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## American Journal of Infection Control

journal homepage: [www.ajicjournal.org](http://www.ajicjournal.org)

## Major Article

## An evaluation of provider-chosen antibiotic indications as a targeted antimicrobial stewardship intervention

Veronica Timmons PharmD, BCPS<sup>a,\*</sup>, Jennifer Townsend MD<sup>b</sup>, Robin McKenzie MD<sup>b</sup>, Catherine Burdalski PharmD, BCOP<sup>c</sup>, Victoria Adams-Sommer PharmD, BCPS-AQ ID<sup>c</sup><sup>a</sup> Department of Pharmacy, The Johns Hopkins Hospital, Baltimore, MD<sup>b</sup> Department of Infectious Disease, Johns Hopkins Bayview Medical Center, Baltimore, MD<sup>c</sup> Department of Pharmacy, Johns Hopkins Bayview Medical Center, Baltimore, MD

## Key Words:

Appropriate  
Mismatch  
Failure of indication  
Electronic medical record**Background:** Provider-entered indications for antibiotics have been recommended as a tracking tool for antibiotic stewardship programs. The accuracy and utility of these indications are unknown.**Methods:** Drug-specific lists of evidence-based indications were integrated into an electronic health system as an ordering hard-stop. We reviewed antibiotic orders with provider-entered indications to determine whether the chosen indication matched the documentation and whether antibiotic use was appropriate.**Results:** One hundred fifty-five antibiotic orders were reviewed. Clinical documentation supported the entered indication in 80% of vancomycin orders, 78% of cefepime orders, and 74% of fluoroquinolone orders. The clinical appropriateness for vancomycin, cefepime, and fluoroquinolones were 94%, 100%, and 68%, respectively. When providers chose indications from the list as opposed to choosing "other" and entering free text, antibiotic orders were significantly more likely to be appropriate (odds ratio, 5.8;  $P = .001$ ) but also less likely to match clinical documentation (odds ratio, 0.25;  $P = .0043$ ).**Discussion:** Provider-chosen indications are, overall, an accurate reflection of the true reason for antibiotic use at our institution. Providers frequently documented reasons for fluoroquinolone use that were not among the provided indications.**Conclusion:** Selecting an indication from an evidence-based list as opposed to free-text indications increases the odds that antibiotic agents will be used appropriately.

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Antimicrobial resistance is an increasingly serious threat to global health. Infections caused by resistant bacteria are becoming more difficult to treat due to our limited number of antimicrobial agents.<sup>1</sup> Studies have indicated that antibiotic use is unnecessary or inappropriate in as many as 50% of cases in the United States, creating increased selection pressure for organisms.<sup>2</sup> The development and approval of new antibiotic agents has plateaued; therefore, the focus has shifted to maintaining the efficacy of currently available agents.<sup>2</sup>

Antimicrobial stewardship has been defined in a combined statement from the Infectious Disease Society of America (IDSA), the Society for Healthcare Epidemiology of America, and the Pediatric Infectious Diseases Society as, "coordinated interventions designed to improve and measure the appropriate use of [antibiotic]

drug regimens including dosing, duration of therapy, and route of administration."<sup>3</sup> Not only has antimicrobial stewardship led to improved susceptibility rates to antibiotics, but also to reduced adverse events, including *Clostridium difficile* infection, and improved patient outcomes.<sup>3</sup>

The Joint Commission recently issued standards on antimicrobial stewardship programs that encourage monitoring of antibiotic prescribing patterns and adherence to prescribing guidelines.<sup>4</sup> Understanding why a provider has prescribed an antibiotic for a patient; that is, the indication, is central to guideline adherence and appropriate antibiotic agent use. Stewardship experts are actively seeking ways to standardize and electronically measure antibiotic appropriateness.<sup>5</sup> Asking providers to enter an indication into the electronic medical record (EMR) at the time of ordering is 1 way to quickly assess antibiotic appropriateness assuming the following are true: the available list of indications for the antibiotic reflect appropriate use cases, and the provider is telling the truth about the reason for prescribing; that is, the chosen indication matches clinical documentation. The utility and accuracy of electronic

\* Address correspondence to Veronica Timmons, PharmD, BCPS, 23 E Henrietta St, Baltimore, MD 21230.

E-mail address: [vfoelbe1@jhmi.edu](mailto:vfoelbe1@jhmi.edu) (V. Timmons).

Conflicts of interest: None to report.

indications for stewardship purposes have not been previously reported.<sup>6-8</sup> In an effort to better understand the patterns of prescribing of our highly utilized antibiotics, our stewardship team developed drug-specific lists of appropriate indications using institutional guidelines and asked providers to choose an indication at the time of ordering. Our study was designed to evaluate whether these assumptions hold true in our hospital for a subset of drugs with required indications. The primary objectives were to determine whether the provider-chosen indication for selected antibiotics matched the patient's diagnosis documented in the EMR and whether it was clinically appropriate. The secondary objective was to characterize the use of the "other" indication selection for each antibiotic.

## MATERIALS AND METHODS

Johns Hopkins Bayview Medical Center is a 527-bed academic medical center with 4 intensive care units. We converted our EMR system in December 2015. Our infectious disease department is made up of a consult service and a hospitalist service. In addition, we have an antimicrobial stewardship team led by 2 infectious disease attending physician champions and a clinical pharmacy specialist in infectious disease.

### Patient selection

The study team retrospectively reviewed eligible orders for targeted antibiotics from April 1, 2016, to April 30, 2016, at the Johns Hopkins Bayview Medical Center. A report was generated of eligible antibiotic orders via the electronic health system. A random sample from April 2016 was selected to review and observe current practice. Patients were excluded if they were younger than age 18 years, the antibiotic was ordered via an order set, or if the order was entered by a pharmacist. The study was approved by the institutional review board of the Johns Hopkins Health System.

### Development of indications

Indication lists were developed for cefepime, vancomycin, levofloxacin, ciprofloxacin, and moxifloxacin, which do not require approval for use at our institution (Fig 1). Appropriate use cases were derived from institutional guidelines.<sup>9</sup>

Data were collected through REDCap version 7.3.0 (Nashville, TN). Separate algorithms were developed for each antibiotic and their content was based on institution-specific guidelines (Fig 2). Patient characteristics, such as age, sex, comorbidities, immunosuppression, resistance risk factors, provider service, location, allergies, type of treatment, and culture data were collected for every antibiotic order. Pertinent comorbidities were also collected. Immunosuppression was defined as solid organ transplant, hematologic malignancy, bone marrow transplant, active chemotherapy, or receiving prednisone >20 mg for >30 days. Risk factors for methicillin-

resistant *Staphylococcus aureus* (MRSA) included history of colonization or infection with MRSA, recent (within 3 months) or current prolonged hospitalization >2 weeks, transfer from a nursing home or subacute facility, intravenous drug use, and suspected line infection. Risk factors for *Pseudomonas aeruginosa* included bronchiectasis, broad-spectrum antibiotics for >7 days in the past month, prolonged hospitalization >7 days, debilitated nursing home resident, recent mechanical ventilation >48 hours, immunocompromised due to solid organ transplant, hematologic malignancy, bone marrow transplant, active chemotherapy, and prednisone >20 mg daily for >3 weeks.

Indication matching was determined by reviewing the note or notes that were closest to the time of order entry and written from the primary team taking care of the patient. Consult notes from the infectious disease service were also reviewed if the note was documented close to the time of order entry. Orders were determined to be matching if the diagnosis in the note(s) mirrored the indication in the order. Orders that were mismatched were further characterized into 2 categories: complete mismatch and failure of indication. A complete mismatch was defined as the diagnosis documented in the EMR was a different type of infection from what was indicated in the order (ie, the order stated "cellulitis" but the EMR documented "pneumonia"). A failure of indication was defined as the indication in the order was the closest available indication choice to what was documented in the EMR (ie, the indication chosen was "abscess with risk for MRSA," there was no indication choice for "cellulitis with risk for MRSA," and the EMR stated "cellulitis with risk for MRSA").

To characterize the "other" indication selection used for each antibiotic, our team read through the comments entered by the ordering provider and summarized the indication by syndrome (ie, if the provider typed "positive blood culture" then this was categorized as "Bacteremia/Sepsis"). Observational data analysis was performed using Stata version 13.1 (College Station, TX).

At the time of ordering 1 of these medications, providers were required (via hard stop) to either pick a prepopulated indication or choose "other" and type in an indication for use. The indication requirement went into effect in our electronic health system in December 2015.

## RESULTS

### Patients and baseline characteristics

A total of 3,040 orders were eligible for review; 1,666 orders were excluded (863 entered via order set, 803 entered by a pharmacist). A random sample of 155 antibiotic orders from April 2016 was collected and analyzed. Due to random sampling, no levofloxacin orders were reviewed because this drug is rarely used at our hospital. Ciprofloxacin and moxifloxacin orders were combined as fluoroquinolones. The baseline characteristics are presented in Table 1. The patients were on average 58 years old, which was

**Table 1**  
Baseline characteristics of the study population

Characteristic	Total (N = 79)	Vancomycin (n = 81)	Cefepime (n = 27)	Fluoroquinolones (n = 46)
Age, y	58 ± 18	56 ± 19	59 ± 16	60 ± 17
Female	37 (47)	27 (33)	10 (37)	27 (59)
Type of therapy				
Empiric	64 (81)	70 (86)	25 (93)	39 (86)
Targeted	15 (19)	11 (14)	2 (7)	7 (14)
Location				
Intensive care unit	12 (15)	23 (28)	8 (29)	1 (2.5)
Floor	67 (85)	58 (72)	19 (71)	45 (97.5)

NOTE. Values are presented as mean ± standard deviation or n (%). Some patient's had more than one drug administered.

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