but with respect to Federal Regions. Two of the regions, VI and VII, contain several states that were not targeted for this survey and, thus, are not represented in the sample.

Table 2. Number/percent/representativeness of survey respondents, by region.

Sample (n=105)			Population (n=2195)	
Region	Number	Percent	# Hospitals	% Represented
VI	12	11.4%	748	1.6%
VII	8	7.6%	448	1.8%
VIII	31	29.5%	307	10.1%
IX	46	43.8%	479	9.6%
X	8	7.6%	213	3.8%
TOTALS	**105**	**100.0%**	**2195**	**4.8%**

Region VI: AR*, LA*, OK, NM, TX
Region VII: IA*, MO*, KS*, NE
Region VIII: CO, MT, ND, SD, UT, WY
Region IX: AZ, CA, HI, NV
Region X: AK, ID, OR, WA
*States not approached with survey link

Figure 2. Geographic distribution of survey respondents, by region.

A further characterization of survey respondent and hospital characteristics can be found in Appendix E. The majority of survey respondents were infection control professionals (57.1%), followed by pharmacy directors, infectious disease pharmacists, and other pharmacists (24.8% combined), infectious diseases physicians and medical directors (13.3% combined), and other disciplines such as hospital epidemiologists and quality directors (4.8%). Of note was the representation of various hospital classifications in the sample. Although general acute care hospitals (GACHs) represented 59.0% of the sample, rural/critical access hospitals (CAHs) represented 27.6%, and specialty hospitals represented 9.5%. Regarding hospital characteristics, there was a good balance of hospitals that were part of multi-hospital healthcare systems (59.0%) versus independent hospitals (41.0%). There was also a good representation of proprietary (30.5%) versus not-for-profit hospitals (68.6%), as well as teaching (47.6%) versus non-teaching

hospitals (52.4%). The number of licensed beds ranged from 12 to 1000, with a mean of 203 beds, and the number of critical care beds ranged from 0 to 150, with a mean of 24 beds. The number of critical care units ranged from 0 to 6, with a mean of 1.73. Critical care units included mostly medical (25.7%), surgical (21.0%), mixed medical/surgical (67.6%), and/or cardiac (30.5%), with pediatric/neonatal (9.5%), respiratory (8.6%), trauma (8.6%), and burn units (1.9%) also represented in the sample.

Sizable portions of the survey respondents did not know their hospital's annual discharges (33.3%), case mix index/CMI (88.6%), or annual antimicrobial expenditures (86.7%). However, a large majority of survey respondents (82.9%) did report that they had access to their hospital's antibiogram (laboratory-provided assessment of the level of antimicrobial resistance of isolated microorganisms). Two-thirds of survey respondents (66.7%) reported that their hospital had ID physician service (either on a consultative basis or as actual hospital medical staff). Almost two-thirds (60.0%) reported having a pharmacist assigned to manage antimicrobial prescriptions (either an ID pharmacist or non-specialized clinical pharmacist).

Prevalence of antimicrobial stewardship strategy use

The distribution of the number of antimicrobial stewardship strategies in use in the overall sample is shown in Figure 3. The distribution was relatively symmetrical with a slight left skew. All respondents (100%) reported the use of at least one antimicrobial stewardship strategy. The number of strategies in use ranged from 1-10, and the mean number of strategies used was 6.11. The mean number of strategies in use, by state and by region, is shown in Tables 3 and 4, respectively. Idaho and Alaska reported the highest number of strategies used, at 9.00 and 8.00, respectively; however, these two

states had only one respondent each. States with means of 7.00 to 7.67 strategies used included Arizona, Washington, Texas, Montana, and South Dakota. States with means of 6.00 to 6.70 strategies used included California, Oklahoma, Nebraska, Colorado, and Hawaii. The latter had only one respondent. States with means of 5.37 to 5.67 strategies used included North Dakota, Utah, and Nevada. The states with the lowest means of strategies used were Wyoming (4.58) and Oregon (4.33).

Figure 3. Number of antimicrobial stewardship strategies in use per hospital.

Table 3. Mean number of antimicrobial stewardship strategies in use, by state.

State	# of hospitals	Mean	Standard Deviation
ID	1	*	*
AK	1	*	*
AZ	3	7.67	1.15
WA	3	7.67	1.15
TX	9	7.11	1.90
MT	3	7.00	2.00
SD	2	7.00	1.41
CA	23	6.70	1.43
OK	3	6.67	2.31
NE	8	6.13	1.46
CO	5	6.00	0.00
HI	1	*	*
ND	3	5.67	3.51
UT	6	5.67	1.63
NV	19	5.37	1.50
WY	12	4.58	2.15
OR	3	4.33	1.15
Total	**105**	**6.11**	**1.82**

*Unable to calculate mean/standard deviation

Table 4. Mean number of antimicrobial stewardship strategies in use, by region.

Region	N	Mean	Standard Deviation
VI	12	7.00	1.91
VII	8	6.13	1.46
VIII	31	5.52	2.01
IX	46	6.20	1.59
X	8	6.63	2.13
Total	**105**	**6.11**	**1.82**

The proportion of respondents reporting the use of at least one antimicrobial stewardship strategy was equal between regions, and the number of antimicrobial

stewardship strategies in use did not significantly differ by region either (p=0.139), as determined by ANOVA.

Types of stewardship strategies in use

The percentage of survey respondents using each antimicrobial stewardship strategy is listed in Table 5. Greater than three-quarters of survey respondents reported using dose optimization (93.3%), streamlining/de-escalation (83.8%), education of prescribers (79.0%), and/or antimicrobial combination therapy (79.0%). About two-thirds of respondents reported the use of intravenous-to-oral (IV-to-PO) conversion plans (69.5%) and evidence-based guidelines and pathways (64.8%). Less than half of survey respondents reported the use of prospective audit (47.6%), antimicrobial order forms (42.9%), and formulary restriction (40.0%). The least-used antimicrobial stewardship strategy was antimicrobial cycling (11.4%).

Table 5. Percentage of respondents using each antimicrobial stewardship strategy.

AS strategy*	No. (%) of respondents
Dose optimization	98 (93.3%)
Streamlining/de-escalation	88 (83.8%)
Prescriber education	83 (79.0%)
Combination therapy	83 (79.0%)
IV-to-PO conversion plan	73 (69.5%)
Guidelines & pathways	68 (64.8%)
Prospective audit	50 (47.6%)
Order forms	45 (42.9%)
Formulary restriction	42 (40.0%)
Cycling	12 (11.4%)

*Not mutually exclusive

Regarding the results in the use of each particular antimicrobial stewardship strategy, also determined by ANOVA, the only significant differences found between regions was for formulary restriction with pre-authorization and antimicrobial order forms (Table 6).

Table 6. Differences in use of individual antimicrobial stewardship strategies, between regions.

AS strategy	p-value
Education of prescribers	0.374
Formulary restriction	0.009*
Prospective audit	0.239
Guidelines/pathways	0.938
Cycling	0.844
Order form	0.041*
Combination therapy	0.171
Streamlining/de-escalation	0.129
Dose optimization	0.428
IV-to-PO conversion	0.081

*Significant at $p < 0.05$

Summary data of formulary restriction and antimicrobial order form use by region are shown in Tables 7 and 8, respectively. There was a large range in the use of formulary restriction between regions, with 83.33% of respondents from Region VI reporting the use of formulary restriction at their facilities, while only 25.81% of respondents from Region VIII indicated use of formulary restriction. Similarly, there was also a large range in the use of antimicrobial order forms betweens regions, with 75.00% of respondents from Region VII reporting the use of order forms at their facilities, while only 22.58% of respondents from Region VIII indicated use of order forms. The results

of each post-hoc comparison between regions for formulary restriction and antimicrobial

order form use are shown in Table 9 and 10, respectively.

Table 7. Formulary restriction use, by region.

Region (N)	No. (%) using formulary restriction
VI (12)	10 (83.33%)
VII (8)	4 (50.00%)
X (8)	4 (50.00%)
IX (46)	16 (34.78%)
VIII (31)	8 (25.81%)
Total (105)	**42 (40.00%)**

Table 8. Antimicrobial order form use, by region.

Region (N)	No. (%) using antimicrobial order forms
VII (8)	6 (75.00)%
VI (12)	6 (50.00%)
IX (46)	23 (50.00%)
X (8)	3 (37.50%)
VIII (31)	7 (22.58)%
Total (105)	**45 (42.86%)**

Table 9. Differences in use of formulary restriction, between regions.

Comparison			Mean difference	p-value
VI	vs.	VII	0.33	0.123
	vs.	VIII	0.58	0.000*
	vs.	IX	0.49	0.002*
	vs.	X	0.33	0.123
VII	vs.	VIII	0.24	0.197
	vs.	IX	0.15	0.399
	vs.	X	0.00	1.000
VIII	vs.	IX	-0.09	0.413
	vs.	X	-0.24	0.197
IX	vs.	X	-0.15	0.399

*Significant at p<0.05

Table 10. Differences in use of order forms, between regions.

Comparison			Mean difference	p-value
VI	vs.	VII	-0.25	0.259
	vs.	VIII	0.27	0.098
	vs.	IX	0.00	1.000
	vs.	X	0.13	0.572
VII	vs.	VIII	0.52	0.007*
	vs.	IX	0.25	0.179
	vs.	X	0.38	0.123
VIII	vs.	IX	-0.27	0.016*
	vs.	X	-0.15	0.438
IX	vs.	X	0.13	0.501

*Significant at p<0.05

Barriers to formal antimicrobial stewardship programs

Although all 105 survey respondents reported the use of at least one antimicrobial stewardship strategy at their hospital, only 51 respondents (48.6%) reported the presence of a formal antimicrobial stewardship program (ASP) at their facility (Appendix E). Two

respondents (1.9%) indicated that they were uncertain if their hospital had a formal ASP.

Of the respondents who reported not having a formal ASP (52, or 49.5%), the barriers

indicated for not having one are listed in Table 11. Half of the respondents noted that

staffing constraints were a barrier. Over one-third indicated that inadequate

administration (38.5%) and/or prescriber support (36.5%) or not having antimicrobial

stewardship as a clinical priority (34.6%) were barriers. About a quarter of respondents

indicated the barriers of inadequate information technology support (26.9%) and/or lack

of funding (25%). A smaller percentage of respondents (11.5% to 21.2%) noted the

barriers to establishing a formal ASP as the lack of program leadership, not previously

considering a formal ASP, not needing a formal ASP, and the possibility that a formal

ASP would damage relationships with prescribers.

Table 11. Reasons listed for not having a formal antimicrobial stewardship program (ASP).

Barriers to establishing a formal ASP*	Number (%)
Staffing constraints	26 (50.0%)
Inadequate administration support	20 (38.5%)
Inadequate prescriber support	19 (36.5%)
Not a clinical priority	18 (34.6%)
Inadequate information technology support	14 (26.9%)
Lack of funding	13 (25.0%)
No one has volunteered to lead	11 (21.2%)
Not previously considered	9 (17.3%)
No need for a formal program	7 (13.5%)
Would damage relationships with prescribers	6 (11.5%)

*Not mutually exclusive

The frequency of each of the ten reported barriers to establishing a formal ASP did not

significantly differ by region, as analyzed by ANOVA (see Table 12 for results).

Table 12. Differences in reported barriers to implementation of a formal ASP, between regions.

Barrier to ASP	p-value
Lacking of funding	0.697
Staffing constraints	0.951
No leader has volunteered	0.820
Inadequate prescriber support	0.998
Inadequate admin support	0.732
Not a clinical priority	0.574
Inadequate info tech support	0.719
Damaging MD relations	0.799
Not previously considered	0.764
No need for formal ASP	0.355

Similarly, the total number of reported barriers to formal ASP establishment (with a

possible range of 1 to 10) did not significantly differ between regions (p=0.626).

Factors associated with the number of AS strategies in use

For this study, it was found that the number of antimicrobial stewardship

strategies in use (from 1 to 10) strongly and significantly correlated with the number of

antimicrobial stewardship successes reported (from 1 to 7) (Spearman's rho = +0.500;

p<0.001). The seven antimicrobial stewardship successes offered as choices in the

survey were:

1. Improved patient outcomes
2. Reduced infection rates
3. Decreased antimicrobial costs
4. Decreased antimicrobial doses prescribed
5. Change in antimicrobial resistance patterns/Increased antimicrobial sensitivities
6. Reduced adverse medication events
7. Decreased secondary infections

Univariate analyses of the association between each of 71 categorical and continuous survey respondent/hospital characteristics and the number of antimicrobial stewardship strategies in use yielded 53 significant factors with a p-value of less than 0.1. The results of all 71 analyses are shown in Appendix F.

Of the 53 significant factors, the 37 factors (indicated by ^ in Appendix F) that could be considered "controllable", or open to change with influence, were included in the initial regression model. Multiple regression analysis via forward method was performed, resulting in 6 models with adjusted R-squares ranging from 0.296 for Model 1 with one factor (presence of formal AS program) up to a maximum of 0.538 for Model 6 with six factors (presence of formal AS program, use of clinical decision support, use of computer monitoring of antimicrobial prescriptions, presence of an antibiogram, absence of support from other departments, and having support from the infection prevention/control department). Beta coefficients for Model 6 are listed in Table 13.

Table 13. Regression model for prediction of number of antimicrobial stewardship strategies used.

Coefficients

Model	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
	Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
6 (Constant)	5.747	0.703		8.176	0.000	4.350	7.143
AS program	1.354	0.287	0.382	4.716	0.000	0.784	1.925
Clinical decision support for antimicrobial prescription/dosing	0.989	0.320	0.230	3.093	0.003	0.354	1.624
Antibiogram	1.081	0.358	0.232	3.020	0.003	0.370	1.792
Computer-assisted monitoring of antimicrobial prescriptions	0.765	0.325	0.178	2.357	0.021	0.120	1.410
No support from other departments/committees	-2.365	0.712	-0.367	-3.319	0.001	-3.780	-0.949
Infection Prevention/Control	-1.462	0.648	-0.251	-2.257	0.026	-2.749	-0.175

The mathematical expression for Model 6 is shown below. All of the six included

variables are dichotomous and, thus, to be coded as 0 or 1.

Number of AS strategies in use = 5.747 + 1.354 (presence of formal AS program)

+ 0.989 (presence of clinical decision support)

+ 1.081 (presence of antibiogram)

+ 0.765 (presence of computer-assisted
prescription monitoring)

$$- \text{ 2.365 (absence of support from other}$$
$$\text{departments/committees)}$$

$$- \text{ 1.462 (presence of support from infection}$$
$$\text{prevention/control department)}$$

Positive predictors of the number of antimicrobial stewardship strategies in use, in order of decreasing strength, included the presence of a formal antimicrobial stewardship program (with a beta coefficient of 1.354), presence of an antibiogram (1.081), presence of clinical decision support to assist prescribers with appropriate antimicrobial selection (0.989), and presence of computer-assisted monitoring of antimicrobial prescriptions (0.765) (Table 15). Negative predictors of the number of strategies included the absence of support from other departments or committees within the hospital (-2.365) and the presence of support from the infection prevention and control department, specifically (-1.462). As an example of how to apply the model, a hospital would be expected to be using 5.747 strategies to begin with. If that hospital does not have a formal ASP(+0), but uses clinical decision support (+0.989), receives an antibiogram (+1.081), does not utilize computer-assisted prescription monitoring (+0), and has the support of other departments (+0), one of which is their infection control department (-1.462), one would be expect that hospital to be using 6.355 antimicrobial stewardship strategies.

Discussion

The null hypotheses for Research Questions 1 and 3 were not rejected by the results of the analyses. The number of respondents engaging in at least one antimicrobial stewardship strategy and the reported barriers to the establishment of formal

antimicrobial stewardship programs were the same between regions. The null hypothesis for Research Question 2 was rejected at p=0.009 and p=0.041 for two of the antimicrobial stewardship strategies (formulary restriction and antimicrobial order forms, respectively) but was not rejected for the other eight strategies. The null hypothesis for Research Question 4 was rejected at p<0.05 for 46 factors (with a range of p<0.001 through p=0.046, depending on the factor tested). Although the practice of eight of the antimicrobial stewardship strategies did not vary between regions, the frequency with which the strategies of formulary restriction and antimicrobial order forms are practiced did differ between regions, and there was at least one factor found to be associated with the number of antimicrobial stewardship strategies in place at a facility.

The present survey's estimated response rate of 9-11% may seem low compared to the 53% and 39% response rates for the two single-state antimicrobial stewardship surveys in the literature (Trivedi et al., 2013; Doron et al., 2013); however, our response rate is comparable to the 10% and 7% response rates for the two national (i.e., multi-state) surveys in the literature (Pope et al., 2009; Abbo et al., 2013). Our sample size also fell within the range of the four previously published surveys (105 vs. 82-406). Our survey respondents were more heavily weighted with infection control professionals (57.1% vs. 20-37%) and less weighted with pharmacists (24.8% vs. 41-80%) and physicians (13.3% vs. 20-28%) than the previous surveys, but were similar in proportion with regard to "other" disciplines, such as administrators, microbiologists, and healthcare epidemiologists (4.8% vs. 5-5.1%). Most notably, our sample included a sizable portion of smaller, rural critical access hospitals (27.6%) in addition to general acute care hospitals (59.0%), owing to the size and geography of the states surveyed.

The goal of the present study was to describe the antimicrobial stewardship practices in a sample of hospitals in the western United States and determine the factors associated with the number of antimicrobial stewardship strategies in use at a facility, as opposed to factors associated with the presence of a formal antimicrobial stewardship program, which has been the focus of previous studies (Pope et al., 2009; Abbo et al., 2013; Doron et al., 2013; Trivedi et al., 2013). Similar to the previous surveys, the prevalence of the use of antimicrobial stewardship strategies recommended in the 2007 IDSA/SHEA *Guidelines* in this study (100%) was roughly double the prevalence of formally established antimicrobial stewardship programs (48.6%). Our results also show that hospitals in the western U.S. are actively engaged in antimicrobial stewardship activities despite reporting numerous barriers to the establishment of formalized programs, such as staffing constraints and lack of funding. Although California was the only state in the sample (and is the only state in the U.S.) with legislation mandating the more judicious use of antimicrobials (CA SB739), the results from this survey indicate that hospitals in other states throughout the west are also engaging in antimicrobial stewardship practices, without the necessity for a legislative mandate. However, the establishment of regulatory mechanisms and reimbursement deductions such as those being implemented by The Joint Commission (TJC) and CMS will certainly not hurt the future growth of antimicrobial stewardship practices in healthcare facilities.

The fact that the surveyed regions did not significantly differ in the reported use of eight of the ten distinguishable antimicrobial stewardship strategies may demonstrate the success of educational outreach efforts and communications from various infectious disease authorities such as the CDC and the IDSA, as well as the degree to which hospital

staff regularly review and implement best antimicrobial use practices from the scientific literature. The significant differences between regions in the reported use of formulary restriction and antimicrobial order forms cannot be easily explained and is a topic for further research, but it can be hypothesized that the regulations established by state payers such as Medicaid may account for these differences.

While the primary goal of this study was to examine the factors associated with the number of practices in place, the prevalence for some of the antimicrobial stewardship strategies inquired about in this study did somewhat vary from those found in previous surveys. The prevalence of formulary restriction was 40.0% in the present study, similar to that in the surveys done by Pope (38%) and Trivedi (44-49%). However, the present study's respondents reported a higher prevalence of prescriber education (79.0% vs. 31-69%) and a much higher prevalence of dose optimization (93.3% vs. 22-45%) and streamlining/de-escalation (83.8% vs. 4-28%) than seen in other studies (Pope et al., 2009; Abbo et al., 2013; Doron et al., 2013; Trivedi et al., 2013). This increased use of these antimicrobial stewardship strategies is likely due to the dedicated focus on antimicrobial stewardship in both the scientific literature and by infectious diseases professional societies such as APIC, IDSA, and SHEA, as the primary means with which to combat the increasing problem of antimicrobial resistance. The fact that CMS and other healthcare payers are implementing reimbursement reductions based on the presence of infections within the hospital setting certainly may also be playing a large role in promoting the greater use of antimicrobial stewardship strategies.

While the totality of our sample reported the use of at least one antimicrobial stewardship strategy at their hospital, having a formal antimicrobial stewardship program

(ASP) was found to be significantly associated with the implementation of a larger number of strategies, which in turn was significantly related to a larger number of perceived "successes" reported by respondents. Thus, the barriers to the development of formal ASPs deserve exploration. Barriers to the establishment of formal ASPs are still present, and all barriers examined in this study were found to be universal across the sampled states. The prevalence levels of some barriers in our study were comparable to those from previous surveys, such as staffing constraints (50% vs. 47-56%, respectively) and low prioritization (34.6% vs. 22-44%). However, some barriers had greater prevalence in our study compared to previous surveys, notably inadequate prescriber support (36.5% vs. 18-32%, respectively), inadequate administration support (38.5% vs. 14-18%), and inadequate information technology support (26.9% vs. 19%). On a more positive note, some barriers showed a lower prevalence in comparison to previous surveys, such as lack of funding (25.0% vs. 36-69%) and lack of a willing leader for the program (21.2% vs. 42%). There were also a lower percentage of respondents in this study (compared to other studies) who indicated that their facility had never considered having a formal ASP (17.3% vs. 24-37%) (Pope et al., 2009; Abbo et al., 2013; Doron et al., 2013; Trivedi et al., 2013).

As a counter to the funding barrier, there is ever-growing evidence in the literature that ASPs can be self-funding through the cost savings they achieve (Pope et al., 2009; Goff et al., 2011). Partnerships between acute care hospitals and the rural critical access hospitals in the surrounding regions, as well as the involvement of quality and patient safety organizations such as the CMS QIOs, can be instrumental in increasing the prevalence of ASPs and the use of multiple antimicrobial stewardship strategies.

However, the more difficult task of overcoming inadequate institutional commitment to antimicrobial stewardship remains, and obtaining this support will be essential for the more widespread establishment of ASPs.

When evaluating what factors are associated with the number of antimicrobial strategies in use, the author felt it useful to differentiate between those factors deemed to be "unchangeable" – such as hospital classification or number of critical care units – and those that could be considered to be more "controllable", or subject to influence – such as the presence of an antibiogram or support for stewardship by other departments and/or disciplines. While it is certainly informative to posit the baseline number of antimicrobial stewardship strategies that might be expected for a facility based on certain hospital characteristics, it is perhaps even more important to predict the changes in the number of strategies that may occur in association with factors that are more open to influence. Previous studies have examined factors associated with the presence of an ASP (Doron et al., 2013; Trivedi et al., 2013), but none have looked at the factors associated with the actual number of antimicrobial stewardship strategies in use without regard for whether a formalized program was present.

In the proposed model of "controllable" predictors in the present study, the presence of a formal ASP is actually one of the significant positive predictors of the number of stewardship strategies in use at a hospital. The other predictors of the number of stewardship strategies in place at a hospital – the positive association with use of an antibiogram, use of clinical decision support, and use of computer-assisted monitoring of prescriptions, as well as the negative association with the absence of support from other departments -- are similarly intuitive. However, the fact that the involvement of the

infection control department was a negative predictor for the number of stewardship

strategies appears counter-intuitive. This quizzical association might have its origins in

the slightly different focal points of infection control versus antimicrobial stewardship.

For infection control, the focus is on preventing initial infection and preventing the

spread of infection that is already present; whereas, for antimicrobial stewardship, the

focus is on the prevention of antimicrobial resistance through the appropriate use of

antibiotics in those already infected. Regardless, the practicality of this predictive model

should be underscored, as it represents one of the first attempts to provide evidence-

driven direction to the many hospitals that are seeking to combat the public health issue

of antimicrobial resistance within their facilities. The utility of the model lies in

application of the six factors in order to develop the infrastructure from which the

practice of antimicrobial stewardship strategies can be more effectively supported.

The results of the present survey may not be generalizable to other U.S. hospitals

due to response bias, because the sample was drawn from QIO, SHEA, and APIC

associates; thus, the respondents might have been more likely to respond to a query

regarding antimicrobial stewardship. Another possible limitation of the survey was that

there was only one spokesperson for each hospital and their opinion of the antimicrobial

stewardship practices may have been inaccurate; however, in most cases, by virtue of

their position/discipline at their facility, this representative would have had knowledge of

the information required to answer the survey questions. The survey received a fair

degree of participation from some states, but no or very little participation from others,

representing only 6.4% of the total number of hospitals in participating states.

Additionally, this total number of hospitals was gleaned from the CMS Hospital Compare

hospital database, which identifies only hospitals that are licensed and seek reimbursement from Medicare. Other limitations of this study include the self-report bias usually associated with surveys and the possibility of duplicate hospitals reporting because respondents were not required to provide facility identifiers beyond state of location and various hospital characteristics such as bed size. Nevertheless, this study did include hospitals that were varied in their characteristics, confirmed the widespread implementation of antimicrobial stewardship strategies, and pointed at the challenges and successes that can be utilized to guide the further development of antimicrobial stewardship in facilities that are struggling with MDROs.

In conclusion, the results of this survey of antimicrobial stewardship practices in the Western United States have demonstrated the widespread use of stewardship strategies in general, as well as an increase from previous surveys in the reported usage of dose optimization, streamlining and de-escalation, and prescriber education in particular. Similar to previous surveys, there is a continuing struggle with the development of formal antimicrobial stewardship programs, although the barriers appear to have changed from lack of funding and program leadership to lack of administrator and prescriber support for antimicrobial stewardship. Importantly, this survey identified several "controllable" predictors of antimicrobial stewardship success besides having a formal program – namely, the presence of an antibiogram and the necessity of support from other disciplines, as well as the use of information technologies such as clinical decision support and computer-assisted monitoring of antimicrobial prescriptions. Future directions include the delineation of which antimicrobial stewardship strategies are associated with the greatest number of successes in terms of improved patient outcomes

and the further stratification of the data by general acute care versus critical access hospitals to assist in determining which strategies are most beneficial to each hospital classification.

Q4 How would you classify your hospital?

❍ Rural/Critical Access (1)
❍ General Acute Care (2)
❍ Specialty Hospital (Cardiac, Rehab, etc.) (3)
❍ Other (please specify) (4) _____

Q5 Is your hospital proprietary or not-for-profit?

❍ Proprietary (1)
❍ Not-for-profit (2)
❍ Other (please specify) (3) _____

Q6 Is your hospital teaching or non-teaching?

❍ Major physician teaching (Students, Interns, Residents, Fellows) (1)
❍ Limited physician teaching (Residents, Fellows) (2)
❍ Non-teaching (3)
❍ Other (please specify) (4) _____

Q7 What is the number of licensed beds in your hospital (without Nursery)? _____

Q8 What was your hospital's total number of discharges last calendar year?

❍ Less than 100 (1)
❍ Between 101 and 500 (2)
❍ Between 501 and 1000 (3)
❍ Between 1001 and 2000 (4)
❍ Between 2001 and 4000 (5)
❍ Between 4001 and 6000 (6)
❍ Between 6001 and 8000 (7)
❍ Between 8001 and 10,000 (8)
❍ Greater than 10,000 (9)
❍ I don't know (10)

Q9 What is the number of designated critical care beds in your hospital? _____

Q10 What type(s) of Critical Care Units does your hospital have? Check all that apply.

- ❏ Mixed Medical/Surgical (1)
- ❏ Medical (2)
- ❏ Surgical (3)
- ❏ Cardiac Care (4)
- ❏ Respiratory (5)
- ❏ Burn (6)
- ❏ Trauma (7)
- ❏ Other (please specify) (8) _____

Q11 If you know the average monthly case mix index (CMI) for your hospital, please enter it here.

- ❍ CMI: (1) _____
- ❍ I don't know (2)

Q12 How frequently do you receive facility-specific susceptibility data (i.e. antibiogram)?

- ❍ Every 6 months (1)
- ❍ Yearly (2)
- ❍ Other (please specify) (3) _____
- ❍ Don't receive facility-specific susceptibility data (4)

Q13 Please specify the characteristics of the facility-specific antibiogram. Check all that apply.

- ❏ Provides unit-specific data also (i.e., ICU) (1)
- ❏ Limited to organisms with >30 pathogens per cycle (2)
- ❏ Cumulative numbers provided for organisms with <30 pathogens per cycle (3)
- ❏ None of these characteristics (4)
- ❏ Don't receive a facility-specific antibiogram (5)

Q14 Does your microbiology laboratory provide individualized patient-specific susceptibility data in addition to culture results?

❍ Yes (1)
❍ No (2)
❍ I don't know (3)

Q15 Does your microbiology laboratory provide Minimum Inhibitory Concentration (MIC) results when reporting patient-specific susceptibility data, in addition to the classifications of Sensitive, Intermediate, Resistant?

❍ Yes (1)
❍ No (2)
❍ I don't know (3)

Q16 What is the total yearly antimicrobial expenditure (antibacterials and antifungals only) at your hospital?

❍ Annual antimicrobial expenditure: (1) _____
❍ I don't know (2)

Q17 What percent of your hospital's total inpatient pharmacy drug budget is represented by antimicrobials (antibacterials and antifungals only)?

❍ Less than 10% (1)
❍ Between 10% and 20% (2)
❍ Between 21% and 30% (3)
❍ Between 31% and 50% (4)
❍ Greater than 50% (5)
❍ I don't know (6)

Q18 Does your hospital have an Infectious Disease specialty physician-based service?

❍ Yes, but it is consult only (1)
❍ Yes, the physicians are paid hospital staff (i.e., employees of hospital) (2)
❍ No (3)
❍ I don't know (4)

Q19 Does your hospital have a pharmacist assigned to manage antimicrobials?

❍ Yes, and they are board-certified in Infectious Diseases Pharmacy (1)
❍ Yes, but they are NOT board-certified in Infectious Diseases Pharmacy (2)
❍ No (3)
❍ I don't know (4)

Q20 Does your hospital have an Infectious Disease specialty physician fellowship training program?

❍ Yes (1)
❍ No (2)
❍ I don't know (3)

Q21 Which of the following techniques are utilized in your hospital to educate physicians/prescribers about the appropriate prescription of antimicrobials? Check all that apply.

❑ Newsletter/Written guidelines (1)
❑ Email alerts (2)
❑ Grand Rounds for students/house staff (3)
❑ Conference presentations (4)
❑ Webinars (5)
❑ Other (please specify) (6) _____
❑ No formal education of prescribers has been done (7)

Q22 Does your institution utilize any of the following antimicrobial restriction methods? Check all that apply.

❑ Specific antimicrobials are only dispensed after approval is obtained (also known as "formulary restriction with preauthorization") (1)
❑ Antimicrobials are dispensed but subject to future review with recommendations (also known as "prospective audit with feedback and/or intervention") (2)
❑ Infectious Disease consult required (3)
❑ None (4)
❑ Other (please specify) (5) _____

Q23 Who is responsible for providing the approval for restricted antibiotics? Check all that apply.

❑ Infectious Diseases physician (1)
❑ Infectious Diseases pharmacist (2)
❑ Infectious Diseases fellow (3)
❑ Other (please specify) (4) _____
❑ I don't know (5)
❑ Don't utilize formulary restriction and preauthorization (6)

Q24 Who is responsible for reviewing antimicrobial prescriptions and making recommendations? Check all that apply.

❑ Infectious Diseases physician (1)
❑ Infectious Diseases pharmacist (2)
❑ Infectious Diseases fellow (3)
❑ Other (please specify) (4) _____
❑ I don't know (5)
❑ Don't utilize prospective audit with feedback and/or intervention (6)

Q25 Does your facility have a designated group (e.g. Pharmacy &Therapeutics committee or special subcommittee) that determines formulary restrictions?

❍ Yes (please specify the committee or discipline) (1) _____
❍ No (2)
❍ I don't know (3)

Q26 Does your hospital utilize institutional evidence-based practice guidelines and clinical pathways that incorporate local resistance patterns when making decisions with regard to antimicrobial prescription?

❍ Yes (1)
❍ No (2)
❍ I don't know (3)

Q27 Does your hospital utilize antimicrobial cycling, or the periodic substitution of a specific antimicrobial class for another, in order to prevent antimicrobial resistance?

❍ Yes (1)
❍ No (2)
❍ I don't know (3)

Q28 Does your hospital utilize antimicrobial order forms (with built-in automatic stop orders and/or physician justification requirements) in the antimicrobial prescription process?

❍ Yes (1)
❍ No (2)
❍ I don't know (3)

Q29 Does your hospital utilize antimicrobial combination therapy (use of multiple antimicrobials) for empirical initial treatment of infections in order to increase the breadth of coverage?

❍ Yes (1)
❍ No (2)
❍ I don't know (3)

Q30 Does your hospital utilize streamlining (switching to a more targeted narrow-spectrum antimicrobial once an organism is identified via culture) or de-escalation (discontinuing the empirical antimicrobial if the culture is negative)?

❍ Yes -- both streamlining and de-escalation (1)
❍ Yes -- streamlining only (2)
❍ Yes -- de-escalation only (3)
❍ No, neither streamlining nor de-escalation (4)
❍ I don't know (5)

Q31 Does your hospital utilize dose optimization (i.e., account for individual patient characteristics such as age, renal function, and weight; causative organism; site of infection; and pharmacodynamics of the drug) when prescribing antimicrobials?

○ Yes (1)
○ No (2)
○ I don't know (3)

Q32 Does your hospital utilize a systematic plan for conversion of parenteral to oral (I.V. to P.O.) administration of antimicrobials once a patient meets defined clinical criteria?

○ Yes (1)
○ No (2)
○ I don't know (3)

Q33 Are you satisfied with the degree of implementation of these antimicrobial stewardship strategies/techniques at your hospital (i.e., actual practice)?

	Yes (1)	Somewhat (2)	No (3)
Formulary restriction/Preauthorization (1)	○	○	○
Prospective audit with feedback/intervention (2)	○	○	○
Evidence-based guidelines and clinical pathways (3)	○	○	○
Antimicrobial cycling (4)	○	○	○
Antimicrobial order forms (5)	○	○	○
Combination therapy (6)	○	○	○
Streamlining/de-escalation of therapy based on culture results (7)	○	○	○
Dose optimization (8)	○	○	○
Parenteral to oral conversion (9)	○	○	○

Q34 Are you satisfied with the outcomes/successes obtained from the implementation of these antimicrobial stewardship strategies/techniques at your hospital?

	Yes (1)	Somewhat (2)	No (3)	Not used (4)
Formulary restriction/Preauthorization (1)	○	○	○	○
Prospective audit with feedback/intervention (2)	○	○	○	○
Evidence-based guidelines and clinical pathways (3)	○	○	○	○
Antimicrobial cycling (4)	○	○	○	○
Antimicrobial order forms (5)	○	○	○	○
Combination therapy (6)	○	○	○	○
Streamlining/de-escalation of therapy based on culture results (7)	○	○	○	○
Dose optimization (8)	○	○	○	○
Parenteral to oral conversion (9)	○	○	○	○

Q35 What successes have you experienced at your facility as a result of the implementation of antimicrobial stewardship strategies? Check all that apply.

❑ Improved patient outcomes (e.g. lower mortality, decreased length of stay) (1)
❑ Reduced infection rates (2)
❑ Decreased antimicrobial expenditures/costs (3)
❑ Decreased antimicrobial doses prescribed (4)
❑ Change in antimicrobial resistance patterns/Improved antimicrobial sensitivity (5)
❑ Reduced adverse medication events (6)
❑ Decreased development of secondary infections (7)
❑ Other (please specify) (8) _____
❑ Have not had success with antimicrobial stewardship strategies (9)
❑ Not currently using any antimicrobial stewardship strategies (10)
❑ Have not been monitoring these indicators with regard to antimicrobial stewardship (11)

Q36 What measures is your facility using to monitor antimicrobial use? Check all that apply.

❑ Antimicrobial purchasing/acquisition costs (1)
❑ Cost of antimicrobials dispensed (2)
❑ Number of antimicrobial doses prescribed (3)
❑ Number of antimicrobial doses dispensed (4)
❑ Defined daily dose (DDD) -- standardized calculation from World Health Organization (5)
❑ Days of antimicrobial therapy (6)
❑ Other (please specify) (7) _____
❑ Not measuring antimicrobial use (8)

Q37 What measures is your facility using to monitor outcomes of antimicrobial use? Check all that apply.

❑ Antimicrobial resistance patterns (1)
❑ Infection rates (2)
❑ Patient outcomes such as mortality and length of stay (LOS) (3)
❑ Adverse drug reactions (4)
❑ Other (please specify) (5) _____
❑ Not measuring outcomes of antimicrobial use (6)

Q38 Which microorganism is the most difficult to eradicate or control within your hospital?

❍ *Clostridium difficile* (1)
❍ Methicillin-resistant *Staphylococcus aureus* (2)
❍ Vancomycin-resistant *Enterococcus* (3)
❍ *Acinetobacter baumannii* (4)
❍ Carbapenem-resistant *Enterobacteriaceae* (*Escherichia coli, Klebsiella pneumoniae*) (5)
❍ *Pseudomonas aeruginosa* (6)
❍ *Proteus mirabilis* (7)
❍ *Serratia marcescens* (8)
❍ *Enterococcus faecium/faecalis* (9)
❍ Other (please specify) (10) _____

Q48 Which microorganism is the second most difficult to eradicate or control within your hospital?

❍ *Clostridium difficile* (1)
❍ Methicillin-resistant *Staphylococcus aureus* (2)
❍ Vancomycin-resistant *Enterococcus* (3)
❍ *Acinetobacter baumannii* (4)
❍ Carbapenem-resistant *Enterobacteriaceae* (*Escherichia coli, Klebsiella pneumoniae* (5)
❍ *Pseudomonas aeruginosa* (6)
❍ *Proteus mirabilis* (7)
❍ *Serratia marcescens* (8)
❍ *Enterococcus faecium/faecalis* (9)
❍ Other (please specify) (10) _____

Q39 Do you have the active support of any of the following entities for antimicrobial stewardship efforts? Check all that apply.

❑ Hospital administration (1)
❑ Medical staff leadership (2)
❑ Physicians/prescribers (3)
❑ None of these entities actively support antimicrobial stewardship (4)
❑ I don't know (5)

Q40 Do you have the support of other hospital departments/committees for antimicrobial stewardship efforts? Check all that apply.

❑ Infection Prevention/Control (1)
❑ Pharmacy & Therapeutics (2)
❑ Quality/Performance Improvement (3)
❑ Patient Safety (4)
❑ Nursing Leadership (5)
❑ Microbiology Laboratory (6)
❑ Information Technology (7)
❑ Other (please specify) (8) _____
❑ No support from other departments/committees (9)

Q41 Which of the following information technologies are in use at your facility? Check all that apply.

- ❑ Electronic medical records (EMRs) (1)
- ❑ Computerized physician order entry (CPOE) (2)
- ❑ Clinical decision support for antimicrobial prescription/dosing (3)
- ❑ Computer-based surveillance (of hospital-acquired infections, adverse medication events, resistance patterns) (4)
- ❑ Computer-assisted monitoring of antimicrobial prescriptions (5)
- ❑ Other (please specify) (6) _____
- ❑ None of these (7)

Q42 Does your hospital have a formally organized and identified Antimicrobial Stewardship Program (ASP), in addition to utilizing various antimicrobial stewardship strategies? An ASP is typically defined as a multidisciplinary team officially recognized by hospital administration who meets regularly for the set purpose of planning and coordinating antimicrobial stewardship efforts to accomplish specific goals or outcomes for the facility.

- ❍ Yes (1)
- ❍ No (2)
- ❍ I don't know (3)

Q43 What disciplines are represented on your facility's Antimicrobial Stewardship Program team? Check all that apply.

- ❑ Infectious Diseases Physician (1)
- ❑ Other physician (2)
- ❑ Infectious Diseases Pharmacist (3)
- ❑ Other pharmacist (4)
- ❑ Infection control professional (5)
- ❑ Clinical microbiologist (6)
- ❑ Hospital epidemiologist (7)
- ❑ Hospital administrator (8)
- ❑ Information technology specialist/Data analyst (9)
- ❑ Other discipline (please specify) (10) _____
- ❑ I don't know (11)
- ❑ Team still in development, even though we have a recognized Antimicrobial Stewardship Program (12)
- ❑ Don't have a formal Antimicrobial Stewardship Program (13)

Q44 How long has your facility's Antimicrobial Stewardship Program been in place?

- ❍ It is currently in development (1)
- ❍ Less than 1 year (2)
- ❍ Between 1 and 3 years (3)
- ❍ Greater than 3 years (4)
- ❍ I don't know (5)
- ❍ Don't have a formal Antimicrobial Stewardship Program (6)

Q45 Why doesn't your hospital have a formally organized and identified Antimicrobial Stewardship Program? Check all that apply.

❑ Lack of funding (1)
❑ Staffing constraints (2)
❑ No one has volunteered to lead the program (3)
❑ Insufficient physician/prescriber support of antimicrobial stewardship (4)
❑ Insufficient administration support of antimicrobial stewardship (5)
❑ Not high on the list of clinical priorities (6)
❑ Inadequate information technology support (7)
❑ Concern about damaging relationships with physicians/prescribers (8)
❑ Organized program has not previously been considered (9)
❑ No identified need for a formally organized program at this time (10)
❑ Other (please specify) (11) _____
❑ We have a formal Antimicrobial Stewardship Program (12)

Q46 Thank you for completing this survey! Please provide your contact information below. This information is optional but strongly encouraged, and will be used to clarify responses, obtain additional information, and return the blinded study results. Composite data will be shared with participants who provide contact information in order to help them with their practice. If you wish to receive the results of this survey and/or are willing to be contacted with any questions or clarifications to your responses, you MUST complete this section.

Name (1)
Email address (2)
Phone number (3)
Position/Title (4)
Associated hospital/facility (5)

Q47 Please feel free to share below any comments, concerns, or challenges in regard to antimicrobial stewardship initiatives. Be sure to click the >> button below when you are finished. You will then be redirected to a screen confirming that you have successfully completed the survey. Thank you once again!   If you have any immediate questions or comments, please contact Gayle Allenback at allenbac@unlv.nevada.edu.

In an effort to characterize antimicrobial stewardship practices in healthcare systems, the Division of Infectious Diseases at Tufts Medical Center is conducting this important survey to assess the antimicrobial stewardship methods at individual hospitals. Our goal is to characterize current antimicrobial practices and to better understand the efficacy and success of these programs. Please take ~10 minutes to complete this national survey, the largest of its kind to date. Note: this survey is best completed by ONE ID pharmacist, pharmacy director, or ID physician per institution. The responding institutions will be de-identified and results from this survey will be returned to each participant for use in the continual development or initiation of a stewardship program.

Section 1: Demographics

1. How would you best describe your position at your facility?
ID pharmacist
Pharmacy Director
ID Physician
Other (please specify)

2. How would you classify your healthcare system?
University teaching hospital.
University-affiliated teaching hospital.
Non-university teaching hospital.
Not a teaching hospital.
Rural or critical access
Acute/Rehab

3. What is the number of licensed beds in your facility?
Fewer than 100
Between 101 and 300
Between 301 and 500
More than 500

4. What is the average annual number of admissions for your healthcare facility?
Less than 1,000
Between 1,001 and 2,500
Between 2,501 and 5,000
Between 5,001 and 10,000
More than 10,000

5. What state is your institution located in?

State: _____

6. If you know the average monthly case mix index for your healthcare system, please enter it here.

_____   I do not know

7. Does your facility produce a cumulative susceptibility guide (i.e. antibiogram)?

Yes

No

I don't know

8. If the answer to question 7 is yes, how frequently is your cumulative susceptibility guide (antibiogram) produced?

Every six months

Yearly

Less than yearly

Other (please specify)

9. If the answer to question 7 is yes, what is the publication date of your current cumulative susceptibility guide (antibiogram)?

_____

10. Would you be willing to share specific antimicrobial purchase information in the future for additional analysis?

Yes

No

11. What is the total yearly antimicrobial expenditure (antibacterials and antifungals only) at your institution?

_____

12. What percent of the total inpatient pharmacy drug budget is represented by antimicrobials (antibacterials and antifungals only)?

Less than 10%

Between 10% and 15%

Between 16% and 25%

Greater than 26%

I do not know

13. Does your institution have an Infectious Disease consult service?

Yes, full - time.

Yes, part - time.

No.

14. If your institution has an Infectious Disease consult service, are your consultants any of the following? ** *.

Private

Hospital - based

Combination of private and hospital based

Other (please specify)

15. Does your institution have a pharmacist dedicated to the management of antimicrobials?

Yes

No

I don't know

16. Does your institution have an antimicrobial stewardship program?

Yes

No

Section 2: Institutions with an Antimicrobial Stewardship Program

1. If you have an antimicrobial stewardship team at your facility, who comprises it? Check all that apply.

Infectious Disease Physician(s)

 Infectious Disease Pharmacist(s)

Clinical Microbiologist

Information system specialist

Infection control professional

Hospital Epidemiologist

We have no formal "team"

Other (please specify)

2. How long ago was the stewardship program put in place?

It is in development

It is just starting

Less than 1 year ago

1 - 3 years ago

Greater than 3 years ago

3. Is your program utilized for adults, pediatrics, or both?

Adults only

Pediatrics only

Both adults and pediatrics

4. Which of the following educational techniques are used to educate prescribers about appropriate prescription of antimicrobials? Check all that apply.

Newsletter

Email

Grand Rounds

Conferences

None

Other (please specify)

5. Does your institution have an ID fellowship program?

Yes

No

6. If the answer to question 4 is yes, what is the level of involvement of the ID fellow in the antimicrobial stewardship program?

The ID fellow approves restricted antimicrobials

The ID fellow approves restricted antimicrobials at certain times only, e.g. nights or weekends

The ID fellow does not approve restricted antimicrobials

Other (please specify)

7. Does your institution utilize any of the following restriction methods? Check all that apply.

A "front end" approach in which specific antimicrobials are only dispensed after approval is obtained.

A "back end" approach in which antimicrobials are prescribed but are subject to prospective audit.

Automatic stop orders

ID Consult required

Verbal approval required (telephone or face to face)

Other (please specify)

8. If a "front end" approach is used, who is responsible for providing the approval for restricted antibiotics? Check all that apply.

Physician on the Antimicrobial Stewardship team

ID Pharmacist

ID Fellow

Other (please specify)

9. Does your institution have a specific group that approves formulary restrictions?

No

I do not know.

Yes (please specify)

10. Which of the following antimicrobial stewardship techniques are utilized by your institution? Check all that apply.

Guidelines and Clinical Pathways

Antimicrobial cycling

Antimicrobial order forms

Streamlining or de - escalation of therapy

Dose optimization

Parenteral to oral conversion

Closed Formulary

None

Other (please specify)

11. Are you satisfied with the degree to which clinicians at your institution streamline or de - escalate therapy based on culture data?

Yes

No   Please explain:

12. Are any of the following medications or medication classes on formulary at your institution? Check all that apply.

Piperacillin - Tazobactam Ticarcillin- Clavulanate Ampicillin- Sulbactam Ertapenem Meropenem Imipenem Doripenem Moxifloxacin Levofloxacin Ciprofloxacin Gatifloxacin Cefepime Ceftazidime Ceftriaxone Cefotaxime Cefoxitin Cefazolin Tigecycline Vancomycin Polymyxin E (Colistin) Amphotericin B Products Daptomycin

Linezolid Fluconazole Voriconzaole Posaconazole Micafungin Caspofungin Anidulafungin Other (please specify)

13. Are there any restrictions on the following medications or medication classes? Check all that apply.

Check Restricted by time, Restricted by provider, ID consult required, Other restrictions for the following:

Piperacillin - Tazobactam Ticarcillin - Clavulanate Ampicillin - Sulbactam Ertapenem Meropenem Imipenem Doripenem Moxifloxacin Levofloxacin Ciprofloxacin Gatifloxacin Cefepime Ceftazidime Ceftriaxone Cefotaxime Cefoxitin Cefazolin Tigecycline Vancomycin Polymyxin E (Colistin) Amphotericin B Products Daptomycin Linezolid Fluconazole Voriconzaole Posaconazole Micafungin Caspofungin Anidulafungin

Please describe other restriction methods or agents that are not on this list

14. What is your perception of the extent to which physicians at your institution agree with the restrictions on antimicrobials?

The vast majority agree.

A small majority agree.

The physicians are neutral.

A small majority disagree.

The vast majority disagree.

I do not know.

15. How does your institution measure the effectiveness of the antimicrobial stewardship program? Check all that apply.

Antimicrobial expenditures

Antimicrobial resistance

Frequency of physicians' acceptance of the antimicrobial stewardship team's recommendations

We do not measure the effect of the antimicrobial stewardship program

Other (please specify)

16. What is your perception of the percent of the total number of requests for restricted antimicrobials that is denied?

Less than 10%

Between 10% and 25%

Between 26% and 50%

More than 50%

I do not know.

17. Does your institution use proprietary or self developed software to facilitate your antimicrobial stewardship program?

No

Self Developed

I don't know

Proprietary (please specify name of program).

18. Comments/concerns/challenges.

Section 3: Institutions without Antimicrobial Stewardship Program

1. Has your institution ever considered having an antimicrobial stewardship program? If your answer is "yes", jump to question 3. If your answer is "no", continue on to question 2. If your answer is "I don't know" jump to question 4.

Yes

No

I don't know

2. If your institution has not ever considered having an antimicrobial stewardship program, why not? Check all that apply. If this question applies to you, jump to question 4 after you complete this question.

Funding

Staffing constraints

Insufficient medical staff buy - in

Not high on the list of priorities

Too many other things on the table

Organized program has not been proposed

Other (please specify)

3. If your institution has considered having an antimicrobial stewardship program, why has it not been implemented? Check all that apply.

Funding

Staffing constraints

Insufficient medical staff buy - in

Not high on the list of priorities

Too many other things on the table

Organized program has not been proposed

Other (please specify)

4. If your institution implemented an antimicrobial stewardship program, would it be utilized for adults, pediatrics, or both?

Adults only

Pediatrics only

Both adults and pediatrics

5. Does a formal education program exist to educate prescribers about the appropriate prescription of antimicrobials?

Yes

No

I do not know

6. If the answer to question 4 is yes, which of the following educational techniques is utilized? Check all that apply.

Newsletter

Email

Grand Rounds

Conferences

Other (please specify)

7. Does your institution have an ID fellowship program?

Yes

No

8. Does your institution utilize any of the following restriction methods? Check all that apply.

A "front end" approach in which specific antimicrobials are only dispensed after approval is obtained.

A "back end" approach in which antimicrobials are prescribed but are subject to prospective audit.

Automatic stop orders

ID consult required

Verbal approval required (telephone or face to face)

None

Other (please specify)

9. If a "front end" approach is used, who is responsible for providing the approval for restricted antibiotics? Check all that apply.

ID Physician

ID Pharmacist

ID Fellow

Other (please specify)

10. Does your institution have a specific group that approves formulary restrictions?

No

I don't know.

Yes (please specify)

11. Please check any techniques that your institution uses with regards to antimicrobials.

Guidelines and Clinical Pathways

Antimicrobial cycling

Antimicrobial order forms

Streamlining or de - escalation of therapy

Dose optimization

Parenteral to oral conversion

Closed Formulary

None

Other (please specify)

12. Are you satisfied with the degree to which clinicians at your institution streamline or de - escalate therapy based on culture data?

Yes

No   Please explain:

13. Are any of the following medications or medications on formulary at your institution? Check all that apply.

Piperacillin - Tazobactam Ticarcillin - Clavulanate Ampicillin - Sulbactam Ertapenem Meropenem Imipenem Doripenem Moxifloxacin Levofloxacin Ciprofloxacin Gatifloxacin Cefepime Ceftazidime Ceftriaxone Cefotaxime Cefoxitin Cefazolin Tigecycline Vancomycin Polymyxin E (Colistin) Amphotericin B Products Daptomycin Linezolid Fluconazole Voriconzaole Posaconazole Micafungin Caspofungin Anidulafungin Other (please specify)

14. Are there any restrictions on the following medications or medication classes? Check all that apply.

Please check Restricted by time, Restricted by provider, ID consult required, Other restrictions for the following:

Piperacillin - Tazobactam Ticarcillin - Clavulanate Ampicillin - Sulbactam Ertapenem Meropenem Imipenem Doripenem Moxifloxacin Levofloxacin Ciprofloxacin Gatifloxacin Cefepime Ceftazidime Ceftriaxone Cefotaxime Cefoxitin Cefazolin Tigecycline Vancomycin Polymyxin E (Colistin) Amphotericin B Products Daptomycin Linezolid Fluconazole Voriconzaole Posaconazole Micafungin Caspofungin Anidulafungin

Please describe other restriction methods or agents that are not on this list

15. What is your perception of the extent to which physicians at your institution agree with the idea of restricting antimicrobials?

The vast majority agree.

A small majority agree.

The physicians are neutral.

A small majority disagree.

The vast majority disagree.

I do not know.

Section 4: Almost done!

1. Thank you for completing this survey! Please provide your contact information below. This information is optional but strongly encouraged, and will be used to clarify responses, obtain additional information, and return the blinded study results. Data will be shared with participants who provide contact information in order to help them with their practice. If you wish to receive the results of this survey and/or are willing to be contacted with any questions or clarifications to your responses, you MUST complete this section.

Name:

E- mail Address:

Phone Number:

Position/Title:

Associated Institution/Facility:

2. Would you be interested in joining a collaboration or listserv for future discussion of antimicrobial stewardship programs?

Yes

No

3. Are you receptive to filling out a similar follow- up questionnaire?

 Yes

No

4. Please enter any comments, concerns, or challenges that you wish to share in regards to antimicrobial stewardship initiatives. This may include any suggestions for questions to be included or excluded on a future survey. Please be sure to click the "done" button below when you are finished. You will then be redirected to a screen confirming that you have successfully completed the survey. Thank you once again!

Dear XXXXXX,

I am doing another (but larger and more in-depth) antimicrobial stewardship web-based survey for my thesis, and I was wondering if you can help me get the survey link distributed to acute care and critical access hospitals in your state. Of course, I would share the results during a future webex or meeting….Participants who provide an email address (which is optional) will receive a compilation of useful antimicrobial stewardship literature as well as the aggregated survey results.

Here is the text I have been using in the distribution emails:

The School of Community Health Sciences, Department of Epidemiology and Biostatistics, at the University of Nevada, Las Vegas, is conducting a survey to assess current antimicrobial stewardship practices at acute care and critical access hospitals in a sample of states that have been previously under-represented in the Antimicrobial Stewardship literature.

Please take 20 minutes to complete this survey, whether or not you feel that your hospital uses antimicrobial stewardship strategies (you might be surprised to find out that your hospital actually is!). This survey is best completed by ONE professional (e.g. ID pharmacist, pharmacy director, ID physician, medical director, or infection control professional) per hospital, even if the hospital is part of a multi-hospital healthcare system.

Responding facilities will be de-identified, and composite results from this survey, as well as other potentially useful Antimicrobial Stewardship literature, will be shared with each participant for use in the continual development or initiation of antimicrobial stewardship efforts. THANK YOU!!!

*Click on the link below to take the survey: **DUE DATE: FEBRUARY 14, 2014***
https://unlvhospitality.qualtrics.com//SE/?SID=SV_2aFXom8JDqw6swB

Let me know if you can help out, or have other suggestions… Thank you!

Gayle Allenback, MS
Infection Prevention Analyst
Valley Health System
gayle.allenback@uhsinc.com

Appendix D – Letter to APIC/SHEA members

As a fellow APIC/SHEA member, I am requesting your assistance with the completion of a web-based Antimicrobial Stewardship practices questionnaire that I have designed for the thesis requirement of my MPH degree, in order to assess current Antimicrobial Stewardship practices at acute care and critical access hospitals in western states that have been previously under-represented in the Antimicrobial Stewardship literature. Please take a quick 15 minutes to complete this survey, whether or not your hospital uses antimicrobial stewardship strategies. Many thanks!

Copy and paste the URL below to take the survey:

DUE DATE: MARCH 7, 2014

https://unlvhospitality.qualtrics.com//SE/?SID=SV_2aFXom8JDqw6swB

Gayle Allenback, MS

Infection Prevention Analyst – Valley Health System, Las Vegas, NV

MPH Graduate Student – University of Nevada, Las Vegas

gayle.allenback@uhsinc.com

allenbac@unlv.nevada.edu

Appendix E -- Characteristics of survey respondents

Characteristic	No. (%) of survey respondents
No. of respondents	105 (100%)
Discipline of respondents	
Infection Control Professional	60 (57.1%)
Pharmacy Director	14 (13.3%)
Infectious Diseases Physician	12 (11.4%)
Infectious Diseases Pharmacist	7 (6.7%)
Other Pharmacist	5 (4.8%)
Other Discipline	5 (4.8%)
Medical Director	2 (1.9%)
Member of multi-hospital healthcare system	
Yes	62 (59.0%)
No	43 (41.0%)
Hospital classification	
General acute care	62 (59.0%)
Rural/critical access	29 (27.6%)
Specialty (Cardiac, Rehab, etc.)	10 (9.5%)
Other	4 (3.8%)
Hospital profit status	
Not-for-profit	72 (68.6%)
Proprietary	32 (30.5%)
Hospital teaching status	
Non-teaching	55 (52.4%)
Major or minor physician/nurse teaching	50 (47.6%)
Number of licensed beds	Range 12 - 1000, Mean 203
Number of annual discharges	
Between 101 and 500	14 (13.3%)
Between 501 and 1000	6 (5.7%)
Between 1001 and 2000	4 (3.8%)
Between 2001 and 4000	12 (11.4%)
Between 6001 and 8000	6 (5.7%)
Between 8001 and 10,000	2 (1.9%)
Greater than 10,000	22 (21.0%)
I don't know	35 (33.3%)
Number of critical care beds	Range 0 -150, Mean 24
Types of critical care units*	

Characteristic	No. (%) of survey respondents
Mixed medical/surgical	71 (67.6%)
Cardiac care	32 (30.5%)
Medical	27 (25.7%)
Surgical	22 (21.0%)
Pediatric/neonatal	10 (9.5%)
Respiratory	9 (8.6%)
Trauma	9 (8.6%)
Burn	2 (1.9%)
Number of critical care units	Range 0 - 6, Mean 1.73
Knowledge of average monthly case mix index (CMI)	
Yes	12 (11.4%)
No	93 (88.6%)
Receive an antibiogram (ABG)	
Yes	87 (82.9%)
No	18 (17.1%)
Knowledge of annual antimicrobial expenditures	
Yes	14 (13.3%)
No	91 (86.7%)
Have Infectious Diseases physician service	
Yes	70 (66.7%)
No	35 (33.3%)
Have pharmacist assigned to manage antimicrobials	
Yes	63 (60.0%)
No	38 (36.2%)
Have a formal antimicrobial stewardship program (ASP)	
Yes	51 (48.6%)
No	52 (49.5%)
I don't know	2 (1.9%)

* Not mutually exclusive

Appendix F -- Results of univariate analyses of 71 factors vs. number of antimicrobial stewardship strategies used

Categorical variables (n=63)	Significance level
Region	0.139
Discipline of respondent	0.287
Multi-hospital system membership	0.001*
Hospital classification (4 categories)	0.005*
Acute care vs. Critical access	0.001*
Profit status	0.202
Teaching status	0.003*
Number of annual discharges	0.046*
Presence of Mixed Medical/Surgical CC unit	0.174
Presence of Medical CC unit	0.276
Presence of Surgical CC unit	0.041*
Presence of Cardiac CC unit	0.786
Presence of Respiratory CC unit	0.708
Presence of Burn CC unit	0.140
Presence of Trauma CC unit	0.007*
Presence of Pediatric/Neonatal CC unit	0.003*
Knowledge of case mix index (CMI)	0.916
^Receive antibiogram (ABG)	<0.001*
Frequency of ABG	0.146
^ABG provides unit-specific data	0.006*
^ABG cumulative for isolates <30	0.093*
^ABG provides patient-specific data	0.086*
^Lab provides minimum inhibitory concentrations (MICs)	0.034*
^Knowledge of annual antimicrobial expenditures	0.072*
Percent of pharmacy budget that are antimicrobials	0.362
Knowledge of percent of pharmacy budget	0.759
^ID physician service present	<0.001*
^Presence of pharmacist dedicated to antimicrobials	<0.001*
^Presence of ID fellowship program	0.059*
^Measurement of antimicrobial purchasing costs	0.009*
^Measurement of cost of antimicrobial dispensed	0.001*
^Measurement of # antimicrobial doses prescribed	0.083*
^Measurement of #antimicrobial doses dispensed	0.001*
^Measurement of defined daily dose	0.003*
^Measurement of days of antimicrobial therapy	0.002*

Categorical variables (n=63)	Significance level
^Presence of antimicrobial use measures	0.004*
Number of antimicrobial use measures	0.001*
^Measurement of antimicrobial resistance patterns	<0.001*
^Measurement of infection rates	0.002*
^Measurement of patient outcomes	0.041*
^Measurement of adverse reactions	0.026*
Number of antimicrobial outcome measures	0.003*
^Presence of antimicrobial outcome measures	0.004*
Most difficult microorganism to control	0.090*
^Support of hospital administration	<0.001*
^Support of medical staff leadership	<0.001*
^Support of prescribers	<0.001*
Number of three main supports	<0.001*
^Support of infection control dept.	0.020*
^Support of pharmacy dept.	0.002*
^Support of quality/performance improvement dept.	0.022*
Support of patient safety dept.	0.174
Support of nursing leadership	0.584
^Support of microbiology laboratory dept.	<0.001*
Support of information technology dept.	0.362
^Presence of support of other depts.	<0.001*
Use of electronic medical records (EMRs)	0.572
^Use of computerized physician order entry (CPOE)	0.039*
^Use of clinical decision support	<0.001*
^Use of computer-based surveillance	0.007*
^Computer-monitoring of antimicrobial prescriptions	<0.001*
Number of information technology supports	<0.001*
^Presence of a formal AS program	<0.001*

Continuous variables (n=8)	Significance level
Number of hospitals in system	0.866
Number of licensed beds	<0.001*
Number of critical care beds	0.002*
Number of CC units	0.003*
^Number of ABG attributes	0.003*
Annual antimicrobial expenditures	0.501
^Number of committee/department supports	0.001*
^Number of information technology supports	0.035*

* p<0.1 (n=53)

^ Significant factors considered to be "controllable" (n=37)

<u>Appendix G</u> – List of abbreviations

ABG	Antibiogram
AK	Alaska
ANOVA	Analysis of variance
APIC	Association for Professionals in Infection Control and Epidemiology
AS	Antimicrobial stewardship
ASP	Antimicrobial stewardship program
AZ	Arizona
CA	California
CAH	Critical access hospital
CC	Critical care
CDC	Centers for Disease Control and Prevention
CMI	Case mix index
CMS	Centers for Medicare and Medicaid Services
CO	Colorado
CPOE	Computerized physician order entry
CRE	Carbapenem-Resistant Enterobacteriaceae
DDD	Defined daily dose
EMR	Electronic medical record
GACH	General acute care hospital
HAI	Healthcare-associated infection
HI	Hawaii
ID	Idaho
ID	Infectious diseases
IDSA	Infectious Diseases Society of America
IV-to-PO	Intravenous to oral
KS	Kansas
MDRO	Multi-drug resistant organism
MIC	Minimum inhibitory concentration
MRSA	Methicillin-Resistant *Staphylococcus aureus*
MT	Montana
ND	North Dakota
NE	Nebraska
NM	New Mexico
NV	Nevada
OK	Oklahoma
OR	Oregon
PIDS	Pediatric Infectious Diseases Society
QIO	Quality Improvement Organization
SD	South Dakota
SHEA	Society for Healthcare Epidemiology of America
SPSS	Statistical Package for the Social Sciences
TJC	The Joint Commission
TX	Texas
UNLV	University of Nevada, Las Vegas
UT	Utah

VRE	Vancomycin-Resistant Enterococci
WA	Washington
WY	Wyoming

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