Long-term outcomes of an electronic medical record (EMR)–integrated antimicrobial stewardship (AMS) intensive care unit (ICU) ward round

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To the Editor—Intensive care units (ICUs) are an important target for antimicrobial stewardship (AMS) programs due to their high usage of antimicrobials.[1,2] Audit and feedback, with face-to-face education within the ICU is associated with a short-term decrease in antimicrobial consumption, beneficial effects on resistance rates, and a reduction in antimicrobial costs.[3-6] We previously demonstrated the impact of an EMR-integrated AMS-ICU ward round over a 9-month period.[7] In this current study, we have demonstrated the long-term (>12 months) sustained improvement in antimicrobial prescribing following the implementation of an EMR-integrated AMS-ICU ward round. Additionally, we explored clinical and patient factors that affect the decision to provide AMS recommendations.

In August 2017, a new 5-day-per-week, EMR-integrated, AMS-ICU ward round was implemented at Austin Health (Melbourne, Australia), a tertiary referral hospital with a 29-bed mixed medical-surgical ICU.[7] From August 2017 to July 2019 (inclusive), we audited the results of this intervention. These recommendations were categorized according to the previously published "Five Moments" metric.[7] Compliance with AMS recommendations was reviewed 24 hours after each ward round by the AMS pharmacist. Multidrug-resistant colonization monitoring was performed routinely in the ICU (see definitions in the Supplementary Material online), and subsequent data were collected.

To monitor antimicrobial use 2 years before and after the intervention, defined daily dose (DDD) per 1,000 occupied bed day (OBD) data were obtained from the National Antimicrobial Utilisation Surveillance Program (NAUSP) (see definitions in the Supplementary Material online).[8] Appropriateness scores from the yearly point-prevalence National Antimicrobial Prescribing Survey (NAPS; see definitions in the Supplementary Material online) were also compared before implementation (2015–2016) and after implementation (2017–2018) of the EMR-integrated AMS-ICU ward rounds. Appropriateness scoring was undertaken by the same infectious diseases clinician each year, independent from this intervention.[9]

A sensitivity analysis was performed utilizing additional data collected over a 9-week period (February–April 2019). The analysis consisted of all ICU antimicrobials reviewed by the AMS-ICU service within 48 hours of prescription to determine factors (patient vs clinician) associated with recommendations made as a result of the AMS-ICU ward rounds. Adjusted odds ratios (aORs) were calculated for these factors, correcting for Charleston comorbidity index and ICU physician years of experience (<5 years and ≥5 years). Antimicrobial classes were compared against piperacillin/tazobactam and amoxicillin/clavulanate (IV). Infectious syndromes were compared with infections of unclear source. This study was approved by the Austin Health Ethics Committee (no. CD 18-004).

In the 2-year postintervention period, 1,992 AMS recommendations were given as a result of the AMS-ICU ward rounds for the 916 patients reviewed (Supplementary Table 1 online). The rates of methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), and multidrug-resistant gram-negative (MDR-GN) colonization before and after the intervention are shown in Supplementary Table 2 (online). We detected a significant increase in MRSA colonisation after the intervention versus before the intervention (2.29% vs 0.06%; $P < .0001$), with no difference noted for VRE or MDR-GN isolation ($P > .05$).

Duration of the ward round was collected from November 2017 onward; the median duration was 0.5 hours (IQR, 0.38–0.65). All of the ward rounds had at least an infectious diseases consultant or a registrar present. During the first year after the intervention, 876 (87.6%) of 1,000 recommendations were implemented by the ICU, compared with the second year, during which 886 (89.3%) of 992 recommendations were implemented ($P = .23$). Recommendations and acceptance rates are outlined in Supplementary Table 3 (online).

Utilizing DDD per 1,000 OBD data, we demonstrated an immediate decrease in the use of ceftriaxone, meropenem, piperacillin/tazobactam, and vancomycin. Additionally, we demonstrated an ongoing significant reduction in the use of vancomycin and ciprofloxacin after the intervention; however, we detected no significant long-term change in the utilization of ceftriaxone or piperacillin/tazobactam postintervention (Fig. 1). Prescribing appropriateness (utilizing yearly NAPS appropriateness scores) increased from 41 (51%) of 80 during the preintervention period (2015–2016) to 62 (73%) of 85 after the intervention was implemented (2017–2018) ($P = .0061$).

The additional sensitivity analysis was performed for 184 patients (Supplementary Table 4 online) to examine factors that affected the decision to make AMS recommendations. This

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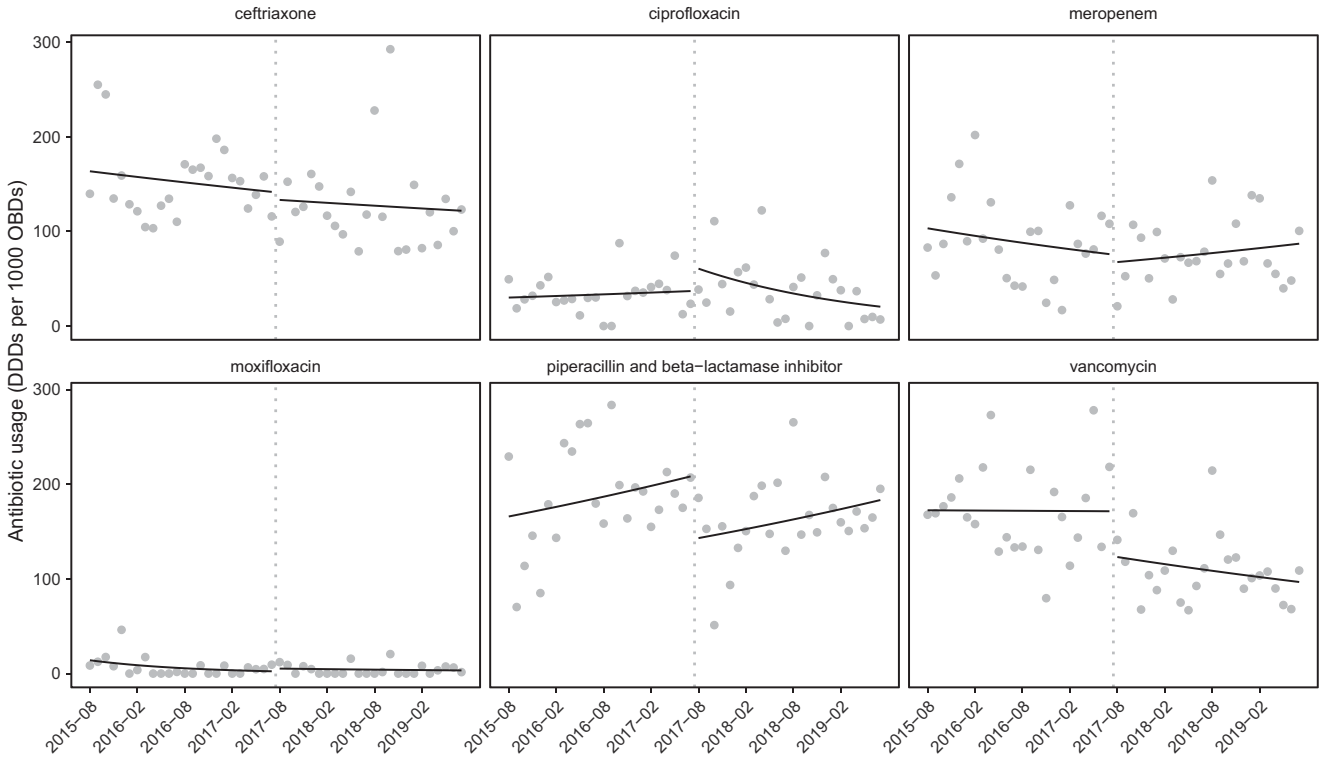

Fig. 1. Change in antimicrobial use after implementation of AMS-ICU intervention. Dotted vertical lines represent commencement of intervention. Solid lines represent preintervention and postintervention trends in antimicrobial use estimated using Poisson segmented regression. The dots on the graph are raw data points. Note. ICU, intensive care unit; AMS, antimicrobial stewardship; DDDs, defined daily doses; OBDs, occupied bed days.

analysis revealed that significantly more recommendations were made for IV therapy than for oral therapy: adjusted odds ratio (aOR), 2.64 (Supplementary Table 5 online). No antimicrobial class was associated with an increased ratio of recommendations (Supplementary Table 5 online). Pneumonia was the only infectious syndrome associated with a higher ratio of recommendations (aOR, 6.85, IQR, 1.83–25.63).

Similarly to other studies, our audit has demonstrated an immediate decrease in the utilization of our target antimicrobials (ceftriaxone, meropenem, piperacillin/tazobactam and vancomycin) after the intervention.[3,4] In addition, we demonstrated an ongoing significant reduction in vancomycin and ciprofloxacin use after this intervention. Interestingly, during the audit period, we noted a significant increase in MRSA colonization. Nevertheless, we achieved an ongoing reduction in vancomycin use. We hypothesize that this is due to our low rates of MRSA before and after the intervention, which allowed us to stratify risk when prescribing vancomycin. In addition, our institution has a strong focus on antibiotic allergy assessment, which could account for some of the ongoing reduction in ciprofloxacin and vancomycin use.[10]

Our study was limited by the provision of a Monday–Friday AMS-ICU service. However, this study included an exploratory sensitivity analysis to examine factors associated with recommendations being made by the AMS-ICU ward rounds. We observed a greater proportion of recommendations for IV compared to oral antimicrobial therapy. Also, 87.2% of prescriptions during this period were for IV therapies, a key target for "de-escalation" and "switch." Prescriptions for patients with pneumonia were more likely to receive a recommendation supporting earlier findings that pneumonia is a target for AMS-ICU programs.[7]

This audit demonstrates that the benefits of an EMR-integrated AMS-ICU ward-round intervention can be sustained in the long term. Future research should focus on risk-stratifying patients who would most benefit from an AMS review within the ICU.

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Improved empiric antibiotic prescribing for common infectious disease diagnoses using order sets with built-in clinical decision support in the emergency department

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To the Editor—The Centers for Disease Control and Prevention estimated that in 2018, emergency departments (EDs) generated 12.7 million antibiotic prescriptions.[1] Up to 50% of these prescriptions may have been inappropriate with respect to antibiotic use or selection, dosing, and duration, based on outpatient prescribing estimates.[2] Improving prescribing is imperative, but historically, EDs are underrepresented in antibiotic stewardship studies.[4] EDs may benefit from implementation of the recommended components of an antimicrobial stewardship program, including decision-making tools based on facility-specific practice guidelines.[3] For example, antibiotic order sets within an electronic medical record (EMR) have been shown to improve adherence to evidence-based prescribing for single diagnoses,[5,6] although the use of multiple order sets for a variety of diagnoses has not been well studied. We implemented EMR order sets for common infectious diagnoses in the ED, compared the prescribing practices of providers who utilized them to those who did not, and surveyed providers for barriers to use.

Methods

This study was part of a larger intervention to improve antibiotic prescribing and reduce *Clostridioides difficile* infection (CDI) at a 500-bed quaternary-care academic medical center with ~50,500 yearly ED visits. Order sets were created for cystitis, pyelonephritis, pneumonia, chronic obstructive pulmonary disease (COPD), and cellulitis that included recommended antibiotics and first dose in the ED, followed by a prepopulated prescription for an appropriate duration. Antibiotic choices were prioritized based on clinical practice guidelines,[7–9] the hospital antibiogram, and a desire to avoid antibiotics associated with higher CDI risk (eg, fluoroquinolones), with guidance included for dosing in patients with renal impairment.

The order sets were deployed in March 2019, with clinician education via a presentation (40% attendance), 1-on-1 sessions (60% of clinicians), and 3 informational e-mails. A survey adapted from Vandenberg et al[10] was sent to all ED clinicians in November 2019 to assess whether the order sets were being used and whether they were beneficial to their practice.

Additionally, a retrospective chart review was conducted from October 1, 2019, to November 1, 2019, to assess the impact on prescribing practices for patients presenting with 1 of the 5 diagnoses with a corresponding order set, identified using *International Classification of Disease, Tenth Revision* (ICD-10) codes. Charts were manually reviewed for whether an order set was used, antibiotic doses given in the ED, antibiotic prescribed, creatinine clearance, special population status (eg, pregnancy or organ transplant), prior culture data, and whether a subspecialty consultation was obtained. Patients were excluded from the analysis if antibiotics were not prescribed, if they belonged to a special population, or if they received subspecialty consultation. In total, 213 charts were reviewed and 104 met inclusion criteria. Encounters with order-set use were compared to those without order-set use for appropriate

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