Development of Antibiotic Stewardship Practices
Targeting Urinary Tract Infections in a Hospital With Consultant-Based Infectious Disease Services

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ABSTRACT

Purpose: Ensuring proper use of antimicrobials through the development and implementation of stewardship programs translates to improved patient outcomes. This article will describe the development of an antibiotic stewardship program at a facility with consultant-based infectious disease services.

Methods: Program development involved a multifaceted approach, including identification of a physician stewardship champion, design of a retrospective analysis, development of a physician scoring card, and creation and auditing of a real-time reporting system targeting prospective de-escalation opportunities. A seven-month retrospective chart analysis was performed on patients from two medical telemetry units with a diagnosis-related code for urinary tract infection to identify current prescribing practices of antimicrobials. The primary endpoint assessed the percentage of patients with missed opportunities for de-escalation. Secondary endpoints evaluated the impact on costs and hospital length of stay, comparing patients who were appropriately treated with those with missed de-escalation opportunities.

Results: Seventy-five patients were evaluated, 30 (40%) of whom were identified as having had missed opportunities for de-escalation. The cost of antibiotics for patients who were de-escalated averaged approximately $22.18 per day, compared with $70.26 per day \( (P = 0.04) \) for those with missed de-escalation opportunities. Patients receiving appropriate therapy had an average hospital length of stay of 6.42 days compared with 8.13 days for the missed-opportunity group \( (P = 0.052) \).

Conclusion: The development of stewardship services at a consultant-based hospital is possible through a systematic approach, ultimately resulting in the expansion of available personnel and promotion of collaborative efforts.

Keywords: antibiotic stewardship, urinary tract infections, consultant, de-escalation, program development

INTRODUCTION

The development, production, and utilization of antimicrobials mark one of the most important public health interventions of the past century, having significantly reduced infectious morbidity and mortality.\(^1,2\) Prompt initiation of antimicrobials has the capability to save many lives; however, it is estimated that 20% to 50% of all antibiotics prescribed and administered to patients in U.S. acute-care hospitals are utilized inappropriately.\(^1\) As misuse is coupled with the impressive ability of microorganisms to rapidly develop resistance, the incidence of adverse events, *Clostridium difficile* infection, and the development and spread of resistant organisms continues to rise.\(^1,3\)

In September 2014, the White House announced a National Strategy for Combating Antibiotic-Resistant Bacteria. One of the five interrelated goals included the improvement of antibiotic resistance prevention, surveillance, and control. Thus, the development of interventions that promote proper antibiotic use to reduce resistance and provide the best patient outcomes is imperative. Both the Centers for Disease Control and Prevention (CDC) and the Infectious Diseases Society of America (IDSA) have provided strategies and elements for the development of antimicrobial stewardship programs (ASPs)\(^1,4\). Such programs guide leadership and encourage accountability for antimicrobial utilization throughout a health care institution. The Department of Health and Human Services has also proposed rules aimed at improving appropriate antibiotic utilization that may ultimately tie into how hospitals are reimbursed or penalized in the future.\(^5\)

Ensuring the proper use of antimicrobials through the development and implementation of ASPs helps to ensure the best patient outcomes, improve patient safety, foster cost-effectiveness, and reduce the development and spread of resistant organisms.\(^2,6\) However, challenges remain in staffing, funding, and support for the implementation of ASPs.\(^7\) The development of hospital initiatives to combat resistance requires sustained and coordinated efforts by health care providers. Each institution has specific barriers to overcome in order to implement ASPs. For instance, not all institutions have infectious disease physicians who are hospital employees; some of these specialists perform services on a consulting basis, making it difficult to develop a uniform program and establish measures of accountability in regard to antimicrobial usage. In addition, not all physicians prescribing antimicrobials are trained in infectious disease, and the need to provide efficient tools to implement interventions may include disease-specific guidelines and education. On the other hand, pharmacists are most frequently employed by the hospital and may be in an optimal position to provide guidance and surveillance for the development of stewardship practices. This article will describe the development of an ASP at a consultant-based facility and the results obtained from a retrospective audit of current antimicrobial prescribing practices in urinary tract infections (UTIs) that served as an initial method for feedback and program guidance.

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**Figure 1 Development of Antibiotic Stewardship Practices in a Consultant-Based Institution**

- Collaboration between pharmacy and antibiotic stewardship physician champion
- Design of retrospective analysis
- Development of antibiotic stewardship scorecard
- Creation of rules for real-time reporting system
- Results presented to senior leadership
- Building accountability
- Initiation of collaborative prospective analysis
- Growth of staff to implement and expand stewardship practices

**PROGRAM DEVELOPMENT**

The steps involved in the development of this program were multifaceted (Figure 1). The initial stage required identification of an antibiotic stewardship champion. This individual was selected from among the infectious disease (ID) consultants who provide care for patients at the hospital. Candidates were selected by evaluating their years of service consulting at the facility, their rapport, and, most importantly, their willingness to work collaboratively in the development of a formalized structure for the improvement of stewardship practices.

Once the ID physicians were identified, a formal evaluation of baseline antibiotic practices targeting a specific set of patients was discussed and study methodology established. Identifying a quantifiable measure of current practices would serve as a way to encourage practice improvement among all providers in the institution, develop support from hospital executives, and measure improvements once practice measures had been put into place.

During the first months of program design, several meetings were held between pharmacy and the ID physicians to identify ways to build alignment in this practice area and create a measure of accountability. A scoring card was designed that listed each ID consultant and their current practices. We pulled diagnosis codes for UTIs for a four-month span and evaluated each physician’s use of antimicrobials based on patients’ average length of stay, percentage of patients who received antibiotics, mean utilization of antibiotics, average total cost associated with each case, percentage of patients in intensive care units, and length of stay in the intensive care units. This scorecard ultimately helped to evaluate a variety of components of averaged patient results from four months of data. This scorecard would serve as a way for each consultant to see how he or she measured up among peers and to identify areas of improvement with respect to treatment of UTIs. Scorecards were given to the ID stewardship champion in a blinded and unblinded fashion to share with fellow ID physicians as he deemed necessary; they were not released publicly. Following the completion of this study, a more formalized manner of disseminating future quarterly reports and comparing the results will be discussed by the stewardship working group.

Finally, the need to develop a method of prospective evaluation of antibiotic usage was established. Through a real-time reporting system, patients were aggregated to gather potential opportunities for de-escalation practices. The working group agreed to identify and start with one specific disease state to improve antimicrobial use across the hospital in an effort to avoid potential pushback while allowing for an effective way to identify patients through culture results. The real-time reporting system has the potential to be used by both pharmacists and selected physicians.

**METHODS**

**Study Design**

The study methodology for analysis of baseline antibiotic usage practices was determined and agreed upon by pharmacy and the antibiotic stewardship champion, after which it was submitted to and approved by the institutional review board. A total of 272 charts were captured using a data-mining software interface to identify patients with an ICD code relating to genitourinary infections. These patients had received antimicrobial therapy from January 2015 through July 2015 on two medical telemetry units at our academic tertiary care facility. A randomized retrospective study was performed to evaluate appropriateness of empiric antibiotic therapy administered to target UTIs. Two to three patients from each week across a seven-month span were analyzed for inclusion to account for possible changes in staffing and scheduling in regard to physicians, residents, and consultant ID doctors assigned to those units during a given time frame. In addition, rules in a real-time reporting system were created and underwent pilot testing to assess effectiveness and ability to capture patients with de-escalation opportunities for implementation in future active admissions.

**Inclusion and Exclusion Criteria**

Patients hospitalized with a diagnosis code of UTI or pyelonephritis between January 1, 2015, and September 1, 2015, underwent retrospective analysis, and patients with the same diagnosis code between November 15, 2015, and December 1, 2015, were assessed in the pilot test of the real-time reporting system. Patients younger than 18 years of age were excluded.

**Data Analysis**

Specific patient-related data and baseline characteristics collected included the following: age, gender, height, weight, disease state including concurrent infectious processes, metabolic panel, history of prior hospital admission in the...
most recent six months, and residence at a long-term-care or subacute facility. Data related to baseline treatment included analysis of microbiology results, time of urine collection in relation to antimicrobial initiation, and review of provider documentation to determine reasons for therapy decisions.

Electronic medical records assessed included those patients admitted to two prespecified patient care areas within the hospital in order to maintain a baseline level of consistency and patient care management. An algorithm was established through guideline and literature recommendations and ID physician approval to allow for assessment of appropriate initiation of empiric patient therapy. Due to a poorly established antibiogram, this empiric algorithm was based primarily on guideline information. A snapshot of this process can be seen in Table 1. This algorithm assessed patients’ baseline characteristics and stratified them based on risk factors for more complicated infections and need for certain empiric antimicrobial therapy. Patients’ culture results were then analyzed for de-escalation opportunities. The patients’ treatment was considered to be appropriate if they were maintained on a therapy given susceptibilities of a pathogen and if they were escalated or de-escalated to appropriate therapy given susceptibility results of the organism’s panel. Patients who grew multidrug-resistant organisms and who were maintained or escalated to a therapy susceptible for a given pathogen were also considered appropriate. Patients who grew pathogens with susceptibility to more narrow-spectrum therapy and were de-escalated within a 24-hour period of culture results were considered appropriately optimized.

The real-time reporting system underwent a two-week prospective analysis to determine if the rules created within it were capable of identifying patients actively on the unit with opportunities for de-escalation. These patients were assessed based on antimicrobial usage and urine panel results.

Endpoints

The primary endpoint was to assess the percentage of missed opportunities for de-escalation (opportunity group) during this

Table 1  Genitourinary Infections8–12 Assessment Tool Snapshot

<table>
<thead>
<tr>
<th>Category</th>
<th>Asymptomatic Bacteriuria</th>
<th>Uncomplicated Community-Acquired UTI</th>
<th>Complicated Community-Acquired UTI</th>
<th>Health Care-Associated UTI/Urosepsis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Absence of fever</td>
<td></td>
<td></td>
<td>Male</td>
<td>Severeely ill (SIRS)</td>
</tr>
<tr>
<td>• Absence of flank pain</td>
<td></td>
<td></td>
<td>• Pregnant female</td>
<td>Hospitalized in past six months or &gt; 48 hours</td>
</tr>
<tr>
<td>• No urological abnormalities</td>
<td></td>
<td></td>
<td>• Structural abnormality</td>
<td>From long-term-care facility</td>
</tr>
<tr>
<td>• Female</td>
<td></td>
<td></td>
<td>• History of renal transplant</td>
<td></td>
</tr>
<tr>
<td>• Positive urine cultures ≥ 100,000 CFU/mL with no signs or symptoms</td>
<td></td>
<td></td>
<td>• Positive urine cultures ≥ 100,000 CFU/mL</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Positive signs and symptoms (dysuria, urgency, suprapubic pain, etc.)</td>
<td>Positive signs and symptoms (dysuria, urgency, suprapubic pain, etc.)</td>
</tr>
<tr>
<td>Treatment*</td>
<td>No treatment recommended</td>
<td></td>
<td>Oral</td>
<td>Intravenous</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Nitrofurantoin 100 mg every 12 hours</td>
<td>• Cefepime 1–2 g every 12 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Cephalexin 500 mg four times a day</td>
<td>• Gentamicin 1 mg/kg every 8 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Levofloxacin 250 mg once a daya</td>
<td>• Cefazolin 1 g every 24 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• TMP-SMX DS every 12 hours</td>
<td>• Ceftriaxone 1 g every 24 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Fosfomycin 3 g one dose</td>
<td>• Gentamicin 1 mg/kg every 8 hours</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Intravenous</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Cefazolin 1 g every 8 hours</td>
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<td></td>
<td></td>
<td></td>
<td>• Ceftriaxone 1 g every 24 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Gentamicin 1 mg/kg every 8 hours</td>
<td></td>
</tr>
</tbody>
</table>
| CFU/mL = colony-forming units per milliliter; SIRS = systemic inflammatory response syndrome; TMP-SMX DS = trimethoprim/sulfamethoxazole; UTI = urinary tract infection.
* Doses should be adjusted as appropriate for patients with renal or hepatic abnormalities.
a Deemed appropriate empiric therapy during study analysis and prior to FDA warning of quinolone use; contraindicated in pregnancy
b Agent serves as option in pregnant women
c Reserved for patients with penicillin allergies
d Reserved for patients with suspected extended-spectrum beta-lactamase infection
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Table 2  Patient Baseline and Clinical Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Opportunity Group (n = 30)</th>
<th>Appropriate Group (n = 45)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age, years</td>
<td>71.4</td>
<td>78.2</td>
</tr>
<tr>
<td>Male gender, n (%)</td>
<td>9 (30)</td>
<td>20 (44.4)</td>
</tr>
<tr>
<td>Patients with concomitant infections, n (%)</td>
<td>18 (60)</td>
<td>25 (55.6)</td>
</tr>
<tr>
<td>Previous residence in long-term care, n (%)</td>
<td>15 (50)</td>
<td>23 (51.1)</td>
</tr>
<tr>
<td>Current indwelling catheter, n (%)</td>
<td>5 (16.7)</td>
<td>10 (22.2)</td>
</tr>
<tr>
<td>Recent hospitalization (≤ 6 months), n (%)</td>
<td>21 (70)</td>
<td>27 (60)</td>
</tr>
<tr>
<td>SIRS at time of antibiotic administration, n (%)</td>
<td>16 (53.3)</td>
<td>27 (60)</td>
</tr>
<tr>
<td>Hospitalized &gt; 48 hours prior to antibiotic initiation, n (%)</td>
<td>3 (10)</td>
<td>3 (6.7)</td>
</tr>
<tr>
<td>Previous conditions, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>7 (23.3)</td>
<td>19 (42.2)</td>
</tr>
<tr>
<td>Cancer</td>
<td>8 (26.7)</td>
<td>12 (26.7)</td>
</tr>
<tr>
<td>Human immunodeficiency virus</td>
<td>0 (0)</td>
<td>1 (2.2)</td>
</tr>
<tr>
<td>Transplant</td>
<td>1 (3.3)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Critical care during admission, n (%)</td>
<td>2 (6.7)</td>
<td>6 (13.3)</td>
</tr>
<tr>
<td>Urine cultures sent during admission, n (%)</td>
<td>24 (80)</td>
<td>43 (95.6)</td>
</tr>
<tr>
<td>Urine cultures sent prior to antibiotic initiation, n (%)</td>
<td>20 (66.7)</td>
<td>38 (77.8)</td>
</tr>
<tr>
<td>Infectious disease consultation, n (%)</td>
<td>19 (63.3)</td>
<td>24 (53.3)</td>
</tr>
</tbody>
</table>

SIRS = systemic inflammatory response syndrome

**results**

**retrospective analysis of UTIs**

This study evaluated 75 patients through the months of January 2015 to July 2015 on two specific patient care areas within the institution to capture baseline antibiotic use. Baseline patient characteristics can be found in Table 2. The proportion of patients started on appropriate initial therapy given patient-specific risk factors, systemic inflammatory response syndrome criteria, and assessment of provider documentation was approximately 53.3% (n = 40). Patients who were maintained on initial therapy appropriately or de-escalated appropriately accounted for 60% of patients assessed (n = 45; appropriate group). We analyzed how many patients had a potential opportunity for de-escalation as per our primary endpoint and determined that 30 patients had such an opportunity, accounting for 40% (opportunity group) of patients receiving suboptimal therapy. For secondary endpoints, patients who received appropriate or optimized therapy averaged approximately $822.18 in antibiotic cost expenditure per day, while those maintained on suboptimal therapy averaged approximately $70.26 in antibiotic cost expenditure per day ($P = 0.04$). The antimicrobial usage between groups can be seen in Figure 2. Patients on appropriate therapy had an average hospital length of stay of 6.42 days compared to the opportunity group at 8.13 days ($P = 0.052$). Cultures were sent for only 67 of the 75 patients analyzed, accounting for additional missed opportunities in optimization of patients' antimicrobial regimens. The pathogens that were isolated from urine cultures are presented in Figure 3.

**DISCUSSION**

Resources at each institution vary, and methods for building collaborative stewardship programs with infectious disease consultants may face difficulty and/or inconsistency. Our program was designed to align efforts through a shared vision in order to effectively promote the appropriate usage of antimicrobials. Instead of a larger focus with multiple disease states, it was decided that concentrating on the prescribing practices for one disease state would be most appropriate. The main goal was to provide meaningful, evidence-based, and pertinent data that could be evaluated effectively and communicated to the prescribing practitioners. This study was able to identify opportunities in antimicrobial utilization with respect to UTI treatment. The data obtained from this study were presented to infectious disease specialists, hospitalists, and medical residents through noon conferences as well as a medical grand rounds focused on antimicrobial stewardship activities.

Although it is imperative to recognize that the primary goals of stewardship are not driven by monetary outcomes, this study showed a nearly threefold increase in antimicrobial costs per day for patients who were maintained on suboptimal or inappropriate therapy. Patients in the opportunity group had
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Figure 2  Antimicrobial Usage Days of Therapy

- **ESBL** = extended-spectrum beta-lactamases
- **MRSA** = methicillin-resistant *S. aureus*
- **VRE** = vancomycin-resistant enterococci

Figure 3  Urinary Pathogens Isolated

- **ESBL** = extended-spectrum beta-lactamases
- **MRSA** = methicillin-resistant *S. aureus*
- **VRE** = vancomycin-resistant enterococci

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a much higher usage of daptomycin, which contributed to the higher costs, and this may seem like a limitation; however, these patients all had a singular diagnosis of urosepsis, with each having an organism susceptible to another more appropriate agent. An average hospital day at the facility costs $1,800, which can either add to health care costs if paid by insurance or result in a hospital loss if insurance is denied for the extended stay. As a result, the trend toward a shorter hospital length of stay in patients who received optimal antibiotics has vast implications for practice and emphasizes the need to foster collaborative efforts in establishing stewardship practices.

While the sample size for the analysis of current stewardship practices reflected only a small portion of antibiotic usage at the facility, these data were brought to the attention of hospital executives. These results facilitated the hospital-wide initiation and recognition of stronger stewardship practices. The data were also used as a platform to support the expansion of the pharmacy residency program for growth of collaborative multidisciplinary stewardship initiatives. The department received approval and financial support for expansion of the pharmacy residency program from two to four residents.

Partnership, specifically with an infectious disease consultant, allowed for development of new initiatives and provided a way in which data could be disseminated among colleagues within the profession. The scorecards and real-time reporting system will be used with further analysis on the overall impact of these interventions as the hospital continues to progress in improving antimicrobial utilization. Implementation of such initiatives is in line with recommendations of the 2016 stewardship guidelines of IDSA and the Society for Healthcare Epidemiology of America that specify the need to build on institution-specific parameters.4 Although the study had several limitations, including its retrospective data collection and small sample size, the data have promoted methods to initiate communication among stakeholders. As the program continues, we plan to optimize stewardship practices in other disease states with program evaluation. Our study did not focus primarily on reductions in antimicrobial resistance patterns, but this remains the primary objective for implementation of stewardship practices.

The CDC estimates that antibiotic-resistant bacteria cause nearly 23,000 deaths and two million illnesses annually in the United States.1,2 Control of antibiotic resistance is a major public health concern, with science ministers of the G8 industrialized nations (France, Germany, Italy, the United Kingdom, Japan, the United States, Canada, and Russia) in 2013 identifying it as one of the major health security challenges of the 21st century.3 The appropriate utilization of antibiotics does not impact only the patient currently receiving therapy—instead, antibiotic usage has implications for all future patients who present to the hospital.

CONCLUSION

The development of stewardship services at a consultant hospital is possible through a systematic approach of baseline analysis and promotion of joint efforts. The patient data collected provide a glimpse of current practices within the hospital and solidify the need for antibiotic stewardship initiatives. The implementation of a robust stewardship initiative is challenging, but through the use of a real-time reporting system, patients can be identified and opportunities to enhance proper antimicrobial utilization, through collaborative efforts, can be optimized.

REFERENCES