

# Factors Associated With Acceptance of Telehealth-Based Antimicrobial Stewardship Program Recommendations in a Community Hospital Health System

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**Background.** Telehealth-based antimicrobial stewardship programs (TeleASPs) have led to reduced broad-spectrum antimicrobial utilization. Data on factors associated with acceptance of stewardship recommendations are limited.

**Methods.** A TeleASP, facilitated by remote infectious disease physicians and local pharmacists, was implemented in 2 community hospitals from February 2018 through July 2020. Variables potentially affecting acceptance of TeleASP recommendations were tracked. Odds ratios of acceptance were determined utilizing multiple logistic regression.

**Results.** During the 30-month period, 4863 (91.2%) of the total 5333 recommendations were accepted. Factors associated with a higher odds of acceptance in multivariable analysis were recommendations for antimicrobial dose/frequency adjustment (odds ratio [OR], 2.63; 95% CI, 1.6–4.3) and order for labs/tests (OR, 3.30; 95% CI, 2.1–5.2), while recommendations for antimicrobial de-escalation (OR, 0.75; 95% CI, 0.60–0.95) and antimicrobial discontinuation (OR, 0.57; 95% CI, 0.42–0.76) were associated with lower odds of acceptance. Female physicians were more likely to accept recommendations compared with males (93.1% vs 90.3% acceptance; OR, 1.65; 95% CI, 1.3–2.2). Compared with physicians with <3 years of experience, who had the highest acceptance rate (96.3%), physicians with ≥21 years of experience had the lowest (87.1%; OR, 0.26; 95% CI, 0.15–0.45).

**Conclusions.** TeleASP recommendations were accepted at a high rate. Acceptance rates were higher among female physicians, and recommendations to stop or de-escalate antimicrobials led to lower acceptance. Recommendations made to the most experienced physicians were the least accepted, which may be an important factor for stewardship programs to consider in education and intervention efforts.

**Keywords.** antimicrobial stewardship; acceptance; antibiotic stewardship; community hospital; telehealth.

Antimicrobial stewardship programs (ASPs) are important for patient safety, required at all hospitals in the United States, and have been associated with improved antimicrobial utilization, improved patient outcomes, reduced adverse events, and reduced cost [1–4]. However, all facilities do not have on-site access to the necessary expertise to conduct a robust ASP. Telehealth-based antimicrobial stewardship programs (TeleASPs) may thus be important to allow all hospitals to meet regulatory requirements and ensure optimal antimicrobial utilization for all patients [5]. A variety of models exist, and these programs have demonstrated the ability to achieve outcomes comparable to those facilitated on-site [6–10].

It is important to understand factors associated with acceptance of ASP recommendations to gauge their influence and appropriately target future education and interventions. Prior work has found that the type of ASP recommendation, as well as clinical factors such as disease state, may influence the odds of acceptance [11–16]. Clinician-level factors have been less thoroughly evaluated but have suggested that clinician specialty service may be an important predictor [11, 14–16], and 1 study from a children's hospital also found that more years of experience was associated with a higher likelihood of disagreement with ASP recommendations [12].

There are currently no data regarding factors influencing acceptance of TeleASP recommendations, or regarding factors influencing acceptance of ASP recommendations for adult inpatients in the United States. The objective of this study was to evaluate the acceptance rates of recommendations made via our TeleASP and to characterize the factors associated with acceptance of recommendations.

## METHODS

### Setting

Allegheny Health Network (AHN) is a nonprofit health care system that operates 9 hospitals in Western Pennsylvania and

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1 hospital in Western New York, with ASP activities coordinated at the network level. Three community hospitals within the network are facilitated via TeleASP, with the remainder being locally run. The setting for this study is a separate nonprofit health care system in Western Pennsylvania that operates 2 community hospitals (with sizes of 285 and 176 licensed beds), at which a TeleASP was launched in February 2018, facilitated by AHN. The design and implementation of this TeleASP have been described in detail previously [7]. Briefly, the program was facilitated by 3 AHN board-certified infectious diseases (ID) physicians, who were also responsible for conducting on-site education before the launch of the TeleASP. This consisted of several Grand Rounds presentations as well as multiple on-site visits for one-on-one or small group introductions to hospitalists, advanced practice practitioners (APPs), and specialists for a personal introduction to the TeleASP and to review the management of common disease states. Local pharmacists preliminarily reviewed the charts of patients receiving select antibiotics as well as those with certain disease states, with subsequent calls with an AHN ID physician 2 to 3 times per week. During the calls, the AHN ID physician also reviewed the electronic medical records of patients remotely and made recommendations, which were subsequently relayed to the primary team by the local pharmacist.

#### Data Collection

Data were collected for this analysis for 30 months, from February 2018 through July 2020. The number and acceptance rate of recommendations were tracked in 9 categories: change duration of therapy, antimicrobial de-escalation, antimicrobial discontinuation, antimicrobial dose/frequency adjustment, escalate therapy, initiate therapy, switch from intravenous to oral, order labs/tests (frequently but not limited to orders that would facilitate diagnosis and subsequent antibiotic discontinuation or de-escalation, such as procalcitonin, cultures, or nasal swab for methicillin-resistant *Staphylococcus aureus*), and suggest ID consultation. Modified acceptances were also tracked, defined as an acceptance of a recommendation in altered form as a result of new information made available to the TeleASP at the time the recommendation was provided. For the purpose of analysis, modified acceptances were considered acceptances. The hospital campus for each recommendation, as well as the clinical service to which the recommendation was made and the attending physician of that service, was also recorded. Characteristics of the attending physician responsible for acting on the recommendation, including gender, years of experience, and whether they had a personal introduction meeting with a TeleASP physician, were also collected. If the recommendation was given to an APP rather than directly to the attending physician, this was noted. As the family practice and podiatry services are residency programs, recommendations were generally given to residents. Given frequent changes

in the attending physician on these services, characteristics of the attending physician were not considered for the purposes of this study, and those services were analyzed at the service level only. Recommendations were excluded from analysis if there was no documented outcome (acceptance or rejection) or if the service was not documented. Recommendations with service documented but without a documented attending physician were still analyzed at the service level only.

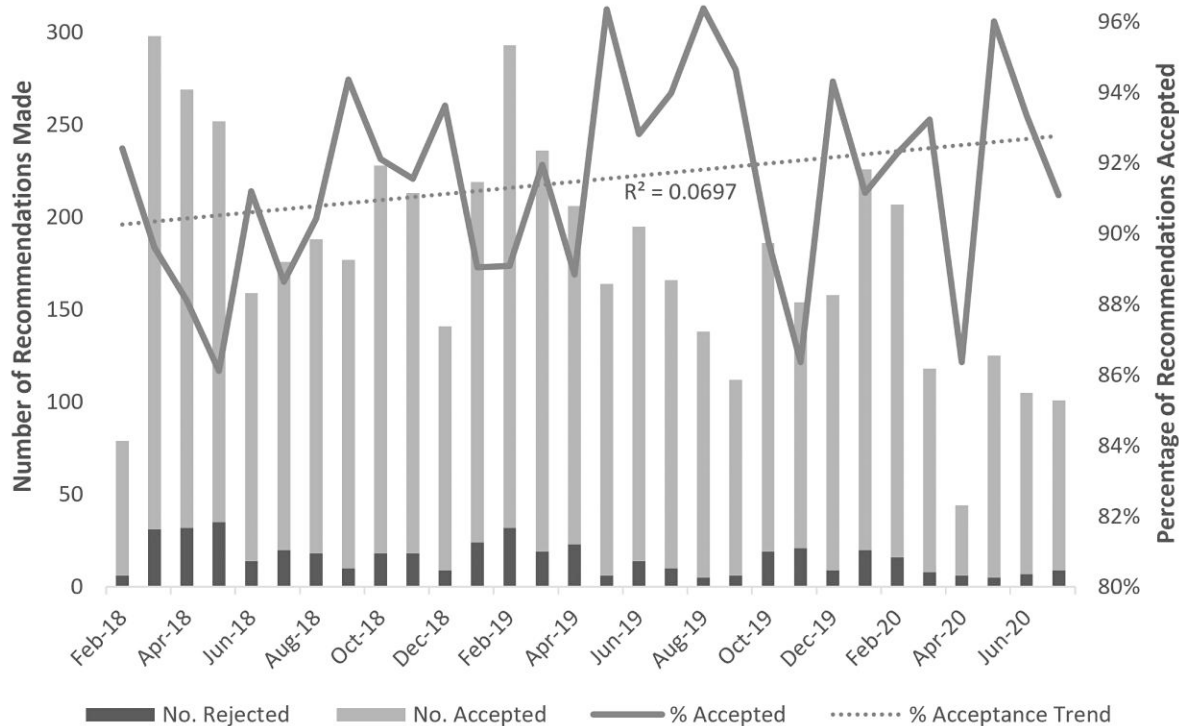
#### Statistical Analysis

Variable groups of campus, type of recommendation, service, whether an APP received the recommendation, attending physician gender, years experience, and whether the attending physician had a personal introduction to the TeleASP were analyzed. Continuous variables were compared by acceptance vs rejection using *t* tests and Mann-Whitney *U* tests, as appropriate. Likewise, categorical variables were compared using the chi-square or Fisher exact test, as appropriate. Univariate logistic regression models were used to calculate odds ratios of acceptance. A multivariable logistic regression model was created to determine the odds of acceptance when adjusted for other variables, with variables with  $P < .2$  from the univariable model included in the multivariable model. All statistical tests were calculated at  $\alpha = 0.05$ . SAS Enterprise Guide 7.15 HF3 (SAS Institute, Inc, Cary, NC, USA) was used to conduct the statistical analysis.

## RESULTS

Over the 30-month period, 5410 recommendations were made. Seventy-seven recommendations were excluded (no documented outcome [acceptance/rejection] of the recommendation,  $n = 76$ , and no documented service or attending,  $n = 1$ ). After exclusions, 5333 recommendations (mean, 178 recommendations per month) made to 135 unique attending physicians were available for analysis, of which 4665 (87.5%) were accepted and another 199 (3.7%) were accepted on a modified basis, for an overall acceptance rate of 91.2%. The monthly number and acceptance of recommendations are demonstrated in Figure 1. Recommendations were most commonly made to the hospitalist service (3059 [57.3%] recommendations), of which 2832 (92.6%) were accepted, followed by private practice primary care physicians (PCPs; 553 [10.4%] recommendations, 481 [87.0%] accepted), and general surgery (457 [8.6%] recommendations, 395 [86.4%] accepted). Recommendations were most commonly made to male physicians (3214 [66.7%] recommendations) on the Beaver campus (3455 [64.8%] recommendations) and to physicians with more than 21 years of experience (2054 [38.5%] recommendations) (Table 1).

On univariate analysis, factors significantly associated with the acceptance of ASP recommendations were physician gender, years of experience, campus, type of recommendation,



**Figure 1.** Number and percent acceptance of antimicrobial stewardship program recommendations over time.

and service. Whether a personal introduction meeting occurred with a physician and whether an APP was involved in the communication of the recommendation were not significantly associated (91.6% [2402/2622] acceptance with meeting vs 90.6% [2180/2406] acceptance with no meeting;  $P = .2$ ; and 91.0% [821/902] acceptance with APP involvement vs 91.2% [4042/4431] acceptance with no APP involvement;  $P = .8$ ; respectively) (Supplementary Table 1).

On univariate, univariable analysis, services with significantly higher odds of acceptance included hospitalist (OR, 1.49; 95% CI, 1.2–1.8) and critical care medicine (OR, 3.98; 95% CI, 2.0–7.8), while general surgery (OR, 0.58; 95% CI, 0.44–0.78), private practice PCP (OR, 0.61; 95% CI, 0.46–0.72), pulmonology (OR, 0.54; 95% CI, 0.40–0.73), and urology (OR, 0.38; 95% CI, 0.16–0.94) services had significantly lower odds of acceptance. The Beaver campus had lower odds of acceptance as compared with the Sewickley campus (OR, 0.65; 95% CI, 0.52–0.81) (Supplementary Table 1).

In multivariable analysis, however, campus was no longer a significant predictor of acceptance. The only service that remained significant was the critical care medicine service, with increased odds of acceptance. Recommendations made to female physicians had a significantly higher odds of acceptance, as did recommendations for antimicrobial dose/frequency adjustment and order for labs/tests. Recommendations of antimicrobial de-escalation and antimicrobial discontinuation were

associated with a lower odds of acceptance. Having more than 21 years of experience was associated with the lowest odds of acceptance (Table 1).

## DISCUSSION

After implementation of a successful TeleASP within a community hospital health system [7], this study aimed to characterize the factors associated with acceptance of ASP recommendations. Although limited prior literature exists characterizing such factors in other settings [11–16], this study is the first, to our knowledge, to investigate factors associated with the acceptance of ASP recommendations given via a telehealth model and also those given regarding adult patients in the United States. Given the importance of ASPs as a patient safety initiative [2, 17], the requirement that all hospitals in the United States have ASPs in place [3, 4], and the often limited resources available to facilitate such programs [18, 19], such data may help ASPs best determine how to most efficiently target interventions and education efforts.

We evaluated over 5000 recommendations made over 30 months through our TeleASP to a community hospital health system and found an overall acceptance rate of 91.2%. This high acceptance rate, which was sustained over time, helps to highlight the viability of the TeleASP model as an alternative to fully on-site ASPs for facilities without sufficient local

**Table 1. Multivariable Analysis of Factors Influencing Acceptance of Antimicrobial Stewardship Recommendations**

Variable	No. Accepted	No. Rejected	% Accepted	OR [95% CI]	P Value
Physician gender					
Male	3214	344	90.3	Ref	Ref
Female	1368	102	93.1	1.65 [1.3–2.2]	.0003
Years of experience					
<3	395	15	96.3	Ref	Ref
3–5	464	44	91.3	0.40 [0.22–0.74]	.65
6–10	843	67	92.6	0.45 [0.25–0.81]	.76
11–20	1091	55	95.2	0.73 [0.40–1.3]	.0008
21+	1789	265	87.1	0.26 [0.15–0.45]	<.0001
Campus					
Beaver	3111	344	90.0	0.91 [0.72–1.2]	.44
Sewickley	1752	126	93.3	Ref	Ref
Type of recommendation					
Antimicrobial de-escalation	1542	201	88.5	0.75 [0.60–0.95]	.02
Order labs/tests	837	23	97.3	3.30 [2.1–5.2]	<.0001
Antimicrobial discontinuation	565	90	86.3	0.57 [0.42–0.76]	.0001
Antimicrobial dose/freq adj.	518	19	96.5	2.63 [1.6–4.3]	.0001
Service (No. physicians represented)					
Hospitalist (46)	2832	227	92.6	1.15 [0.70–1.9]	.59
Private practice PCP (24)	481	72	87.0	1.01 [0.58–1.8]	.98
General surgery (8)	395	62	86.4	0.89 [0.51–1.6]	.68
CCM (2)	350	9	97.5	3.23 [1.4–7.5]	.006
Pulmonology (6)	325	55	85.5	1.21 [0.68–2.2]	.53
Podiatry	53	2	96.4	3.17 [0.72–14]	.13
Hematology/oncology (6)	45	1	97.8	5.19 [0.66–41]	.12
Urology (3)	24	6	80.0	0.75 [0.27–2.1]	.58

Abbreviations: Adj., adjustment; CCM, critical care medicine; Freq, frequency; OR, odds ratio; PCP, primary care physician.

expertise. On univariate analysis, all variable groups we evaluated were found to be significant with regard to an influence on the acceptance of ASP recommendations, with the exception of whether an APP received the recommendation and whether a personal introduction to the TeleASP had occurred with the attending physician. While antibiotics are more frequently prescribed by nurse practitioners and physician assistants as compared with physicians in outpatient settings [20–22], it is not known if this trend extends to inpatient settings. Our results suggest that APPs, when working on teams with physicians in the inpatient setting, do not influence a different rate of acceptance of ASP recommendations compared with when physicians are working alone. Given the reported success of “handshake” stewardship [23, 24], the lack of a difference in acceptance rate between attending physicians who had met personally with TeleASP physicians and those who had not might seem surprising. However, these meetings generally occurred early in the program, and there was not a regular on-site presence of TeleASP physicians. Instead, local pharmacists were empowered to be the on-site stewardship champions and became a trusted local resource. In this light, this finding may actually be encouraging, as if on-site presence of the generally remote ID physicians responsible for oversight of a

TeleASP is less important, this expands the geography for which a given TeleASP could feasibly have an impact.

On multivariable analysis, we found that recommendations of dose/frequency adjustments and recommendations to order labs or tests had higher odds of acceptance, and we found lower odds of acceptance with recommendations for antimicrobial de-escalation or discontinuation. This is in line with prior research that found that recommendations that decrease antibiotic exposure have a lower odds of acceptance compared with neutral recommendations and those that increase antibiotic exposure [15]. Upon initial analysis, we also found that general surgery, private practice PCPs, pulmonology, and urology had lower odds of acceptance, and hospitalists and CCM physicians had higher odds of acceptance. This is in line with prior studies that have found that surgical services are less likely to accept stewardship recommendations [13–16, 25]. However, with the exception of CCM, in multivariable analysis the findings regarding these services were no longer significant. Particularly notable was the importance of years of experience, as recommendations given to physicians with  $\geq 21$  years of experience had the lowest odds of acceptance. To our knowledge, only 1 other study has evaluated this, and it similarly found that the odds of rejecting an ASP recommendation increased with



more years of experience [12], though this finding is also in keeping with other work finding that late-career physicians prescribe longer courses of antibiotics [26] and that general practitioners with longer work experience prescribe antibiotics more frequently [27] and are less likely to believe their prescribing behavior influences drug resistance than those earlier in their career [28]. Such findings may be the result of training in an era before the widespread recognition of the importance of antimicrobial stewardship [12, 29]. While further research is necessary to elucidate the reasons this group of physicians may be less apt to follow ASP guidance, this may be important for ASPs to consider as they develop educational initiatives and targeted interventions. We also found that female physicians had higher odds of accepting ASP recommendations compared with their male counterparts. While this is a novel finding with regard to acceptance of stewardship recommendations, it tracks with prior research suggesting that female physicians are less likely to prescribe antibiotics than males [30, 31].

Our study has important limitations. This was a retrospective study of ASP recommendations at a single 2-hospital community health system geographically close to our institution. Some specialties had a limited number of physicians represented, which may limit generalizability. For example, there were only 2 dedicated CCM physicians represented, 1 of whom was highly engaged in the TeleASP and frequently participated in calls. There may also be variables that influence the odds of an ASP recommendation being accepted that were not assessed in this study, such as recommendations for different disease states, time of day recommendations were made, which pharmacist was making the recommendation, or other factors. Finally, there were a small number of physicians who were difficult for the ASP to engage, which ultimately resulted in a lower number of recommendations being given to such physicians. As these physicians frequently refused recommendations, this could have marginally skewed our overall acceptance rate higher and limited the number of rejections for us to evaluate as part of this study.

In conclusion, we found a high acceptance rate of TeleASP recommendations in a community hospital health system. The type of recommendation, as well as clinician-level variables, such as service, gender, and years of experience, may be associated with acceptance of recommendations. While some additional focus on services such as surgery, pulmonology, and private practice PCPs may be warranted, years of experience appears to be a potentially more important and less well-described predictor of ASP recommendation acceptance, with those with the most years of experience being least likely to accept recommendations. As ASPs strive to gain efficiency and target interventions and education where they will be most helpful, these findings may inform these important efforts.

### Supplementary Data

Supplementary materials are available at *Open Forum Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the

posted materials are not copyrighted and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

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**Patient consent.** This study did not include factors necessitating patient consent. It was approved by Heritage Valley Health System Institutional Review Board.

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