Development of an antimicrobial stewardship module in an electronic health record: Options to enhance daily antimicrobial stewardship activities

Kathryn Dzintars, PharmD, Department of Pharmacy, The Johns Hopkins Hospital, Baltimore, MD, USA

Valeria M. Fabre, MD, Division of Infectious Diseases, Department of Medicine, Johns Hopkins University School of Medicine, Baltimore, MD, USA

Edina Avdic, PharmD, MBA, Department of Pharmacy, The Johns Hopkins Hospital, Baltimore, MD, USA

Janessa Smith, PharmD, Department of Pharmacy, Orlando Regional Medical Center, Orlando, FL, USA

Victoria Adams-Sommer, PharmD, Department of Pharmacy, The Mount Sinai Hospital, New York, NY, USA

Jennifer Townsend, MD, Division of Infectious Diseases, Department of Medicine, Johns Hopkins Bayview Medical Center, Baltimore, MD, USA

Alice Jenh Hsu, PharmD, Department of Pharmacy, The Johns Hopkins Hospital, Baltimore, MD, USA

Sara E. Cosgrove, MD, MS, Division of Infectious Diseases, Department of Medicine, Johns Hopkins University School of Medicine, Baltimore, MD, USA

Address correspondence to Dr. Dzintars (kdzinta1@jhmi.edu).

Twitter: @katesabol

Purpose. The purpose of this manuscript is to describe our experience developing an antimicrobial stewardship (AS) module as a clinical decision support tool in the Epic electronic health record (EHR).

Summary. Clinical decision support systems within the EHR can be used to decrease use of broad-spectrum antibiotics, improve antibiotic selection and dosing, decrease adverse effects, reduce antibiotic costs, and reduce the development of antibiotic resistance. The Johns Hopkins Hospital constructed an AS module within Epic. Customized stewardship alerts and scoring systems were developed to triage patients requiring stewardship intervention. This required a multidisciplinary approach with a team comprising AS physicians and pharmacists and Epic information technology personnel, with assistance from clinical microbiology and infection control when necessary. In addition, an intervention database was enhanced with stewardship-specific interventions, and workbench reports were developed specific to AS needs. We herein review the process, advantages, and challenges associated with the development of the Epic AS module.

Conclusion. Customizing an AS module in an EHR requires significant time and expertise in antimicrobials; however, AS modules have the potential to improve the efficiency of AS personnel in performing daily stewardship activities and reporting through a single system.

Keywords: antimicrobial stewardship, clinical decision support system, interventions

Antibiotic stewardship programs (ASPs) are dedicated to improving antibiotic use by ensuring that patients who need antibiotics receive the correct agent at the right dose for the optimal duration. ASPs are now required in hospitals by the Joint Commission and by the Centers for Medicare and Medicaid Services.[1,2] A critical component of ASPs, as detailed in the Centers for Disease Control and Prevention (CDC)'s *Core Elements of Hospital Antibiotic Stewardship Programs*, includes performing daily interventions to optimize antibiotic use.[3]

Successful operationalization of this work requires a mechanism to detect patients who are on antibiotics and meet criteria for an intervention. Clinical decision support systems (CDSSs) within electronic health records (EHRs) are tools that can streamline antibiotic interventions by identifying a variety of areas for improvement in antibiotic prescribing.[4,5] Examples of these include "drug-bug" mismatch, in which the antibiotic that a patient is receiving does not cover the organism identified, and opportunities for de-escalation, in which a patient can be switched to a less broad-spectrum antibiotic. Other examples of opportunities for intervention include identification of drug-drug interactions, duplicate antimicrobial coverage (eg, dual anaerobe coverage with piperacillin/tazobactam and metronidazole), and excess duration of therapy. Substantial benefits associated with the use of these systems include decreased use of broad-spectrum antibiotics, improved antibiotic selection and dosing, less frequent adverse effects, reduction in antibiotic costs, reduction in the development of antibiotic resistance, and decreased length of hospitalization.[5-8] For example, Ghamrawi and colleagues[9] demonstrated that, with CDSS-built antimicrobial stewardship (AS) alerts, time to de-escalation was significantly reduced from 28.8 hours to 4.7 hours. Herein, we describe our experience in customizing an AS dashboard in one EHR, from Epic System Corporation (Verona, WI), to facilitate a CDSS for stewardship within the Johns Hopkins Health System (JHHS).

Baseline Epic AS functionality

1. Epic is one of the leading providers of EHR systems in the United States, with 28% of the acute care hospital market share in 2018.[10] Entry-level tools available to all Epic users include (1) iVents, an intervention system to record and communicate recommendations; (2) order sets and/or panels; (3) dose-checking decision support, including maximum doses recommended and default dosing weight capabilities; (4) algorithms in the form of navigators that present information in a single location within the EHR to assist with clinical decision-making; (5) patient scoring and monitoring systems; (6) intravenous-to-oral (IV-to-PO) algorithms; (7) and best practice alerts (BPAs), which can be used at the time of ordering to alert providers of potential prescribing problems.[5] Epic released an enhanced version of their EHR in 2014, which included the option to add an infection control (ICON) module for an additional cost. ICON (since renamed Bugsy) features are designed for use by infection preventionists and include days of therapy (DOT) per 1,000 patient-days present calculations for reporting to the National Healthcare Safety Network–Antimicrobial Use and Resistance (NHSN-AUR) module and real-time antibiogram compilation and reporting.[5] Additionally, an AS module was released and has features designed to assist physicians and pharmacists leading stewardship activities. The AS module works in concert with ICON and Willow, the pharmacy medication management system, to allow a multidisciplinary approach to AS practices. The primary feature of the AS module is the AS dashboard,

which organizes all AS tools in a single location and includes patient lists, stewardship scoring systems, and stewardship workbench reports. A significant benefit of the dashboard is the inclusion of institution-specific links, which allows providers to access clinical pathways, antibiotic approval policies, hyperlinks to local antibiotic treatment guidelines, antibiotic dosing protocols, and formulary restrictions (for example, Johns Hopkins Hospital Guidelines for Antimicrobial Use [mobile application software]; Cosgrove S, Avdic E, Dzintars K, Fabre M, Bernice F).

AS scoring system customization

Epic was implemented at 5 of the 6 hospitals that make up the JHHS. These 5 sites include 2 academic hospitals and 3 community hospitals in the Baltimore and District of Columbia region. All sites have independent ASPs, although there is variation in the resources available to each program, with the academic sites having greater physician and pharmacist full-time equivalents dedicated to AS. Because of the greater resources of the academic sites, the customized AS module was developed by those ASPs. The ASPs desired Epic support for its existing daily interventions of antibiotic preauthorization, prospective audit and feedback, syndrome-related interventions, and real-time review of rapid diagnostic tests and blood culture results; all of these functions required customization in the Epic AS module. The community hospitals adopted the customized module after implementation at the academic hospitals and were given the flexibility to incorporate the rules and interventions that met their needs. For instance, not all rapid diagnostics are available at these sites, so rules related to these components were not included in their workflows.

Alerts and patient scoring system. To maximize the potential of the Epic system, the AS team engaged in weekly hour-long telephone calls with Epic information technology (IT) support to build rules for customized alerts and scoring systems in order to prioritize patients in need of stewardship interventions. Table 1 provides a comprehensive list of all standard columns as well as customized alerts with their assigned point value made available at our institutions. Standard columns include a patient's cumulative AMS score as well as a column that generates the change in AMS score over a 24-hour period. These scores comprise values on a scale of 1 to 5 assigned to each rule by the AS team during the build. Once the rule(s) associated with each customizable alert are activated within Epic and are triggered for an individual patient, the standard AS columns will adjust with cumulative scores and score changes. Customizable alerts may have multiple rules associated with them. An example of this would be the "de-escalation of therapy exists" rule. Scenarios at our institution that would trigger this alert include (1) *Enterococcus* susceptible to ampicillin flagging patients with *Enterococcus faecalis* in the blood receiving vancomycin or linezolid; (2) positive cultures for methicillin-susceptible *Staphylococcus aureus* (MSSA) flagging patients receiving vancomycin; and (3) azole-susceptible *Candida* spp. in the blood flagging patients receiving micafungin. In the example provided here, the AS team assigned a point value of 5 for a patient with Gram-positive bacteremia (*E. faecalis*, MSSA), while the rules for candidemia and nonblood *S. aureus* infections were assigned a value of 3. These assigned values give weight to the alerts that trigger and allow pharmacists to prioritize their work, with higher values requiring attention sooner rather than later.

An example of a new rule created by our group is an alert notification of results from Verigene (Luminex Corporation, Austin, TX), a rapid diagnostic test for bacterial identification in positive blood cultures. This alert activates for patients with blood cultures growing Gram-positive bacteria when the organism (eg, *S. aureus*) and/or resistance marker (eg, *mecA*) are identified by the rapid diagnostic test. Other new rules developed by the AS team are the "restricted antimicrobials overnight" rule to alert pharmacists that orders exist for restricted antimicrobials that are initiated outside of "approval hours" and require approval the following day, as well as the "de-escalation Vanc Zosyn Meropenem greater than 72 hours" rule, a specific rule directing pharmacists to take an "antibiotic time-out" and assess whether ongoing coverage is necessary based on the patient's clinical status and culture results available at that particular point in time. While this rule was developed because documentation of review of the use of vancomycin, piperacillin/tazobactam, and meropenem after 72 hours was a health-system performance metric, similar rules for other antimicrobials can be developed easily.

iVent clinical documentation. iVents are Epic tools used to communicate and/or document AS recommendations and interventions within the pharmacy department (Johns Hopkins Hospital Guidelines for Antimicrobial Use). iVents can only be entered by pharmacists, are not visible to nonpharmacist providers, and are not considered part of the medical record unless the documentation is transcribed by the user into a progress note or the "copy and paste" feature is used to enter the iVent as a progress note. Links to iVent entries are also accessible from the AS dashboard. Figure 1 provides an example of iVent documentation in which the rounding pharmacist recommended use of nitrofurantoin in a patient currently on ciprofloxacin for the treatment of cystitis caused by pan-susceptible *Escherichia coli*.

The AS team developed several iVents to correspond with the customized rules discussed above (Table 2). AS-specific iVents allow pharmacists to easily document interventions that are specific yet standardized as they review alerts. These iVents populate in the AS dashboard report that can be run in real time and used as a reporting metric for the AS program, including the number and type of interventions made, the time spent, and whether the recommendation was accepted. An example of an AS-specific iVent is "better therapeutic options existed," which contains a series of subtypes to optimally define the intervention being made. In this instance, better therapeutic options include (1) narrowing an agent based on available culture data, (2) need for an alternative agent given prior extensive antibiotic exposure, (3) existence of more effective therapy, (4) patient able to transition from intravenous to oral antibiotics, or (5) current therapy based on a fallacious allergy. An important limitation of iVents is that their use for documentation is limited to pharmacists; other members of the stewardship team (eg, physicians, infection preventionists) do not have access to this function. If data from iVents are used to demonstrate the number and type of stewardship interventions, interventions made by nonpharmacists will not be captured.

Enhanced AS dashboard workflow

Figure 2 demonstrates how each of the components of the AS module are used together to facilitate workflow. Patient lists are sorted by AMS score, with the highest score suggesting the highest priority for intervention. Additionally, the change in the AMS score is provided along with a notation for when the case was last reviewed and if any AS-related iVents have been documented. The score is derived from the customized alerts that appear on the right side of Figure 2. The first 2 patients both have an AMS score of 14, but the reasons for the high score differ. The first patient's score is composed of 5 individual alerts with the most points resulting from positive blood cultures (5 points). The alerts for a broad-spectrum agent for greater than 3 days (3 points), need for therapeutic drug monitoring (TDM) (3 points), and final culture results (3 points) are all related to vancomycin use for the patient's positive blood culture. The second patient's score results from 3 alerts: positive blood cultures (5 points), initiation of a restricted antimicrobial agent overnight (5 points), and final culture results (5 points). While these patients have the same AMS score, the patient with alerts for both a positive blood culture and a restricted antimicrobial should take higher priority for intervention. The AMS score is beneficial to identify patients who require stewardship intervention, but additional evaluation by the AS team is necessary for further stratification.

Once a patient row on the dashboard is highlighted, an individual patient AS report appears (bottom box in Figure 2) providing information including vital signs and current antibiotic orders as well as a link to "document scoring system review." This is a separate mechanism to document an intervention, provide communication to other team members, or indicate that a particular patient has been reviewed. At our institution, stewardship pharmacists use this to communicate with other pharmacists involved in the care of the same patients (Figure 3). This enhancement may prompt more rapid communication between the unit pharmacists and the ASP pharmacist regarding needed changes or may expedite the unit pharmacists' prompting of primary teams to make the necessary changes.

Reporting

The AS and ICON modules have options for developing real-time reports on use of specific antimicrobials, antibiograms, and overall antimicrobial utilization. Workbench reports, or reports that identify patients receiving specific antimicrobial(s), have been instrumental in identifying all patients within the institution on a particular antimicrobial during drug shortages or for medication utilization evaluation (MUE) projects. For example, a postgraduate year 1 (PGY1) resident was tasked with completing an MUE for ertapenem to assess compliance with institutional guidelines for use. The AS team designed a report to capture patients receiving ertapenem on any adult inpatient hospital unit. The PGY1 resident then verified the ertapenem indication and intervened if an antibiotic change was necessary. These data were collected and presented to the Johns Hopkins Hospital AS committee, and it was determined that ertapenem was being used appropriately within our institution. This functionality is also essential if information about which patients are receiving a certain antimicrobial is needed rapidly, such as in the case of a new antimicrobial shortage where patients receiving the agent must be identified and evaluated for whether they need an alternative regimen.

Antibiogram reporting is one of the key features of ICON and can be run in real time. These reports follow the rules set forth by the Clinical Laboratory Standards Institute (CLSI). Antibiograms are available for each hospital and can be customized to fit individual hospital needs in terms of time frame, location, source of infection, or infecting organism. Examples of specialized antibiogram reports available at our institution include intensive care unit (ICU) only, oncology units only, urine isolates only, *Candida* spp. only, and anaerobic organisms only. An additional benefit of the antibiogram feature is the ability to assess minimum inhibitory concentration (MIC) distribution, allowing for assessment of breakpoint changes, susceptible dose-dependent (SDD) designations, and epidemiological cutoff values (ECVs). The antibiograms can be made available to all frontline clinicians or be restricted to AS team members only.

Finally, ICON has the ability to calculate DOT per 1,000 patient-days present with the option to automatically submit to the NHSN-AUR module once validation is completed. Information on data validation can be found in the CDC document *Antibiotic Use and Resistance Module*.[11] Epic uses a proprietary formula that removes patient-level details and transmits data in the format required by the CDC. It is possible to develop a report with these data for internal use without relying only on output from the NHSN-AUR module; however, there are limitations to how these data can be displayed. It is difficult to develop reports assessing and comparing trends over time by unit, service, and antibiotic, and it is not possible to obtain patient-level data to assess which patients contributed to the rates shown. This is particularly a limitation for larger hospitals or health systems with a high number of specialized units. For our health system, we elected to transfer antibiotic use data to a data analytics software platform to develop more useful and actionable antibiotic use dashboards.

Stepwise approach to implementation

There are several advantages to having the AS module directly embedded within the health system's chosen EHR. Operationalizing this module within existing software avoids the need for additional contract negotiations with outside vendors as well as the acquisition of financial support for these supplemental programs. Because the program language and logic are the same, there is no requirement to force multiple electronic systems to communicate. The costs that are incurred include the time and efforts of the stewardship team for the build process; however, this is balanced by the improvements in efficiency after implementation. Even though measuring the impact of the AS dashboard is not within the scope of this report, we estimate that this customized AS module allowed us to intervene on 35% more patients and expedite interventions on blood culture results and de-escalation of therapy.

Several considerations exist before implementing use of the ICON and AS modules. These include identification of all pertinent members of the implementation team; the time commitment of team members to develop, build, and validate customizable alerts, scoring, and reporting; and how the hospital or health system will fund this add-on component to the EHR.

Step 1: identify key stewardship priorities. Before starting the build process, it is critical for the AS group to identify all alerts, interventions, and reports that may be useful to their daily workflow and then prioritize these in order of importance. Setting an intervention priority list may require several rounds of review and discussion among the AS group, and it is helpful to set these priorities before meeting with the Epic IT team. We advise creating a broad list of items initially, as it may not be possible for some requests to be built in the dashboard.

Step 2: assemble the team. Identification of team members with content expertise in antimicrobials, microbiology, and pharmacy was vital to the successful creation and implementation of our enhanced AS module. Our implementation team comprised AS physicians and pharmacists, as well as several members of the Epic IT team, who we preferred to have backgrounds in either pharmacy or clinical microbiology. Epic IT members with backgrounds in these areas were effectively able to both understand the needs of the AS end users and know how to create the necessary programming in Epic to meet those needs. When necessary, infection control preventionists and members of the microbiology laboratory also took part in the build and validation.

Step 3: schedule regular meetings. The time commitment to develop the dashboard is significant. Weekly hour-long telephone calls were scheduled for all members of the implementation team beginning in 2015 and continuing for 18 months before the scheduled Epic go-live on July 1, 2016. During initial telephone calls with Epic IT, the AS priority list was reviewed and we determined what was and was not possible in the build process. Once the list was finalized, the weekly telephone calls followed a stepwise approach, first focusing on rules and alerts, then on iVent types and subtypes, and finally on desired workbench reporting.

Step 4: AS dashboard pilot and validation. Once the dashboard is implemented, ensuring alerts are accurately firing and reports are populated with the relevant data is an important aspect of customizing the AS module. Depending on the complexity of the build, there could be numerous alerts that may not be actionable for individual users or hospitals, resulting in risk that clinically important alerts could be lost and an opportunity for an intervention missed.[5,12] We recommend a trial period to ensure dashboard functionality and to allow for modifications based on observations once the module is implemented. The Nebraska Medical Center reported their experience with the implementation of an electronic CDSS and noted that 76% of the alerts that fired were considered nonactionable; however, others have reported that 40% of the CDDS-AS alerts were actionable.[13] Customization of Epic alerts allows the end user to remove nonactionable alerts from their list and add newly developed alerts. However, we recommend that AS teams reevaluate alerts annually to assess whether they are still value added or no longer relevant.

Step 5: customize the process for each hospital site. AS resources vary across hospitals and health systems. In our health system, the academic hospitals moved forward with robust dashboard capabilities with Epic implementation in July 2016, while the community hospitals adopted the customized alerts as more AS human resources became available. For hospitals that wish to enhance the AS module in Epic with limited AS resources, it is advisable to start with 2 to 3 priority interventions and add complexity to the build as the AS team becomes comfortable with the changes. For example, an alert column for an IV-to-PO switch and an alert that triggers once a patient has been on vancomycin for a defined period of time are reasonable initial interventions due to the relative simplicity of the build. These are meaningful interventions that can be tracked and show stewardship impact quickly. Medical centers with established AS programs and/or prior Epic experience can evaluate combinations of alerts, iVents, and workbench reporting to identify what best suits their needs. Health-system–level standardized interventions such as our “Vanc Zosyn Meropenem greater than 72 hours” rule that identified patients who were receiving 1 of these broad-spectrum agents for a minimum of 3 days can be developed to function as a metric to drive AS improvements.

Step 6: ongoing validation and upkeep. Continuous surveillance is necessary to ensure that the dashboard continues to function as expected. Validation of data submitted to the NHSN-AUR requires a time commitment from the stewardship team, and additional reports need to be generated in Epic to validate data (eg, calculation of DOTs and days present manually). Antibiogram reporting requires frequent upkeep because bacterial nomenclature and clinical breakpoints for antibiotics often change, leading to the need for updates in Epic and subsequent validation to ensure the reporting is accurate. Finally, the AS team should continuously monitor for institutional changes or new priorities that may require development of new dashboard alerts. For example, a new diagnostics rapid test deployed by the microbiology laboratory will need a new alert so that the AS team can respond rapidly to results and contact the treating provider with recommendations.

Conclusion

The Epic AS module can be customized to the needs of individual ASPs to increase the effectiveness and efficiency of AS personnel. While building and implementation are time consuming, in our health system, the time investment was worth the subsequent benefits of a robust AS electronic tracking system.

Disclosures

The authors have declared no potential conflicts of interest.

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Figure 1. Example of iVent documentation. Demonstration of pharmacy input of intervention to change fluoroquinolone therapy to nitrofurantion for management of cystitis per institutional guidelines.

Figure 2. Screenshot of the antimicrobial stewardship dashboard with alerts for daily patient assessment and to identify who may be in need of stewardship intervention. Top left box, standard AS columns depicting current AMS score, the score change over 24 hours, the last review by the AS team, and any open AS-related iVents. Top right box, customized AS alerts modified or built by the AS team. Bottom box, individual patient AS report. AMS indicates XXX; AS, antimicrobial stewardship.

Figure 3. Screenshot of an antimicrobial stewardship review note to document daily communication among the stewardship team.

Key Points

- Clinical decision support systems in antimicrobial stewardship can be customized to meet the needs of health systems to increase the efficiency of the stewardship program.
- Time and resources are needed to allow participation from all hospitals within a health system and to optimize the components of the antimicrobial stewardship module for all entities.
- A multidisciplinary team (physicians, pharmacists, microbiology, and electronic health record information technology personnel) is instrumental to identify antimicrobial stewardship priorities to enhance daily workflow and streamline the intervention list.

Table 1. Standard Columns and Customized Rules Available Through Epic in The Johns Hopkins Health System

Type of Item	**Item**	**Description**	**Assigned Point Value**
Standard AS columns	AMS score	Provides cumulative score for all customized alerts that have fired for a patient	
	AMS score change	Determines whether the AMS score value has increased, decreased, or remained the same in a 24-hour period	
	AMS last reviewed	Time since AS team has evaluated and/or intervened on patient. Free text notes here can also be used for pharmacist-pharmacist communication.	
	AMS iVents	Column indicator is present if open AS iVent exists	
Customized alerts	Bug-drug mismatch	Flags patients with positive cultures for *Enterobacter* spp. and receiving ceftriaxone, cefotaxime, or ceftazidime	5
		Flags patients with extended-spectrum β-lactamase organism (*Escherichia coli*, *Klebsiella pneumoniae*, *Klebsiella oxytoca*, *Proteus mirabilis*) receiving cephalosporins or piperacillin/tazobactam	5
		Flags patients receiving ciprofloxacin or levofloxacin with quinolone-resistant *E. coli* or *Pseudomonas aeruginosa*	5
		Flags patients without an active order for an antifungal and with blood cultures positive for yeast	5
		Flags patients without an active order for amphotericin B, voriconazole, or posaconazole and with positive blood cultures for a filamentous organism	5
	Verigene results	Flags patients with preliminary positive blood cultures with Verigene identification available within the past 3 days	5
	Positive blood culture (preliminary)	Flags patients with preliminary positive blood cultures within the last 5 days	5
	De-escalation of therapy	Flags patients with *Enterococcus faecalis* in blood susceptible to ampicillin who are receiving vancomycin or linezolid	5
		Flags patients with MSSA and on vancomycin	3 (nonblood isolates); 5 (blood isolates)
		Flags patients who are on micafungin and have positive blood cultures for *Candida* spp. susceptible to fluconazole	3

Duplicate coverage exists	Flags patients with duplicate anaerobic coverage (metronidazole plus ampicillin/sulbactam, piperacillin/tazobactam, ertapenem, meropenem, or imipenem/cilastatin)	3
	Flags patients with duplicate broad-spectrum therapy (combination of any 2: meropenem, imipenem/cilastatin, piperacillin/tazobactam, cefepime, ceftazidime, ceftriaxone)	3
	Flags patients receiving clindamycin with either moxifloxacin or ampicillin/sulbactam	2
	Flags patients receiving multiple azoles	5
	Flags patients receiving both micafungin and fluconazole	3
Final culture tesults	Results when susceptibilities have been finalized and receiving systemic antibiotics	3
Vanc Zosyn Mero greater than 3 days	Flags patients receiving greater than 3 but fewer than 6 days of therapy for vancomycin, meropenem, or piperacillin/tazobactam	3
Restricted antimicrobial overnight	Flags patients with open iVents for restricted antimicrobials started overnight	5
TDM (antimicrobial) iVents	Flags patients with opent TDM iVent for the following antimicrobials within the last 3 days: voriconazole, itraconazole, posaconazole, flucytosine, vancomycin, tobramycin, amikacin, gentamicin	3
Fungemia	Flags patients who have positive blood cultures for yeast and no active order for fluconazole or micafungin	5
	Flags patients who have positive blood cultures for a mold and no active order for amphotericin B, voriconazole, or posaconazole	5

Abbreviations: AMS, XXX; AS, antimicrobial stewardship; MSSA, methicilin-susceptible *Staphylococcus* aureus; TDM, therapeutic drug monitoring.

Table 2. Antimicrobial Stewardship iVents Available Through Epic in the Johns Hopkins Health System

iVent Type	Subtype
Better therapeutic options existed	Can narrow based on culture data
	Different agent needed based on culture data
	Effective and more cost-effective treatment options existed
	More effective therapy existed
	Patient can transition to oral therapy
	Therapy based on fallacious allergy
Bug-drug mismatch	
Drug-drug interaction	
Equally effective formulary agent existed	
Inappropriate dosing regimen	Dose too high
	Dose too low
	Initial dosing
	Other
	Wrong frequency
AS other	Drug information
	Recommend ID consult
Too broad	Unnecessary anaerobic coverage
	Unnecessary atypical coverage
	Unnecessary ESBL coverage
	Unnecessary fungal coverage
	Unnecessary Gram-negative coverage
	Unnecessary MRSA coverage
	Unnecessary *Pseudomonas* coverage
	Unnecessary VRE coverage
Too narrow	Failure to cover Gram-positive organisms
	Failure to cover anaerobes
	Failure to cover atypical organisms
	Failure to cover fungi
	Failure to cover Gram-negative organisms
	Failure to cover MRSA
	Failure to cover *Pseudomonas*
	Failure to cover VRE
	Other
Treatment was not needed	Double anaerobe coverage
	Double atypical coverage
	Double Gram-negative coverage
	No evidence of infection
	Prophylaxis not indicated
	Therapy aimed at colonization
	Treatment course completed

Abbreviations: AS, antimicrobial stewardship; ESBL, extended-spectrum β-lactamases; ID, infectious diseases; MRSA, methicillin-resistant *Staphylococcus aureus*; VRE, vancomycin-resistant enterococci.

Figure 1. Example of iVent Documentation

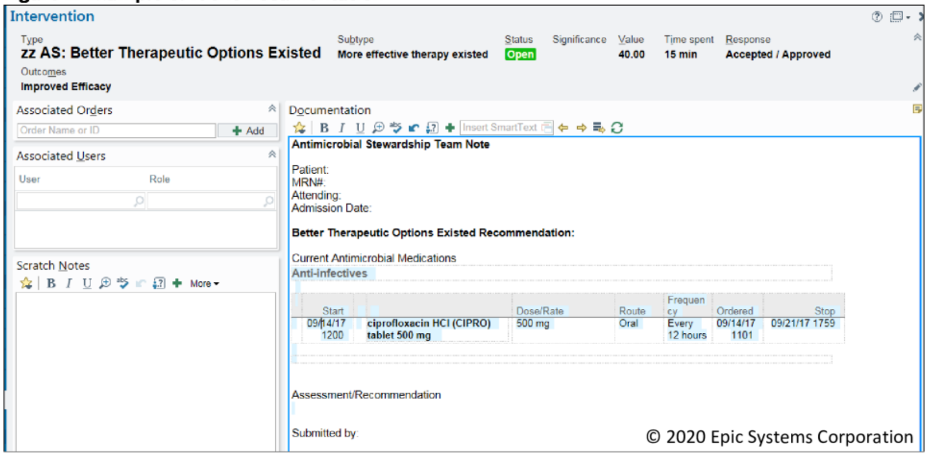
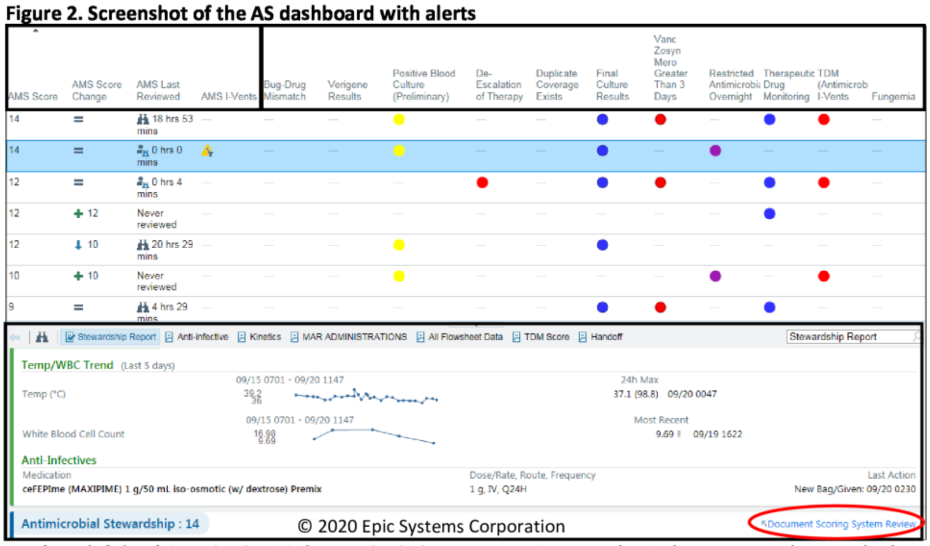


Figure 2. Screenshot of the AS dashboard with alerts



a. (Top left box) Standard AS Columns depicting current AS score, the 24 hours score change, the last review by AS team, and any open AS-related iVents
b. (Top right box) Customized AS alerts modified or built by the AS team
c. (Bottom box) Individual Patient AS report

Figure 3. Snapshot of an AS review note