

A Prospective Study of Antibiotic Cost Containment in a University Teaching Hospital over a 13-Year Period

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ABSTRACT A multidisciplinary group, consisting of Infectious Disease (ID) physicians and pharmacists, was formed to develop a unique antibiotic monitoring program to track and control antibiotic costs. A clinical pharmacist and a medical Fellow from Infectious Diseases screened all patients receiving monitored antibiotics at Hackensack University Medical Center in New Jersey for their appropriate use. Antibiotic changes were recommended to the ordering physician for equally efficacious and less expensive therapy according to the center's estab-

lished criteria, a review of the patient's chart, and the patient's antibiotic sensitivities.

Over 13 years, from 1986 to 1998, the program successfully accomplished 5,334 antibiotic changes, with an overall estimated savings of \$2,194,173. In approximately 99% of cases, the ordering physician accepted the program's recommendations for changes. This program appears to be effective in promoting cost savings, at an average of \$168,782 per year and at \$411 per antibiotic change.

INTRODUCTION

Over the past decade, health care costs have increased at an alarming rate. Antimicrobials have become one of the most widely used categories of prescription drugs and probably account for 35% of a hospital's total pharmacy budget.¹⁻³ However, approximately 50% of antibiotics are incorrectly prescribed, and this remains an issue for many hospitals.^{4,5}

Hospital pharmacies are faced with the difficult task of maintaining quality medical care while attempting to reduce budget costs. One aspect of the hospital pharmacy budget that merits evaluation for possible cost savings relates to the use of antibiotics. Fifty percent of all patients admitted to a hospital receive an antibiotic during the course of their hospital stay.^{6,7} Several published studies have addressed the potential of antibiotic monitoring to reduce overall costs while maintaining efficacy.^{3,8-10} Restrictions on hospital formularies have been instituted, and substitutions have been made with less expensive, yet equally effective, antibiotics. The application of pharmacoeconomics to appropriate antimicrobial use has previously been shown to bring about savings.¹³

Hackensack University Medical Center, a 624-bed university teaching hospital in New Jersey, has developed a unique and successful antibiotic monitoring program.¹⁰ The program was established to control antibiotic costs without sacrificing quality of care. A clinical pharmacist and a medical Infectious Diseases Fellow coordinate to monitor the appropriateness of selected antibiotic therapy and to curb antibiotic expenditures.

METHODS

The antibiotic monitoring program, which became effective in January 1986, is based upon continuous, prospective antibiotic tracking, data collection, and cost-savings analysis. All or-

ders for antibiotics are written on a preprinted order sheet.

From 1986 to 1991, the clinical pharmacist manually screened all of the previous 24-hour antibiotic order sheets, targeting specific antibiotics (Table 1). The screening process utilized computer-generated daily reports of monitored antibiotics ordered (see Table 1). Surveillance was based on (1) cost; (2) patient safety, sensitivity, and resistance patterns; (3) clinical indications; (4) duration of therapy; and (5) dosage. On the basis of patient-specific parameters such as diagnosis, culture, sensitivity data (if available), and drug allergy information, previously approved criteria were used to highlight presumed inappropriate use of antibiotics for further evaluation. The criteria for appropriate antibiotic use were developed by the antibiotic utilization subcommittee and approved by the medical center's medical board (Table 2).

The clinical pharmacist met daily with the Fellow to discuss any inappropriately prescribed antibiotic or antibiotic combinations. The Fellow immediately reviewed the patient's chart to finalize the screening process.

After a thorough review, a decision was made to either continue the treatment or to substitute an equally efficacious and less costly antibiotic or a combination of antibiotics. Recommendations for antibiotic changes were discussed with the ordering physician to evaluate and determine the optimal clinical course to be followed. Potential changes included narrowing unnecessary broad-spectrum coverage, eliminating redundancy in coverage, switching from intravenous to oral step-down therapy, and optimizing dosing regimens.

Changes were documented, and the clinical pharmacist calculated the monthly savings from the antibiotic changes. Cost savings were determined by calculating the daily cost for the difference between the antibiotic originally prescribed and the newly recommended one, multiplied by the estimated duration of additional therapy for a specific indication. The duration of treatment was based on published guidelines, expert opinions, and local consensus for each infectious disease monitored.

The clinical pharmacist collected monthly data to determine the total savings, the number of changed antibiotics, the num-

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ber of doses before the antibiotic change, and the monthly cumulative savings. After all information was collected, the data were presented each month to the antibiotic utilization subcommittee and each quarter to the hospital's performance improvement committee.

RESULTS

From 1986 to 1998, 173,066 antibiotic orders were reviewed at Hackensack University Medical Center. Of the 5,370 recommended changes, 5,334 (99%) were accepted by the attending physician. This consisted of approximately 34 antibiotic changes per month and 410 changes per year. Figure 1 shows the number of changes per year made from 1986 to 1998.

Over the initial years, as the number of antibiotics monitored increased, the number of interventions increased correspondingly, until the 1990s (Figures 1 and 2). Continuous educational efforts resulted in a decrease in inappropriate antibiotic use and a subsequent reduction in the number of interventions needed. Dollars saved per year are shown in Figure 2. The pattern of savings is similar to the pattern of interventions.

Vancomycin was the most commonly replaced antibiotic, with 1,291 changes (24%) at a cost savings of \$438,018. Savings were realized with other drug changes such as ciprofloxacin, \$358,096, with 870 changes (16%); ceftazidime, \$149,555, with 337 changes (6%); ticarcillin/clavulanate, \$88,420, with 236 changes (4%); and cefoxitin, \$41,485 with 103 changes (2%). In addition to these modifications and savings, all other antibiotics listed in Table 1 accounted for 2,497 changes, for a savings of \$1,118,599 (Figure 3).

The estimated total savings over the 13 years was \$2,194,173, with 5,334 total successful antibiotic changes, at an average of \$168,782 per year, and \$411 per antibiotic change (see Table 1).

DISCUSSION

When the antibiotic monitoring program was initiated, not all of the antibiotics listed in Table 1 were under surveillance. As new antibiotics came onto the formulary, criteria were estab-

lished and efforts were undertaken to educate the physician staff. A downward trend, from 1990 to 1995, was subsequently noted in inappropriate antibiotic use and in the number of interventions needed (see Figures 1 and 2). This trend continued until 1995, when the medical center became an integrated university-based teaching center, resulting in monthly rotation of house staff between the medical center and other affiliated institutions. Before this time, the medical center had its own residency program and its residents were familiar with the antibiotic monitoring program.

Several factors may explain the downward trend in cost savings in the late 1990s. These include

- the reduced number of interventions made
- the decrease in acquisition costs for several compounds during this time because of the generic availability and the reduced cost of some trade name products such as vancomycin
- bundled pharmaceutical purchase agreements

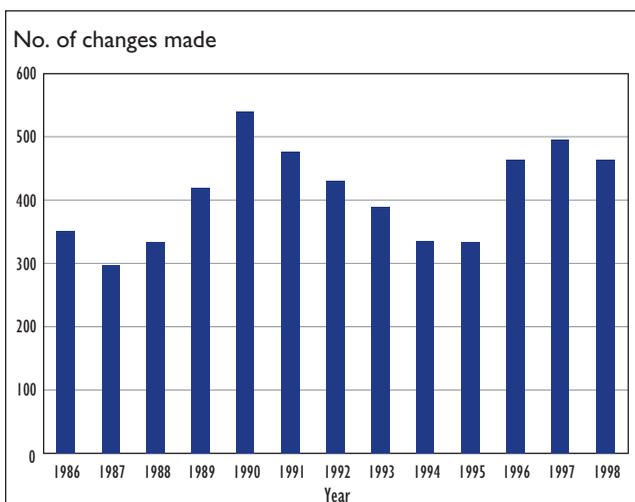


Figure 1 Antibiotic interventions from 1986 to 1996.

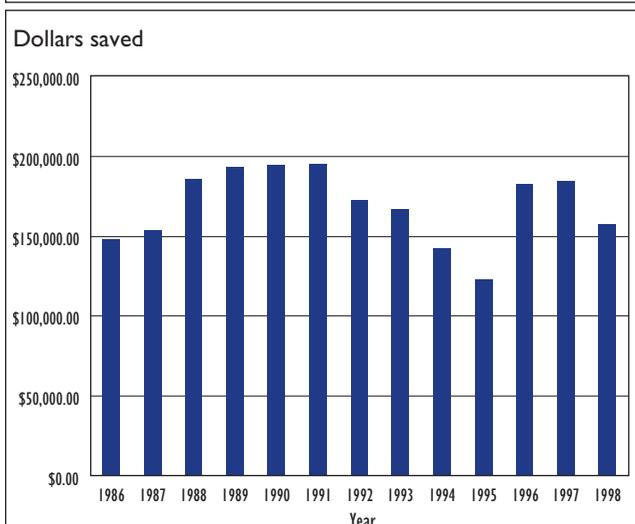


Figure 2 Antibiotic cost savings from 1986 to 1998.

Table 1 Antibiotics Under Surveillance

Agent	Time Period
Amikacin	1986–1998
Amphotericin B – lipid complex	1996–1998
Ampicillin/sulbactam	1992–1998
Aztreonam	1988–1998
Cefoxitin	1986–1998
Ceftazidime	1986–1998
Ceftriaxone	1986–1998
Ciprofloxacin	1990–1998
Clindamycin	1986–1998
Imipenem	1987–1998
Fluconazole	1990–1998
Meropenem	1996–1998
Mezlocillin	1988–1998
Ticarcillin/clavulanate	1993–1998
Tobramycin	1986–1998
Vancomycin	1986–1998

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Table 2 Criteria for Antibiotic Use

Amikacin

1. Gentamicin-resistant and tobramycin-resistant organisms
2. *Mycobacterium avium-intracellulare* (MAI)

Amphotericin Lipid Complex

1. Suspected or proven fungal infections in patients who are refractory to or intolerant of conventional amphotericin

Aztreonam

1. When the need for aerobic gram-negative coverage in a penicillin-allergic patient arises
2. As an alternate to aminoglycoside therapy when the use of aztreonam would obviate the risk of nephrotoxicity and ototoxicity:
 - age > 70 years
 - concomitant use of other medications that may potentiate the incidence of nephrotoxicity and ototoxicity
3. Multiresistant gram-negative organisms

Cefoxitin

1. Intra-abdominal/pelvic sepsis
2. Biliary sepsis
3. Appendicitis
4. Mixed anaerobic, aerobic infections
5. Surgical prophylaxis for biliary tree, large bowel
6. When sensitivities dictate the use of the agent

Ceftazidime

1. Empirically for neutropenic patients with fever
2. Documented *Pseudomonas aeruginosa* infections
3. Empirically for nosocomial pneumonia when *P. aeruginosa* infection is suspected

Ceftriaxone

1. Bacterial meningitis
2. Advanced stages of Lyme disease
3. Community-acquired pneumonia

Ciprofloxacin IV

1. Penicillin-allergic patients with gram-negative infections
2. Bone marrow transplant (BMT) patients per protocol
3. Resistant gram-negative organisms
4. Presumed or documented enteric diarrhea with a susceptible organism when oral therapy cannot be tolerated

Clindamycin

1. Intra-abdominal sepsis in combination with an aminoglycoside or with ampicillin
2. Aspiration pneumonia/lung abscess
3. Diabetic foot in combination with an aminoglycoside
4. Cellulitis
5. Mixed aerobic gram-positive/anaerobic infections
6. *Staphylococcus aureus* coverage in penicillin-allergic patients except for endocarditis and meningitis
7. Toxoplasmosis

Imipenem

1. Resistant organisms
2. Bone marrow transplant or neutropenic patients when conventional treatment has failed

Intravenous Fluconazole

1. Severe dysphagia and odynophagia caused by *Candida*
2. Patients who can take nothing by mouth (NPO status) for other reasons and who require fluconazole
3. Candidemia
4. Candidal infection—peritoneal
5. Fungal pneumonia
6. Bone marrow transplant patients as per protocols
7. Cryptococcal meningitis—as acute early therapy in selected cases, in patients with renal failure who cannot take fluconazole orally
8. Surgical patients in intensive care units per protocol

Meropenem

1. For pediatric patients only
2. For resistant organisms and when conventional therapy has failed
3. Bone marrow transplant or neutropenic patients when conventional treatment has failed

Mezlocillin

1. Any gram-negative infection, including *P. aeruginosa*
2. Anaerobic infections, including *Bacteroides fragilis* for salpingitis, cholecystitis
3. Infections with susceptible group D enterococcus

Ticarcillin-Clavulanate

1. Skin and soft tissue infections
2. To replace the combination of nafcillin and mezlocillin for broad-spectrum coverage
3. Nosocomial infections in combination with an aminoglycoside
4. Bone and joint infections
5. Complicated urinary tract infections
6. Respiratory infection and intra-abdominal infections
7. Beta lactamase-positive staphylococcal infections

Tobramycin

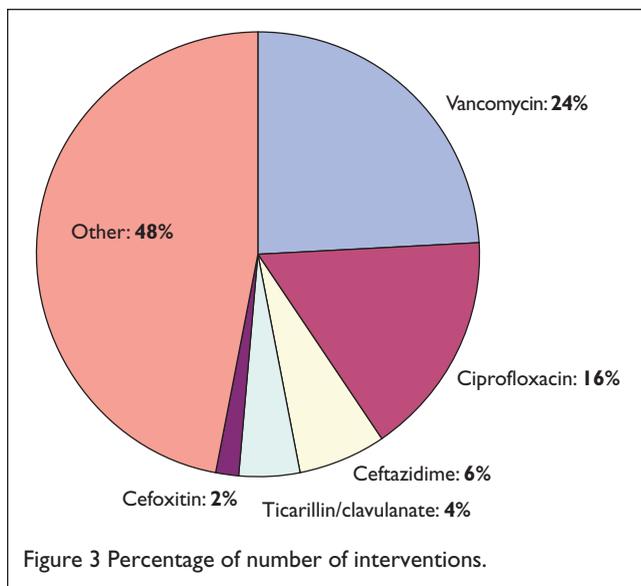
1. Documented *Pseudomonas* infections
2. Age > 70 yr
3. Renal insufficiency (creatinine > 2 mg/ml)
4. Neutropenic patients with fever

Vancomycin

1. Methicillin (nafcillin)-resistant, gram-positive infection
2. Penicillin allergy for gram-positive infections, including group D enterococcus*
3. Ampicillin-resistant group D enterococcus
4. Outpatient dialysis per vancomycin protocol
5. Orally, for severe pseudomembranous antibiotic-associated colitis when metronidazole therapy has failed
6. Orally for pediatric use (<16 yr of age) for pseudomembranous antibiotic-associated colitis

* Penicillin skin testing may be helpful.

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Issues with rotating house staff may also contribute to the increased amount of savings resulting from the increase in the number of interventions noted during 1995 and 1996.

Physician acceptance is key to the success of any clinical program. This is particularly true in hospital settings, where physicians hold privileges at more than one institution, and when formularies differ among institutions. As mentioned, the ordering physician accepted 99% of the interventions recommended under the antibiotic monitoring program.

Other methods that contributed to the program's success included one-on-one sessions for physicians and house staff, distribution of criteria for appropriate usage of antibiotics, and newsletters. In addition to the development of criteria for antibiotic use, surgical prophylactic guidelines, based on guidelines of the Infectious Disease Society of America¹⁴ were created for general surgery, cardiac surgery, noncardiac vascular surgery, obstetrics and gynecology, orthopedics, otolaryngology, and neurosurgery.

SUMMARY

An antibiotic monitoring program can be effective in promoting significant cost savings, in this case averaging more than \$168,000 per year and \$400 per antibiotic switch. This amount reflects only the savings from a change in the type of antibiotic used. Admixture solutions, intravenous tubing, pharmacy preparation time, nurse administration time, laboratory

monitoring, and switching of antibiotics by physicians independently as a result of education programs were not calculated in cost savings. Also not included were the expenses of the Fellow, whose time was considered part of the training program, and those of the pharmacist, whose time was considered part of routine pharmaceutical hospital job responsibilities. A smaller facility, without an Infectious Disease Fellow or an attending physician on staff, might easily incorporate the antibiotic monitoring program by utilizing an appropriately trained pharmacist and the support of an interested physician champion.

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