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Original Article

Exploring unconventional antimicrobial stewardship models: options beyond traditional prospective audit and feedback

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Abstract

Background: Prospective audit and feedback (PAF) is a core antimicrobial stewardship strategy. Discontinuing PAF in favor of alternative interventions has not been previously evaluated.

Methods: This descriptive study assessed changes in antimicrobial days of therapy per 1,000 patient days (DOTs/1,000 PD) following PAF removal at two urban hospitals. Preintervention PAF included daily review of broad-spectrum antibiotics and oral therapy transitions. Postintervention efforts emphasized system standardization, education, guideline optimization, and electronic medical record enhancements. Secondary outcomes included trends in antibiotics previously reviewed under PAF: antibiotics targeting methicillin-resistant *Staphylococcus aureus* (MRSA) or *Pseudomonas aeruginosa*, carbapenems, and oral antibiotics.

Results: Hospital A demonstrated a change in the trend of DOTs/1,000 PD with a significant downward slope after PAF removal (−5.994; 95% CI −8.072 to −3.929; P < .001). Hospital B continued to down-trend postintervention. At hospital A, carbapenem use decreased significantly postintervention (slope change −0.117; 95% CI −0.198 to −0.036; P = .007), with no changes in anti-MRSA or anti-pseudomonal agents. Hospital B demonstrated increasing use of anti-MRSA (slope change + 0.394; 95% CI 0.198 to 0.589; P < .001), anti-pseudomonal (slope change + 0.378; 95% CI 0.075 to 0.681; P = .016), and carbapenem agents (slope change + 0.124; 95% CI 0.020 to 0.228; P = .021). No changes were observed in oral antibiotic use or C. difficile rates.

Conclusion: Shifting stewardship resources away from PAF did not increase total antibiotic use trends. Broad-spectrum antibiotics increased modestly with unclear clinical significance (≤1.3 DOT/1,000 PD). Antimicrobial stewardship strategies, beyond PAF, should continue to be assessed to maximize effectiveness relative to effort.

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Background

Prospective audit and feedback (PAF), recognized as a "priority intervention" by the CDC for hospital antimicrobial stewardship programs (ASPs), involves reviewing antimicrobial prescriptions for appropriateness and advising prescribers on optimizing use.[1] Despite what the name suggests, it is often a retrospective process performed after antimicrobials have been prescribed and administered to hospitalized patients.[2] This work is often completed by a specialized pharmacist with infectious diseases (ID) training or another member of the ASP. PAF typically includes review of patients receiving broad-spectrum agents, specifically those targeting methicillin-resistant *Staphylococcus aureus* (MRSA) (eg, vancomycin, linezolid), *Pseudomonas aeruginosa* (eg, anti-pseudomonal beta-lactams, fluoroquinolones), and ESBL-producing organisms (eg, carbapenems).[3] State boards of pharmacy require pharmacists to ensure that medications prescribed in hospitals are safe and appropriate before administration. In addition to this, the expansion of clinical pharmacy services in the United States means that hospital-based pharmacists routinely provide clinical care, with medication review occurring daily for most hospitalized patients.[4,5] As a result, subsequent PAF processes by ASPs may constitute redundant work.

PAF has demonstrated effectiveness in decreasing antimicrobial[3] use but is inherently time-consuming and duplicative in nature. Despite these drawbacks, the use of PAF was given a strong recommendation in the 2016 Infectious Diseases Society of America and Society for Healthcare Epidemiology of America guidelines and has since become a central component of most ASPs.[2,6–9] Defining optimal ASP strategies is key to determining effective ID pharmacist staffing ratios, as these depend on program workload and desired outcomes. Using a limited resource (eg, ID pharmacists) to complete time-consuming work on individual admitted patients that are already being reviewed by other

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clinicians may not be efficient. We posit that this time could be better spent educating and supporting the clinicians already doing this work, standardizing care across health systems, gathering meaningful data and strategically developing new initiatives that address known issues. This has the potential to expand ASP reach without adding resources.

The aim of this study is to describe the effect of PAF removal from ASP workflows at two urban hospitals to allow adequate protected time for standardization, collaboration and educational initiatives with the hypothesis that overall antimicrobial use would not be negatively affected given the alternative strategies aimed at improving antimicrobial use.

Methods

This was a pre, post descriptive study comparing 18 months before (September 2021–February 2023) and 18 months after (March 2023–August 2024) removal of PAF from 2 large hospitals within an 8-hospital health system.

Setting

Two community-based teaching hospitals were chosen because they were the only hospitals within the health system with dedicated antimicrobial stewardship pharmacist resources and those resources were mainly being used to perform PAF. Each hospital had a dedicated full-time ID/ASP pharmacist, supported by a small amount of ID physician time at hospital B only (0.1 FTE or 4 hours per week) for PAF. The approximate number of staffed hospitals beds included 420 beds at hospital A and 450 beds at hospital B. Both hospitals have clinical pharmacists assigned to each clinical service who provide medication review services to hospitalized patients daily. Hospital A has 42 ICU beds and provides medical and surgical services. Hospital B is a level 1 trauma center, with 46 ICU beds, offering extracorporeal membrane oxygenation (ECMO), medical and surgical services. Hospital B also has a burn unit and special care nursery unit. Each hospital has a separate ID department that offers in person consultation services. There are approximately 6 full-time ID physicians at hospital A with 2 physicians available for hospital consults daily and 7 ID physicians at Hospital B with 3–4 available for consults daily.

Intervention

In March of 2023, the 2 full-time hospital-based ID pharmacists shifted from PAF-based ASP model to a system-based model and the 0.1 FTE of physician time that had supported PAF interventions was re-allocated to other activities within the ID department. This decision was driven by hospital-based ID pharmacists' concerns regarding limited capacity to devote sufficient time to policy improvement, electronic medical record optimization, standardization, and educational efforts. Preintervention, ID pharmacists worked independently at their respective hospitals to review patients on broad-spectrum antibiotics generated from lists in the electronic medical record and performing intravenous to oral therapy transitions. EPIC Systems Corporation was used as the electronic medical record across all hospitals throughout the study duration and was used to generate broad-spectrum antibiotics lists for review. Broad-spectrum antibiotics included vancomycin, linezolid, and daptomycin, piperacillin-tazobactam, cefepime, ceftazidime, levofloxacin, ciprofloxacin, meropenem, and imipenem, and ertapenem. PAF was performed daily by ID pharmacists during daytime weekdays hours and included patients in all units of each hospital. PAF was completed independently by the ID pharmacist daily at hospital A. ID physicians (0.1 FTE) supported PAF processes at hospital B. The ID pharmacist at Hospital B would identify patients requiring interventions and review those patients with ID physicians prior to making any recommendations to the patients' primary care teams. There were no changes in the PAF or general antimicrobial stewardship approach during the preintervention phase. There were no notable process changes, changes to computerized physician order entry, or other initiatives that would be expected to significantly influence antibiotic use. In the postintervention phase, the ID pharmacists worked collaboratively to improve system standardization, electronic medical record enhancements such as order set development, diagnostic stewardship, staff education, and guideline and clinical resource creation. A list of distinct antimicrobial stewardship activities performed by both pharmacists, collaboratively, is included in Supplemental Table 1.

Outcomes

The primary outcome was days of antimicrobial therapy per 1,000 patient days (DOTs/1,000 PD) which included all systemic antibiotics, antifungals, and antiviral agents. Mental health, obstetrics, and rehabilitation units were excluded from all analyses due to their low rates of antimicrobial utilization and the potential for disproportionate augmentation of patient-day counts and align with national reporting comparisons.[10] Secondary outcomes assessed changes in broad-spectrum antibiotic classes that had previously been reviewed under PAF: antibiotics targeting MRSA (vancomycin, linezolid, and daptomycin), antibiotics targeting *Pseudomonas aeruginosa* (piperacillin-tazobactam, cefepime, ceftazidime, levofloxacin, ciprofloxacin, meropenem, and imipenem) and carbapenems (ertapenem, meropenem, and imipenem). Oral therapy DOTs were assessed by comparing percentages of oral antimicrobials used (oral to total DOTs). Hospital-onset *Clostridioides difficile* infection rates per 10,000 patient days were assessed as a balancing measure.

Evaluation

An interrupted time-series analysis was used to evaluate changes in monthly antimicrobial utilization associated with the intervention. For each outcome, data were converted into monthly time points and ordered chronologically. The intervention date was defined a priori as March 1, 2023. A segmented regression model was used to estimate whether the postintervention trend differed from the preintervention trajectory. Models were estimated using ordinary least squares. For each model, we report the postintervention immediate change and slope-change estimates with corresponding 95% confidence intervals and two-sided p-values. Analyses were performed separately for hospital A and hospital B using identical parameterization to ensure comparability across all stewardship metrics.

Results

At hospital A, the total DOTs per 1,000 patient days were 447.5 before the intervention and 457.4 after, while at hospital B, they were 353.8 before and 328.1 after the intervention. Antimicrobial DOTs/1,000 PD and oral antimicrobial use are described in Table 1.

A change in the direction of antimicrobial DOTs/1,000 PD at hospital A was observed postintervention with a shift from an

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Table 1. Changes in antimicrobial use and *C. difficile* pre-and post-intervention

Outcome	Pre	Post	Immediate change (95% CI)	*P* value	Slope change (95% CI)	*P* value
DOTs/1000 patient days						
Hospital A	447.5	457.2	−7.236 (−28.744, 14.273)	.498	−5.994 (−8.072, −3.929)	<.001
Hospital B	353.8	328.1	−9.019 (−25.873, 7.835)	.284	+0.039 (−1.583, 1.667)	.956
Anti-MRSA DOTs/1000 patient days						
Hospital A	12.9	11.8	−1.056 (−2.851, 0.739)	.240	−0.073 (−0.247, 0.101)	.391
Hospital B	19.6	20.9	1.202 (−0.817, 3.221)	.234	+0.394 (0.198, 0.589)	<.001
Anti-Pseudomonas DOTs/1000 patient days						
Hospital A	24.5	23.1	−1.414 (−3.988, 1.160)	.272	−0.061 (−0.305, 0.183)	.654
Hospital B	28.5	28.7	+0.238 (−2.923, 3.399)	.876	+0.378 (0.075, 0.681)	.016
Carbapenem DOTs/1000 patient days						
Hospital A	4.5	4.4	−0.852 (−1.684, −0.020)	.046	−0.117 (−0.198, −0.036)	.007
Hospital B	4.0	4.6	+1.106 (0.062, 2.150)	.039	+0.124 (0.020, 0.228)	.021
Percent of Oral DOTs						
Hospital A	23.8%	23.3%	−1.368 (−3.061, 0.325)	.110	−0.092 (−0.254, 0.070)	.262
Hospital B	31.6%	34.1%	+0.731 (−2.238, 3.701)	.620	+0.113 (−0.176, 0.402)	.437
Hospital-onset *C.difficile* Infections per 10,000 patient days						
Hospital A	1.9	2.2	+1.275 (−0.664, 3.214)	.188	+0.085 (−0.098, 0.268)	.345
Hospital B	1.8	2.9	+0.274 (−1.163, 1.711)	.702	+0.043 (−0.090, 0.176)	.518

DOT = Days of Antibiotic Therapy.

upward trend preintervention to a significant downward trend postintervention (slope change −5.994; 95% CI −8.072 to −3.929; $P < .001$) (Figure 1). At hospital B, there was a continued downward trend in antimicrobial DOTs/1,000 PD postintervention (slope change + 0.039; 95% CI −1.583 to 1.667; $P = .956$) (Figure 1).

There were no statistically significant differences in anti-MRSA or anti-pseudomonal antibiotics at hospital A but a significant reduction in carbapenem use was observed postintervention (slope change −0.117; 95% CI −0.198 to −0.036; $P = .007$) (Figure 2). Only hospital B observed increases in broad-spectrum antibiotic use postintervention, with a significant change in anti-MRSA antibiotics (slope change + 0.394; 95% CI 0.198 to 0.589; $P < .001$), anti-pseudomonal antibiotics (slope change + 0.378; 95 CI 0.075, 0.681; $P = .016$), and carbapenems (slope change + 0.124; 95% CI 0.020, 0.228; $P = .021$) (Figure 3). Crude increases in broad-spectrum antibiotics were all less than or equal to 1.3 DOT/1,000 PD (Table 1).

Percentages of oral antimicrobial use and hospital-onset *C. difficile* rates did not demonstrate a significant change between study periods (Table 1). Standardized Antimicrobial Administration Ratio (SAAR) values remained less than 1 for the duration of the study period (Supplemental Figure 1).

Discussion

The removal of PAF at two urban hospitals did not result in a significant rise in antimicrobial use. Despite a small increase of 9.7 DOTs/1,000 PD at hospital A over the postintervention time-period, both hospitals continued to trend down postintervention. Negligible increases in broad-spectrum antibiotic utilization were observed, the magnitude and direction of these changes differed between hospitals. These findings may be explained by the change in ID pharmacists' activities, given the removal of daily broad-spectrum antibiotic monitoring. Importantly, the increases in broad-spectrum use did not appear to negatively affect overall trends in antimicrobial use which may have been offset by the benefits of other stewardship interventions, including order set optimization, provider education, and guideline development.

It is important to note that PAF continued to occur at the point of care through routine clinical pharmacy services across all inpatient units and services daily. These findings reflect the removal of formal ASP-led PAF strategies rather than complete elimination of daily antibiotic prescription review.

PAF remains one of the most commonly implemented ASP strategies, with PAF being conducted in 93% of programs.[9] Numerous studies in adult and pediatric populations have demonstrated associations between PAF and reductions in antibiotic use, including shorter durations of therapy and earlier de-escalation of broad-spectrum antibiotics.[1,3,7] For example, a prepost study assessing the impact of PAF on de-escalation of anti-MRSA agents, observed a 1-day reduction in median time to de-escalation.[12] Notably, these studies evaluated PAF in conjunction with newly implemented programs or additional ID pharmacist resources. Although it is reasonable to conclude that PAF improves antibiotic utilization compared to the absence of such interventions, it remains unclear whether it should be the primary strategy to sustain program objectives in mature ASPs. It is possible that focusing solely on historical practices may restrict innovation and undervalue the broader contributions of ID pharmacists.

Despite the demonstrated benefits of PAF on antibiotic discontinuation and deescalation, it is widely recognized as a resource-intensive for ASPs that are consistently reported to be understaffed.[13,14] In one study, only 24% of chart reviews resulted

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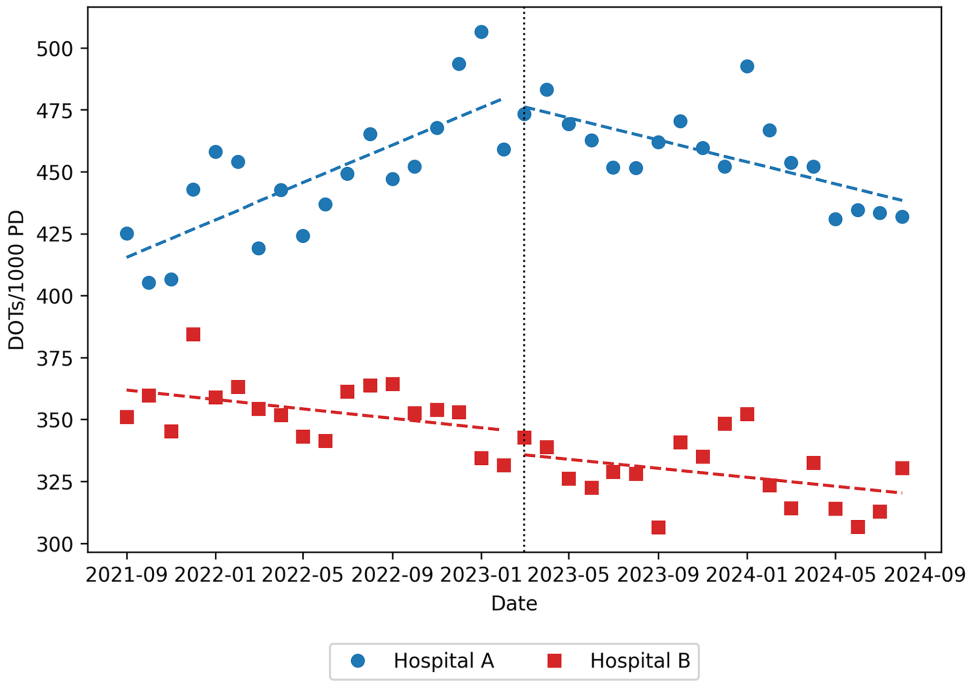


Figure 1. Trends in monthly days of antibiotic therapy per 1,000 patient days pre and post intervention.

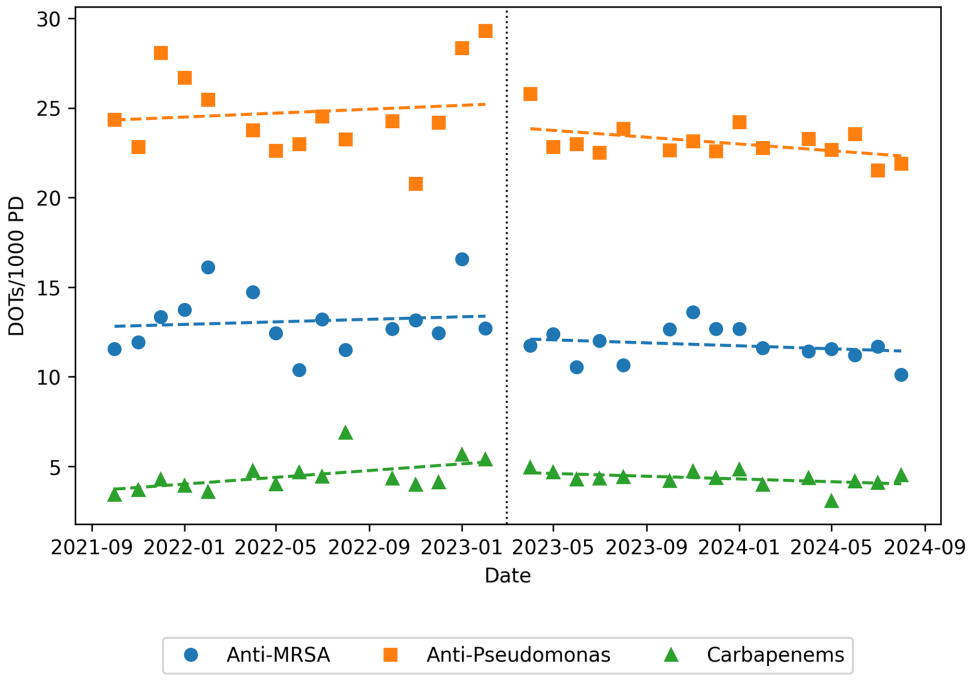


Figure 2. Trends in broad spectrum antibiotic use pre and post intervention at hospital A.

in an actionable intervention, highlighting the inefficiency of this intervention.[8] Likewise, a recent randomized trial evaluated an ASP-led opt-out de-escalation strategy for patients with sepsis.[15] In this trial, 9,440 patients were screened using a 23-point safety checklist, yet only 8% met criteria to proceed with the intervention. Among the 358 intervention cases, antibiotics were discontinued in only 59 cases (15%) despite direct contact from the ASP for each individual patient. Although the authors are to be commended for their rigorous methodology, this outcome raises room for discussion regarding the opportunity costs of PAF. Lastly, the impact of PAF is limited to the patients that undergo chart review and does not generally extend to patients outside the PAF workflow, demonstrating areas of opportunity that remain unaddressed by PAF.[16]

To our knowledge, no research has examined the withdrawal of PAF by ASP members in favor of alternative strategies designed to enhance program visibility, prescriber support, pharmacist education, or other related measures. Emerging tools, including artificial intelligence (AI), have the potential to influence stewardship practice by providing patient-specific recommendations

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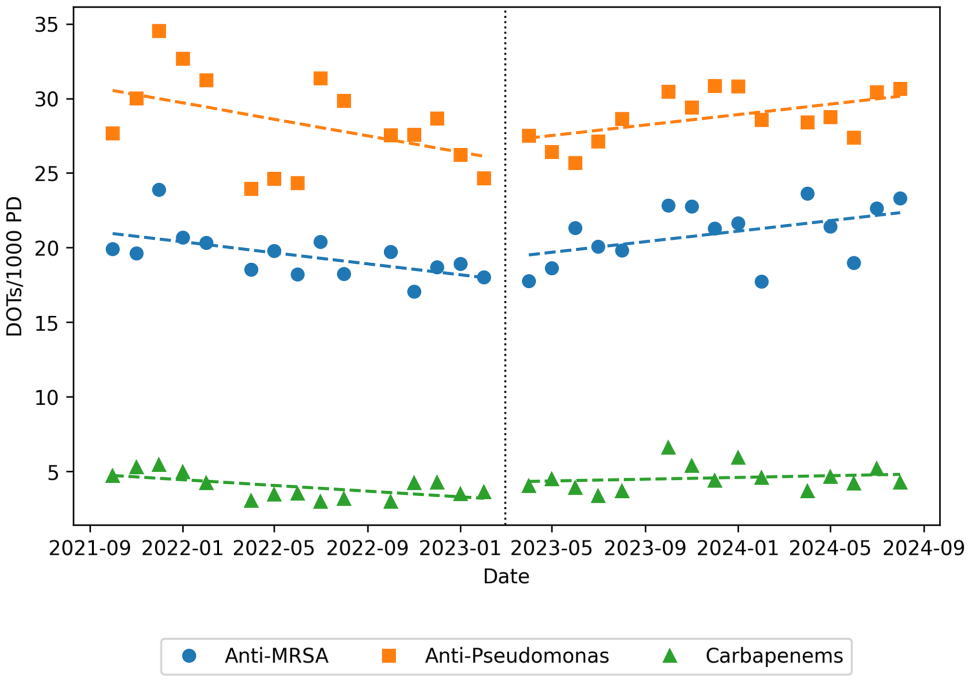


Figure 3. Trends in broad spectrum antibiotic use pre and post intervention at hospital B.

and comparing prescribing practices against internal guidelines.[17] These tasks demand ASP staff time, which may be lacking in programs with conventional PAF models.

This descriptive study has several limitations. Mainly, antibiotic use is affected by various, complex confounding factors such as the covid-19 pandemic, evolving prescribing culture, seasonal disease patterns, and more.[18–20] Secular trends and concurrent institutional priorities represent important sources of potential confounding. Given the multifaceted nature of antimicrobial stewardship, including several guideline updates, education, electronic medical record enhancements, and evolving quality initiatives, it is not possible to isolate the effect of discontinuing PAF from these broader influences. It is possible that the observed trends in antibiotic use may have been influenced by these confounders, or that antibiotic may have been driven even lower had PAF continued. Our findings should be interpreted as descriptive rather than causal, reflecting real-world antibiotic use patterns during a system-level stewardship transition.

Second, antibiotic use metrics are imperfect. Although DOTs/1,000 PD is commonly used in hospitals to measure antibiotic use, it has limitations in assessing the effectiveness of ASPs. This metric does not reflect the multitude of ways ASPs enhance patient care, such as by optimizing dosage, increasing antibacterial effectiveness, minimizing adverse reactions, or ensuring appropriate therapy durations. Since antibiotics are a vital component of the treatment of hospitalized patients with bacterial infections, it can be difficult to identify optimal targets and large, non-specific reductions have the potential to cause patient harm. The National Healthcare Safety Network's SAAR compares observed to expected antibiotics use across facilities.[10] A SAAR value is generated for total antibiotic use and specific antibiotic classes. Keeping this ratio under one can serve as an ASP target to ensure use remains within the expected range. Both hospitals A and B maintained SAAR values less than one, for overall antimicrobial use and broad-spectrum classes throughout the duration of the study. While this is reassuring, there are still limitations with observing and trending the SAAR. SAAR values observed in the postpandemic period warrants caution given these benchmarks remain influenced by pandemic-related changes in patient acuity, ICU capacity, diagnostic uncertainty, and care delivery models.[21–24] Although antibiotic use has declined from pandemic peaks, national data indicate that utilization patterns have not fully returned to pre-pandemic distributions. In addition to the limitations on antibiotic use metrics, *C. difficile* infection rates may not represent an optimal balancing metric due to the low sensitivity, and influence from multiple confounding factors.[25]

It remains unclear whether PAF should continue to be used as a core strategy to reduce or maintain reductions in antibiotic use. Discontinuing PAF and reallocating ID pharmacist time may confer advantages that are difficult to quantify such as increased visibility among hospital leaders, enhanced collaboration with physician or other departments, and protected time necessary to effectively collect, analyze and communicate improvements in patient care. Collectively, these advantages may strengthen and expand long-term impact of ASPs.

Conclusion

Down-ward trends in antimicrobial DOTs/1,000 PD were observed after removal of PAF from ASP workflows. These data support the exploration of alternative ASP models at institutions with low SAAR values (<1) to achieve similar goals and may guide future research in this area. Although variable effects on broad-spectrum antibiotic classes were observed between hospitals, the clinical significance of this is questionable given the negligible increase in DOTs (≤1.3 DOTs/1,000 PD) and maintenance of optimal SAAR values. Future studies should continue to seek alternative practice models that optimize ID pharmacist time and improve patient care. Investments in standardization, guideline development, and electronic health record enhancements may ultimately yield greater benefits over time than traditional, labor-intensive PAF review processes.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/ice.2026.10500.

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