Pharmacist-driven initiative for management of *Staphylococcus aureus* bacteremia using a clinical decision support system

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**Purpose.** The development and implementation of a clinical decision support system (CDSS) for pharmacists to use for identification of and intervention on patients with *Staphylococcus aureus* bacteremia (SAB) are described.

**Summary.** A project team consisting of 3 informatics pharmacists and 2 infectious diseases (ID) pharmacists was formed to develop the CDSS. The primary CDSS component was a scoring system that generates a score in real time for a patient with a positive blood culture for *S. aureus*. In addition, 4 tools were configured in the CDSS to facilitate pharmacists’ workflow and documentation tasks: a patient list, a patient list report, a handoff note, and a standardized progress note. Pharmacists are required to evaluate the patient list at least once per shift to identify newly listed patients with a blood culture positive for *S. aureus* and provide recommendations if necessary. The CDSS was implemented over a period of 2.5 months, with a pharmacy informatics resident dedicating approximately 200 hours in total. An audit showed that the standardized progress note was completed for 100% of the patients, with a mean time to completion of 8.5 hours. Importantly, this initiative can be implemented in hospitals without specialty-trained ID pharmacists. This study provides a framework for future antimicrobial stewardship program initiatives to incorporate pharmacists into the process of providing real-time recommendations.

**Conclusion.** A pharmacist-driven patient scoring system was successfully used to improve adherence to quality performance measures for management of SAB. A pharmacist-driven CDSS can be utilized to assist in the management of SAB.

**Keywords:** antimicrobial stewardship, bacteremia, electronic medical record, health information technology, pharmacist intervention, *Staphylococcus aureus*

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Since the establishment of the Health Information Technology for Economic and Clinical Health (HITECH) Act in 2009, electronic medical records (EMRs) have become an integral component of healthcare in the United States. EMRs are transforming the U.S. healthcare system from one that is primarily paper based to one that uses technology to provide clinicians with integrated information, enabling them to deliver higher-quality and more efficient care. The Centers for Medicare and Medicaid Services has identified EMRs as “the next step in the continued progress of healthcare.” EMRs also have potential as a tool for assisting in antimicrobial stewardship programs (ASPs).

The use of an EMR in combination with antimicrobial stewardship can assist in the management of patients with specific diseases, in-
cluding Staphylococcus aureus bacteremia (SAB). SAB is a formidable disease due to its propensity to result in metastatic infection and the associated mortality rate of 16–31%.7,13 The Infectious Diseases Society of America recommends the use of evidence-based quality performance measures for the management of SAB.12 However, evidence suggests that hospitals’ adherence to the performance measures is suboptimal, ranging from 27.1% to 72.9%.13,14 ASPs are well suited to direct evidence-based management of SAB in order to improve clinical and microbiological outcomes.

Despite the known benefits, only half of U.S. hospitals have implemented a structured ASP.15,16 The primary barrier to the implementation of an ASP, one consistently cited throughout the literature, is lack of personnel.17 To overcome limitations, institutions must implement novel ways to conduct antimicrobial stewardship. Healthcare information technology, including the use of an EMR system, provides a unique opportunity to engage pharmacists, including those without specialized training in infectious diseases (ID) or antimicrobial stewardship, in this area of patient care. The Epic integrated EMR (Epic Systems Corporation, Verona, WI) provides a clinical scoring tool that serves as a clinical decision support system (CDSS) for the prioritization of patients and subsequent intervention and documentation. This article describes the development and implementation of a CDSS for pharmacists to use in targeting patients with SAB for recommended interventions.

**CDSS development**

An interprofessional team consisting of an ID physician and pharmacists completed and implemented an evidence-based guideline for the diagnosis and management of SAB. The guideline was available on our institution’s intranet. However, the guideline was not available in the EMR to guide clinicians at the point of diagnosis and prescribing. The team believed that it was important to incorporate the guideline into the EMR. The mechanism to provide the incorporation was the implementation of a CDSS.

A project team consisting of 3 informatics pharmacists (the director of pharmacy informatics, the senior system analyst, and the pharmacy informatics resident) and 2 ID pharmacists was formed to develop the CDSS. A proposal for the implementation of a CDSS for the management of SAB was completed by the project team and presented to the directors of the pharmacy department during a weekly leadership meeting. The project proposal consisted of 3 main components: real-time pharmacist notification regarding all patients with a blood culture positive for *S. aureus*, improved pharmacist workflow, and appropriate pharmacist documentation. Previously, the department of pharmacy had implemented CDSSs in 3 other areas (pharmacokinetic dosing, renal dosing, and anticoagulation). Importantly, these CDSSs focused solely on medication management. In contrast, the CDSS for the management of SAB focused on a specific disease and provided recommendations aligned with an evidence-based guideline.

The primary component of the CDSS was real-time generation of a score for a patient with a positive blood culture for *S. aureus*. Prior to the configuration of CDSS functionality in the EMR, a work group consisting of the project team, pharmacy managers, staff pharmacists, critical care pharmacy specialists, and internal medicine pharmacy specialists identified the CDSS triggering criteria, triggering time, and triggering duration for SAB. A decision was made to program the CDSS for alert triggering by a blood culture positive for *S. aureus*. At our institution, all positive blood cultures are further evaluated using a rapid diagnostic test that can identify *S. aureus* (Verigene BC-GP, Luminex, Austin, TX). A specific string of data, “*Staphylococcus aureus* DNA Detected,” is generated for inclusion in the patient’s laboratory order record. Additional information is provided, including notation of the presence or absence of the mecA gene, respectively indicating methicillin-resistant *S. aureus* and methicillin-sensitive *S. aureus*. The time at which the microbiology laboratory assigned an “accession number” to a blood culture positive for *S. aureus* serves as a time stamp. The accession number is the identification number assigned to a blood culture specimen, which is always available in a laboratory order before *S. aureus* is identified. To confirm that the accession number would be a reliable surrogate marker, the project...
team extracted over 200 laboratory test order records. The project team confirmed that the average time from accession number assignment to *S. aureus* identification was approximately 24 hours, with a minimum of 18 hours and a maximum of 30 hours.

After identifying the alert triggering criteria and triggering time, the project team created 2 rule records in the EMR to configure inclusion and quit logic for the CDSS build (Figure 1). The inclusion logic captured all new *S. aureus*-positive blood cultures and automatically assigned an “antimicrobial score” of 500 points in the scoring system; this was an arbitrary number that the department of pharmacy selected for all scoring systems to notify pharmacists that a patient intervention was necessary and required. The inclusion logic allowed the 500 points to stay active in the CDSS for 42–54 hours before the score was reset to 0. Furthermore, the quit logic activated so that positive repeat blood cultures did not retrigger the scoring system within the same patient visit. These 2 rule records were placed under a third rule record (a base rule). In the base rule, the quit logic was placed ahead of the inclusion logic in the evaluation cascade to enhance system performance. Lastly, the base rule was attached to the scoring system record, allowing the appearance of the 500 points in the patient list in the EMR.

**CDSS components**

In addition to the scoring system, 4 tools were configured in the CDSS to facilitate pharmacists’ workflow and performance of documentation tasks: a patient list, a patient list report, a hand-off note, and a standardized progress note.

The patient list (Figure 2) identifies patients with a blood culture positive for *S. aureus* in real time so that pharmacists can evaluate and intervene as appropriate. The list contains columns displaying patient information such as medical record number, hospital location, and service line. Additionally, this list contains scoring system–related functionalities, including current antimicrobial score, score change, score review status, and hand-off information. When a score of 500 points is generated, it is displayed in the score column in real time. Once the specified time frame has elapsed, the score resets back to 0, which is indicated in the score-change column for 24 hours. There are several pre-configured icons in the score review status column that can be changed by pharmacists to indicate intervention progress. For example, a green check mark icon visually indicates that the patient record has been reviewed by a pharmacist.

A report appears once a particular entry is highlighted on the patient list. The purpose of this report is to provide relevant information for pharmacist-
to-pharmacist hand-offs and monitoring. This report includes a hand-off note, which is a temporary note that is visible to pharmacists during the patient’s current visit. This report also includes a score explanation and relevant patient information, including weight, temperature, renal function, fluid intake, urinary output, microbiology information, and information on antimicrobial administration.

Finally, a standardized progress note (Figure 3) contains prepopulated verbiage, drop-down lists, and fields for entry of required data. The progress note provides for standardized pharmacist communication to the treating clinician and is a permanent component of the EMR. The standardized progress note also functions as a checklist, as it prompts a pharmacist to complete specific recommended interventions.

CDSS implementation

Process mapping was completed to demonstrate the steps in the pharmacists’ workflow. Two members of the project team (the informatics pharmacy resident and the ID pharmacist) presented a pharmacy continuing-education (CE) session to provide guidance on the CDSS implementation. The CE session included discussion of the evidence-based SAB management guideline, demonstration of the various tools within the scoring system, and description of the pharmacists’ workflow and expectations related to the CDSS. The session was recorded for required viewing by all pharmacists.

Pharmacists are required to evaluate the patient list at least once per shift to identify newly listed patients with a blood culture positive for S. aureus. There are 3 shifts (8 hours each) within the pharmacy department, with the third shift being an overnight shift. At least 2 pharmacists staff each shift. However, clinical pharmacy specialists are only available during the first shift. If a score of 500 points is generated, a pharmacist is required to review the patient’s EMR and evaluate the patient’s information for documentation of ordering of antistaphylococcal therapy (i.e., vancomycin, daptomycin, ceftaroline, nafcillin, or cefazolin), repeat blood cultures, transthoracic echocardiography or transesophageal echocardiography, and an ID consult. After reviewing the patient’s EMR, pharmacists are required to contact the treating physician if the patient is not receiving antistaphylococcal therapy and to recommend additional interventions. Pharmacists are also required to complete the standardized progress note. If a pharmacist is unable to contact the treating physician, a hand-off note is created to communicate information to the pharmacist staffing the next shift. The pharmacist is not responsible for providing information to the treating clinician regarding source identification, source control, duration of therapy, and management of treatment failure or persistent bacteremia.

Experience with the CDSS

The CDSS for the management of
SAB was implemented on December 15, 2015. The implementation of the CDSS required 2.5 months, with a pharmacy informatics resident dedicating approximately 200 hours to the project in total. The project required several 1-hour meetings, including 6 meetings with members of the project team, 3 meetings with the project workgroup, and 2 meetings with pharmacy administration staff.

A retrospective audit was completed during the period January 1–March 1, 2016, to evaluate compliance and identify opportunities to improve the process. The audit evaluated 2 endpoints: (1) the number of progress notes completed relative to the number of listed patients with a blood culture positive for *S. aureus*, and (2) the mean time from positive blood culture notification to standardized progress note completion. The audit identified 58 patients with a blood culture positive for *S. aureus* during the study period. A standardized progress note was completed for 58 of 58 patients (100%). The mean time to completion of a standardized progress note was 8.5 hours (range, 0.15–26.2 hours). Clinical and microbiological outcomes were evaluated in a recently published article by Wenzler and colleagues.  

**Discussion**

The project evaluated a pharmacist-driven patient scoring system designed to improve adherence to quality performance measures for SAB. We observed 100% pharmacist compliance with evaluation and documentation requirements targeting patients with a blood culture positive for *S. aureus*. The mean time from positive blood culture to pharmacist documentation was 8.5 hours, which was within an acceptable time frame given that pharmacists are required to evaluate the CDSS once per shift during an 8-hour shift. We identified cases in which pharmacist documentation was not performed in a timely manner. These cases were discussed with the pharmacists involved, and it was determined that they had not completely understood the expectation of evaluation and documentation before the end of their shift. Ad-
ditional education was provided to all pharmacists to ensure an appropriate understanding of evaluation and documentation processes.

Other published studies have evaluated the use of an ASP or intervention bundle for ID physician–led management of SAB. Nguyen and colleagues evaluated the impact of an ASP-led intervention for SAB. They evaluated compliance with an ASP-driven comprehensive bundle and associated clinical outcomes for patients with SAB. Overall bundle adherence improved from 56.1% (46 of 82 patients) in a preintervention group to 84.1% (74 of 88 patients) in an intervention group (p < 0.001). Two other studies evaluated the impact of a bundle approach on the management of SAB by ID physicians. Lopez-Cortes et al. demonstrated improved adherence to a quality-of-care indicator bundle at 12 tertiary hospitals in Spain. Borde and colleagues conducted a single-center study of 59 cases and also found that a bundle approach increased adherence to bundle endpoints in the care of patients with SAB. Our study differed from those studies in that we evaluated a pharmacist-driven scoring system to help improve management of SAB. We were able to demonstrate that all pharmacists, regardless of specialty, were able to evaluate the patient’s EMR and provide guideline-based recommendations for the management of SAB.

The CDSS can be applied to other ID situations and by clinicians in other disciplines. However, an important technical consideration is that the EMR must have the ability to perform comprehensive disease-state audits. Forrest and colleagues advised that EMRs should be configured to not only identify specific medications or laboratory test values but to focus on the identification of specific clinical syndromes. Currently, available EMRs do not reliably incorporate all components of information on a specific disease that are required in order for clinicians to make meaningful decisions. An informatics pharmacist may be able to assist with overcoming these barriers to construct the scoring system.

There were several limitations to our study. Physicians’ responses to pharmacy recommendations were not collected during the study. The patient scoring system was designed specifically for the study site, and some of the configurations may not be applicable to other hospitals, especially those with an alternative EMR. The project required a notable amount of resources from the pharmacy department, which can be a limiting factor for institutions that do not have a dedicated pharmacy informatics group. Ideally, the time stamp generated when the “Staphylococcus aureus DNA Detected” message is initially filed into the laboratory test order record (i.e., the time when S. aureus is identified in a blood culture) would be the CDSS alert triggering time. However, due to the structure of laboratory order records in our institution’s EMR, we had to use the accession number assignment time to predict the triggering time, since the time of initial S. aureus identification would be overridden by a subsequent time stamp in the laboratory test order records. Due to this limitation, the project team had to abandon the proposed triggering duration of 24 hours and adopt a range duration of 42–54 hours to account for the variability of the accession number assignment time in each laboratory test order. Lastly, the mean time to pharmacist documentation was 8.5 hours. Moving forward, pharmacists may be required to review CDSS data more than once per shift to potentially decrease the time to intervention for patients with SAB.

Conclusion

A pharmacist-driven patient scoring system was successfully used to improve adherence to quality performance measures for management of SAB.

Disclosures

The authors have declared no potential conflicts of interest.

Previous affiliations

At the time of the project, Dr. Wang and Dr. Bauer were affiliated with Ohio State University Wexner Medical Center.

References


