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## Original Article

# CLinician and patient characteristics effect on Antimicrobial Stewardship Interventions (CLASI) study

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### Abstract

Objective: To determine whether the gender of clinicians making antimicrobial stewardship recommendations has an impact on intervention acceptance rate.

Design: A retrospective, multivariable analysis of antimicrobial stewardship prospective audit and feedback outcomes.

Setting: A multisite healthcare system including Mayo Clinic Rochester (MN), Mayo Clinic Arizona, Mayo Clinic Florida and 17 health-system hospital sites, where prospective audit and feedback is performed and documented within an electronic tool embedded in the medical record.

Participants: The study included 143 Mayo Clinic clinicians (84 cisfemales and 59 cismales).

Methods: Outcomes were analyzed from July 1, 2017, to June 30, 2022, for intervention rates, communication methods, and intervention acceptance by clinician gender, profession, patient age, and intensive care unit (ICU) status of patient.

Results: Of 81,927 rules, 71,729 rules met study inclusion. There were 18,175 (25%) rules associated with an intervention. Most of the rules were reviewed by pharmacists (86.2%) and stewardship staff (85.5%). Of 10,363 interventions with an outcome documented, 8,829 (85.2%) were accepted and 1,534 (14.8%) were rejected. Female clinicians had 6,782 (86.5%) of 7,843 interventions accepted, and male clinicians had 2,047 (81.2%) of 2,520 interventions accepted ($P = .19$). Female patients had more interventions than male patients (female vs male: 25.9% vs 24.9%; OR, 1.04; 95% CI, 1.02–1.08; $P = .001$). Patients in the ICU had a significantly lower intervention acceptance rate (ICU vs non-ICU: 78.2% vs 86.7%; OR, 0.56; 95% CI, 0.45–0.7; $P < .001$).

Conclusions: Female and male clinicians were equally effective at prospective audit and feedback in a multisite antimicrobial stewardship program. Patients in the ICU were less likely to have stewardship interventions accepted.

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Designing and implementing effective antimicrobial stewardship interventions is a crucial component of antimicrobial stewardship programs (ASPs). In the United States, several regulatory agencies and professional societies (eg, The Joint Commission, Centers for Medicare and Medicaid Services, Infectious Diseases Society of America, Centers for Disease Control and Prevention)[1–4] provide guidance on potential antimicrobial stewardship interventions in a broad range of healthcare settings. In acute-are facilities, prospective audit and feedback[5] has been shown to improve antimicrobial prescribing.

Recently, antimicrobial stewardship research has shown that clinician characteristics may have an impact on intervention acceptance rates. In examination of a telestewardship program, female physicians were more likely to accept recommendations than were male physicians. Additionally, physicians with <3 years of experience, critical care specialist and hospitalist were also associated with higher intervention acceptance rates.[6] In contrast, a study of a 6-month antimicrobial time-out program examined characteristics of generalist clinical pharmacists that made 82 antimicrobial stewardship recommendations to change an antibiotic from 295 antibiotic time-outs with physicians within 48 hours of anticipated patient discharge. Notably, male pharmacists had a significantly higher intervention acceptance rate than their female counterparts, regardless of the gender of the reviewing physician: female pharmacists had 10 (33.3%) of 30 interventions accepted versus male pharmacists that had 41 (78.8%) of 52 interventions accepted.[7] The relatively small number of interventions may limit applicability of these findings, but it signals a potential implicit bias among healthcare clinicians involved in antimicrobial stewardship.

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The primary purpose of this study was to determine whether clinician gender affects the acceptance rates of prospective audit-and-feedback interventions in a large, multisite ASP. Secondary outcomes examined the relationship between clinician gender, profession, ASP staff status, and patient characteristics intervention rate, acceptance rate, and method of communication.

## Methods

Antimicrobial stewardship rules and associated interventions documented within a prospective audit-and-feedback tool embedded in the Mayo Clinic electronic health record (EHR) between July 2017 and June 2022 were analyzed. The custom-built electronic tool consists of antimicrobial clinical monitoring rules used to populate a patient list. The customized electronic stewardship tool has been previously described.[8] Stewardship clinicians (physicians and pharmacists) review the patient list for their site(s) during traditional business days and hours, across the multisite system that includes Mayo Rochester (Minnesota), Mayo Arizona, Mayo Florida, and 17 health-system hospitals. All antimicrobial stewardship clinicians included in this study used the same EHR tool; the physical location (on site or remote) while interacting with the tool could vary. Each antimicrobial stewardship rule is associated with a documentation form in the EHR. Preprogrammed selections in the documentation form provides input standardization. Patients without research authorization in Minnesota were excluded according to state requirements.

A comprehensive report of antimicrobial stewardship rule documentations was used to analyze the antimicrobial stewardship interventions for this study. Report information included: name of documenting clinician, patient demographics, rule name, rule category, and whether the clinician intervened. Additionally, for rules that had an intervention, the intervention action, how the intervention was communicated, intervention date and time, and whether the intervention was accepted or not were reported. Patient gender, Charlson comorbidity index, whether the rule generated an intervention or not, intervention acceptance, and method of communication were analyzed.

Documentation that could not be interpreted by the study team (eg, "no intervention warranted" combined with "intervention accepted") was excluded from analysis. Interventions documented as 'accepted' or 'rejected' were completed outcomes included in the analysis. Documentation of "awaiting provider response" was considered undetermined and was excluded from the intervention acceptance analysis.

Communication methods were grouped into similar types of interaction with the primary services. 'Direct communication' includes verbal and phone interactions and real-time electronic 'chat' communications. 'Change made by the intervener' is a direct action undertaken by the intervener, and 'asynchronous communication' method is an electronic clinician to clinician (or clinician team) communication within the EHR via email or in-basket.

Stewardship clinicians were characterized by gender and profession. Clinician gender was categorized as cisgender male, cisgender female, transgender male, transgender female, or nonbinary by the study team. Professions were identified as pharmacist, physician, advanced practice provider (APP), pharmacy student, or medical student. Clinicians not known to the study team had gender and profession identified using publicly available sources including npiprofile.com, doximity.com, and LinkedIn according to the published method.[9] Staff with ongoing, dedicated staffing hours dedicated to ASP were assigned as ASP staff. All others, including learners, were assigned as non-ASP staff.

The Mayo Clinic Institutional Review Board approved this study. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines were followed.[10]

A summary of study definitions is provided in Supplementary Table 1.

### Statistical analysis

Data have been summarized using frequencies and percentages. Generalized estimating equations utilizing logistic regression were used to assess associations among patient, staff, and intervention characteristics and the outcomes of intervention acceptance, intervention, and communication method. We used an exchangeable correlation structure to account for the potential correlation of interventions within a staff member. Associations were assessed both univariately and after adjusting for other factors. The variables included in the multivariable models were clinician gender, profession, ASP staff, day of week, time of day, rule category, whether the patient was in the ICU, patient age (<18 years vs ≥18 years), patient gender, and patient Charlson comorbidity index. Associations are summarized using odds ratios (ORs) and corresponding 95% confidence intervals (CIs). All 2-way interactions between clinician gender, profession, ASP staff, if the patient was in the ICU, patient age (<18 years vs ≥18 years), patient gender, and patient Charlson comorbidity index were assessed. No significant interactions were found (data not shown). All tests were 2-sided, and $P \leq .05$ was considered statistically significant. All analyses were performed using SAS version 9.4 software (SAS Institute, Inc, Cary, NC).

## Results

In total, 81,927 rules were reviewed by 143 staff members and trainees comprising 84 cisfemales and 59 cismales, which will be described herein going forward as "male/males" and "female/females." Pharmacist was the most common profession (n = 104), followed by physician (n = 35), pharmacy student (n = 3), and APP (n = 1). The minority of interveners were ASP staff (n = 31) and the remainder non-ASP staff (n = 112) (Table 1).

### Intervention rate

Of 71,729 rules meeting study inclusion, 18,175 rules (25%) were associated with an intervention. Most rules were reviewed by pharmacists (86.2%) and ASP staff (85.5%) (Table 1). There was no statistically significant difference in the intervention rate by intervener gender: a total of 42,268 rules were reviewed by women, of which, 12,680 (30%) resulted in an intervention. In comparison, of 29,461 rules reviewed by men, 5,495 (18.7%) resulted in interventions ($P = .58$). However, there was a statistically significant difference by patient gender, with female patients having a higher percentage of interventions accepted than male patients (female vs male: 25.9% vs 24.9%; OR, 1.04; 95% CI, 1.02–1.08; $P = .001$). We detected no difference in Charlson comorbidity index between male and female patients that could have accounted for the difference. Most of the rules occurred in floor patients, with similar rate of intervention between ICU and non-ICU patients (ICU vs non-ICU: 25.4% vs 25.1%; OR, 1.11; 95% CI, 0.95–1.29; $P = .18$) (Table 1). Patients with a higher Charlson comorbidity

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**Table 1.** Intervention Rate by Baseline Demographics of Clinicians and Patients

| Characteristic | Total (N=71,729), No. (%) | Intervention (N=18,175), No. (%)[a] | No Intervention (N=53,554), No. (%)[a] | Univariate | | Multivariable[b] | |
|---|---|---|---|---|---|---|---|
| | | | | Odds Ratio (95% CI) | *P* Value | Odds Ratio (95% CI) | *P* Value |
| **Clinician gender** | | | | | | | |
| Cisfemale (N=84) | 42,268 (58.9) | 12,680 (30.0) | 29,588 (70.0) | Reference | | Reference | |
| Cismale (N=59) | 29,461 (41.1) | 5,495 (18.7) | 23,966 (81.3) | 1.10 (0.78–1.57) | 0.58 | 0.90 (0.55–1.46) | 0.66 |
| **Profession** | | | | | | | |
| APP (N=1) | 24 (0.0) | 13 (54.2) | 11 (45.8) | 1.96 (1.60–2.41) | <.001 | 1.72 (1.08–2.75) | .023 |
| Pharmacist (N=104) | 61,865 (86.2) | 15,196 (24.6) | 46,669 (75.4) | Reference | | Reference | |
| Pharmacy student (N=3) | 58 (0.1) | 31 (53.4) | 27 (46.6) | 4.07 (0.94–17.57) | .060 | 3.39 (0.86–13.41) | .081 |
| Physician (N=35) | 9,782 (13.6) | 2,935 (30.0) | 6,847 (70.0) | 1.03 (0.71–1.49) | .89 | 0.94 (0.60–1.47) | .78 |
| **ASP staff** | | | | | | | |
| ASP (N=31) | 61,339 (85.5) | 14,699 (24.0) | 46,640 (76.0) | Reference | | Reference | |
| Non-ASP (N=112) | 10,390 (14.5) | 3,476 (33.5) | 6,914 (66.5) | 1.20 (0.83–1.75) | .34 | 1.07 (0.69–1.65) | .76 |
| **ICU** | | | | | | | |
| No | 57,120 (79.6) | 14,514 (25.4) | 42,606 (74.6) | Reference | | Reference | |
| Yes | 14,609 (20.4) | 3,661 (25.1) | 10,948 (74.9) | 1.11 (0.95–1.29) | .18 | 1.11 (0.96–1.29) | .16 |
| **Age** | | | | | | | |
| Pediatric (<18 y) | 1,989 (2.8) | 465 (23.4) | 1,524 (76.6) | 0.31 (0.14–0.69) | .004 | 0.33 (0.16–0.69) | .004 |
| Adult (≥18 y) | 69,740 (97.2) | 17,710 (25.4) | 52,030 (74.6) | Reference | | Reference | |
| **Patient gender** | | | | | | | |
| Female | 30,574 (42.6) | 7,908 (25.9) | 22,666 (74.1) | Reference | | Reference | |
| Male | 41,147 (57.4) | 10,266 (24.9) | 30,881 (75.1) | 0.96 (0.93–0.98) | .001 | 0.95 (0.93–0.98) | <.001 |
| Charlson comorbidity index, median (IQR) | 0 (0–5) | 0 (0–6) | 0 (0–4) | 1.02 (1.01–1.03) | <.001 | 1.02 (1.01–1.03) | <.001 |

Note. APP, advanced practice provider; ASP, antimicrobial stewardship program; ICU, intensive care unit.
[a]Row %.
[b]Multivariable model was also adjusted for day of week and time of day.

index were more likely to have an intervention in the univariate and multivariable model (Table 1).

### *Intervention acceptance rate*

In total, 10,363 interventions had an outcome documented, of which 8,829 (85.2%) were accepted and 1,534 (14.8%) were rejected. There was no difference in the acceptance rate between the intervening clinician's gender. Female clinicians had 6,782 (86.5%) of 7,843 interventions accepted and male clinicians had 2,047 (81.2%) of 2,520 interventions accepted. There was no difference in the staff profession as it related to recommendation acceptance. The pharmacist acceptance rate was 8,060 (85.5%) of 9,429 interventions and the physician acceptance rate was 751 (82.3%) of 913 interventions. However, the acceptance rate was significantly higher for non-ICU patients, with 7,373 (86.7%) of 8,501 interventions accepted, than for the ICU patients, with 1,456 (78.2%) of 1,862 interventions accepted ($P < .001$). This difference remained significant in the multivariable model (non-ICU vs ICU: OR, 1.75; 95% CI, 1.47–2.13; $P < .001$). There was no significant difference in acceptance rate based on any patient demographics (Table 2).

### *Communication method*

We examined 3 distinct methods of communication for 18,175 interventions. Of 18,175 interventions, 11,569 (63.6%) were conveyed as a direct communication between the intervener and treating service staff. There was no difference in method of communication used by female versus male interveners. Pharmacists, acting under institutional policy allowing for independent adjustment of antimicrobial doses based on renal function and treatment indication, were significantly more likely than physicians to intervene directly to make a change to the

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**Table 2.** Intervention Acceptance

| Variable | Total (N=10,363), No. (%) | Accepted (N=8,829), No. (%)[a] | Rejected (N=1,534), No. (%)[a] | Univariate | | Multivariable[b] | |
|---|---|---|---|---|---|---|---|
| | | | | Odds Ratio (95% CI) | *P* Value | Odds Ratio (95% CI) | *P* Value |
| **Clinician gender** | | | | | | | |
| Cisfemale | 7843 (75.7) | 6782 (86.5) | 1,061 (13.5) | Reference | | Reference | |
| Cismale | 2520 (24.3) | 2047 (81.2) | 473 (18.8) | 0.77 (0.52–1.14) | .19 | 0.82 (0.53–1.28) | .39 |
| **Profession** | | | | | | | |
| Pharmacist | 9429 (91.0) | 8,060 (85.5) | 1,369 (14.5) | Reference | | Reference | |
| Pharmacy student | 21 (0.2) | 18 (85.7) | 3 (14.3) | 1.03 (0.69–1.56) | .88 | 0.52 (0.35–0.77) | .001 |
| Physician | 913 (8.8) | 751 (82.3) | 162 (17.7) | 0.85 (0.52–1.41) | .54 | 0.77 (0.49–1.21) | .25 |
| **ASP staff** | | | | | | | |
| ASP | 9,034 (87.2) | 7,686 (85.1) | 1,348 (14.9) | Reference | | Reference | |
| Non-ASP | 1,329 (12.8) | 1,143 (86.0) | 186 (14.0) | 1.27 (0.85–1.88) | .25 | 1.57 (1.06–2.32) | .025 |
| **ICU** | | | | | | | |
| No | 8,501 (82.0) | 7,373 (86.7) | 1,128 (13.3) | Reference | | Reference | |
| Yes | 1,862 (18.0) | 1,456 (78.2) | 406 (21.8%) | 0.56 (0.45–0.70) | <.001 | 0.57 (0.47-0.68) | <.001 |
| **Age** | | | | | | | |
| Pediatric (<18 y) | 279 (2.7) | 247 (88.5) | 32 (11.5%) | 0.87 (0.54–1.40) | .57 | 0.99 (0.45–2.17) | .97 |
| Adult (≥18 y) | 10,084 (97.3) | 8,582 (85.1) | 1,502 (14.9) | Reference | | Reference | |
| **Patient gender** | | | | | | | |
| Female | 4,537 (43.8) | 3,857 (85.0) | 680 (15.0) | Reference | | Reference | |
| Male | 5,826 (56.2) | 4,972 (85.3) | 854 (14.7) | 1.04 (0.95–1.14) | .38 | 1.06 (0.96–1.16) | .26 |
| Charlson comorbidity index, median (IQR) | 0 (0–5) | 0 (0–6) | 0 (0, 4) | 1.02 (1.00–1.04) | .026 | 1.02 (1.00–1.03) | .050 |

Note. APP, advanced practice provider; ASP, antimicrobial stewardship program; ICU, intensive care unit.
[a]Row %.
[b]Multivariable model was also adjusted for day of week, time of day, and rule category.

patient's therapy ($P < .001$), but both types of staff relied on direct communication as their primary ommunication method. Physicians were more likely than pharmacists to utilize asynchronous communications as a communication method ($P < .001$). Pediatric interventions were less likely to be conducted via asynchronous route compared to direct communication than adult interventions ($P < .001$) (Table 3).

### *Intervention outcome documentation*

In total, 10,363 interventions had a documented outcome and 6,878 were left undetermined. Physicians and non-ASP staff were significantly less likely to document an intervention outcome than pharmacists and pharmacy students ($P < .001$) (Table 4).

## Discussion

To our knowledge, this is the largest study to date evaluating the acceptance of antimicrobial stewardship interventions based on gender of the recommending clinician. This study evaluated 81,927 antimicrobial stewardship rule reviews performed by 143 staff and found no difference between acceptance of interventions based on the intervener's gender (female or male). This finding contrasts with the study results of Vaughn et al,[7] in which female clinical pharmacist recommendations were less likely to be accepted by hospitalists. This study was limited to 12 female pharmacists and 8 male pharmacists performing only transitions-of-care antibiotic time-outs.[7] Despite improvements in gender disparity in healthcare, women continue to experience gender bias in the workforce.[11–13] The results of our study showing no gender bias in acceptance rates of antimicrobial stewardship recommendations may be multifactorial. Our ASP is well established, with >15 years of existence at the flagship site and a positive reputation and rapport with primary services. Additionally, most interveners (58.9%) and interventions (75.7%) were conducted by female staff. We are optimistic that there continues to be an improvement in decreasing gender bias among healthcare workers, but we acknowledge that much work remains.

The results of the study by Vaughn et al[7] were particularly important because research evaluating gender bias in either pharmacist or antimicrobial stewardship interventions is limited.

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**Table 3.** Communication Method for Interventions

| Variable | Total (N=18,175), No. (%) | Change Made by Intervener (A) (N=935), No. (%)[a] | Direct Communication (B) (N=11,569), No. (%)[a] | Asynchronous (C) (N=5,671), No. (%)[a] | A vs B *P* Value | A vs C *P* Value | B vs C *P* Value | A vs B Adjusted *P* Value[b] | A vs C Adjusted *P* Value[b] | B vs C Adjusted *P* Value[b] |
|---|---|---|---|---|---|---|---|---|---|---|
| **Clinician gender** | | | | | .65 | .65 | .99 | .74 | .74 | .74 |
| Cisfemale | 12,680 (69.8) | 790 (6.2) | 8,470 (66.8) | 3,420 (27.0) | | | | | | |
| Cismale | 5,495 (30.2) | 145 (2.6) | 3,099 (56.4) | 2,251 (41.0) | | | | | | |
| **Profession** | | | | | | | | | | |
| APP | 13 (0.1%) | 1 (7.7) | 12 (92.3) | 0 (0.0) | . . . | . . . | . . . | . . . | . . . | . . . |
| Pharmacist | 15,196 (83.6) | 926 (6.1) | 9,925 (65.3) | 4,345 (28.6) | Ref | Ref | Ref | Ref | Ref | Ref |
| Pharmacy student | 31 (0.2) | 0 (0.0) | 31 (100.0) | 0 (0.0) | . . . | . . . | . . . | . . . | . . . | . . . |
| Physician | 2,935 (16.1) | 8 (0.3) | 1,601 (54.5) | 1,326 (45.2) | <.001 | <.001 | .006 | .096 | <.001 | .096 |
| **ASP staff** | | | | | .63 | .63 | .67 | .33 | .53 | .33 |
| ASP | 14,699 (80.9) | 868 (5.9) | 9,191 (62.5) | 4,640 (31.6) | | | | | | |
| Non-ASP | 3,476 (19.1) | 67 (1.9) | 2,378 (68.4) | 1,031 (29.7) | | | | | | |
| **ICU** | | | | | .57 | .81 | .28 | .009 | .65 | .10 |
| No | 14,514 (79.9) | 829 (5.7) | 8,996 (62.0) | 4,689 (32.3) | | | | | | |
| Yes | 3,661 (20.1) | 106 (2.9) | 2,573 (70.3) | 982 (26.8) | | | | | | |
| **Age** | | | | | .99 | .024 | <.001 | .96 | .96 | .96 |
| Pediatric (<18 y) | 465 (2.6) | 21 (4.5) | 419 (90.1) | 25 (5.4) | | | | | | |
| Adult (≥18 y) | 17,710 (97.4) | 914 (5.2) | 11,150 (63.0) | 5,646 (31.9) | | | | | | |
| **Patient gender** | | | | | .94 | .94 | .69 | .97 | .66 | .97 |
| Female | 7,908 (43.5) | 414 (5.2) | 4,948 (62.6) | 2,546 (32.2) | | | | | | |
| Male | 10,266 (56.5) | 521 (5.1) | 6,621 (64.5) | 3,124 (30.4) | | | | | | |
| Charlson comorbidity index, median (IQR) | 0 (0–6) | 0 (0–6) | 0 (0–5) | 0 (0–6) | .99 | .45 | .33 | .12 | .24 | .24 |

Note. APP, Advanced practice provider; ASP, antimicrobial stewardship program; ICU, intensive care unit.

[a]Row %.

[b]Model included clinician gender, profession, ASP staff, if the patient was in the ICU, patient age, patient gender, and patient Charlson comorbidity index and was also adjusted for rule category, day of week, time of day.

**Table 4.** Interventions Outcome Documentation

| Variable | Total (N=17,241), No. (%) | Completed (N=10,363), No. (%)[a] | Undetermined (N=6,878), No. (%)[a] | Univariate | | Multivariable[b] | |
|---|---|---|---|---|---|---|---|
| | | | | Odds Ratio (95% CI) | *P* Value | Odds Ratio (95% CI) | *P* Value |
| **Clinician gender** | | | | | | | |
| Cisfemale | 12,212 (70.8) | 7,843 (64.2) | 4,369 (35.8) | Reference | | Reference | |
| Cismale | 5,029 (29.2) | 2,520 (50.1) | 2,509 (49.9) | 0.99 (0.66–1.51) | .98 | 1.17 (0.76–1.81) | .47 |
| **Profession** | | | | | | | |
| APP | 2 (0.0) | 0 (0.0) | 2 (100.0) | . . . | | . . . | |
| Pharmacist | 14,531 (84.3) | 9,429 (64.9) | 5,102 (35.1) | Reference | | Reference | |
| Pharmacy student | 29 (0.2) | 21 (72.4) | 8 (27.6) | 3.31 (1.08–10.17) | .037 | 3.43 (0.89–13.16) | .073 |
| Physician | 2,679 (15.5) | 913 (34.1) | 1,766 (65.9) | 0.44 (0.28–0.68) | <.001 | 0.41 (0.25–0.68) | <.001 |
| **ASP staff** | | | | | | | |
| ASP | 14,431 (83.7) | 9,034 (62.6) | 5,397 (37.4) | Reference | | Reference | |
| Non-ASP | 2,810 (16.3) | 1,329 (47.3) | 1,481 (52.7) | 1.69 (1.08–2.64) | .022 | 1.55 (0.96–2.50) | .074 |
| **ICU** | | | | | | | |
| No | 13,764 (79.8) | 8,501 (61.8) | 5,263 (38.2) | Reference | | Reference | |
| Yes | 3,477 (20.2) | 1,862 (53.6) | 1,615 (46.4) | 0.91 (0.83–1.00) | .042 | 0.92 (0.83–1.01) | .069 |
| **Age** | | | | | | | |
| Pediatric (<18 y) | 455 (2.6) | 279 (61.3) | 176 (38.7) | 1.05 (0.51–2.15) | .90 | 1.02 (0.49–2.12) | .96 |
| Adult (≥18 y) | 16,786 (97.4) | 10,084 (60.1) | 6,702 (39.9) | Reference | | Reference | |
| **Patient gender** | | | | | | | |
| Female | 7,519 (43.6) | 4,537 (60.3) | 2,982 (39.7) | Reference | | Reference | |
| Male | 9,721 (56.4) | 5,826 (59.9) | 3,895 (40.1) | 1.00 (0.94–1.06) | .87 | 1.00 (0.94–1.07) | .97 |
| Charlson comorbidity index, median (IQR) | 0 (0–6) | 0 (0–5) | 0 (0–6) | 0.99 (0.98–1.00) | .27 | 0.99 (0.98–1.00) | .20 |

Note. APP, advanced practice provider; ASP, antimicrobial stewardship program; ICU, intensive care unit.
[a]Row %.
[b]Model included clinician gender, profession, ASP staff, and was also adjusted for rule category, day of week, time of day, if the patient was in the ICU, patient age, patient gender, and patient Charlson comorbidity index.

In this study, there was no difference in intervention acceptance based on intervener's profession; however, pharmacists documented their intervention outcome more frequently compared to physicians. ASP staff documented intervention outcomes more often than non-ASP staff. This could reflect different levels of commitment to finalizing documentation in the antimicrobial stewardship tool, variation in the confidence level of the intervener regarding the acceptance of their intervention, or pharmacists acting directly to make changes to antimicrobial orders. However, the statistical limitations of these comparisons are notable because only 35 physicians and 31 ASP staff were included in the study.

Based on previous evidence, women have been identified to have an indirect, more tentative communication style compared to men.[14,15] From these historical rhetoric and data, it could be hypothesized that females would be more likely to send an email or place a recommendation in an in-basket as a more tentative communication approach versus direct communication. However, this was not the case in our study, and communication methods were not different based on gender.

Across a variety of disease states, male patients have been shown to receive better care than female patients.[16–18] In our study, more rules were reviewed for male patients (male, 57.4%, female 42.6%), but the clinician intervened more often for female patients. It is unclear whether these male-to-female rule proportions follow the gender split of hospitalized patients during the study timeframe, which could be an influencing factor on number of rules per gender. Regardless, this result does raise awareness of possible patient gender bias in antimicrobial stewardship interventions and the need for more studies.

We identified a significantly lower rate of antimicrobial stewardship intervention acceptance when the patient was ICU status as opposed to general floor status (78.2% vs 86.7%). Stewardship interventions in the ICU setting are known to be challenging owing to the critical status of the patients and caution of primary ICU providers.[19] A review of general pharmacist interventions in a hospital setting identified that interventions made through verbal as opposed to electronic communication were 27.7% more likely to be accepted.[20] In terms of ICU

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antimicrobial stewardship specifically, higher rates of intervention acceptance occur when stewardship teams interact with the ICU team in person and on a regular basis.[21] Because our antimicrobial stewardship intervention communication methods have an appreciable electronic component, including when directly communicating via EHR messaging feature, the lack of face-to-face or direct verbal communication with teams could have hampered success in ICU patients.

This study had several limitations. The first limitation was that intervener gender was identified by perceived gender based on appearance and name by the authors. This does not account for individuals' gender identity. The most accurate avenue of gender identification would be a survey asking clinicians their gender identity; however, in this study, the volume of individuals involved from multiple sites over a long timeframe would make a survey extremely logistically challenging. Additionally, our data lacked identification of any relevant information, including gender, practice specialty or professional role, of the clinician accepting or rejecting the recommendation. Since other studies have found a difference in antimicrobial stewardship intervention acceptance rate based receiving clinician gender,[6,7] it is unknown whether gender or other characteristics of the receiving clinicians affected intervention acceptance rates. This is an area for future focus to expand knowledge on how the receiving clinician impacts antimicrobial stewardship interventions. Furthermore, future studies exploring the intersectionality of gender and profession and potential influence of telehealth are needed. Despite these limitations, our study is the largest to date antimicrobial stewardship intervention acceptance by gender, and one of the few studies evaluating outcomes of pharmacist interventions based on gender.

Female and male clinicians were equally effective at prospective audit and feedback in a multisite antimicrobial stewardship program. Patients in the ICU were less likely to have antimicrobial stewardship interventions accepted.

**Supplementary material.** To view supplementary material for this article, please visit https://doi.org/10.1017/ice.2023.93

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