The “Epic” Challenge of Optimizing Antimicrobial Stewardship: The Role of Electronic Medical Records and Technology

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Antimicrobial stewardship programs (ASPs) are established means for institutions to improve patient outcomes while reducing the emergence of resistant bacteria. With the increased adoption and evolution of electronic medical records (EMRs), there is a need to assimilate the tools of ASPs into EMRs, using decision support and feedback. Third-party software vendors provide the mainstay for integration of individual institutional EMR and ASP efforts. Epic is the leading implementer of EMR technology in the United States. A collaboration of physicians and pharmacists are working closely with Epic to provide a more comprehensive platform of ASP tools that may be institutionally individualized. We review the historical relationship between ASPs and the EMR, cite examples of Epic stewardship tools from 3 academic medical centers’ ASPs, discuss limitations of these Epic tools, and conclude with the current process in evolution to integrate ASP tools and decision support capacities directly into Epic’s EMR.

Keywords. Epic; electronic medical records; technology; antimicrobial stewardship.

Antimicrobial resistance has been recognized by the Centers for Disease Control and Prevention and the World Health Organization as both a “major public health issue” and “one of the three greatest threats to human health” [1]. In fact, the theme of World Health Day 2011 was “antimicrobial resistance: no action today and no cure tomorrow,” emphasizing not only the concern for resistance, but also the worrisome aspect of few novel antibiotics in the development pipeline [2]. Now, in the 21st century, we are faced with bacterial infections for which no treatment exists.

In response to this significant problem to society, antimicrobial stewardship programs (ASPs) have been implemented worldwide, with the Infectious Diseases Society of America and Society for Healthcare Epidemiology of America (IDSA/SHEA) guidelines for developing ASPs recommending that healthcare institutions invest in data systems that are capable of measuring quality improvement from antimicrobial stewardship implementation [3]. Effective programs have improved patient outcomes and decreased antibiotic usage by up to 35%, with an annual savings to institutions of up to $900,000 [4–10]. Due to these substantial findings, in 2010 the California Department of Public Health Healthcare Associated Infections Program developed the only statewide ASP initiative mandating general acute care hospitals to monitor and evaluate the utilization of antimicrobials [11].

For ASPs to be optimized fully and truly make a viable long-term impact on patient outcomes, information technology (IT) must be employed. Electronic medical records (EMRs), online referral and prescription systems, and computerized provider order entry have been relied on heavily in all aspects of healthcare, including antimicrobial stewardship. To encourage the
use of this technology, the Medicare and Medicaid EMR Incentive Programs are providing financial incentives to qualified institutions as they adopt, implement, upgrade, or demonstrate "meaningful use" of certified EMR technology to improve patient care by meeting several predefined objectives established by the Centers for Medicare and Medicaid Services [12]. Although it would seem that ASPs should naturally work within the EMR to seamlessly provide interventions, education and training, and data, the initial design and implementation of EMR systems were not built around the strategies of current needs of ASPs [13]. This is especially true for those medical centers in the early adoption phase of EMR where specific programming is required to tailor to ASP objectives.

Due to the rapidly increasing adoption of EMR technology, the potential for the assimilation of healthcare information for ASPs to use appears unprecedented. Epic (Verona, Wisconsin; www.epic.com) has captured 53 of 82 (64.6%) and 75 of 300 (25%) new EMR vendor contracts for hospitals of ≥200 and <200 beds, respectively [14, 15]. Therefore, the objective of this article is to describe the role that Epic EMR has in integrating ASPs in institutions, based on our experience, and present useful approaches to optimizing these interfaces for ASPs.

EMR VENDORS AND CLINICAL DECISION SUPPORT SYSTEMS

To optimize the analysis and collation of antimicrobial information available for hospital-based computer systems in an organized and efficient fashion for analysis, third-party software vendors geared toward stewardship (Table 1) are working parallel with EMRs, such as Epic and Cerner (Kansas City, Missouri). These vendors originally developed their software to target infection control objectives, with antimicrobial stewardship as a secondary goal. Hospital antimicrobial information is sent through the third-party software, and algorithms written by the end user or vendor provide more meaningful collation of data for ASPs. This software is relatively expensive depending on institution size, ranging from $100 000 to $500 000 per year.

With hospital administrations cognizant of costs, it has been difficult to convince administrators to spend extra dollars for third-party vendor software, despite data supporting its cost effectiveness [16], and hence they ask ASPs to work within the limitations of their EMR, often just seeking "low hanging fruit" [6].

Third-party vendors can sustain clinical decision support systems (CDSSs) that, when integrated within the EMR, have been shown to significantly improve the function of ASPs [17–21]. CDSSs can alert a clinician about a drug–drug interaction, or they may serve a more complex function as a clinical tool to aid in the management of community-acquired pneumonia in providing a recommendation regarding the appropriateness of inpatient or outpatient therapy [22]. If CDSS tools are developed internally, a multidisciplinary strategic committee consistent with ASP guidelines should provide input. At the 3 institutions represented by the authors, this occurs via the ASP and Pharmacy and Therapeutics subcommittee tasked to create, review, and approve evidence-based CDSSs prior to “go-live” status by the pharmacy IT group. Depending on the structure of the IT department, the requests need to enter the hospital queue of new CDSS tools and frequently can be a rate-limiting step to timely implementation of ASP CDSS tools, as every department competes for prioritization on the IT task list.

Intermountain LDS Hospital in Salt Lake City, Utah, established a successful CDSS, reporting significant reductions in excess drug dosages, antibiotic susceptibility mismatches, antimicrobial adverse events, and overall hospital costs nearly 20 years ago [17, 18]. In 2006, the University of Maryland Medical Center presented the first study published to establish in a randomized controlled trial that CDSSs could improve existing ASPs [19]. The authors revealed that with the assistance of a CDSS (PharmWatch, Cereplex Inc, now SafetySurveillor, Premier Inc), the ASP intervened on nearly twice as many patients as the control arm (359 vs 180 patients, respectively), and spent approximately 1 hour less each day performing patient review. Of note, during the 3-month study period, the University of Maryland Medical Center spent approximately $84 000 less on antimicrobials in the intervention group than the control group, representing an average cost savings of $37.64 per patient. More recently, Hermsen et al [20] evaluated the consequence of the implementation of a CDSS (TheraDoc, Hospira Inc) for the ASP to perform a prospective audit with intervention and feedback at the Nebraska Medical Center. In this study, the implementation of a CDSS led to statistically significant increases in intervention attempts that were accepted in 88% of all cases. However, a major drawback was the amount of time required by ASP teams and IT personnel to implement and maintain the system. Significant time was spent reviewing alerts (2–3 hours/day, with an additional 1–2 hours for interventions on actionable alerts and documentation), leading to alert fatigue. The importance of ASPs working with

Table 1. Third-Party Software Vendors Focused Toward Antimicrobial Stewardship

<table>
<thead>
<tr>
<th>Software</th>
<th>Vendor and Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>SafetySurveillor</td>
<td>Premier Inc; Charlotte, North Carolina</td>
</tr>
<tr>
<td>TheraDoc</td>
<td>Hospira Inc; Salt Lake City, Utah</td>
</tr>
<tr>
<td>Vecna</td>
<td>QC Pathfinder; Cambridge, Massachusetts</td>
</tr>
<tr>
<td>MedMined</td>
<td>CareFusion; San Diego, California</td>
</tr>
<tr>
<td>Senti7</td>
<td>Pharmacy OneSource Inc; Bellevue, Washington</td>
</tr>
<tr>
<td>Allscripts</td>
<td>Chicago, Illinois</td>
</tr>
<tr>
<td>McKesson</td>
<td>San Francisco, California</td>
</tr>
</tbody>
</table>
vendors to reduce the number of nonactionable alerts was stressed by the authors. Ultimately, one of the challenges facing ASPs is finding a way to integrate CDSSs into the daily clinical workflow.

EPIC’S ROLE IN ASPs

In 2003, Kaiser Permanente spent $4 billion in converting their 37 hospitals to the Epic EMR system and currently has the largest nongovernmental digital depository of medical records in the world. According to a recent publication by the Permanente Medical Group, Kaiser has reduced inpatient mortality rates in patients with sepsis by 40% since 2008 [23]. They developed treatment algorithms, order sets, Best Practice Alerts (BPAs), and chart abstraction tools to screen and reliably provide effective treatments to hospital patients identified at risk for sepsis. The Epic database allowed Kaiser to understand the progression of sepsis and recognize why early intervention is so crucial.

Accordingly, there have been several key features developed in Epic including iVents, antibiotic order forms and dose checking alerts, “navigator” and BPAs, 96-hour stop date, patient scoring and monitoring, and intravenous-to-oral interchange to aid in the optimization of ASPs. All of these tools are available in Epic without the need of a third-party vendor. However, various tools, such as patient scoring, the navigator, and intravenous-to-oral interchange alerts require institution-specific programming, which requires IT directed time and effort similar to the limitations discussed above with third-party vendors. We are aware that with future updates of Epic, beginning in 2014, many of these tools will be available within the basic framework of the updated EMR program software, limiting the need for institutional programming. Our experience is limited to Epic; however, we describe both early (18 months) and late (5 years) experience with Epic for ASP.

iVents

ASP pharmacists are able to enter information in an iVent (Figure 1), an Epic tool used to communicate and record ASP recommendations and interventions. This is a convenient way to track metrics for stewardship and is available to all providers. iVents are not considered part of the medical record but can be easily retrieved. In addition, iVents may not be viewed by physicians unless the pharmacist uses the “copy and paste as a note” feature to post the iVent to the progress notes. This is only recommended if a “smartphrase” has been developed in the progress notes. A smartphrase allows for all ASP recommendations from physicians and pharmacists to be queried from the progress notes. ASP physicians can only enter ASP interventions in the progress notes, whereas pharmacists can enter interventions in iVents or progress notes, which makes the collection of ASP metrics in potentially 2 different locations within Epic.

In 2007, the ASP at East Carolina University utilized Epic iVents to review antimicrobial utilization and create messages for providers [24]. In this retrospective, interrupted time series

Figure 1. iVent in Epic. Scratch pad: comments are not part of the permanent medical record. Documentation box: comments are not part of the permanent medical record but can be retrieved. Copy and paste note: uploads the comments to the physician progress notes and is part of the medical record.
analysis, the investigators showed a significant increase in chart reviews and antimicrobial recommendations, resulting in a sustained decrease in antimicrobial use. Furthermore, there was a significant reduction by 45.2% in nosocomial methicillin-resistant Staphylococcus aureus infections and a trend toward decreasing nosocomial Clostridium difficile infections by 18.7% following implementation of the EMR.

**Antibiotic Order Form and Dose Checking Alerts**

The antibiotic order form (Figure 2), a current Epic capability, is a series of questions directed at the clinician end user to gain information about the intent of the antimicrobial order and, in our experience, takes about 15 hours to create, validate, and implement. The order form asks about the intended indication, organism coverage, infection site, type of therapy, and approving provider for restricted antimicrobials, and prompts the clinician to obtain microbiology samples. The order form is placed on all antimicrobial orders and all 6 questions are required to be answered. The data from this form can be retroactively utilized for medical use evaluation audits. Clinical pharmacists and the ASP pharmacist review the answers during the course of order verification and patient review for appropriateness. Further, allergy and dose checking alerts (Figure 3) prompt both physicians and pharmacists to scrutinize orders falling outside defined parameters.

**Navigator and BPAs**

Most traditional antibiotic stewardship occurs in a delayed or reactionary fashion. However, “real-time” stewardship, occurring through coordination of clinical microbiology and a stewardship pharmacist, is more effective as it allows for early detection and intervention-based rapid diagnostics [25] or is based on the susceptibilities of the microorganism [6, 26]. Creation of a stewardship or infectious disease “navigator,” (Figure 4) which is available in certain Epic versions, collates most of the ASP information needed to evaluate and make an educated decision regarding patient therapy into a single location. This reduces the amount of user searching by centralizing the location of data and standardizing the variety of data presentation formatting. Users are directed to the “navigator” by a BPA activated by the ASP. The BPA is accompanied with a progress note detailing the ASP-recommended intervention. Making stewardship recommendations using Epic’s tool, BPAs as a communication method is an effective and minimally invasive mechanism to effect change [27]. BPAs directed at antimicrobial de-escalation have a high acceptance rate and generally are well received by the primary prescribing team [27]. A navigator built for the BPA allows for 2-way communication by permitting healthcare providers to respond to the BPA (Figure 4). Each institution can individualize BPAs. Hyperlinks from the navigator allow infectious disease and ASP educational opportunities to occur in real time from within the EMR. Although the

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**Figure 2.** Antibiotic order form in Epic.

<table>
<thead>
<tr>
<th>Prompt</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. [DAPTomyacin] Indication</td>
<td>Prophylaxis-Surgical, Prophylaxis-Medical, Non-infectious, Infection-Documented, Infection-Suspected</td>
</tr>
<tr>
<td>2. [DAPTomyacin] Site (select all that apply)</td>
<td>Abdominal/Pelvic, Bloodstream, Burn, Cellulitis, HEENT, IV Line, Lower RTI, Meningitis, Musculoskeletal, Neutropenic Fever, Surgical Wound, URI, UTI, Non-infectious, Transplanted Organ</td>
</tr>
<tr>
<td>3. [DAPTomyacin] Cultures Ordered (YN)</td>
<td>Yes, No</td>
</tr>
<tr>
<td>4. [DAPTomyacin] Type of Therapy (YN)</td>
<td>New Therapy, Modification of Therapy, Change Route of Therapy, Continuation of Therapy</td>
</tr>
<tr>
<td>5. [DAPTomyacin] Coverage (select all that apply)</td>
<td>Anaerobes, Enteric GNR, Enteroococcus, Not VRE, Enteroococcus VRE, Mycobacteria, Pseudomonas aeruginosa, Staph, Beta-Lactam Susceptible, Staph, Methicillin Resistant, Streptococcus-Penicillin Susceptible, Streptococcus-Penicillin Resistant, Non-infectious, Methicillin-resistant CoNS, Organism NOS</td>
</tr>
<tr>
<td>6. [DAPTomyacin] Authorizing ID provider protocol (From 23-07, the pharmacy may dispense a bridging quantity to initiate therapy until 1200)</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 3.** Maximum dose checking alert in Epic.
Antimicrobial Stewardship Recommendations


Recommendation: Your patient is on piperacillin/tazobactam and metronidazole both of which have anaerobic coverage. Unless the patient has an undrained abscess OR has both an infection and Clostridium difficile one of the anti-anaerobic antibiotics should be discontinued.

Sincerely,

Figure 4. Best Practice Alert in “navigator” of Epic.
navigator is a useful tool in ASP, providers might experience “alert fatigue” from other non-ASP BPA alerts.

The 96-Hour Stop Date

The 96-hour stop date (Figure 5) for restricted antibiotics is a list that is generated based on stop times of the antibiotics and takes about 15 hours to create, validate, and implement. A protocol is developed by ASP and is approved by the pharmacy and therapeutics committee, which allows for removing the stop date if use is appropriate. This task takes between 30 and 60 minutes per day to manage and verify that antimicrobials are not unintentionally discontinued. If use is inappropriate, a BPA is manually entered by the ASP pharmacist notifying the team that further approval is necessary.

Patient Scoring and Monitoring

Currently requiring institutional customization, patient scoring (Figure 6) is a programming tool used to identify and stratify patients on the basis of weighted characteristics that prioritize stewardship review. Based on the complexity of the weighted characteristics (written as logic rules), programming can take 2–5 hours per rule. For example, all patients receiving vancomycin would appear in a list. Patients with rapidly changing renal function or supertherapeutic vancomycin troughs appear higher on the list because intervention on these patients is more urgent. As displayed in Figure 6, serum creatinine monitoring has been provided as an example. When the serum creatinine changes by a predefined amount, the patient accrues points. The points total in a patient list column and allow clinicians to quickly sort by patients with a change in creatinine. When combined in a patient list comprised of only patients receiving vancomycin, this would alert clinicians to a patient at risk for under/overdosing. This tool, which will be available and standardized in the software in future versions of Epic, required several months for the hospital IT to develop; however, the value to ASP is high as it allows programs with limited

<table>
<thead>
<tr>
<th>Unit</th>
<th>Order Name</th>
<th>End Date</th>
<th>End Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>F4/6</td>
<td>micafungin (MYCAMINE) 100 mg in sodium chloride 0.9% 100 mL bag</td>
<td>05/01/2013</td>
<td>07:59:00 AM</td>
</tr>
<tr>
<td>B4/6</td>
<td>voriconazole (VFEND) tab 200 mg</td>
<td>05/02/2013</td>
<td>09:59:00 AM</td>
</tr>
<tr>
<td></td>
<td>amphotericin B LIPOSOMAL (AMBISOME) 425 mg in dextrose 5% 250 mL bag</td>
<td>05/01/2013</td>
<td>09:59:00 AM</td>
</tr>
<tr>
<td>B4/4</td>
<td>DAPTOMycin (CUBICIN) 410 mg in sodium chloride 0.9% 50 mL bag</td>
<td>05/02/2013</td>
<td>11:59:00 PM</td>
</tr>
<tr>
<td>D4/4</td>
<td>meropenem (MERREM) 500 mg vial + minibag</td>
<td>04/29/2013</td>
<td>09:59:00 PM</td>
</tr>
<tr>
<td>B6S3</td>
<td>meropenem (MERREM) 500 mg vial + minibag</td>
<td>05/02/2013</td>
<td>07:59:00 PM</td>
</tr>
<tr>
<td></td>
<td>voriconazole (VFEND) 236 mg in dextrose 5% 100 mL bag</td>
<td>05/02/2013</td>
<td>09:59:00 PM</td>
</tr>
</tbody>
</table>

Figure 5. The 96-hour stop date.

Figure 6. Patient scoring and monitoring.
resources to identify which patients need ASP attention in real time.

**Intravenous-to-Oral Interchange**

The intravenous-to-oral monitoring (Figure 7) capability provides a medication report that pulls into the clinical pharmacists’ daily monitoring report. This report displays only medications on the institution’s approved route interchange protocol (intravenous to oral and oral to intravenous). The second report is a nutrition order report, displaying to the clinical pharmacist the patient’s diet order to allow for easy identification of patients who may be switched from intravenous to oral therapy. The intravenous-to-oral interchange tool saves time as non-ASP pharmacists are prompted to automatically change the order. They are usually able to do this per protocol without contacting the provider. This is the first step toward bringing medication stewardship to all providers and is a high-impact intervention.

**LIMITATIONS OF EPIC**

Realizing that hospital EMRs have been built with the primary goal of maximizing billing, ASPs should not expect their daily stewardship activities and work flow to change significantly immediately after their hospitals’ Epic “go-live” date. Clinicians should expect to spend a significant amount of time customizing their system. These time investments include promoting needs to institution IT leaders, creating and validating tools with IT developers, and implementing the systems with ASP pharmacists and physicians. Several of these programming changes come with high software and implementation charges. The limitations of Epic for ASPs may be greater if the hospital does not have third-party CDSSs (Theradoc, SafetySurveillor), as experienced by 2 of the 3 institutions represented by the authors. Currently, Epic “out of the box” is limited for ASPs, but with time and continued collaboration between ASPs and hospital IT in addition to Epic updates, its value to stewardship grows.

**DISCUSSION**

The tools discussed above require numerous hours of institution-specific IT programming, making the availability of these tools at least 6–18 months after the institution’s individual Epic “go-live” date. Although Epic has the capability of optimizing several areas of ASPs, a summary of the strengths and shortcomings of Epic are summarized in Table 2. ASPs will find themselves competing with other departments within the hospital for prioritization on the IT project list of builds within Epic unless the pharmacy department maintains control over a portion of the IT group. In response to this issue, a national group of stewardship practitioners from various hospitals is working with Epic to create and enhance EMR tools in order to provide standardized ASP tools. By gathering many comprehensive ASPs together, these practitioners are striving to reduce the amount of individual internal programming needed to apply basic stewardship decision support tools. These tools will be available in future Epic versions and some programming

<table>
<thead>
<tr>
<th>Table 2. Strengths and Shortcomings of Epic</th>
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<tbody>
<tr>
<td>Strengths</td>
</tr>
<tr>
<td>Eliminates cost of external vendor</td>
</tr>
<tr>
<td>Integrated ASP alerts and monitoring in single system improves efficiency</td>
</tr>
<tr>
<td>Education tools built into each order</td>
</tr>
<tr>
<td>Real-time interventions and alerts possible</td>
</tr>
<tr>
<td>Templating of ASP tools possible, allowing integration across institutions</td>
</tr>
<tr>
<td>Allows for easy retrieval of patient data necessary for ASP research</td>
</tr>
</tbody>
</table>

Abbreviations: ASP, antimicrobial stewardship program; EMR, electronic medical record; IT, information technology.
may not be compatible with older, unsupported versions, although customization is still possible by working with individual IT groups. From the 5-year Wisconsin–Epic stewardship experience, coordinating internal IT resources with Epic technical support resources, in addition to utilizing SafetySurveillor, results in a high-quality, low-maintenance program.

The Epic stewardship group is also seeking methods to measure the impact of ASPs. Epic projects that by 2014, on-demand antimicrobial utilization reports by hospital or unit will be available describing days of therapy per 1000 patient-days. An externally available reporting option following the National Healthcare Safety Network Antimicrobial Utilization Reporting module rules is also being investigated. Providing high-level antimicrobial utilization reports, especially by clinical service, permits the stewardship team to identify targets for intervention or education and provide prescribers with reports and evaluations of their prescribing habits. Furthermore, Epic has a technical support assigned to each customer that can help stewardship team members navigate the Epic system and customize institutional systems.

The above goals will hopefully come to represent a new standard for ASPs. As we have described, individual institutional programs that desire customized programming may be accomplished by working with individual IT departments. By 2013, 127 million patients, or nearly 40% of the US population, will have its medical information stored in an Epic digital record [28]. Several major academic medical centers, including the 3 centers represented by the authors, have Epic EMRs, with each institution at various stages of integrating Epic into their ASPs.

CONCLUSIONS

Although medicine changes slowly in adopting new technology, EMRs are here to stay. Currently, Epic’s ability to optimize efficiency in the daily stewardship interventions is limited in hospitals without third-party CDSSs (ie, TheraDoc, SafetySurveillor). The interventions described in this review will help ASPs to develop this programming within Epic and further enhance their impact. We predict that with these tools, rapid and powerful data can be generated to improve patient care. Epic’s impact on patient outcomes and costs needs to be further evaluated.

Note

Potential conflicts of interest. R. K. has received speaking honoraria from Cubist Pharmaceuticals and Forest Laboratories; has served on the advisory board of Optimer Pharmaceuticals; is currently employed by Cubist Pharmaceuticals; and owns Cubist Pharmaceuticals stock. D. A. G. has received grant support from Merck and serves on the advisory board of Optimer, Cubist, Merck, Rempex, and Forest. B. C. F. has received grant support from Merck. W. E. R. has received grant support and speaking honoraria from Cubist and is a consultant for The Medicines Company and Visante, Inc. L. T. S. reports no potential conflicts.

All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

References