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Major Article

Dramatic effects of a new antimicrobial stewardship program in a rural community hospital

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Background: New Joint Commission antimicrobial stewardship requirements took effect on January 1, 2017, promoted as a central strategy for coping with the emerging problems of antimicrobial resistance and *Clostridium difficile* infection. Our objective was to measure the effects of a new antimicrobial stewardship program (ASP) in a rural community hospital with no prior ASP, in the context of having a new infectious disease specialist on staff.

Methods: An ASP team was formed to implement a prospective audit with health care provider feedback and targeting 12 antimicrobial agents in a rural hospital in Georgia. An educational grand rounds lecture series was provided before implementation of the ASP to all prescribers. After implementation, algorithms to aid the selection of empirical antibiotics for specific infectious disease syndromes based on local antibiograms were provided to prescribers to improve this selection. Rates of *C difficile* infections, total targeted antimicrobial costs, and drug utilization rates were calculated for 1 year pre-ASP implementation (2013) and 1 year post-ASP implementation (October 2014-December 2015).

Results: The patient safety metric of *C difficile* infections decreased from 3.35 cases per 1,000 occupied bed days (OBDs) in 2013 to 1.35 cases per 1,000 OBDs in 2015. Total targeted antimicrobial costs decreased 50% from $16.93 per patient day in 2013 to $8.44 per patient day in 2015. Overall antimicrobial use decreased 10% from before the ASP initiative to 1 year after it. Annualized savings were $280,000 in 1 year, based on drug savings only.

Conclusions: Judicious use of antimicrobials and resources can improve a patient safety metric and decrease costs dramatically in rural institutions where the average hospital census is <100 patients per day. The savings would allow the institutions to spend better while improving the use of antimicrobials.

New Joint Commission antimicrobial stewardship requirements took effect on January 1, 2017.[1] The requirements apply to community hospitals and critical access hospitals and stem from the anticipated final rule by the Centers for Medicare and Medicaid Services (CMS), which will require antimicrobial stewardship programs (ASPs) as a condition of CMS participation in 2017.[2] This government mandate is promoted as a central strategy for coping with the emerging problems of antimicrobial resistance and *Clostridium difficile* infection (CDI). The approach on how to implement an ASP depends on many factors, including need for an infectious disease (ID) consultant, an ID-trained pharmacist, or a person with a doctor of pharmacy degree, or a combination of these; institution size; composition of the providers; and resources provided by the institutional leadership. Little data exist from community hospitals with low daily patient census about the outcomes of ASPs. Our objective was to measure the effects of a new ASP in a rural community hospital with an average occupied bed census of <100.

METHODS

In 2013, our institution assumed operations of a rural health system in Georgia. Its average daily census typically was <100 patients. An ID physician, who joined the staff in the beginning of the second quarter of 2014, championed the implementation of a new ASP to reduce the occurrence of antibiotic resistance and unnecessary

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adverse effects, such as CDI. A work group was created that included infection prevention nurses, a microbiology supervisor, and 2 lead pharmacists (neither with specialty training in IDs). The ID physician led clinical topics of discussion at biweekly meetings and fostered the ASP implementation to various hospital committees, whose approval was required before implementation at the rural hospital, including its medical executive governing bodies.

The constituency and content of the ASP was adopted from the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines issued in 2007.[3] Revision of the guidelines was published in 2016.[4] The ASP focused on a core strategy of a postprescriptive audit with intervention and feedback. A targeted list of antimicrobial agents was developed from use and cost criteria plus local antibiograms from 2012 and 2013. In total, 12 antimicrobials were selected to be prospectively audited on indications for use. The agents were collectively referred to as targeted antimicrobial agents and were amikacin, aztreonam, cefepime, ceftaroline, daptomycin, doripenem, ertapenem, fosfomycin, imipenem, linezolid, meropenem, and tigecycline. No formulary restriction and preauthorization were used for the targeted antimicrobial agents. ASP intervention included a pre-ASP implementation education lecture series and the dissemination of clinical guidelines and algorithms on advised antibiotic use for specific ID syndromes. The intervention did not include strategies to limit antibiotic therapy to the shortest effective duration.

The 12 targeted antimicrobials were reviewed when the provider's indication for use of the given antimicrobial was not delineated in the prescription order or was deemed not appropriate after review by a clinical pharmacist and the ID physician. A provider was able to order an initial 72-hour course of antimicrobial therapy while awaiting microbiologic data to aid in pathogen-targeted antimicrobial selection and therapy de-escalation. At the time of computerized order entry, a message alerted the prescriber that the medication was targeted to be monitored and required an indication for use. Daily, the clinical pharmacist reviewed, with the ID specialist's supervision, the active list generated by the medical information system (Meditech version 5.65; Medical Information Technology, Westwood, MA) for appropriate empirical antibiotic selection. The clinical pharmacist contacted the ordering provider as soon as possible after the order was generated if the indication was deemed inappropriate after discussion with the ID physician.

Education was an integral component of the ASP. The ID specialist joined the hospital staff on April 1, 2014. Since an ASP did not exist at the hospital before October 1, 2014, a grand rounds series on antimicrobials was given by the ID specialist before the ASP initiation from July 1-September 31, 2014. The ID clinical guidelines and algorithms of empirical antimicrobial recommendations for specific ID syndromes were disseminated to all prescribers who attended the lectures. After ASP implementation, prescribers received direct, personalized communication about how they could improve antimicrobial prescribing after review of indications and health records of the patients by the pharmacist, under the supervision of the ID specialist. This intervention occurred immediately after the prescription was generated in the electronic health record, except during late evening hours. Those late orders would be reviewed at the beginning of the next day. The pharmacist discussed the recommendations with the ID specialist before communicating with the prescriber. If needed, the ID specialist was available for further discussion of the case. As microbiologic data were reported, or at a 72-hour point after starting empirical antimicrobial therapy (whichever occurred first), a second review to de-escalate the antimicrobial effect was done by the ID specialist. Antimicrobial dose optimization was the responsibility of the clinical pharmacists during each shift, which was an established clinical practice before ASP implementation.

The outcome of the interaction between pharmacist and ordering provider was documented in a software application (TheraDoc; Premier, Charlotte, NC). However, compliance with recommendations was not the end point in the ASP initiative, but rather the patient safety metric, utilization rates, and cost. De-escalation and streamlining of antimicrobial use was done by the ID provider (ie, not the pharmacist or doctor of pharmacy) after review of microbiologic data and the clinical record, as previously described. If an intervention was indicated, the ID physician spoke with the provider caring for that patient about the data, rendering guidance in antimicrobial selection and de-escalation.

No additional training was provided to the clinical pharmacist other than ongoing daily education during case discussion between the clinical pharmacist and the ID physician. The institution granted a 0.25 full-time equivalent position for the ID physician, who was a hospital employee. No additional clinical pharmacists were hired to participate in the program.

Data from January 1, 2013-September 30, 2014, on usage of these 12 targeted antimicrobial agents were used for comparison with the post-ASP initiation time of October 1, 2014-December 31, 2015. A technical unit of measurement was created to compare antibiotic consumption, called defined daily dose (DDD). The data of DDDs per 1,000 patient days (PDs) were analyzed. The DDD defined the assumed average maintenance daily dose for a day, used for its main indication in adults and assigned by the World Health Organization Collaborating Centre using established principles. Similarly, cost comparisons were conducted for the 12 agents before and after ASP implementation. Because of limited resources to calculate costs, cost data were compared quarterly, not monthly. The chosen quality safety metric was CDI reduction.

RESULTS

Nosocomial CDI rate declined from 3.35 cases per 1,000 occupied bed days (OBDs) at the end of the fourth quarter in 2013 to 1.35 cases per 1,000 OBDs at the end of the fourth quarter in 2015 (difference between rates, 2.0 cases per 1,000 OBDs; 95% confidence interval [CI], 0.62-3.39 cases; $P < .001$). Figure 1 shows the actual quarterly number of inpatient CDIs for 2 years. A 6-month rolling average of inpatient CDIs and a regression line show the trend

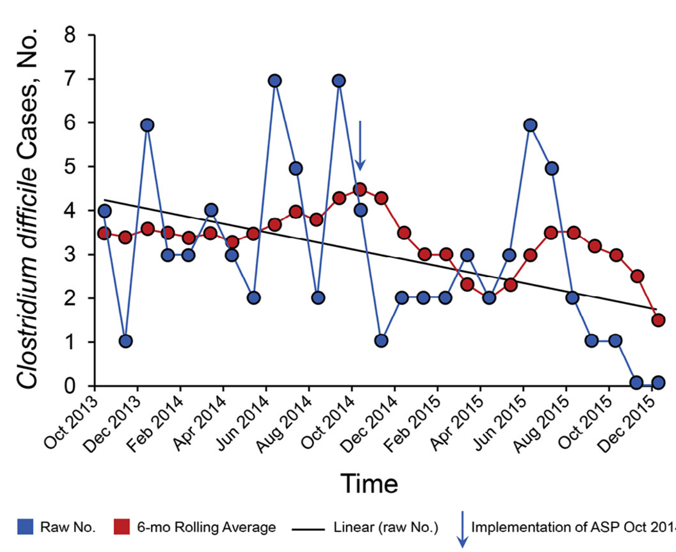

Fig 1. Inpatient *Clostridium difficile* infection rate for a 6-month rolling average and linear regression. *ASP*, antimicrobial stewardship program.

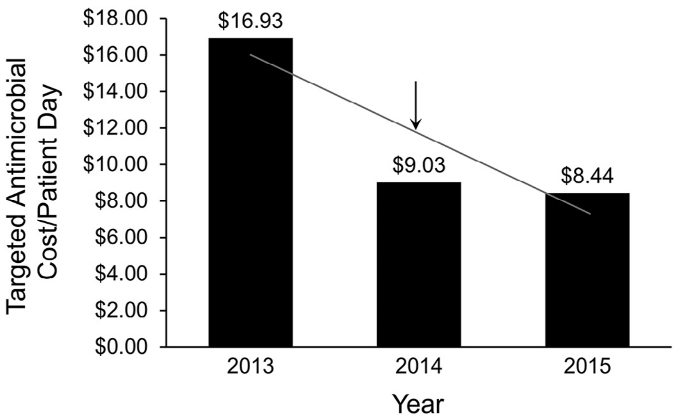

Fig 2. Fourth quarter targeted antimicrobial cost per patient day before (2013) vs after antimicrobial stewardship program implementation (2014-2015). The arrow indicates implementation of the program in October 2014.

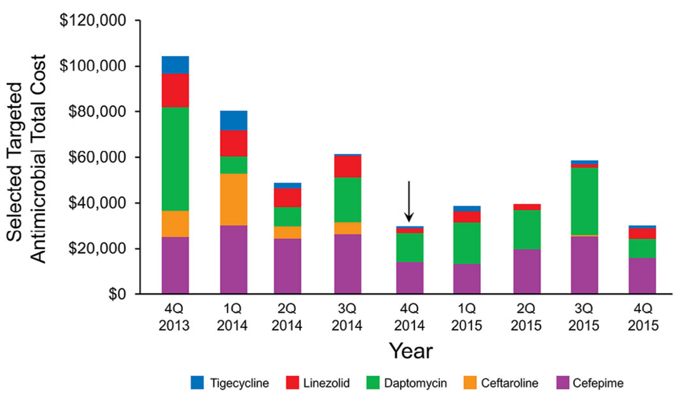

Fig 3. Selected targeted antimicrobial total cost in the 4Q of 2013 before antimicrobial stewardship program implementation and in 2014 and 2015 after its implementation. The arrow indicates implementation of the program in October 2014. *1Q*, first quarter; *2Q*, second quarter; *3Q*, third quarter; *4Q*, fourth quarter.

of improvement in CDI rates after ASP implementation on October 1, 2014.

Total targeted antimicrobial costs decreased 50%—from $16.93 per PD at the end of the fourth quarter in 2013 to $8.44 per PD at the end of the fourth quarter in 2015 (difference between rates, $8.49; 95% CI, $7.80-$9.18; $P < .001$) (Fig 2). Annual savings in drug costs alone was $280,000, primarily because of reducing the use of 5 of the 12 targeted antimicrobial agents (42%): cefepime, ceftaroline, daptomycin, linezolid, and tigecycline. Figure 3 shows the dramatic decline in cost for the fourth quarter of 2013, 2014, and 2015 for these 5 antimicrobials. A decrease in the second quarter in 2014 likely was from the effect of having an ID specialist in the hospital. The ASP initiative decreased the cost in the fourth quarter of 2014 and the fourth quarter of 2015, both being after ASP implementation.

Use of all antimicrobial agents (beyond the 12 targeted drugs) decreased 10% for the comparable period, from 126.7 DDDs per 1,000 PDs at the end of the fourth quarter of 2013 to 115.0 DDDs per 1,000 PDs at the end of the fourth quarter of 2015 (difference between rates, 11.7 DDDs per 1,000 PDs; 95% CI, 11.1-12.3; $P < .001$). Of note, the use of ceftaroline and tigecycline was virtually eliminated, whereas daptomycin use decreased 77% (difference between rates, 5.8 DDDs per 1,000 PDs; 95% CI, 4.9-6.6; $P < .001$) and linezolid use decreased 25% (difference between rates, 3.6 DDDs per 1,000 PDs; 95% CI, 2.5-4.7; $P < .001$).

DISCUSSION

The Joint Commission's antimicrobial stewardship requirements are mandatory since their implementation on January 1, 2017.[5] Regardless of hospital size, the mandate stems from the anticipated final rule by the CMS that will require ASPs as a condition of CMS participation in 2017. Although most persons in the United States reside in metropolitan areas, nearly 20% of the U.S. population resides in rural areas.[6] These rural settings have distinctive cultural, social, economic, and geographic characteristics that place their populations at greater risk for myriad diseases and health challenges.

Problems in implementing comprehensive change have been documented primarily in mandated educational and environmental programs in rural areas.[7,8] In many rural areas, the population is proud of its traditions, and government-mandated changes are perceived as threats to the ability to control the area's own destinies and decisions. Our quality initiative shows that a new ASP can result in dramatic reduction in CDI rates, drug utilization rates, and antimicrobial cost savings within 1 year despite these perceived challenges in a small rural hospital. The economic measure for stewardship is not standardized[9]; therefore, antimicrobial acquisition cost was used as a surrogate. Other areas of the cost of care—such as readmission rates, cost of CDI per case, and length of stay—need to be added to the health care finance metric in the future. An attempt to calculate these costs was beyond the resources available in our rural hospital.

A prospective audit with intervention and feedback methods was implemented with multiple educational forums used to respectfully influence the antimicrobial use and selection process by prescribers.[10] Development of a collegial environment for a health care provider's growth in ASP knowledge was important in achieving acceptance of the program. Use of all antimicrobial agents declined 10% for the comparable periods from 2013 (pre-ASP) to 2015 (post-ASP initiation). Overuse of expensive, newer agents with specific indications was targeted. Ceftaroline and tigecycline use was virtually eliminated, whereas daptomycin use decreased 77% and linezolid use decreased 25%. We were not surprised that overuse of newer antimicrobials existed; however, we demonstrated that with effective leadership, reduction in the use of these antimicrobial agents does occur voluntarily and in a rural setting. An understanding of physician prescribing behavior was important to the development of interventions.[11] No provider was denied use of an antimicrobial.

The main quality indicator to determine success of the ASP was the reduction in CDI prevalence from before the ASP to after the ASP initiation period. Figure 1 shows the significant decrease in CDIs after ASP initiation ($P < .001$). The total number of CDIs decreased from 43 pre-ASP to 27 post-ASP initiation. The dramatic decrease in CDIs reinforced for local providers the effect their prescribing practices had on patients. By being receptive to adjustments in their initial antimicrobial selections, providers received positive, fortifying encouragement to continue adjusting their selections, whether self-selected or advised by the ID physician. The real objective of improving the use of antimicrobials by indication and dose was to reduce the occurrence of antimicrobial resistance and unnecessary adverse effects, such as CDI.

Finally, and of importance for health care administrators, the overall antimicrobial use and cost decreased during the analysis period in 2015 compared with the baseline period in 2013. Total cost of the targeted antimicrobial agents decreased 50% ($P < .001$) (Fig 2). Projected annual savings were $280,000, primarily because of the decreased use of 5 of the 12 targeted antimicrobials (42%) (Fig 3). Savings did not include the cost reduction to the institution that resulted from the CDI rate reduction. Those saved costs could be better spent by the institution, such as supporting the full-time employee needed to lead the ASP by the ID specialist. Other metrics in health care finances may be needed to gain financial support to operate an ASP. Regulations require a program at this time, but not necessarily the financial support or funding from an institution's leadership.[12]

In summary, small rural hospitals with <100 OBDs can benefit greatly from a new ASP by decreasing CDI rates, decreasing overall antimicrobial use, and better spending of monies saved in antimicrobial costs to improve patient care.

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References

1. The White House. National action plan for combating antibiotic-resistant bacteria. 2015. Available from: https://www.whitehouse.gov/sites/default/files/docs/national_action_plan_for_combating_antibotic-resistant_bacteria.pdf. Accessed December 22, 2016.
2. Centers for Medicare & Medicaid Services. CMS issues proposed rule that prohibits discrimination, reduces hospital-acquired conditions, and promotes antibiotic stewardship in hospitals. 2016. Available from: https://www.cms.gov/Newsroom/MediaReleaseDatabase/Fact-sheets/2016-Fact-sheets-items/2016-06-13.html. Accessed December 22, 2016.
3. Dellit TH, Owens RC, McGowan JE Jr, Gerding DN, Weinstein RA, Burke JP, et al. Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. Clin Infect Dis 2007;44:159-77.
4. Barlam TF, Cosgrove SE, Abbo LM, MacDougall C, Schuetz AN, Septimus EJ, et al. Implementing an antibiotic stewardship program: guidelines by the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America. Clin Infect Dis 2016;62:e51-77.
5. Joint Commission joins White House effort to reduce antibiotic overuse. Jt Comm Perspect 2015;35:4-11.
6. US Census Bureau. 2010 census data. 2010. Available from: http://www.census.gov/2010census/data/. Accessed December 22, 2016.
7. Scott C. Northwest matters: transforming rural schools under the every student succeeds act: learning from the past. 2016. Available from: http://educationnorthwest.org/northwest-matters/transforming-rural-schools-under-every-student-succeeds-act-learning-past. Accessed December 22, 2016.
8. Stewart RB. Pyramids of sacrifice? Problems of federalism in mandating state implementation of national environmental policy. Yale Law J 1977;86:1196-272.
9. Nagel JL, Stevenson JG, Eiland EH 3rd, Kaye KS. Demonstrating the value of antimicrobial stewardship programs to hospital administrators. Clin Infect Dis 2014;59(Suppl):S146-53.
10. Kotwani A, Wattal C, Katewa S, Joshi PC, Holloway K. Factors influencing primary care physicians to prescribe antibiotics in Delhi India. Fam Pract 2010;27:684-90.
11. Fishman N. Antimicrobial stewardship. Am J Infect Control 2006;34(Suppl):S55-63.
12. Spellberg B, Bartlett JG, Gilbert DN. How to pitch an antibiotic stewardship program to the hospital c-suite. Open Forum Infect Dis 2016;3:ofw210.