Implementation of an antimicrobial stewardship program in a rural hospital

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Purpose. The implementation of a pharmacy-directed antimicrobial stewardship (AMS) program involving the use of telemedicine technology is described.

Summary. Pursuant to a gap analysis of AMS services at a rural hospital where physician specialists in infectious diseases (ID) or pharmacists with advanced ID training were not available, a multidisciplinary team was formed to implement a stewardship program targeting six antimicrobials with a high potential for misuse. A key part of the program was the participation of a remotely located ID physician specialist in weekly case review teleconferences. An evaluation of the first 13 months of the initiative (May 2010–June 2011) indicated that pharmacist-initiated AMS interventions increased dramatically after program implementation, from a baseline average of 2.1 interventions per week to an average of 6.8 per week; the rate of antimicrobial streamlining increased from 44% to an average of 96%. Due to inconsistent documentation, an increase in the rate of physician–pharmacist agreement could not be demonstrated; however, anecdotal evidence suggested an increase in physician requests for case reviews by the AMS team and enhanced interdisciplinary collaboration. An analysis of 2010 purchasing data demonstrated a decrease in annual antibiotic costs of about 28% from 2009 levels (and a further decrease of about 51% in the first two quarters of 2011). The rate of nosocomial *Clostridium difficile* infection decreased from an average of 5.5 cases per 10,000 patient-days to an average of 1.6 cases per 10,000 patient-days.

Conclusion. Implementation of an AMS program at a rural hospital led to increases in pharmacist-recommended interventions and streamlining of antimicrobial therapy, as well as decreases in health care-associated *C. difficile* infections and antimicrobial purchasing costs.

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Antimicrobial stewardship (AMS) is increasingly recognized as an essential practice element for health care institutions to adopt and implement effectively. As morbidity and mortality and health care costs associated with antimicrobial resistance and misuse increase, AMS programs are becoming more prevalent.

Stevenson et al.[1] conducted a survey to assess pharmacist involvement in and the presence of antimicrobial surveillance in rural community hospitals in Idaho, Nevada, Utah, and eastern Washington in 2000. In that survey, only 5% of responding hospitals reported 24-hour onsite pharmacist availability. While many of the surveyed hospitals (71%) had policies in place related to antimicrobial use and monitoring, only 28% had systems in place for monitoring compliance with existing policies. Less than 30% of the surveyed hospitals had an established method of recommending antimicrobial therapy changes based on susceptibility test results, and less than 30% had the ability to monitor prescriber compliance with pharmacist-recommended doses.[1] Many survey respondents indicated that they did not have the key components of AMS programs outlined by various organizations.[2,3]

Guidelines recommended by organizations such as the Infectious Diseases Society of America (IDSA) and the Society for Healthcare Epidemiology of America (SHEA) have

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been published in an effort to help improve the use of antimicrobials in the hospital setting.[4,5] In 2010, the Centers for Disease Control and Prevention launched a campaign to improve antimicrobial use through the implementation of AMS programs; the campaign included the publication of a recommended 12-step approach to the prevention of antimicrobial resistance.[6] Although practice strategies and educational opportunities have been provided through the aforementioned organizations and others, creating an effective and sustainable AMS program is a difficult task for community hospitals, which often lack critical practice elements and resources. Community hospitals must consider the need to stay current with established guidelines while addressing staffing, personnel, and infrastructure challenges. In such an environment, the role of the pharmacist becomes even more critical.[6]

Background

Providence St. Mary Medical Center is a community hospital with 141 licensed beds and an accredited pharmacy practice residency; it serves rural communities in southeastern Washington and northeastern Oregon. Like the institutions surveyed by Stevenson et al.,[1] until relatively recently the institution was not routinely monitoring antimicrobial use, nor was the existing clinical surveillance system software able to effectively support such monitoring. Neither a physician nor a pharmacist with postgraduate specialized training in infectious diseases (ID) was available, nor was computerized prescriber order entry (CPOE) in place. The hospital's pharmacy does not have a designated clinical pharmacist position; rather, each pharmacist rotates through the position, providing clinical services, including AMS review, in the patient care unit. The only pharmacist with residency training and an extensive clinical background was added to the staff in June 2010 as the pharmacy residency director.

After a review of baseline data, a novel process for AMS was developed and piloted from May 2010 to June 2011. The basic strategy in developing the AMS program was to follow jointly recommended IDSA–SHEA guidelines while addressing major gaps in hospital resources.[2] Creative use of a remotely located physician specialist in ID, improvement of existing information technology, and education and training of pharmacists to provide daily antimicrobial reviews were the major strategies employed to provide a strong AMS program suitable for use in a rural setting. The purposes of this article are to describe the development and implementation of the ongoing program and to report the results of an evaluation of the program's impact on antimicrobial therapy interventions and costs.

Program development

Identification of the roles of each team member was the initial step in the development of the AMS program. Members within the hospital included the chief medical officer, the director of pharmacy, the pharmacy practice residency director, pharmacy practice residents, pharmacists, a clinical microbiologist, and staff members involved in quality-improvement and infection-control activities (Table 1).

An ID physician at a remote institution who could devote time to weekly teleconference "rounding" was identified. This physician was contracted to provide 30 minutes of paid time each week for the review of patient cases. This physician also served as a consultant to the AMS team on a daily basis when immediate or additional consultations were needed. Additionally, the ID physician provided consultations to in-house physicians when requested. In most cases, the attending physician was the prescribing physician. At times when the ID physician was unavailable, the pharmacist collaborated with the chief medical officer, pharmacy residency director, or both.

Program oversight, daily patient review, metric monitoring, report generation, and AMS education for the hospital staff were provided by the department of pharmacy. The reporting structure for the program included progress reports that were discussed at meetings of the pharmacy and therapeutics and infection-control committees. The results of those discussions were reviewed by the medical executive committee. A microbiology–pharmacy subgroup was also established and assigned specific goals and objectives; the subgroup reported to the larger stewardship team.

The next step in the development of the program was to define the characteristics of an AMS program that would meet the needs of the hospital and also be in keeping with the recommendations of professional organizations. The strategies that are employed to ensure appropriate antimicrobial use, as well as the terms used to describe such strategies, vary widely among U.S. institutions. Activities that hospitals are already engaged in can be considered to be elements of AMS.[7] We defined AMS as a system by which a multidisciplinary team follows evidence-based data and guidelines to develop a comprehensive action plan to influence and guide antimicrobial prescribing in an effort to optimize the use of antimicrobials.

Program implementation and evaluation

For the AMS program evaluation described in this article, it was decided that the primary endpoints to be measured would include (1) the number of interventions after the review of antimicrobial therapy by the clinical pharmacist, (2) the rate of empiric antimicrobial streamlin-

Table 1.
Antimicrobial Stewardship (AMS) Team Members, Roles, and Responsibilities

Member Type (No. Participants)	Role	Responsibilities
Infectious diseases physician (1)	Expert consultant	Participate remotely in weekly AMS rounds, provide information and suggestions, consult with onsite physicians via telephone when necessary, provide education to hospital staff
Chief medical officer (1)[a]	Physician champion	Represent AMS team at medical executive committee and medical staff meetings, provide program oversight, participate in AMS rounds, provide physician leadership and support
Pharmacy residency director (1)[b]	Program manager and educator	Provide program oversight, data monitoring and tracking, and pharmacist and hospital staff education; generate reports; participate in AMS rounds
Quality-improvement staff member (1)	Project oversight	Represent AMS team at hospital administrative meetings, occasionally participate in AMS rounds
Director of pharmacy (1)	Project leader	Represent AMS team at health-system level, occasionally participate in AMS rounds
Pharmacy practice resident (2)	Participant	Review AMS patient profiles daily during clinical rotations, work with residency director in program oversight, participate in AMS rounds
Pharmacist (4)	Participant	Review AMS patient profiles daily when assigned to clinical duties and when resident not on clinical rotation, participate in AMS rounds
Microbiologist (1)	Participant	Identify quality-improvement processes in the microbiology department that affect AMS, serve as consultant on individual patient cases, participate in AMS rounds
Infection-control staff member (1)	Participant	Identify quality-improvement processes in infection control that affect AMS, serve as consultant on individual patient cases, participate in AMS rounds

[a]Physician is a pulmonologist and intensivist, with previous non-board-certified infectious diseases training.
[b]Pharmacist is residency-trained, board-certified pharmacotherapy specialist with extensive clinical leadership background.

ing on the basis of culture results or elimination of redundant therapy, (3) the percentage agreement between pharmacist and ID physician recommendations, (4) cost savings associated with AMS activities, and (5) *Clostridium difficile* infection rates before and after program implementation. The main elements of practice implemented, as adopted from IDSA–SHEA guidelines, were prospective review, streamlining of therapy, dose optimization, incorporation of information technology, and education.[2]

Antimicrobials determined to have the highest potential for misuse or overuse, as well as those with specific indications requiring judicious use, were identified for pharmacy review. The medications identified were piperacillin–tazobactam, imipenem–cilastatin, ertapenem, vancomycin, linezolid, and daptomycin. The measurement of AMS endpoints in our study included only interventions related to those six antimicrobials. Total AMS-related cost savings were measured for each of the antimicrobials and expressed as a percentage change per 1000 patient-days.

Since the pharmacy is not staffed 24 hours a day, antimicrobial orders received overnight were reviewed immediately the following day. After reviewing the patient profile, the pharmacist serving in the clinical role (or, in some cases, a pharmacy resident on clinical rotation) communicated recommendations on antimicrobial therapy to the prescriber directly and through written communication forms. Patient rounds with the chief medical officer occurred each Wednesday, with discussion and preparation of patient cases for review with the ID physician conducted on Thursday mornings. Case synopses regarding all patients who were receiving or had received any of the six targeted antimicrobials were then sent electronically to the ID physician. Initially, all patient cases involving any of the six targeted antimicrobials were reviewed with the ID physician; however, approxi-

mately six months after program initiation, when the volume of cases increased significantly, only cases remaining unresolved at the end of the Wednesday rounding–review session were presented at Thursday rounds (i.e., any cases that were previously addressed during the week, either independently by the pharmacist or after communication with the ID physician, were not presented).

Antimicrobial prescribing restrictions did not exist at the hospital before AMS program initiation and were not implemented during the initial phase of the 13-month evaluation project. Proposed changes to existing formulary restrictions and potential prescribing restrictions based on prescribing patterns and medication-use evaluations (MUEs) were reviewed. MUEs focused on antimicrobials for which pharmacy data showed a trend of increased usage, those that were added to the formulary, and high-use agents such as fluoroquinolones. Nonformulary use of antimicrobials was addressed through a different, existing process.

Streamlining of therapy. Empiric antimicrobial therapy streamlining mainly involved recommending the drug with the narrowest spectrum of activity that was appropriate for a particular case, promoting avoidance of unnecessary combination therapy, and emphasizing the importance of antimicrobial use for the appropriate duration. When the AMS team identified cases requiring intervention, the pharmacist communicated proposed changes in therapy to the prescriber. The rate of streamlining interventions could not be measured until January 2011 due to limitations of the existing clinical surveillance system. In order to capture the percentage of cases involving streamlining interventions before that time, a random sample of 40 patient cases involving use of the six targeted antimicrobials during the period January–April 2010 were reviewed in detail.

Dose optimization. Patients receiving medications whose use required dosage adjustments based on renal or hepatic monitoring, including the six targeted antimicrobials, were identified through the pharmacy clinical surveillance software. If a change in dosage was recommended as part of an AMS review, the recommendation was identified as an AMS intervention. Care was taken to ensure that dosage adjustments that were not made pursuant to AMS activities were not counted as resulting from stewardship efforts in order to differentiate usual pharmacy dosing service consultations and those conducted under the new stewardship program. Although any dosing services involving antimicrobials are properly considered to be part of AMS, it was important during the initial phase of the program to identify instances in which dosage changes were made solely on the basis of an AMS review.

Use of information technology. Health care information technology in the form of electronic medical records and CPOE has been shown to improve patient safety and reduce medication error rates and redundancy.[2] AMS programs should ideally have information technology systems in place that allow the team to monitor compliance with policies and agreement with program recommendations.[2] CPOE was not available at the time of the study, and the existing commercial clinical surveillance software used by the pharmacy to quantify clinical interventions initially did not allow the accurate tracking of all primary endpoints. Modification and customization of the surveillance system occurred in December 2010 to facilitate the monitoring of metrics and acceptance of AMS recommendations.

Education efforts. In addition to the use of an offsite ID physician, the provision of educational development in ID therapy for the pharmacists was vital. In order to help ensure that the stewardship team was making accurate recommendations, rigorous education efforts targeting all pharmacists involved in daily AMS review were launched. A longitudinal education plan that focused on the pharmacists but also included other hospital staff was developed. Continuing medical education sessions regarding AMS were conducted for the hospital physician staff by the pharmacy project manager and pharmacy residents, and ID-focused hospital newsletters addressing hot topics and areas for practice improvements were published. Stewardship team members also participated in AMS certificate programs offered by the nonprofit organization Making a Difference in Infectious Diseases Pharmacotherapy[3] and attended the 2011 IDSA annual meeting.

The rate of agreement between the pharmacists' recommendations and the ID physician's clinical opinion (one of the primary study endpoints) also served as a measure of whether the pharmacists were able to correctly evaluate and recommend antimicrobial therapy plans independently.

Results of outcome evaluation

Pharmacist reviews of antimicrobial therapy increased significantly over the first 13 months of the program, with a total of 311 patient cases reviewed; during that period, the number of AMS interventions per 1000 patient-days gradually increased from the baseline rate of 2.1 per week to a rate of more than 25 per week in mid-2011 (Figure 1). AMS interventions were categorized as follows: antimicrobial change, antimicrobial discontinuation, drug or laboratory level ordered, therapeutic duplication avoided, dosage change, and streamlining of therapy.

Streamlining of antimicrobial therapy was the most emphasized and common intervention, followed by antimicrobial discontinuation and antimicrobial change. The review of baseline data collected from January

2010 through April 2010 (i.e., before the initiation of AMS efforts) showed a streamlining rate of 44%. A random audit of 40 patient cases during the first eight months of the AMS program (May–December 2010) showed a sharp rise in streamlining interventions that was maintained through mid-2011 (Figure 2).

The percentage concordance of pharmacist recommendations and ID physician recommendations could not be quantified for recommendations made before December 2010. Random case reviews were conducted before that time, but there was no definitive method of precisely determining the rate of pharmacist–physician agreement. Except for the month of February 2011, during which the agreement rate was 86%, in 100% of the cases throughout the study period the ID physician's antimicrobial therapy actions were consistent with the pharmacist's recommendations.

For antimicrobial cost control, the initial goal of the program was to maintain antimicrobial costs per 1,000 patient-days at the same level as costs in 2009. Antibiotic purchase costs decreased from $13,521 to $9,756.56 per 1,000 patient-days in 2010 and to $6,583.52 per 1,000 patient-days in the first two quarters of 2011 (Figure 3).

Reduction of hospital-acquired *C. difficile* infection was another goal and measurement of the program. Before the initiation of AMS services, there was a trend of increased *C. difficile* infection rates at the hospital,

Figure 1. Antimicrobial therapy interventions resulting from stewardship program.

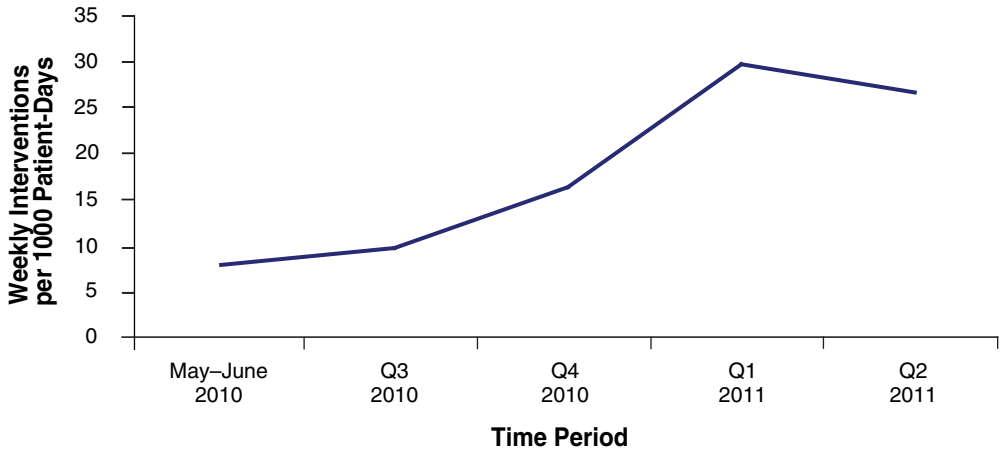
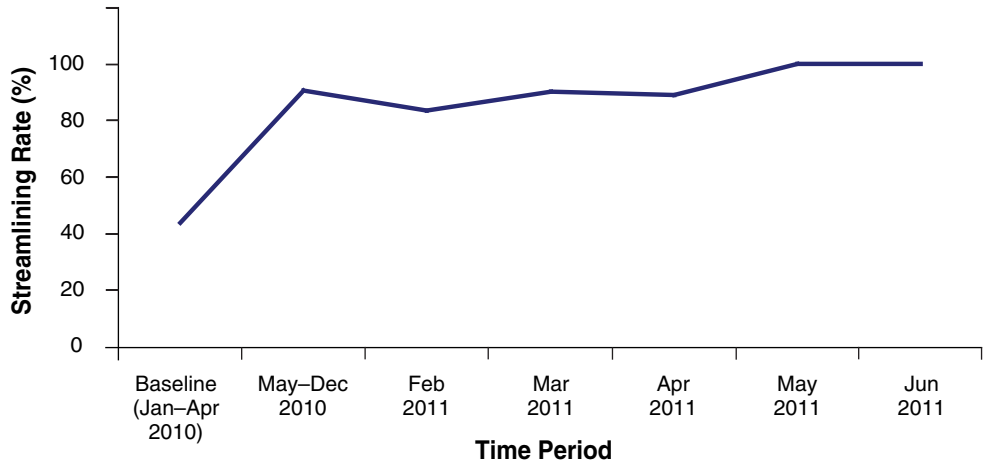


Figure 2. Rate of antimicrobial streamlining before and after implementation of stewardship program.



with the rate rising from 4 cases per 10,000 patient-days in 2008 to 8.2 cases per 10,000 patient-days by the end of 2010. This rate began to drop in the first quarter of 2011 and continued to decline to an annual rate of 3.1 per 10,000 patient-days by the end of the study period (Figure 4).

Discussion

The lack of critical AMS practice elements at our institution was addressed through the provision of ID education, collaboration with an ID physician via telemedicine, and improvement of the existing clinical surveillance system. Of the metrics that were examined, the most dramatic changes were seen in the number of AMS cases reviewed that resulted in pharmacist intervention, antimicrobial streamlining rates, and pharmacy antimicrobial costs for the six targeted medications. Additional improvements were seen in infection control, with a decrease in the number of hospital-acquired *C. difficile* infections. Due to the increasing rate of *C. difficile* infections before implementation of the AMS program, the infection-control committee performed a review of practices and root-cause analyses of *C. difficile* cases that led to changes in the cleaning of supplies and devices used in multiple-patient rooms.

The percentage agreement of pharmacist and ID physician recommendations was chosen as a metric to help monitor improvements in pharmacist ability to make optimal recommendations regarding antimicrobial therapy; monitoring of this metric was impractical because of the difficulty in defining the metric, as the process of clinical decision-making is both objective and subjective. MUEs that were a result of the AMS program included the review of cefepime and levofloxacin. Levofloxacin use was too frequent for the AMS team to follow daily but will be reviewed annually. Additionally, an ID rotation within the pharmacy

Figure 3. Annualized antimicrobial costs per 1000 patient-days.

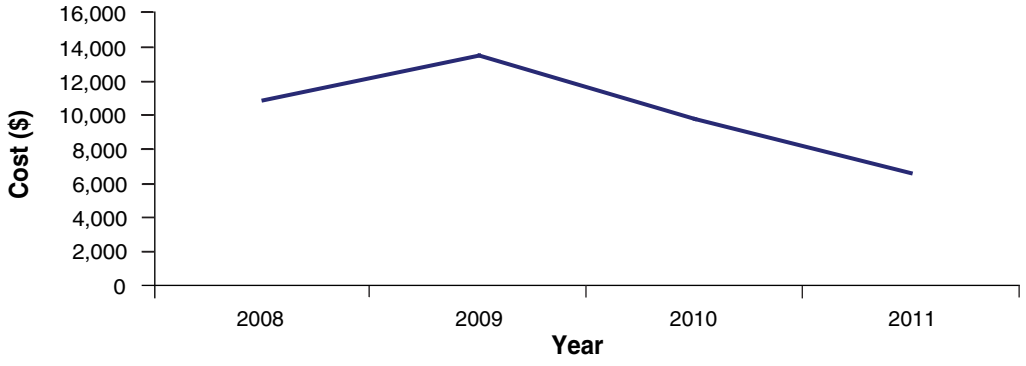
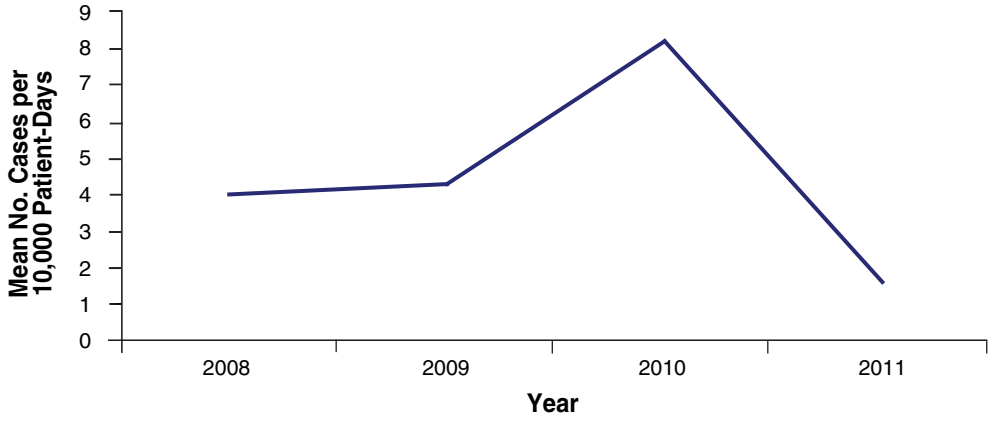


Figure 4. Cases of hospital-acquired *Clostridium difficile* infection before and after implementation of stewardship program in May 2010.



residency program began in October 2011, and all patients receiving fluoroquinolones are now more closely evaluated and followed by the pharmacy resident.

In implementing the stewardship program, the AMS team aspired to effect positive changes in antimicrobial prescribing behavior, pharmacists' knowledge of stewardship principles, and physicians' confidence in pharmacists' AMS recommendations. The significance and impact of behavioral change strategies in influencing antimicrobial prescribing were recently highlighted by Charani et al.[10] Although an attempt to quantify such changes was unsuccessful, anecdotal evidence (i.e., informal observations during the study period) suggested that the AMS program was effective in producing the desired changes.

First, it was observed that physicians began to make specific requests for AMS team review of patient cases involving antimicrobial use. Over time, physicians also appeared to recognize that the AMS team was a bridge to ID specialist access, as evidenced by physician requests to either personally attend AMS rounds to discuss specific patient cases or relay case information to the ID physician for review. As the program progressed, such requests for AMS review became more proactive (i.e., physicians often discussed patient cases with the pharmacist before prescribing or modifying antimicrobial therapy).

Second, it was observed that the number of cases in which antimicrobial streamlining recommendations were accepted before Thursday rounds with the ID physician increased over time, suggesting increased prescriber confidence in the pharmacists' ability to make appropriate AMS recommendations and function independently.

In addition to those AMS program benefits, the collaboration with the microbiology department opened doors to enhanced interdisciplinary communication and understanding. The microbiologist became an indispensable part of stewardship rounds, providing valuable information pertaining to patient cultures. The pharmacy project manager and the ID physician collaborated with the clinical microbiologist in the review of clinical and laboratory standards in order to select the most appropriate bacterial identification cards for clinical diagnostics. An antibiotic reporting suppression model was also developed where only select antibiotics were displayed on culture and sensitivity reports to encourage the use of agents with narrower spectra of activity.

A major limitation of the AMS program evaluation was the inability to quantify and evaluate the progress of the program due to the lack of consistent pharmacist-reporting methods. Another limitation was the inability of the clinical surveillance reporting software to capture necessary data; once this problem was discovered, it was promptly addressed and documented as a major lesson learned.

Implementing an AMS program in a community hospital presents a number of challenges that can be addressed through innovative practice methods. As the program developed, close collaboration created an environment of positive reinforcement of wise antimicrobial choices, obviating more limiting measures such as prescribing restrictions.

In order to maintain a sustainable program, new metrics will need to be examined. Looking forward, metrics to best measure actual doses received through the use of bedside medication verification will be researched. Specific clinical outcomes to be evaluated as the program matures include hospital length of stay, mortality, and adverse reactions involving antimicrobials. In addition to a change in metrics, the availability of clinical decision support for common infections will be developed as the institution moves forward with CPOE implementation (planned for 2013). Opportunities for collaboration with outpatient facilities and long-term treatment sites in the continuum of care will also be explored as we continue to evaluate and improve the program.

Conclusion

Implementation of an AMS program at a rural hospital led to increases in pharmacist-recommended interventions and streamlining of antimicrobial therapy, as well as decreases in health care-associated *C. difficile* infections and antimicrobial purchasing costs.

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