

# ADD It Up: An Evaluation of Antibiotic Duration at Hospital Discharge at a Community Hospital

Morgan Conner,<sup>1</sup> William H. Harris,<sup>1</sup> and John P. Bomkamp<sup>2</sup>

<sup>1</sup>Purdue University College of Pharmacy, West Lafayette, Indiana, USA, and <sup>2</sup>Department of Pharmacy, Indiana University Health Arnett Hospital, Lafayette, Indiana, USA

**Background.** According to the Centers for Disease Control and Prevention, patients admitted to the hospital are commonly discharged on antibiotic therapy with prolonged courses of therapy, which contributes to excessive antibiotic exposure and adverse events. The purpose of this study was to evaluate total antibiotic duration of therapy at hospital discharge at Indiana University Health Arnett, White Memorial, and Frankfort hospitals.

**Methods.** A multicenter, retrospective electronic health record review was conducted from 1 January to 30 June 2019. Patients were included if they were at least 18 years of age, began antibiotic therapy while admitted, and continued antibiotic therapy at hospital discharge for 1 of the following indications: skin/soft tissue infection (SSTI), urinary tract infection (UTI), community-acquired pneumonia (CAP), or acute exacerbation of chronic obstructive pulmonary disease (AECOPD). The number of days of therapy (DOT) of each inpatient and outpatient antibiotic prescribed was collected to calculate the total DOT, which was utilized to determine the appropriateness of the duration of therapy.

**Results.** Of the 547 patients included, 233 patients (42.6%) had CAP, 120 (21.9%) had UTI, 101 (18.5%) had SSTI, and 93 (17%) had AECOPD. The median duration of antibiotic therapy across all indications was 9 days (interquartile range [IQR], 7–11). Median duration for CAP was 9 days (IQR, 7–10), AECOPD was 7 days (IQR, 5–9), UTI was 8 days (IQR, 6–10), and SSTI was 12 days (IQR, 10–14).

**Conclusions.** Excess antimicrobial duration at hospital discharge represents an unmet need of antimicrobial stewardship programs.

**Keywords.** antibiotic duration; antimicrobial stewardship; days of therapy; DOT; evidence-based medicine; hospital discharge; transitions of care.

Antibiotics are among the most prescribed medications when patients are admitted to the hospital, with more than half of all patients receiving at least 1 antibiotic during their hospital admission [1]. Hospital antimicrobial stewardship programs typically focus on improving inpatient antibiotic prescribing; however, the majority of patients complete their antibiotic course after hospital discharge [1, 2]. Though inappropriate antibiotic prescribing differs among hospitals, antibiotic use for common types of infections such as community-acquired pneumonia (CAP), urinary tract infection (UTI), and skin and soft tissue infection (SSTI) is routinely an area for antimicrobial stewardship efforts [3, 4]. Previous studies have identified that more than half of patients discharged on antibiotics for the aforementioned indications are continued on antibiotics with inappropriate

spectrum of activity, incorrect dosing, extended courses of therapy, or with no clinical indication, all of which contribute to antibiotic overuse [2–4]. Previous studies evaluating antibiotic days of therapy (DOT) at hospital discharge have identified that prolonged durations of therapy are common, with a median excess DOT ranging from 2 to 4 days [3–5]. These findings suggest a need for further intervention regardless of established antimicrobial stewardship programs to address antibiotic overuse in the inpatient and outpatient settings [2–6]. Extended durations of therapy result in excessive antibiotic exposure, which has been linked to adverse events such as an increased risk of *Clostridioides difficile* infections and has contributed to the rising concern for antibiotic resistance [1–5].

For many common types of infections, there are clinical practice guideline recommendations from the Infectious Diseases Society of America (IDSA) or multiple studies supporting shorter courses of antibiotic therapy. According to the IDSA guidelines for CAP, the appropriate duration of therapy is a minimum 5 days. In patients who have been clinically stable for 48–72 hours at day 5, antibiotic therapy can be discontinued at that time [7]. Additionally, IDSA guidelines for SSTI and uncomplicated UTI recommend 5–7 days and 3–5 days of therapy, respectively [8–10]. Last, based on a meta-analysis of studies related to antibiotic use in acute exacerbation of chronic

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Correspondence: John P. Bomkamp, PharmD, BCIDP, AAHIVP, Indiana University Health Arnett Hospital, 5165 McCarty Lane, Lafayette, IN 47905, USA ([jbomkamp@iuhealth.org](mailto:jbomkamp@iuhealth.org)).

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obstructive pulmonary disease (AECOPD), a total duration of 3–5 days is appropriate [11, 12]. These clinical practice guidelines and meta-analysis provide justification for shorter courses of antibiotic duration [7–12]. The transition of care at hospital discharge introduces a challenge for calculating the appropriate duration of therapy as inpatient DOT must be accounted for when antibiotics are prescribed at discharge. If inpatient DOT is not considered, patients are at risk for receiving an extended duration of antibiotic therapy.

Antimicrobial stewardship programs may lack appropriate discharge interventions as the Centers for Disease Control and Prevention (CDC) Core Elements of Hospital Antimicrobial Stewardship Programs do not emphasize the importance of discharge interventions [5, 13]. Integrating antibiotic discharge interventions through antimicrobial stewardship may assist in eliminating antibiotic overuse [2–6]. The gap in care at hospital discharge provides a unique opportunity to enhance established antimicrobial stewardship programs through optimizing antibiotic prescribing [4]. Our study was conducted to evaluate total antibiotic duration of therapy at the time of transition of care from the inpatient to outpatient setting.

## METHODS

This Institutional Review Board–approved study was a multicenter, retrospective electronic health record (EHR) review of patients admitted to any of the 3 hospitals in the Indiana University (IU) Health West Central Region and discharged with an antibiotic prescription from 1 January 2019 to 30 June 2019. IU Health Arnett is a 191-bed community teaching hospital located in Lafayette, Indiana. IU Health White Memorial (25 beds) and IU Health Frankfort (12 beds) are critical access hospitals, both located approximately 20 miles from IU Health Arnett. Current antimicrobial stewardship efforts are centered on prospective audit and feedback for patients admitted to these hospitals. One antimicrobial stewardship pharmacist located at IU Health Arnett provides services to all 3 hospitals. The focus of antimicrobial stewardship in this region is to improve antimicrobial therapy for inpatients. For example, this includes interventions related to dose optimization, antimicrobial de-escalation, duration of therapy, intravenous-to-oral conversion, and susceptibility mismatches. The antimicrobial stewardship pharmacist also participates in interdisciplinary rounds with the inpatient infectious diseases team as well as assisting with outpatient infectious diseases consultations. Antimicrobial prescribing at hospital discharge is not currently monitored by the antimicrobial stewardship pharmacist. Providers commonly rotate through each hospital in the region, which results in similar antimicrobial prescribing patterns at each site.

The initial data pull was based on patients who were admitted to 1 of the hospitals in the West Central Region, received antibiotic therapy during the admission, and were discharged from

the hospital with a prescription for at least 1 antibiotic. Patients were then included in the study if they were 18 years of age or older; received antibiotic therapy for 1 of the following indications: SSTI, CAP, uncomplicated UTI, or AECOPD; and were continued on antibiotic therapy at hospital discharge. Patients were excluded if they were under the age of 18 at the time of diagnosis, pregnant, received antibiotics for an indication not listed in the inclusion criteria, received antibiotics for >1 indication, or were discharged on parenteral antibiotics, or if data regarding antibiotic usage or indication were not present in the EHR. Female patients were presumed not to be pregnant unless pregnancy was confirmed during EHR review or pregnancy test. (See [Supplementary Appendix](#) for definitions of each type of infection and additional sampling methods.)

For eligible patients, an EHR review was performed to collect data including age, sex, antimicrobial-related allergies, indication for antibiotic use, inpatient antibiotics prescribed and the DOT, and outpatient antibiotics prescribed and the DOT. The indication was identified from the diagnosis documented by the primary team provider in the progress note submitted to the EHR. In this study, a DOT was defined as a day in which at least 1 dose of an antibiotic was administered regardless of the dosing frequency, which is based on the CDC Core Elements of Hospital Antimicrobial Stewardship Programs [13]. If a patient received different antibiotics with the same intended indication, only 1 DOT was counted regardless of the number of antibiotics administered for a given day. For example, patients with CAP commonly receive ceftriaxone and azithromycin concurrently. On days a patient received both azithromycin and ceftriaxone, this was counted as 1 total DOT instead of counting it as 2 DOT. If both antibiotics were counted, the total DOT would have been inflated, making the results more difficult to interpret. DOT included all days of antibiotic therapy regardless of if the patient was receiving an antibiotic that did not cover the organism isolated in a culture.

Each antibiotic prescribed inpatient was recorded by name and DOT to determine the total inpatient DOT for each patient. Each antibiotic prescribed outpatient was recorded by name and DOT to determine the total outpatient DOT. From these 2 data points, we calculated the total DOT to determine the total antibiotic duration of therapy. Additionally, for patients diagnosed and treated for CAP, we assessed patients' clinical stability at the time of their hospital discharge using the IDSA/American Thoracic Society consensus guidelines for CAP treatment from 2019 in order to better understand the recommended duration of therapy [7]. Therefore, a patient was considered stable for discharge if they were afebrile for 48 hours and were missing no more than 1 of these signs of clinical stability for 48 hours prior to discharge: able to maintain oral intake, temperature  $\leq 38.7^{\circ}\text{C}$ , heart rate  $\leq 100$  beats per minute, respiratory rate  $\leq 24$  breaths per minute, systolic blood pressure  $\geq 90$  mm Hg, arterial oxygen saturation  $\geq 90\%$ , or partial pressure of oxygen  $\geq 60\%$  on room

air, and normal mental status. All 3 authors discussed and contributed to the data collection phase of this study; however, no audits were performed between the authors. Descriptive statistics were used to evaluate the study's results.

## RESULTS

Between 1 January 2019 and 30 June 2019, 1354 patients were identified as potentially eligible for inclusion in the study. Of this initial data pull, 547 patients met the inclusion criteria for this study and underwent full EHR review. The patient demographics are described in [Table 1](#). The average age of patients in the study was 68 years (range, 20–103 years; standard deviation, 16.2 years). The majority of patients included were female (58.9%), and 31% of patients had antibiotic allergies listed in their charts. Of the 547 patients included in the study, the following indications were present: 233 patients (42.6%) with CAP, 120 patients (21.9%) with uncomplicated UTI, 101 patients (18.5%) with SSTI, and 93 patients (17.0%) with AECOPD. The average length of stay was 4.4 days. The median total duration of antibiotic therapy across all indications was 9 days (interquartile range [IQR], 7–11). The median total duration of antibiotic therapy was also stratified by indication, and the results are summarized in [Table 2](#). The CAP group was further stratified by clinical stability. Of the patients diagnosed with CAP,

231 patients (99.1%) were clinically stable at least 48 hours prior to discharge. The median total duration of antibiotic therapy for CAP was 9 days (IQR, 7–10). The median total DOT for the other indications were 7 days (IQR, 5–9) for AECOPD, 8 days (6–10) for uncomplicated UTI, and 12 days (10–14) for SSTI. The most common antibiotics prescribed at hospital discharge were cephalosporins, amoxicillin-clavulanate, and fluoroquinolones. The breakdown of antibiotic classes prescribed at hospital discharge is available in [Table 3](#).

## DISCUSSION

This evaluation of antimicrobial prescribing practices upon hospital discharge at IU Health Arnett, White Memorial, and Frankfort hospitals identified an opportunity to optimize current antibiotic prescribing. Across all indications, we observed patients receiving prolonged courses of antibiotic therapy for common types of infections. The excess prescribing was most pronounced for CAP and SSTI. The median total DOT for CAP was 9 days (IQR, 7–10), which is 4 days longer than recommended minimum treatment as defined by current IDSA guidelines [7]. In this study, patients with CAP were also reviewed for clinical stability 48 hours prior to the time of discharge, which is the primary factor upon which antibiotic duration can be determined according to these guidelines. Nearly all patients in the CAP group (99.1%) were clinically stable at least 48 hours prior to discharge; therefore, these patients could have routinely received a total of 5 days of therapy. For SSTI, the median total DOT was 12 days (IQR, 10–14). Although SSTIs may range in severity, for the purposes of this study patients were only included if they had an uncomplicated infection such as cellulitis, erysipelas, carbuncle, furuncle, or abscess. Diabetic foot infections and SSTIs complicated by bone and/or joint infection were not included. In these cases, the recommended duration of therapy is 5–7 days based on current literature and IDSA guidelines [8, 9]. As a result, it was observed that patients with SSTI were prescribed 5–7 excess DOT. Similar trends were seen with the indications of uncomplicated UTI and AECOPD. The median total DOT for uncomplicated UTI was 8 days (IQR, 6–10), resulting in approximately 3–5 extra DOT based on current recommendations [10]. Duration of therapy for uncomplicated UTI depends on the antibiotic class used (eg, fluoroquinolone vs  $\beta$ -lactam); however, there was no difference observed between the DOT prescribed at discharge between drug classes. Last, the median total DOT for AECOPD was 7 days (IQR 5–9), which is approximately 2–4 days of excess DOT considering current literature [11, 12]. It is essential that clinicians account for DOT completed while a patient is admitted to determine the remaining DOT necessary following discharge. Appropriate calculation of total DOT is crucial in preventing excess DOT, which may result in antibiotic-related adverse events; however, counting DOT in the EHR medication administration record can be challenging as adjustments

**Table 1. Patient Demographics (N = 547)**

Characteristic	No.	(%)
Age, y, average (SD)	68	(16.2)
Sex		
Female	322	(58.9)
Male	225	(41.1)
Allergies		
Any antibiotic	172	(31.0)
Penicillins	88	(16.1)
Cephalosporins	18	(3.3)
Carbapenems	3	(0.5)
Fluoroquinolone	37	(6.8)
Sulfonamides	68	(12.4)
Tetracyclines	11	(2.0)
Indication		
AECOPD	93	(17.0)
CAP	233	(42.6)
SSTI	101	(18.5)
UTI	120	(21.9)
Length of stay		
AECOPD	93	3.7 <sup>a</sup>
CAP	233	4.7 <sup>a</sup>
SSTI	101	4.8 <sup>a</sup>
UTI	120	4.1 <sup>a</sup>

Data are presented as No. (%) unless otherwise indicated.

Abbreviations: AECOPD, acute exacerbation of chronic obstructive pulmonary disease; CAP, community-acquired pneumonia; SSTI, skin and soft tissue infection; UTI, urinary tract infection.

<sup>a</sup>Average length of stay, in days.

**Table 2. Days of Therapy, by Indication**

Infection Type	Recommended DOT	Median Inpatient DOT (IQR)	Median Outpatient DOT (IQR)	Median Total DOT (IQR)
AECOPD	3–5	3 (2–4)	4 (3–5)	7 (5–9)
CAP	≥5	4 (3–5)	5 (3–5)	9 (7–10)
SSTI	5–7	4 (3–5)	7 (6–10)	12 (10–14)
UTI	3–5	3 (2–4)	5 (3–7)	8 (6–10)
Total	...	4 (3–5)	5 (3–7)	9 (7–11)

Abbreviations: AECOPD, acute exacerbation of chronic obstructive pulmonary disease; CAP, community-acquired pneumonia; DOT, days of therapy; IQR, interquartile range; SSTI, skin and soft tissue infection; UTI, urinary tract infection.

to doses and antibiotic start times can propose difficulty when interpreting DOT in the inpatient setting.

The results of our study contribute to the growing literature surrounding antibiotic overuse following hospital discharge. Current literature analyzes total DOT in SSTI, UTI, and CAP, which are 3 common infections that account for 60% of antibiotics at the time of discharge. Previous studies have concluded a median total DOT ranging from 8 to 10 days [2, 6, 14]. Our study resulted in a median total DOT of 9 days across all indications, which reiterates the overuse of antibiotics through prolonged courses of therapy. In addition to supplementing current literature, our study presents a novel aspect through the analysis of antimicrobial prescribing in AECOPD. When analyzing total median DOT for AECOPD, our study's results mirrored the current literature showing that antimicrobial prescribing surpassed the recommended total DOT for AECOPD similar to SSTI, UTI, and CAP. The overutilization of antibiotics among these indications, regardless of well-established guidelines, makes them ideal targets for prescribing interventions.

In a recent systematic review, Daniels et al summarized current strategies to address antibiotic overuse [15]. Some examples of these strategies include education, medication reconciliation at discharge, culture follow-up after discharge, and order sets with default durations. Generally, these interventions resulted in improvement in overall antimicrobial use;

however, 1 study related to the implementation of prospective audit of discharge prescriptions showed a reduction in median DOT prescribed at discharge, though median total DOT remains unchanged [2]. Similar interventions have been considered at the sites included in this study, but they have not gained support. Though not previously published, educational interventions at these sites have not had sustained success in terms of improving antimicrobial use. Currently, medication reconciliation occurs at hospital discharge. The complicating factor with improving this service is that interventions identified by the pharmacist first need provider approval and then require a new prescription to be sent to a pharmacy. This commonly results in both the patient and outpatient pharmacy becoming confused when there are 2 prescriptions sent with different durations. Default durations for many oral antibiotics currently exist, although they contribute more to the identified problem rather than serve as a solution. At the sites included in the study, default durations are geared toward outpatient treatment. For example, default durations are commonly 5 days, 7 days, 10 days, or 14 days. This is helpful if a patient is treated entirely outpatient but problematic when patients receive a portion of their treatment while admitted. Removing these default durations or creating new default durations for transitions of care had been identified as extremely time consuming and would require support across the entire

**Table 3. Drug Classes Prescribed at Hospital Discharge**

	AECOPD (n = 93)	CAP (n = 233)	SSTI (n = 101)	UTI (n = 120)	Total (N = 547)
Amoxicillin-clavulanate	9 (9.7)	79 (33.9)	19 (18.8)	6 (5.0)	113 (20.7)
Azithromycin	27 (29)	19 (8.2)	0 (0.0)	0 (0.0)	46 (8.4)
Cephalosporin	22 (23.7)	108 (46.4)	58 (57.4)	80 (66.7)	268 (49.0)
Clindamycin	1 (1.1)	0 (0.0)	9 (8.9)	1 (0.8)	11 (2.0)
Fluoroquinolone	18 (19.4)	38 (16.3)	5 (5.0)	22 (18.3)	83 (15.2)
Doxycycline	20 (21.5)	5 (2.1)	6 (5.9)	0 (0.0)	31 (5.7)
Penicillin	0 (0.0)	3 (1.3)	2 (2.0)	9 (7.5)	14 (2.6)
Metronidazole	1 (1.1)	2 (0.9)	1 (1.0)	0 (0.0)	4 (0.7)
Sulfamethoxazole-trimethoprim	1 (1.1)	3 (1.3)	10 (9.9)	2 (1.7)	16 (2.9)
Nitrofurantoin	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.8)	1 (0.2)

Data are presented as No. (%). Percentages may not add up to 100% due to some patients being prescribed >1 antimicrobial at discharge.

Abbreviations: AECOPD, acute exacerbation of chronic obstructive pulmonary disease; CAP, community-acquired pneumonia; SSTI, skin and soft tissue infection; UTI, uncomplicated urinary tract infection.

health system. Last, prospective audit and feedback on discharge antimicrobial prescriptions from the antimicrobial stewardship pharmacist would be valuable, but the time and effort this would add to the responsibilities of this pharmacist makes this intervention currently unfeasible.

Other possible interventions that have been discussed at these sites but not implemented include generating an alert to the provider with the number of DOT the patient received in the hospital or drafting a protocol allowing pharmacists to adjust the duration of therapy using their own clinical judgment. There are limitations to these ideas, as creating additional alerts can contribute to alert fatigue and alerts are often overridden unless a hard stop is implemented, which requires the provider to document the reason for overriding the alert. Creating a protocol allowing pharmacists to adjust the duration is intriguing; however, the protocol would need to be specific on indications and introduces the risk of the pharmacist changing a duration for a patient in which the provider is aware of a patient-specific factor that is not in the EHR.

This study has both strengths and limitations. The multicenter study design and larger number of patients included in the study increase the generalizability of the results. Furthermore, we targeted indications with clinical practice guidelines or strong literature supporting a shorter duration, including SSTI, uncomplicated UTI, CAP, and AECOPD. These indications have recommended treatment durations of 7 days or fewer according to current guidelines and literature; therefore, these patients are at high risk of overutilization of antibiotic therapy, which makes these indications ideal targets for this research [7–12]. Limitations include the retrospective study design. Due to the nature of the retrospective design, researchers had to rely on proper documentation of the indication in the EHR, which may introduce confounding. All 3 authors contributed to data extraction from the EHR. The EHR review audits were not performed during data collection, which is a limitation of the study. Additionally, patients' pharmacies were not contacted to confirm that the patient acquired the prescription upon hospital discharge. The study focused only on prolonged courses of antibiotic therapy; however, additional antibiotic misuse at discharge can be caused by inappropriate spectrum of activity, incorrect dosing, and lack of clinical indication. Last, culture and susceptibility information were not taken into account when determining DOT.

In conclusion, based on the results of this study, patients regularly receive excess antibiotic durations of therapy for common types of infections at hospital discharge. Transitions of care remain an area for improvement for hospital antimicrobial stewardship programs.

## Notes

**Author contributions.** M. C. and W. H. H. contributed to data extraction from the electronic health record, analysis of results, and preparation of the manuscript. J. P. B. contributed to study design, study supervision, data extraction from the electronic health record, analysis of results, and preparation of the manuscript. All authors read and approved the final manuscript.

**Patient consent statement.** The research conducted for this study was approved by the Indiana University Institutional Review Board. Written patient consent was not required due to the retrospective approach to this study and minimal risk to patient confidentiality.

**Potential conflicts of interest.** All authors: No reported conflicts of interest.

All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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