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MAJOR ARTICLE

Development of a Centralized Antimicrobial Stewardship Program Across a Diverse Health System and Early Antimicrobial Usage Trends

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Background. Expanding antimicrobial stewardship to community hospitals is vital and now required by regulatory agencies. UPMC instituted the Centralized Health system Antimicrobial Stewardship Efforts (CHASE) Program to expand antimicrobial stewardship to all UPMC hospitals regardless of local resources. For hospitals with few local stewardship resources, we used a model integrating local non-Infectious Diseases (ID) trained pharmacists with centralized ID experts.

Methods. Thirteen hospitals were included. Eleven were classified as robust (4) or nonrobust (7) depending on local stewardship resources and fulfillment of Centers for Disease Control and Prevention core elements of hospital antimicrobial stewardship. In addition to general stewardship oversight at all UPMC hospitals, the centralized team interacted regularly with nonrobust hospitals for individual patient reviews and local projects. We compared inpatient antimicrobial usage rates at nonrobust versus robust hospitals and at 2 UPMC academic medical centers.

Results. The CHASE Program expanded in scope between 2018 and 2020. During this period, antimicrobial usage at these 13 hospitals decreased by 16% with a monthly change of −4.7 days of therapy (DOT)/1000 patient days (PD) (95% confidence interval [CI], −5.5 to −3.9; $P < .0001$). Monthly decrease at nonrobust hospitals was −3.3 DOT/1000 PD per month (−4.5 to −2.0, $P < .0001$), similar to rates of decline at both robust hospitals (−3.3 DOT/1000 PD) and academic medical centers (−4.8 DOT/1000 PD) ($P = .167$).

Conclusions. Coordinated antimicrobial stewardship can be implemented across a large and diverse health system. Our hybrid model incorporating a central team of experts with local community hospital pharmacists led to usage decreases over 3 years at a rate comparable to that seen in larger hospitals with more established stewardship programs.

Keywords. antimicrobial stewardship; community hospitals; integrated health systems.

Antimicrobial stewardship programs (ASPs) are increasingly common, beginning initially at larger academic medical centers (AMCs) and now expanding to community hospitals of all sizes. Expansion in the United States has been fueled, in part, by regulatory requirements from the Centers for Medicare and Medicaid Services necessitating ASPs at all acute care hospitals, including critical access hospitals [1]. Federal agencies and professional societies have developed guidance for ASPs [2, 3]. Although specific Infectious Diseases (ID) and antimicrobial stewardship (AS) training is not required, recommendations are that physicians and pharmacists with formal training and experience in these fields lead such programs [1, 4]. More specifically, ID practitioner involvement with an ASP has been associated with improved outcomes [5].

Antimicrobial overuse occurs at hospitals of all sizes, including smaller community hospitals [6]. However, limited availability of ID physicians and pharmacists is a barrier to establishing ASPs at smaller community hospitals [7]. Telemedicine can be valuable for hospitals without onsite access to ID expertise, and use of such teleservices for ASPs is endorsed [4]. Although recent studies show beneficial outcomes with tele-ID and telestewardship care [8, 9], their impact on antimicrobial utilization requires further investigation. Furthermore, little is known about whether approaches proven impactful in AMCs lead to similar outcomes in smaller hospitals. A recent evaluation of AS approaches undertaken in community hospitals demonstrated success with prospective audit and feedback [10], but additional and larger studies are needed.

Consolidation of smaller community hospitals within larger health systems can provide access to ID expertise otherwise not usually available at smaller hospitals. Several health

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systems have reported their approach and initial results from implementing AS at a system-wide level [11–13]. Experts at Intermountain Healthcare demonstrated community hospital success by incorporating centralized ID involvement into daily AS activities at system hospitals [14, 15], whereas the Duke Antimicrobial Stewardship Outreach Network (DASON) demonstrated successful improvements in antimicrobial usage at community hospitals outside of a single health system through collaboration with their independent team of ID and AS experts [16]. However, given variability between health systems with regard to size, staffing, degree of centralized control and oversight, and individual hospital characteristics, further study is needed into best approaches for system-wide stewardship.

UPMC is a large health system providing care across 3 states at 40 hospital locations ranging from critical access hospitals to large general hospitals to AMCs caring for highly specialized patient populations. Hospital locations are primarily in western and central Pennsylvania with additional sites in New York and Maryland. In 2018, UPMC instituted a centralized AS oversight group, the Centralized Health system Antimicrobial Stewardship Efforts (CHASE) Program, to develop ASPs at its community hospitals. Before 2018, ASPs existed at larger UPMC hospitals but were rudimentary or lacking at many smaller or medium hospitals. The CHASE Program includes 1 ID physician (J.R.B.) and 1 ID pharmacist (T.M.K.) with dedicated time for AS activities (J.R.B., 70% effort; T.M.K., 80% effort). To balance the number and variety of UPMC hospitals and the relatively small staffing for CHASE, an integrated approach was developed for daily stewardship activities at smaller community hospitals that leveraged both the local clinical pharmacists at each hospital and the centralized ID and stewardship expertise of CHASE. In this study, we present the development of this program, its stages of growth, and trends of antimicrobial usage over time.

METHODS

This report describes CHASE's development and antimicrobial usage trends at 11 UPMC community hospitals (Table 1) connected through a shared electronic medical record (EMR) (Cerner, Kansas City, MO) between January 2018 and December 2020 and at 2 academic medical centers (AMC) with the same shared EMR. One AMC is a large urban hospital with a sizable solid organ transplant population whose ASP started in 2001, and the other is an urban hospital specializing in cancer treatment, including bone marrow transplants, whose ASP started in 2012. Both of these ASPs consisted of ID pharmacists with few duties beyond AS, ID physicians with significant involvement in the program, and support staff. Hospitals that joined UPMC after January 2018 or did not utilize the shared EMR for this entire period were not included.

Table 1. Characteristics of Included UPMC Hospitals Included in the CHASE Program

Hospital Number	Stewardship Program Grouping	Community Description[a]	Approximate Staffed Beds	Stewardship Pharmacist FTE	Stewardship Pharmacist FTE to Bed Ratio	ID Physician Involved in Stewardship	Met All CDC Core Elements	Primary Stewardship Technique
1	AMC	Large	688	3.5	1 FTE per 196 beds	Y	Y	PA
2	AMC	Large	450	2.0	1 FTE per 225 beds	Y	Y	PA
3	Robust	Large	392	1.25	1 FTE per 313 beds	Y	Y	PAF
4	Robust	Midsize	350	2.0	1 FTE per 175 beds	Y	Y	PA/PAF
5	Robust	Midsize	306	0.5	1 FTE per 612 beds	Y	Y	mID
6	Robust	Large	179	1	1 FTE per 179 beds	Y	Y	mID
7	Nonrobust	Midsize	346	.25	1 FTE per 1384 beds	N	N	PAF
8	Nonrobust	Midsize	176	.25	1 FTE per 704 beds	N	N	mID
9	Nonrobust	Midsize	155	.5	1 FTE per 310 beds	N	N	mID
10	Nonrobust	Small	128	.5	1 FTE per 256 beds	N	N	PAF
11	Nonrobust	Midsize	90	.5	1 FTE per 180 beds	N	N	PA/PAF
12	Nonrobust	Small	69	0	No local AS FTE	N	N	None
13	Nonrobust	Small	24	0	No local AS FTE	N	N	None

Abbreviations: AMC, academic medical center; AS, antimicrobial stewardship; CDC, Centers for Disease Control and Prevention; CHASE, Centralized Health system Antimicrobial Stewardship Efforts; ID, Infectious Diseases; FTE, full-time equivalent; PA, prior authorization; PAF, prospective audit and feedback; mID, mandatory Infectious Diseases consult.

[a]Large >90 000 population; midsize population 10 000–100 000; small population <10 000.

We classified the 11 community hospitals as either having robust or nonrobust local ASPs. Robust local ASPs had preexisting onsite ASPs that met all Centers for Disease Control and Prevention (CDC) core elements of hospital antimicrobial stewardship and included ID-trained pharmacists or other clinical pharmacists with experience and/or certificate training in AS. Most stewardship pharmacists at these hospitals were still responsible for other clinical duties unrelated to AS. Although ID physicians were available at all robust sites for ID consultations, ID physician involvement in daily AS activities at these hospitals was minimal and consisted mostly of attendance at meetings, approval of certain restricted antimicrobials, or infrequent assistance with local issues. For hospitals with robust ASPs and for AMCs, CHASE involvement starting in 2018 consisted mostly of external facilitation, data collection and analysis for these hospitals, and support when requested by local ASP teams.

Nonrobust local ASPs had minimal or no dedicated resources for stewardship activities and did not meet all CDC core elements of hospital antimicrobial stewardship prior to CHASE implementation in 2018. All clinical pharmacists at these hospitals had duties in addition to stewardship actions. None had any significant training or experience with AS. Although some nonrobust hospitals had ID physicians on staff, none had any ID physician involvement in stewardship activities. Three nonrobust hospitals had onsite ID physicians for consultations, 3 had ID consultation via telemedicine, and 1 had no ID consultation available. For nonrobust hospitals, CHASE interacted regularly with local pharmacists and providers for patient reviews via teleconference Monday through Friday. Nonrobust hospital pharmacists attended at their discretion and would identify patients for review with the central team at this teleconference. CHASE also assisted with monthly data collection and analysis. Local education, local policies, and AS initiatives, and discussions with individual local providers occurred as needed at these hospitals. For additional analyses, we classified these 11 community hospital ASPs based on community size (large, midsize, or small), relative hospital size within the UPMC system (large, medium, small), and by ratio of local stewardship pharmacists to number of staffed beds.

Facility-wide inpatient days of therapy (DOT) were calculated monthly for all systemic antimicrobials using information from our EMR and data warehouse. Inpatient locations and DOT were defined according to the CDC's National Healthcare Safety Network Antimicrobial Use and Resistance protocol [17]. Antimicrobial DOT were normalized per 1000 patient days (DOT/1000 PD) and are reported here as total antimicrobials, antibacterials, antifungals, or antivirals. Percentage change in DOT/1000 PD from the first 6 months to the last 6 months was calculated for each hospital and by antimicrobial category. Simple linear regression analyses were used to quantify the rate of change in antimicrobial use per month (slope) among all 13 hospitals and then stratified by ASP type (nonrobust, robust, AMC). Best-fit values of the slope, y-intercept, and associated 95% confidence intervals (CIs) were calculated along with *P* values where applicable. This report was observational in nature and not done in a randomized fashion. Statistical analysis was performed with GraphPad Prism version 9.1.0 for Windows (GraphPad Software, San Diego, CA). This report was prepared as part of ongoing UPMC Quality Improvement (Project 3653).

Patient Consent

No patient consent was obtained because this project was performed as part of an ongoing UPMC Quality Improvement project. Only aggregate antimicrobial usage was reviewed and included. No patient specific information was reviewed or recorded.

RESULTS

Development and Implementation of CHASE

Table 1 categorizes the ASPs, and Figure 1 shows the development of CHASE activities over time. Five of the 13 hospitals were located within the city of Pittsburgh, Pennsylvania. The average distance between Pittsburgh and the other 8 hospitals was 61 miles (range, 10–116 miles). After baseline assessments and gap analyses of UPMC community hospitals, initial CHASE activities included developing standardized measurement of inpatient antimicrobial usage at all hospitals, regular reporting of monthly usage to all hospitals, and pharmacist and provider education regarding AS. The CHASE members also conducted site visits at most UPMC hospitals to meet key stakeholders and understand local issues and efforts. Clinical treatment algorithms for common conditions such as cellulitis, community acquired pneumonia, and urinary tract infection, were developed and provided to community hospitals several times throughout these first 3 years. Guideline distribution to community hospital ASPs and providers was done in conjunction with targeted interventions at individual hospitals and based on each site's antibiograms when appropriate. Supplemental Table 1 is a partial list of examples of individual stewardship initiatives undertaken at various hospitals during this period. Although there were no system-wide AS initiatives undertaken outside the development of CHASE, individual sites may have undertaken local small-scale AS initiatives.

As mentioned, additional activities of CHASE included development of targeted interventions at nonrobust hospitals based on analysis of antimicrobial usage patterns and discussions with local pharmacists. These interventions included prospective audits and feedback on targeted agents, reviews of extended lengths of therapy, or other projects unique to each hospital. These collaborations usually consisted of a telephone or video call in which both CHASE and the local ASP member had access to the EMR. After review of cases and discussion

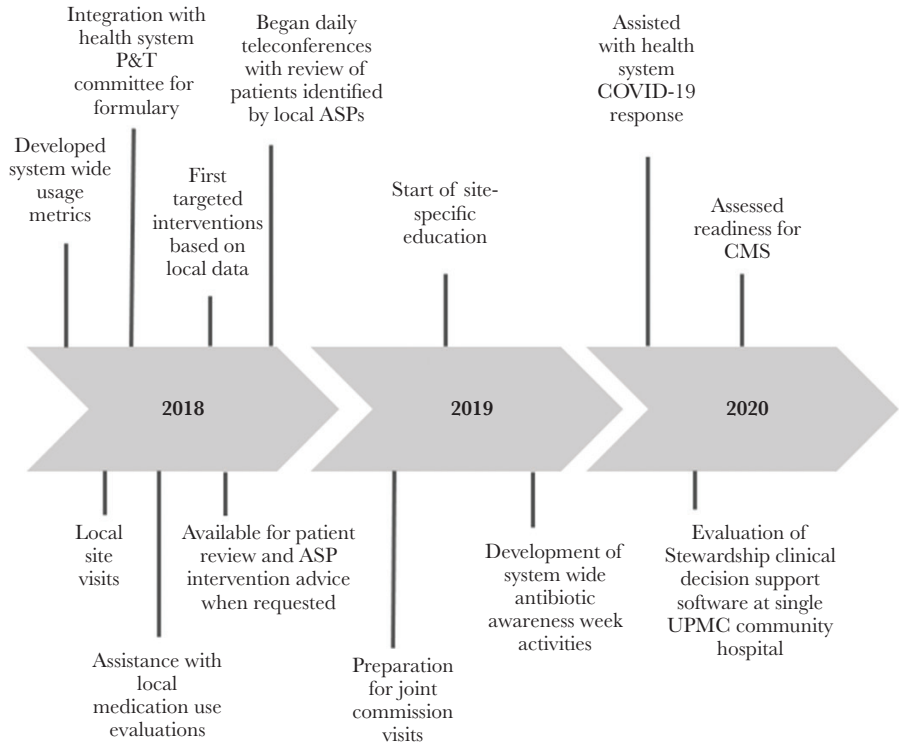

Figure 1. Timeline representation of events started by Centralized Health system Antimicrobial Stewardship Efforts (CHASE). ASP, antimicrobial stewardship program; CMS, Centers for Medicare and Medicaid Services; COVID-19; coronavirus disease 2019; P&T, Pharmacy and Therapeutics Committee.

of relevant details, the local pharmacists intervened with prescribers. For robust hospitals, CHASE assisted with identification of inappropriate usage and development of interventions but was not involved in daily interventions. Clinical pharmacists from any UPMC hospital could consult via teleconference, email, or phone call with a CHASE physician or pharmacist from 8:00 AM to 5:00 PM Monday through Friday.

Impact of CHASE on Antimicrobial Usage

Figure 2 shows inpatient antimicrobial usage since the start of the CHASE program, for all facilities and by category of local ASP (robust, nonrobust, AMC). For the 13 hospitals overall, linear regression analysis revealed a significant decline in antimicrobial DOT/1000 PD per month (slope = −4.7; 95% CI, −5.5 to −3.9; $P < .0001$) (Figure 2A). This corresponds to an overall 16% decrease in antimicrobial usage (individual hospital range, −38% to +19%) when comparing the latest 6 months of the program to the first 6 months (Figure 3) with 12 of 13 hospitals showing usage declines (Figure 4). The one hospital showing an increase in usage was a critical access hospital with limited local pharmacy resources and no local full-time equivalent (FTE) for AS and no ID consultants. All 3 stewardship models (robust, nonrobust, AMC) showed significant declines over time ($P \leq .0001$ for each model), and the slopes of decline were not significantly different from each other ($P = .167$) (Figure 2B and Table 2), suggesting a nonrobust local ASP coupled with support from a centralized team of experts realized changes similar to that at hospitals with robust ASPs and at AMCs.

The relationship between hospital size and rate of change in community hospital antimicrobial usage trended toward significance ($P = .08$) (Supplemental Figure 1). There was no relationship between antimicrobial usage decline per month and AS pharmacist staffing ratios at these community hospitals ($P = .75$) (Supplemental Figure 2), but there was a greater degree of monthly variability unaccounted for by the linear regression model at the 2 hospitals with no local FTE dedicated to ASP activities ($R^2 = 0.20$). We did observe a difference in the rate of change based on size of the community, where the monthly decline in antimicrobial usage was greater in large versus midsize hospitals ($P = .005$) (Supplemental Figure 3).

DISCUSSION

Over the first 3 years of this program, CHASE observed a significant decline in antimicrobial DOT/1000 PD. Declines were observed in 12 of 13 hospitals including those with robust and nonrobust ASP resources. Community hospitals without local stewardship expertise but supported by a central team of stewardship experts experienced similar success as well resourced community hospitals and AMCs.

Our findings, combined with results from other groups, suggest that multiple models of AS approaches for smaller hospitals may lead to successful outcomes. Several tele-antimicrobial

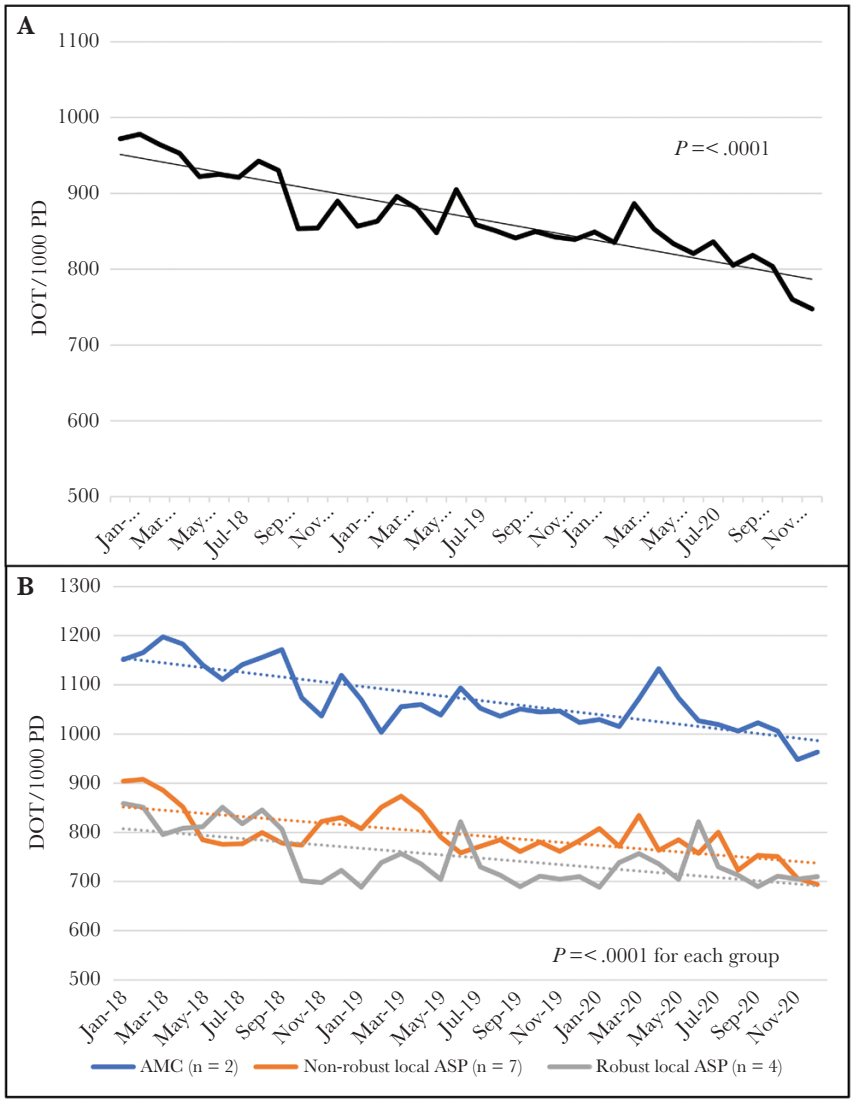

Figure 2. Inpatient antimicrobial usage over time. (A) Total inpatient antimicrobial usage over time at all 13 hospitals. (B) Inpatient antimicrobial usage over time for academic medical centers (AMC), nonrobust local stewardship programs, and robust local stewardship programs. *P* values are for slope of monthly antimicrobial usage decline. ASP, antimicrobial stewardship program; DOT/1000 PD, days of therapy per 1000 patient days.

stewardship models have been reported [18]. In our model described here, smaller hospitals with limited local resources yet aided by a central stewardship team showed similar rates of decline in antibiotic usage as larger hospitals with robust ID and AS resources onsite. Our model allows for continued involvement and autonomy for the local community hospital pharmacists, which was a key goal of our program. At such community hospitals, the local pharmacists had longstanding relationships with providers we believed would be critical to successful interventions. Although our central team traveled regularly and visited providers, we could not replicate the long-term relationships already established in these community hospitals. Our model enabled a small central team to ultimately achieve reduction in antimicrobial usage at several community hospitals dispersed over a wide geographic area within a large healthcare system.

Although many health system stewardship programs focus on broad oversight without involvement in daily interventions [11–13], options for daily involvement do exist. As noted earlier, colleagues at Intermountain Healthcare and DASON have shown success with methods that differ somewhat from the approach reported here. In Intermountain's report [14], the community hospitals were all small (<150 staffed beds), none had routine ID consultation available, and a central ID hotline was provided, thus possibly allowing for more consistent ID recommendations across all sites. In our system, many community hospitals were considered medium or even large. Many also had onsite ID consultants that were not administratively part of our academic ID division or directly employed by UPMC, making coordination between our central team and the ID physicians difficult at times. Intermountain used centralized

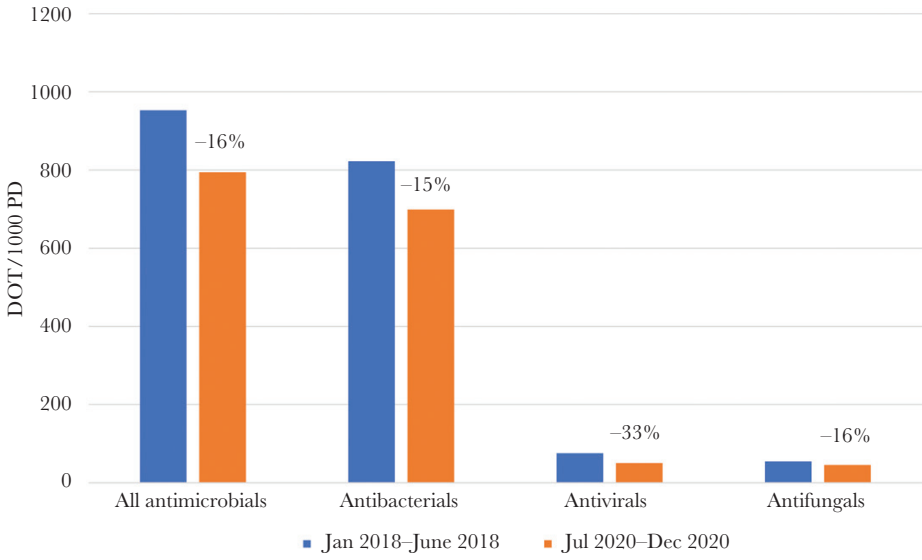

Figure 3. Inpatient antimicrobial usage changes at 13 UPMC hospitals by agent class. DOT/1000 PD, days of therapy per 1000 patient days.

"ID controlled antibiotic restrictions" and "ID review of designated cultures" [14] in their most successful AS model. This level of centralized ID involvement was beyond what we used in our model. Unlike the DASON experience [16], our model exists within a single health system, so we were able to access the shared EMR and discuss or intervene on active inpatients when needed because local hospital credentialing and malpractice insurance coverage were not barriers within our own health system.

We note that, as part of a single health system, all our hospitals could have benefited to some degree from our centralized oversight. Education, data collection, hospital comparison, and development of common clinical pathways were all components of our systemwide stewardship efforts. These efforts could have impacted antimicrobial usage at these hospitals, although indirect efforts such as these are known to be less effective than more direct interventions and are not recommended as standalone strategies [2].

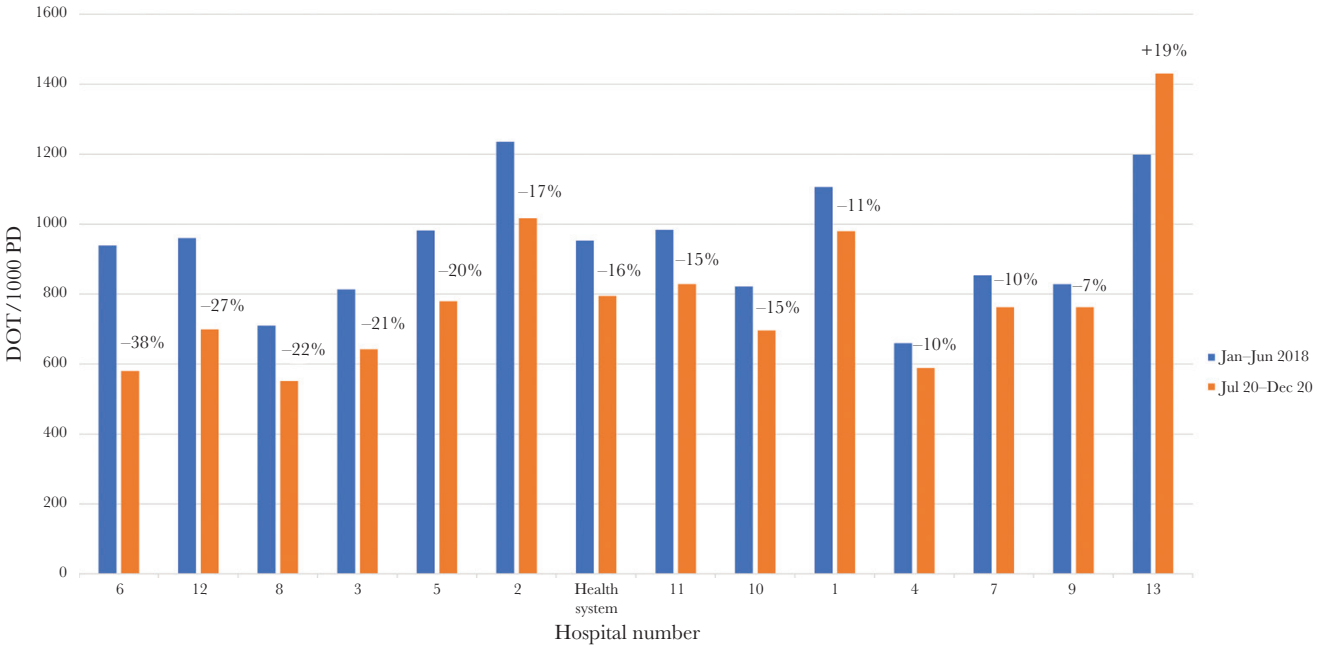

Figure 4. Inpatient antimicrobial usage changes at 13 UPMC hospitals. DOT/1000 PD, days of therapy per 1000 patient days.

Table 2. Change in Antimicrobial Usage Over Time Based on Type of Stewardship Program

Type of Stewardship Program	Slope[a]	95% CI, *P* Value	Y Intercept[b]
AMC (n = 2)	−4.8	−6.0 to −3.5, *P* < .0001	1159 (95% CI, 1133–1186)
Robust local (n = 4)	−3.3	−4.7 to −1.9, *P* < .0001	810 (95% CI, 780–841)
Nonrobust local (n = 7)	−3.3	−4.5 to −2.0, *P* < .0001	855 (95% CI, 829–880)

Abbreviations: AMC, academic medical center; CHASE, Centralized Health system Antimicrobial Stewardship Efforts; CI, confidence interval.

[a]Change in days of therapy per 1000 patient days per month.

[b]Days of therapy per 1000 patient days.

There are limitations to our study. ASPs often realize significant declines in antimicrobial usage in the first years of implementation [19]. Given that our AMC ASPs were established years prior, it is possible they realized more significant initial rates of decline compared to the initial declines seen in these community hospitals. However, for a community hospital with limited local resources, even matching an AMC in its mature stage can be beneficial. We did not include UPMC hospitals that were not on our shared EMR for the entirety of the included time, although these hospitals largely mirror those included here in terms of size, community type, pharmacist staffing, and other characteristics. Although CHASE does interact with these other hospitals and their local ASPs, day-to-day interaction and data collection at the times included here were limited due to this lack of a shared EMR. Because this review occurred over 3 years across a large health system, there were local stewardship initiatives ongoing at any given time. However, most of the hospitals in our nonrobust ASP group had very few local initiatives occurring before our involvement beginning in 2018. CHASE was involved in the development and implementation of any such local interventions at these nonrobust ASP hospitals since 2018. In addition, we examined differences between hospitals based on bed size, community size, and staffing ratios, but larger evaluations are needed to better determine the effects these factors may have on antimicrobial usage. Pharmacist staffing ratios based on bed size have been suggested for ASPs [1]. Recommendations generally suggest more pharmacists than many of our sites had during this period. Although adequate staffing is critical for successful ASPs, further research is needed to identify adequate staffing ratios when utilizing hybrid models such as ours. Although our hybrid model of local pharmacists collaborating with centralized experts showed success, we cannot comment as to whether we would have seen further decrease in usage had we centralized more daily activities. However, the potential for such additional reductions should be weighed against the increased costs of developing an adequately staffed central team for large health systems. Finally, this period includes the first year of the coronavirus disease 2019 pandemic, which impacted antimicrobial use throughout the United States [20]. We cannot comment on how much this impacted usage in 2020 except that we did see transient increases in overall usage during the early parts of 2020.

CONCLUSIONS

Antimicrobial stewardship best practices in community hospitals remain incompletely defined, and the optimal means to leverage stewardship resources across diverse health systems is an underexplored area. However, what is known is that patients at all hospitals deserve the benefits of an effective ASP. In this study, we present initial evidence of success with an integrated hybrid approach to health system stewardship that leverages the local pharmacists at community hospitals with a centralized team of ID and AS experts. Our model allows for this small central team to support numerous community hospitals of varying sizes, complexity, and distance. We have shown that such a model is associated with favorable changes in antimicrobial usage comparable to those observed at larger hospitals with significant local investment in stewardship. Health systems striving to develop uniform AS success throughout their system should consider the hybrid integrated structure presented here.

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