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Harnessing the Power of Health Systems and Networks for Antimicrobial Stewardship

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Twenty of 21 health systems and network-based antimicrobial stewardship programs (ASPs) who were invited participated in a questionnaire, a webinar, and focus groups to understand implementation strategies for system-wide antimicrobial stewardship. Four centralized ASPs structures emerged. Of participating organizations, 3 (15%) confirmed classification as collaborative, 3 (15%) as centrally coordinated, 3 (15%) as in between or in transition between centrally coordinated and centrally led, 8 (40%) as centrally led, 2 (10%) as collaborative, consultative network. One (5%) organization considered themselves to be a hybrid. System-level stewardship responsibilities varied across sites and generally fell into 6 major categories: building and leading a stewardship community, strategic planning and goal setting, development of validated data streams, leveraging tools and technology for stewardship interventions, provision of subject-matter expertise, and communication/education. Centralized ASPs included in this study most commonly took a centrally led approach and engaged in activities tailored to system-wide goals.

Keywords. antimicrobial stewardship; health system; health network; centralized stewardship.

Across the United States, integrated health systems are expanding. In 2018, approximately 75% of US hospitals and >90% of hospital beds were affiliated with a health system [1, 2]. The benefits of integrated health systems may include group purchasing benefits, increased adoption of technology such as electronic health records, measurable care delivery standards, performance tracking, and improved quality of care [3, 4]. Health systems are optimally positioned to efficiently lead multicenter improvement initiatives through central coordination, such as opioid stewardship [5], infusion pump optimization [6], and pressure ulcer programs [7]. Antimicrobial stewardship is another example where centralized programs have emerged to improve antimicrobial use and provide value across the health system spectrum [8–13]. The landscape of health system antimicrobial stewardship has yet to be fully characterized, thus there is a need to better understand the different models and strategies used to implement antimicrobial stewardship in these settings.

The primary objectives of this investigation were to describe the types of structures and functions of centralized stewardship

programs embedded within health systems and to highlight common areas of emphasis and areas of variability.

METHODS

To achieve our objectives, we administered a semi-quantitative, structured questionnaire and performed small, semi-structured focus groups of antimicrobial stewardship program (ASP) leaders from a convenience sample of health systems known to have active centralized stewardship programs. These participants were asked to (1) complete an initial semi-structured questionnaire to identify key aspects of their system or network's current antibiotic stewardship structure and function, (2) participate in a webinar that provided background information to participants in order to set the stage for breakout discussions, (3) participate in virtual breakout focus groups, and (4) provide feedback on select findings from these group discussions. The Infectious Diseases Society of America, Society for Healthcare Epidemiology of America, the Society of Infectious Diseases Pharmacists, the Centers for Disease Control and Prevention, and Pediatric Infectious Diseases Society served as liaison organizations and participated in the development of the questionnaire and breakout discussion interview guide. No official endorsement from any national organization was formally sought.

Site and Participant Recruitment

Sites were selected using the American Hospital Association's definition of a system, "hospitals belonging to a corporate body that owns and/or manages health provider facilities or health-related subsidiaries" [14]. Health networks were defined

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as collaborative, stewardship-focused networks, where the participating facilities were not connected by a corporate structure and were also considered to increase the diversity of participants. The Pew Charitable Trusts and Intermountain Healthcare conducted outreach to a convenience sample of 21 target organizations that were known by the authors (n = 18) or liaison representatives (n = 3) as having active centralized antimicrobial stewardship efforts. Sites were selected to represent a variety of health systems sizes and geography. Two participants were identified from each health system or network to participate in this initiative, specifically 1 pharmacist and 1 physician who were involved with antimicrobial stewardship on a system level.

Questionnaire and Focus Groups

The questionnaire (included as [Supplementary Material](#)) was developed by the study team (D. H., R. Z.) and included basic demographic information regarding the participating health systems and networks. In addition, questions regarding the structure of their centralized antibiotic stewardship program, barriers for developing this program, types of stewardship activities overseen centrally, and system-wide metrics were included. To elucidate variations in structure and function across centralized stewardship programs, a semi-structured interview guide (included in [supplementary material](#)) was created by the study team (D. H., R. Z.) utilizing the Centers for Disease Control and Prevention (CDC) Core Elements as a framework [15]. Feedback was provided on both the questionnaire and interview guide by all study authors followed by the liaison organizations in an iterative fashion to refine and prioritize questions.

Eight virtual, 90-minute, breakout sessions were conducted between 26 March and 30 April 2021 and moderated by a member of the study team (D. H.). Initially, each physician-pharmacist dyad was asked to attend 1 of 7 sessions grouped by organization size. First, the 3 largest health systems with over 100 facilities were grouped together, followed by the 2 consultative programs, and then the remaining facilities were grouped in threesomes ensuring diversity in system size. Due to scheduling conflicts, 1 dyad attended their own breakout session, creating 8 sessions total. No incentives were provided. Liaison organization representatives and the study team were invited to attend all 8 sessions. Each session was recorded and transcribed.

Qualitative Analysis

We used a form of directed content analysis where the primary analyst (W. B.) wrote detailed field notes during the interviews and “coded” and categorized these notes into a construct matrix based on CDC Core Elements framework (hospital leadership commitment, accountability, pharmacy expertise, action, tracking, reporting, education), grouping organization based on similarities and differences. Afterward, the primary analyst listened to audio, read transcripts, and adjusted coded notes as

needed. All study authors participated in a debriefing meeting after all sessions were complete and shared key thematic elements that were incorporated into the matrix. The primary analyst grouped the various types of centralized antimicrobial stewardship programs into like models. All study authors provided feedback on these models. Then each physician and pharmacist dyad were emailed a draft description of model types with a suggested model describing their institution for respondent validation. Feedback from these focus group participants responses were incorporated into the final matrix. Lastly, the final framework was presented to the liaison organizations for feedback. During this final meeting, it was recommended to develop a definition for health system antimicrobial stewardship, which was developed ad hoc, capturing similarities of all system stewardship models.

RESULTS

In total, 20 of 21 health systems and networks responded to the invitation for participation. All 20 (100%) of these responded to the questionnaire. Of the 40 participants (2 invited per organization) invited to the virtual breakout sessions, 36 participated, and all 20 health systems/networks were represented. The 19 nonfederal organizations that participated have hospitals in 37 states plus Washington D.C. In addition, the Veterans Health Administration participated and has at least 1 facility in every state. Represented hospitals ranged from critical access hospitals (<25 beds) to large, tertiary academic medical centers. More details regarding the participating organizations are included in [Table 1](#).

Description of Centralized Stewardship Programs

Definition

The following ad hoc, working definition of centralized stewardship programs was developed: a health system or network level antimicrobial stewardship program is one that includes a community of stewards from multiple sites and settings. The goal is to implement stewardship interventions within this community that provide consistent, high-quality care that improves outcomes, minimizes harms and reduces antimicrobial resistance.

Structure

Health-system Stewardship Leadership Structure

Although antimicrobial stewardship programs in each health system had unique characteristics, they can be generally classified into 4 main approaches: collaborative, centrally coordinated, centrally led, and collaborative, consultative network ([Table 2](#)). The *collaborative* approach is one in which there is no formal administrative or operational structure; however, there is significant collaboration across sites informally through meetings and joint projects. A *centrally coordinated* approach has a formal structure in which the health-system stewardship

Table 1. Participating Health Systems and Networks

| System | No. of Hospitals | Rural or Critical Access Hospitals | No. of Outpatient Facilities | Years Centralized ASP in Existence |
|---|------------------|------------------------------------|------------------------------|------------------------------------|
| Ascension Health | >100 | Yes | >1000 | 4–6 years |
| Atrium Health | 16–30 | Yes | >100 | 7 years or longer |
| Avera Health | 31–100 | Yes | >100 | 4–6 years |
| BJC HealthCare | 5–15 | Yes | >100 | 4–6 years |
| CHI Health | 5–15 | Yes | >100 | 4–6 years |
| DASON | 31–100 | Yes | None | 7 years or longer |
| Emory | 5–15 | No | >100 | 7 years or longer |
| HCA Healthcare | >100 | Yes | >1000 | 7 years or longer |
| Henry Ford Hospital | 5–15 | No | >100 | 7 years or longer |
| Houston Methodist | 5–15 | No | >100 | 4–6 years |
| Intermountain Healthcare | 16–30 | Yes | >100 | 7 years or longer |
| Kaiser Permanente (Southern California) | 5–15 | No | 15–100 | 7 years or longer |
| Mayo Clinic | 16–30 | Yes | >100 | 4–6 years |
| Montefiore | 5–15 | No | >100 | 1–3 years |
| Northwell | 16–30 | No | >100 | 4–6 years |
| OhioHealth | 5–15 | Yes | >100 | 4–6 years |
| UnityPoint Health | 16–30 | Yes | >100 | 4–6 years |
| UPMC | 31–100 | Yes | >100 | 4–6 years |
| UW-TASP | 31–100 | Yes (primary focus) | >100 | 4–6 years |
| Veterans Health Administration | >100 | Yes | >1000 | 7 years or longer |

Abbreviations: ASP, antimicrobial stewardship program; UPMC, University of Pittsburgh Medical Center; UW-TASP, University of Washington Tele-Antimicrobial Stewardship Program.

program is run through a formal committee or taskforce. Typically, this approach requires representation from each site or region, with clear roles, objectives and goals set by the committee or taskforce on a recurring basis. A third approach is the *centrally led* approach, in which there is a designated health system leader of the antimicrobial stewardship program that extends beyond leading a single, site specific, antimicrobial stewardship committee. This third approach may take three different forms with varying levels of financial support, where the designated system stewardship leaders have (1) a non-stewardship leadership position in which antimicrobial stewardship is one of many responsibilities (eg, clinical pharmacy director); (2) a formal system leadership role specifically focused on antimicrobial stewardship (eg, medical director of antimicrobial stewardship); or (3) centrally led but not financially resourced system leader(s), most commonly the system role is added to the antimicrobial stewardship leader(s) at one of the health system's facilities. Lastly, some sites are not part of a

health system or lack adequate resources from their health system (often small community hospitals), and in this setting may pursue a *collaborative, consultative network model*. Joining or subscribing to one of these collaboratives, which are often state-based or regional, is a potential option to enhance antimicrobial stewardship expertise locally.

During respondent validation, 3 (15%) confirmed the best classification for their organization was collaborative, 3 (15%) centrally coordinated, 8 (40%) centrally led, and 2 (10%) collaborative consultative network. Not all institutions fit exactly into each category and institutions may be transitioning between or have overlapping approaches. As such, 3 (15%) felt the best classification was in between or in transition between centrally coordinated and centrally led and one (5%) organization considered themselves to be a hybrid.

Personnel, Funding and Reporting Structures

Eighteen (90%) health systems reported they had a physician and pharmacist co-led antimicrobial stewardship program, whereas the remaining 2 (10%) were physician-led. The majority of organizations (14) identified challenges due to inadequate resources at the local level (11), system level (12), or both (8). Eleven organizations expressed challenges with obtaining adequate site-specific resources, including dedicated time by onsite staff or antimicrobial stewardship and/or infectious diseases expertise locally at the sites. Nine organizations were challenged with either inadequate full-time equivalent (FTE) support, inadequate compensation, or both for their central stewardship program leads. A lack of analyst resources was shared by seven organizations. Lastly, although 7 organizations expressed having information technology (IT) support dedicated to antimicrobial stewardship, this was expressed as a significant barrier to stewardship interventions by 4 organizations. Although all antimicrobial stewardship lead personnel received salary support, for these nine sites, there was often work performed beyond their job description without specific funding coming from a centralized source. A wide variety of reporting structures were described for each health system, in terms of who the antimicrobial stewardship leads reported to as well as the nature of the reporting relationship and the degree of embedded accountability. From an operational standpoint, options included the Division of Infectious Diseases, Quality and Patient Safety, or Pharmacy Services.

Scope

The initial questionnaire discovered that 17 (85%) health systems had 75–100% participation of inpatient facilities, whereas only 3 (15%) had a similar level of participation from outpatient facilities. These 3 had the following: technological solutions in the electronic health record (EHR) for respiratory infection prescribing and measurement, disease-state treatment pathways and order sets to reduce fluoroquinolone prescribing,

Table 2. Models for Health System Antimicrobial Stewardship

| Model | Utilized by Participating Systems and Network, n (%) ^a | Description | Activities |
|---|---|--|---|
| Collaborative | 3 (15%) | <ul style="list-style-type: none"> No formal structure Committee with limited accountability Often formed organically | <ul style="list-style-type: none"> Participation by sites is voluntary Goals are set by individual sites rather than at the system level Data are often inconsistent across sites and locally collected Tools and technology are shared across sites Subject-matter expertise, communication and education are all provided locally |
| Centrally Coordinated | 6 (30%), with 3 (15%) in this category and 3 (15%) in transition to a centrally led model (below) | <ul style="list-style-type: none"> Formal written structure Committee with at least some system accountability Often formed organically after initial collaborative stage | <ul style="list-style-type: none"> Committee-led system stewardship initiatives Participation by sites may be required for some initiatives System goals are coordinated through a central committee (and may be augmented by local goals) Data resources often prioritized by the committee Tools and technology changes may be coordinated and shared through a central committee Subject-matter expertise, communication and education are all provided locally (with some committee support) |
| Centrally led | 8 (40%) | <ul style="list-style-type: none"> Formal system of antimicrobial stewardship leaders^b System accountability held by system leaders, which may be through committees or direct reporting relationships Requires system-level resources | <ul style="list-style-type: none"> Stewardship initiatives are led by system leaders Participation by sites is often required Goals are set by leaders at the system level (and may be augmented by local goals) System leaders are responsible for standardized data across sites, benchmarking is prioritized Tools and technology changes are coordinated by system leaders and universally implemented Subject-matter expertise, communication and education often provided at a system level as well as reinforced locally |
| Collaborative, Consultative Network Model | 2 (10%) | <ul style="list-style-type: none"> Antimicrobial stewardship leaders external to the organization serve as consultants, mentors, or members in collaboration with on-site leaders Allows sites to participate in and receive support from a network Provides access to subject-matter experts | <ul style="list-style-type: none"> Site-specific mentorship Goals, stewardship initiatives and tools may be adopted from other external sites Data, technology, and communication may be developed locally or through the network Subject-matter expertise and education may be provided by external antimicrobial stewardship leaders |

^aOne participating organization self-identified as a hybrid of the first 3 models.

^b(1) A non-stewardship leadership position in which antimicrobial stewardship is 1 of many responsibilities; (2) a formal system leadership role specifically focused on antimicrobial stewardship; or (3) centrally led but not financially resourced system leader(s), most commonly the system role is added to the antimicrobial stewardship leader(s) at 1 of the health-system's facilities.

and a peer-comparison tool for outpatient antibiotic prescribing. During the focus group discussion, 5 additional organizations described in some detail their efforts to provide stewardship in the outpatient setting. This ranged in complexity from didactic presentations at one organization to grant-funded, multimodal stewardship interventions at two health systems. Other examples include developing data streams and dashboards, developing guidelines, providing academic detailing, and creating simple EHR-based interventions. Two health systems had hired dedicated FTE to support antimicrobial stewardship in the outpatient setting. However, most

organizations did not have the staff capacity for stewardship in the outpatient setting, with 2 sites specifically mentioning staffing as the primary concern.

Metrics

From the initial questionnaire, programs reported routinely utilizing the following metrics: antibiotic use data (18/20, 90%), outcomes data (14/20, 70%), antibiotic resistance data (14/20, 70%), and cost data (12/20, 60%). More details are provided in [Supplementary Table 1](#). Eighteen (90%) system-level programs reported performing benchmarking of antibiotic

prescribing within their facilities. Crucial to these efforts is to ensure that metric definitions are consistent across sites, which can be challenging in systems with multiple types of electronic health records. Centralized stewardship programs provide significant support for facility-level metrics, as all 20 health systems indicated that the central stewardship team was involved with obtaining and analyzing antibiotic use data.

During the discussions, 7 stewardship leads highlighted the value of alignment across disciplines whenever possible, such as *Clostridioides difficile* rates with infection preventionists, sepsis management and mortality with intensivists, and readmission rates with hospitalists. These examples highlight that antimicrobial stewardship can assist with improving metrics prioritized and evaluated by other disciplines, creating win-win situations.

Activities

We asked the participating health systems to describe the specific stewardship activities they viewed as core activities at the health system level. Table 3 highlights the responsibilities identified by more than two health systems as important for centralized stewardship programs, with granular examples provided in Supplementary Table 2. From the small group discussions, six major categories of system level stewardship activities emerged: building and leading a stewardship community, strategic planning and goal setting, development of validated data streams, developing and implementing antimicrobial stewardship policies and practices across the health system, provision of subject-matter expertise, and communication/education.

Challenges and Barriers

The most common barriers encountered when establishing and implementing a centralized stewardship program were building out the necessary data infrastructure (16/20, 90%), obtaining adequate personnel funding (13/20, 65%) and securing participation at the individual facility level (13/20, 65%). During the focus groups, all participants acknowledged the challenge that the coronavirus disease 2019 (COVID-19) pandemic posed to their ongoing and planned stewardship activities. Reported impacts included strains on staffing, a need to pause system-level stewardship goals and expansion activities, and an inability to conduct site-visits. There were some benefits mentioned as well, including facilitating a more system-level approach, streamlining IT updates, and bringing facilities closer together.

Beyond staffing and resource challenges already described, several additional challenges and barriers to system-level antimicrobial stewardship also surfaced during the small group discussions. Four organizations specifically mentioned needing to prioritize sustainability, as 1 of the challenges of system-level stewardship. "One size does not fit all" was recognized as a common value, as well as challenge, among 6 organizations.

Table 3. Example Core Centralized Antimicrobial Stewardship Lead Responsibilities

| Category, n (%) ^a | Subtheme |
|--|---|
| Developing and implementing antibiotic stewardship policies and practices, 19 healthcare organizations (95%) | Create and disseminate antimicrobial-stewardship related policies |
| | Create and disseminate antimicrobial stewardship guidelines |
| | Design and implement EHR tools and changes |
| Communication and education, 18 healthcare organizations (90%) | Design and implement 3rd party decision support software |
| | Manage the antimicrobial formulary |
| | Lead committee meetings |
| | Present to system leaders and clinical groups |
| Development of validated data streams, 16 healthcare organizations (80%) | Provide written communication to the health system |
| | Develop and maintain antimicrobial stewardship website |
| | Design education materials |
| | Identify key antimicrobial stewardship metrics and develop data infrastructure |
| Building and leading a stewardship community, 15 healthcare organizations (75%) | Develop and maintain a dashboard |
| | Perform initial and annual data validation |
| | Develop a community of antimicrobial stewards |
| | Advocate for AS resources |
| Provision of subject-matter expertise, 11 healthcare organizations (55%) | Facilitate alignment and build relationships with stakeholders and other clinical groups. |
| | Provide training, mentorship, and coaching |
| | Manage antimicrobial stewardship personnel |
| | Travel to sites and conduct site visits |
| Strategic planning and goal setting, 7 healthcare organizations (35%) | Answer clinical, patient-related questions |
| | Lead regular conference calls for sites to access antimicrobial stewardship and infectious diseases experts |
| | Assist with the design of antimicrobial-related changes or stewardship interventions |
| Miscellaneous activities of note | Assist with local goal selection |
| | Strategic planning and system- or network-level goal setting |
| | Lead or support antimicrobial stewardship research |
| | Set the system standard to provide consistency and reduce variation |

Abbreviation: EHR, electronic health record.

^aThe number of healthcare organizations who described the following category of activities when asked about the core activities of their centralized stewardship program during the focus groups, as shared by the pharmacist lead, physician lead, or both.

Challenges identified by 1 or 2 organizations include: rigidity, contract renewals, hiring qualified infectious diseases experts,

scalability, setting targets, provider education, reticence of private practice ID physicians to participate in stewardship, adoption of technology, having different EHRs, different levels of facility affiliation, and balancing standardization with customization.

DISCUSSION

This is the first in-depth description of antimicrobial stewardship across a geographically and size diverse group of health systems. Through the participation of centralized antimicrobial stewardship program leads across twenty health systems and networks, this study identified four different structures of centralized antimicrobial stewardship programs: collaborative; centrally coordinated; centrally led; and collaborative, consultative network and six major categories of centralized stewardship responsibilities: building and leading a stewardship community; strategic planning and goal setting; development of validated data streams; leveraging tools and technology for stewardship interventions; provision of subject-matter expertise; and communication/education. The centralized approaches summarized here can serve as models for other health systems that are seeking effective solutions to raise the quality and scope of their stewardship activities across their facilities.

Health systems are complex and highly variable, due to a myriad of contextual and environmental factors and different levels of structural, functional and clinical integration [16]. Employed and contracted physicians, unified and non-unified electronic health record platforms, degree of centralization, and presence of a managed care plan are all factors that impact the levers of influence stewards can use within each health system [3, 17]. Therefore, a variety of antimicrobial stewardship models are needed to fit into existing types of health system organizations. A health system's selected model may also need to adapt over time, for example when mergers and acquisitions occur [10]. Additional models not described by our participating health systems could be pursued, particularly in health systems of smaller size, such as a fully integrated antimicrobial stewardship program where a single antimicrobial stewardship team covers all facilities within a health system [18]. The most common model among our participating health-systems was a centrally led approach; however, our study is unable to determine which approach is best and further research is needed to understand factors associated with selecting a model and the outcomes associated with each one.

The activities identified herein could be used in the development of a central antimicrobial stewardship job description. One noticeable factor influencing the roles and responsibilities of system-level stewardship is health system size. Health systems with more than 100 hospitals leverage tools such as surveys, webinars, and toolkits because direct involvement and hands-on assistance at all sites is a much less feasible strategy

[9, 13, 19]. Smaller health systems are better equipped to provide subject matter expertise and support day-to-day stewardship activities within a health system. Thus, the roles and responsibilities of the system stewardship leads appears to vary based on the antimicrobial stewardship model as well as health system size.

This study has several limitations. First, our focus was on larger, multihospital health systems rather than small and medium-sized health systems with 1 or 2 hospitals [1]. Not all health systems that have system stewardship were included and only 17 of 161 non-federal health systems with at least 5 hospitals were represented [20]. Although those included are diverse in region and size to increase generalizability and illustrate a range of activities antimicrobial stewards are engaged in at the health system level, each health system is unique and additional health system stewardship types may exist. Second, we do not provide specific recommendations on the design of health system level antibiotic stewardship program. Associating program characteristics with antimicrobial stewardship outcomes was outside the scope of this investigation. Third, these are self-reported data; therefore, responses may be prone to social desirability bias and accuracy of responses was not verified. Fourth, we used a convenience sample approach, which may introduce bias and limit generalizability; however, the diversity of participants helps to mitigate this potential bias. Lastly, this study did not use classic qualitative research methodologies; however, we performed respondent validation to limit bias. The strength of this approach was that we were able to put together a timely evaluation of 20 health systems' real-world experiences.

Although there remains much to learn about the optimal structure and activities for centralized antimicrobial stewardship programs, there is immense potential to harness the power of health systems and networks to improve and expand antimicrobial stewardship within acute care hospitals and across novel settings. With increasing hospital mergers and acquisitions, health system antimicrobial stewardship is likely to expand in the coming decade and further research in this area is warranted.

Supplementary Data

[Supplementary material](#) is available at *Clinical Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Notes

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