

Reducing Antibiotic Prescription Errors in the Emergency Department: A Quality Improvement Initiative

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Abstract

Introduction: Discharge prescription errors from the pediatric emergency department (ED) are common. Despite the implementation of clinical pathways for common infections recommending specific antibiotic therapy and aids built into the electronic health record, errors in antibiotic prescriptions for patients discharged home from the ED persist. **Methods:** We developed and implemented ED antibiotic discharge order panels for urinary tract infection (UTI) and skin and soft tissue infections (SSTI) that modeled antibiotic therapy from our institutional clinical pathways. We aimed to reduce antibiotic prescription errors by 50% within 6 months of implementation. **Results:** With the implementation of the ED discharge order panels, the overall error rate for prescriptions for UTI and SSTI improved from a baseline rate of 29.3% to 12.6% ($P < 0.001$). Individually, the baseline number of prescriptions with errors for UTI and SSTI improved from 26.1% and 32.8%, respectively, to 13.8% and 12.5% within 6 months. Sustained improvement continued for 17 months after the implementation of the order panels. **Conclusions:** Development and implementation of ED antibiotic discharge order panels decrease antibiotic prescription errors for UTI and SSTI by improving compliance with institutional clinical pathways. Additional order panels should be developed and implemented for other conditions to help reduce discharge prescription errors. (*Pediatr Qual Saf* 2020;4:e314; doi: 10.1097/pq9.000000000000314; Published online 26 June, 2020.)

INTRODUCTION

Antibiotics are frequently prescribed in the emergency department (ED) for common pediatric infections, including urinary tract infections (UTI) and skin and soft tissue infections (SSTI). Prescription errors are common both at our institution and in other centers.^{1,2} ED prescription errors are common in academic centers and may



be more common in pediatric patients than in adult patients.¹ One strategy that has reduced rates of prescription errors in the pediatric ED is an automated alert system built into the electronic health record (EHR).³ Despite these safeguards built into the EHR, prescription errors still occur.^{4,5} Challenges in prescribing antibiotics in pediatric patients include weight-based dosing, variable dosing, duration of therapy, and dosing intervals for different indications.

The choice of correct liquid or tablet formulation depends on the child's ability to take tablets and the conversion of doses into volume for liquid formulations. Dosing errors are the most common type of prescription error in pediatrics.⁶ In academic institutions, prescriptions are often written by rotating residents who may have varying experience with pediatric prescriptions leading to increased risk of errors. Strategies across pediatric disciplines that have reduced medication errors include the use of e-prescriptions, electronic ordering with dosing recommendations, and indication-specific prescribing.⁷⁻¹¹ Kadmon et al¹⁰ reported that despite the initial reduction of inpatient prescription errors with the implementation of computer order entry, increasing inpatient prescription error rates can return over time, with new medications in the order system and new physicians. Updating and revising clinical support tools can decrease these error rates.¹²

Clinical pathways help to standardize care for common ED diagnoses and improve overall timely care.¹³⁻¹⁷ They can help guide both ED management and discharge care,

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including outpatient prescriptions. Clinical pathways for common pediatric infections often recommend the selection of appropriate antibiotics for outpatient care.¹⁸ Antibiotic selection to treat common pediatric infections, including UTI and SSTI, should be guided by local antibiotic resistance patterns and focus on the use of narrow-spectrum antibiotics. Poole et al¹⁸ demonstrated that a clinical pathway for UTI improved narrow-spectrum prescribing for UTIs discharged from the ED and urgent care settings.

Our ED uses a robust library of clinical pathways to guide the evaluation and management of common pediatric infections, including UTI, SSTI, community-acquired pneumonia, animal bite, and preseptal cellulitis. Each pathway has recommendations for outpatient therapy guided by the antibiotic stewardship program using local resistance patterns. The recommendations include appropriate antibiotic guidance (including alternatives for patients with allergies), weight-based dosing, dosing interval, and duration of therapy. Despite having these pathways in place, deviation from prescription recommendations and prescription errors are still common.

We developed a multidisciplinary quality improvement initiative to reduce antibiotic prescription errors in the ED through the implementation of diagnosis-specific standardized discharge prescription order panels. The team created and implemented order panels modeling antibiotic recommendations of our UTI and SSTI clinical pathways. The SMART (Specific, Measurable, Achievable, Realistic, and Timely) aim was to reduce ED antibiotic prescriptions with errors for UTI and SSTI by 50% within 6 months of implementation. The intervention was a high-reliability intervention anticipated to produce sustainable improvement.

METHODS

Context

We conducted the project at an academic urban tertiary children's hospital with an annual ED volume of 60,000 patients. The ED is staffed by board-certified pediatric emergency medicine attending physicians, pediatric emergency medicine fellows, pediatric, emergency medicine, and family medicine residents, physician assistants, and nurse practitioners. The institution has a robust clinical pathway program with many pathways involving both ED and inpatient care (<https://www.connecticutchildrens.org/clinical-pathways/>). The hospital clinical effectiveness committee reviews and approves all clinical pathways before implementation. The monitoring of quality metrics for the pathways occurs monthly. Each pathway undergoes an annual quality review, a triennial review with a full pertinent medical literature review, and pathway revision as necessary. Our institutional antibiotic stewardship committee guides antibiotic selection and recommendations for dosing and length of the antibiotic course for the clinical pathways.

Intervention

A multidisciplinary team including a pediatric emergency medicine attending physician, pediatric emergency medicine fellow, pediatric resident, quality data analyst, and information technology analyst met to design diagnosis-specific ED discharge antibiotic order panels to model the outpatient antibiotic recommendations of preexisting clinical pathways for UTI and SSTI (Fig. 1, Supplemental Digital Content 2, UTI Clinical Pathway, available at <http://links.lww.com/PQ9/A191> and Fig. 2, Supplemental Digital Content 2, SSTI Clinical Pathway, available at <http://links.lww.com/PQ9/A192>) (Table 1). The order panels included the correct antibiotic (including alternatives for patients with allergies), dose (including maximum dose), dosing interval, and duration of therapy. The prescriber could then choose the appropriate formulation of antibiotic (tablet versus liquid) based on the patient's age and ability to swallow pills. The order panels were created in the EHR and accessed by entering a specific diagnosis (ie, UTI, cellulitis, abscess) or specific antibiotic (ie, cephalexin, clindamycin) into the prescription order panel on the patient discharge navigator. The panel automatically populated the correct antibiotic, dose, and dosing interval for the discharge prescription.

The improvement team used the plan-do-study-act cycles described below to create and implement the order panels. Our information technology analyst created the first draft of the order panels with input from all improvement team members. The ED attending and resident physician trialed the order panels in the testing environment of the EHR. Feedback from initial testing led to changes in dose calculations to model the clinical pathways and the revision of the order panels allowing access to them by entering a specific diagnosis (ie, UTI, cellulitis, or abscess). After these changes, the team shared the order panels with a variety of end users, allowing them to use the order panels in the testing area of the EHR. Based on feedback from these sessions, there was no need for additional revisions. Education for end users on the use of the order panels occurred before final implementation. The improvement team created a document with step-by-step instructions for accessing and using the order panels. Vetting of the document by physician members of the improvement team and a small group of end users led to revisions of the document to clarify the process for access and use of the order panels. This document was disseminated by e-mail to all pediatric emergency medicine attending physicians, fellows, and ED advanced practice providers, as well as residents rotating through the ED. The pediatric emergency medicine attending and the fellow on the improvement team introduced the order panels to ED staff during the monthly ED meeting in the month before final implementation.

Measures

We extracted data from an existing clinical pathway dataset to track pathway utilization and specific quality metrics. All patients with International Classification of

Table 1. Antibiotic Recommendations for Treatment of UTI and SSTI in Institutional Clinical Pathways

Clinical Pathway	Antibiotic Recommendation
Urinary tract infection	Cephalexin 50–100 mg/kg/d ÷ every 6–8 h for 7–14 d (maximum dose 4 g/d) If penicillin or cephalosporin allergy: Sulfamethoxazole trimethoprim (TMP) 8 mg TMP/kg/d ÷ twice daily for 7–14 d (maximum dose 160 mg TMP per dose) or Nitrofurantoin 5–7 mg/kg/d ÷ every 6 h for 7–14 d (maximum dose 400 mg/d) For sexually active females: Nitrofurantoin 100 mg twice a day for 5–7 d or Sulfamethoxazole trimethoprim 800 mg/160 mg twice a day for 3 d
Skin and soft tissue infection	Nonpurulent infection: Cephalexin 50 mg/kg/d ÷ every 6–8 h for 7–10 d (maximum dose 1,000 mg/dose) If penicillin or cephalosporin allergy or methicillin-resistant Staphylococcus aureus risk: Clindamycin 30 mg/kg/d ÷ 3 times daily (maximum dose 600 mg/dose) Purulent infection with erythema: Clindamycin 30 mg/kg/d ÷ 3 times daily (maximum dose 600 mg/dose)

Diseases, Tenth Revision (ICD 10) diagnostic codes for UTI and SSTI, who met the criteria for the respective pathway, were included in the quality dataset (Table 2). We only included patients who were discharged home from the ED in the analysis. We defined prescription errors as deviations from antibiotic recommendations in the respective clinical pathway. We included (1) use of an antibiotic not recommended by the clinical pathway, (2) incorrect antibiotic dose (mg/kg), (3) incorrect dosing interval, or (4) incorrect duration of antibiotic therapy. We recorded both the number of patients with an error and the total number of errors. All errors had a manual ED chart review to determine if there was a reason for the deviation from the clinical pathway (ie, past bacterial culture results or other patient-specific factors). If the prescription had clinically justified deviations, we did not count it as an error.

Baseline percentage of prescriptions with errors were reviewed for 5 months from January 2018 through May 2018 before order panel implementation. We introduced the discharge antibiotic order panels for use in the ED on June 4, 2018. Data after implementation were reviewed monthly from the clinical pathway dataset in the same manner as the baseline data. Overall, we tracked 17 months of data after the implementation of the order panels until October 31, 2019.

Analysis

Given the week-to-week and month-to-month variations in the number of cases of UTI and SSTI, which met

clinical pathway criteria, we grouped cases in sets of 10 for data analysis. Data were plotted and tracked for both UTI and SSTI on statistical process control charts. Mean shifts were plotted after 8 consecutive data points above or below the mean with an identifiable cause, signaling special cause variation.¹⁹

Ethical Considerations

This project was deemed to be a quality improvement project and not human subjects research. Therefore, the institutional review board did not require review and approval.

RESULTS

The baseline mean rates of discharge antibiotic prescriptions with errors for UTI and SSTI were 26.1% and 32.8%, respectively. After the implementation of discharge antibiotic order panels, the mean percentage of UTI prescriptions with errors initially decreased to 8.8% (Fig. 1). The mean regressed to 13.8% in December 2018 and sustained at this level for 11 months through October 2019. The sustained reduction in errors represented a 47.1% decrease in prescriptions with errors. Mean discharge prescriptions for SSTI with errors initially decreased to 23.8% and, over time, improved to 12.5% (Fig. 2). The project demonstrated immediate improvement within 6 months of implementation that continued for a total of 17 months. Overall the error rate improved by 61.8% for prescriptions for SSTI. Overall the project decreased prescription errors from a baseline of 29.3% to 12.6% ($P < 0.001$) for both diagnoses combined (Table 3).

By far, the most common type of error was the wrong antibiotic dosing interval, both pre- and postimplementation of the order panels (Fig. 3). The wrong antibiotic dose was the second most common error before the project, whereas wrong antibiotic selection was the second most common after implementation of the order panels.

DISCUSSION

The development and implementation of antibiotic discharge order panels for UTI and SSTI decreased

Table 2. Inclusion and Exclusion Criteria for the UTI and SSTI Pathway

Clinical Pathway	Inclusion Criteria	Exclusion Criteria
UTI	2 mo to 18 y of age First or second UTI	Age younger than 2 months >2 documented past UTI
SSTI	2 months to 18 years of age	Preexisting urinary tract abnormalities Age younger than 2 months or age younger than 1 year if premature Animal bite Patient immunocompromised Orbital or preseptal infection Surgical site infection Traumatic wound with debris

P-Chart ED Antibiotic Prescriptions for UTI with Errors

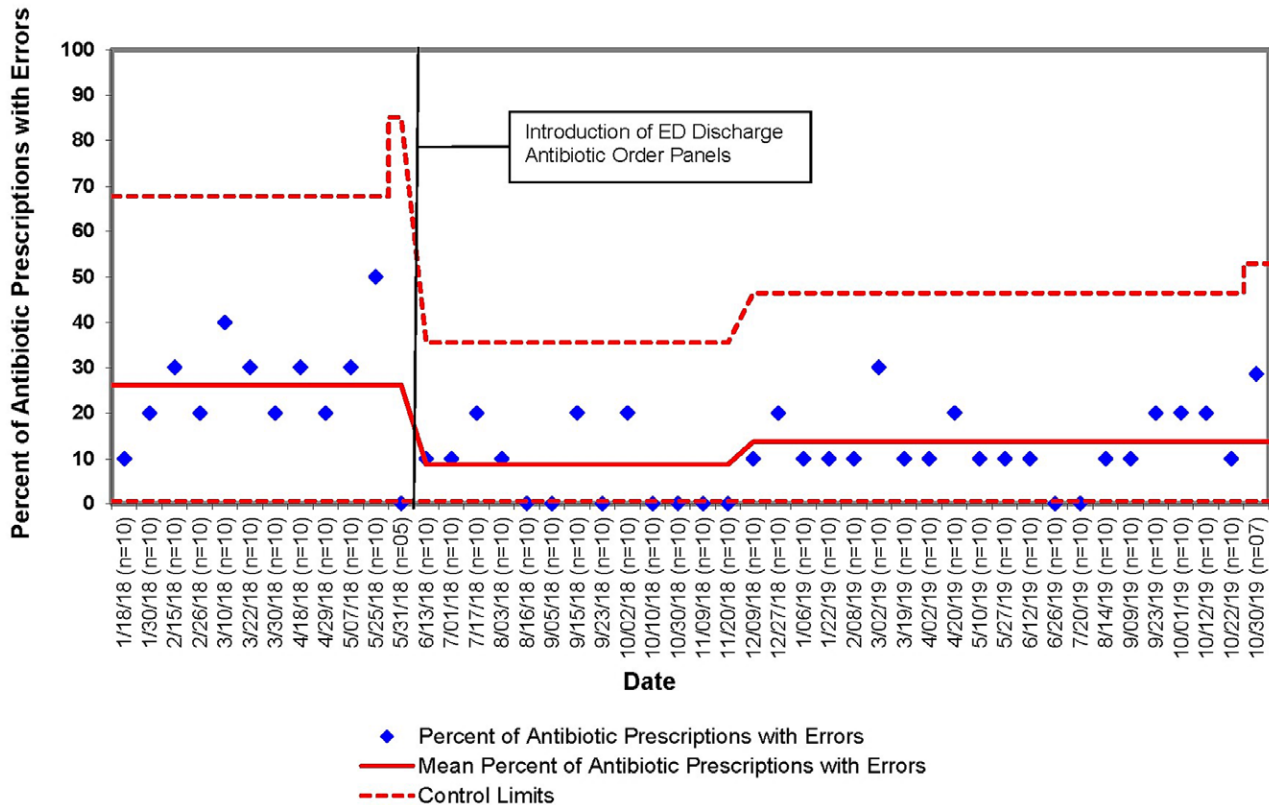


Fig. 1. P-chart for ED antibiotic prescriptions for UTI with errors.

prescription errors by improving compliance with institutional clinical pathways. The overall reduction in prescriptions with errors 6 months after the implementation of the order panel for UTI and SSTI was 47.1% and 61.8%, respectively. These results nearly met our goal of a 50% reduction in errors for UTI and surpassed the goal for SSTI.

Clinical pathways provide standardized, evidence-based care. Any intervention that can increase compliance with such pathways eliminates unnecessary variation in the treatment of common conditions. Antibiotic therapy recommended based on local susceptibility patterns of common bacterial pathogens is a crucial tenant of antibiotic stewardship. Several past studies document the use of technology and the EHR to improve antibiotic stewardship.²⁰⁻²² Implementation of our discharge antibiotic order panels accomplished improvement both in the realm of standardizing care and promoting the use of narrow-spectrum antibiotics and appropriate duration of therapy.

Although the implementation of order panels achieved a significant reduction in antibiotic prescription errors, the antibiotic dosing interval remained the most common error after implementation. There was also an increase in the percentage of wrong antibiotic selection errors based on the clinical pathway. These persistent errors in antibiotic dosing interval and the higher rate of incorrect

antibiotic use after order panel implementation likely reflect a population of ED providers who did not use the order panels. The majority of the dosing interval errors were from twice-daily dosing prescriptions for cephalexin for both UTI and SSTI instead of the recommended dosing of 3 or 4 times a day. These errors likely resulted from ED providers using other dosing references that suggest a dosing interval of twice daily for cephalexin.²³ Despite these references, we considered this an error as it did not align with our clinical pathways and the most current evidence-based recommendations for the treatment of UTI and SSTI.^{24,25}

The current configuration of our EHR made it impossible to track order panel use in the EHR. The final percentages of UTI and SSTI antibiotic prescriptions with errors, 13.8% and 12.5%, respectively, demonstrate less than 100% provider usage of the order panels 17 months after implementation. Given the level 1 reliability of the interventions of both the order panels themselves and the educational initiatives around them, one would expect an 80%–90% adoption of order panel use, which is reflected in the results of our interventions. A higher reliability intervention such as a hard stop in the EHR mandating the use of the order panel may help to increase panel use and decrease the error rate even further. Future improvement work should center on such an intervention.

P-Chart ED Antibiotic Prescriptions for SSTI with Errors

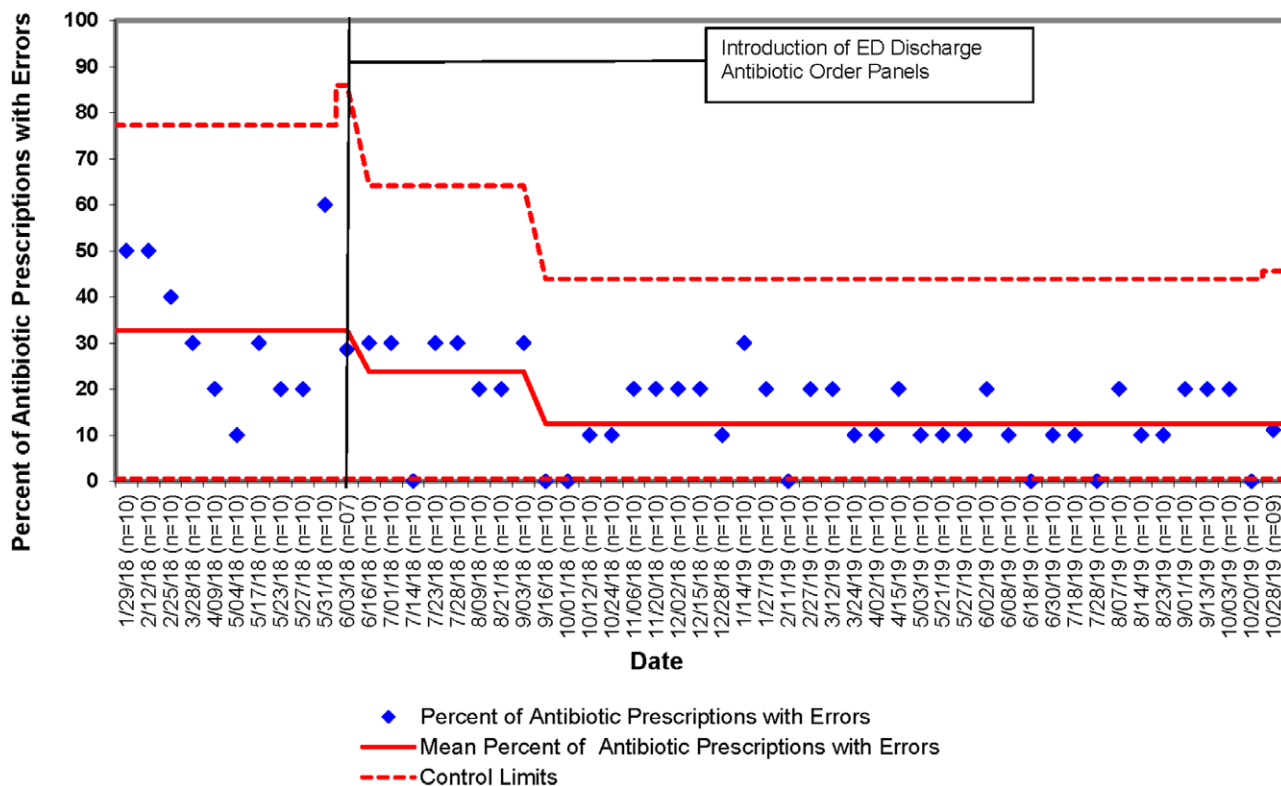


Fig. 2. P-chart for ED antibiotic prescriptions for SSTI with errors.

Table 3. Prescription Errors Before and After Implementation of ED Antibiotic Discharge Order Panels

	Baseline	Postintervention	
Total no. prescriptions	222	755	
Total no. errors	70	100	
Prescriptions with errors	65 (29.3%)	95 (12.6%)	$P < 0.001$

Our improvement was immediate after implementation and sustained over 17 months. Improvements seen initially with UTI prescription errors regressed somewhat after initial improvement but remained well above the preimplementation baseline for 11 months. Factors leading to immediate improvement included ease of use of the refined and pretested order panels, initial educational initiatives, and provider buy-in. The increase in UTI prescriptions with errors 7 months after implementation most likely occurred as the impact of the initial ED provider education waned. Sustained improvement continued because of ongoing monthly education to rotating residents and ongoing provider buy-in. Larger-scale reeducation initiatives may have led to an ongoing reduction in prescription errors.

Limitations

This project tracked the percentage of prescriptions with errors after the implementation of antibiotic order panels.

However, as previously noted, it was unable to monitor for actual use of the order panels. There was a significant improvement in error rates, but we are unable to demonstrate that the implementation of the discharge order panels directly led to all of the improvement. With the project, there may have been an observer effect where provider awareness about the project leads to increased vigilance of following the institutional pathways without the use of the order panels. This possibility could be especially true given the immediate improvement after implementation but would be unlikely to explain the sustained improvement. Over time, with the introduction of more clinical pathways, providers may have been more aware of the institutional pathways and more apt to follow the pathway recommendations without explicitly using the discharge order panels. In the future, establishing a way to directly monitor the use of the ED order panels within the EHR could better quantify their effect.

Another limitation of our project could have been patient-level factors that lead to deviation in therapy from our clinical pathways for UTI and SSTI. Though the improvement team conducted a chart review for every patient with a prescription error, there may have been factors not documented in the chart, which would have led to deviation from the clinical pathway, therefore, increasing the number of prescriptions with errors. This

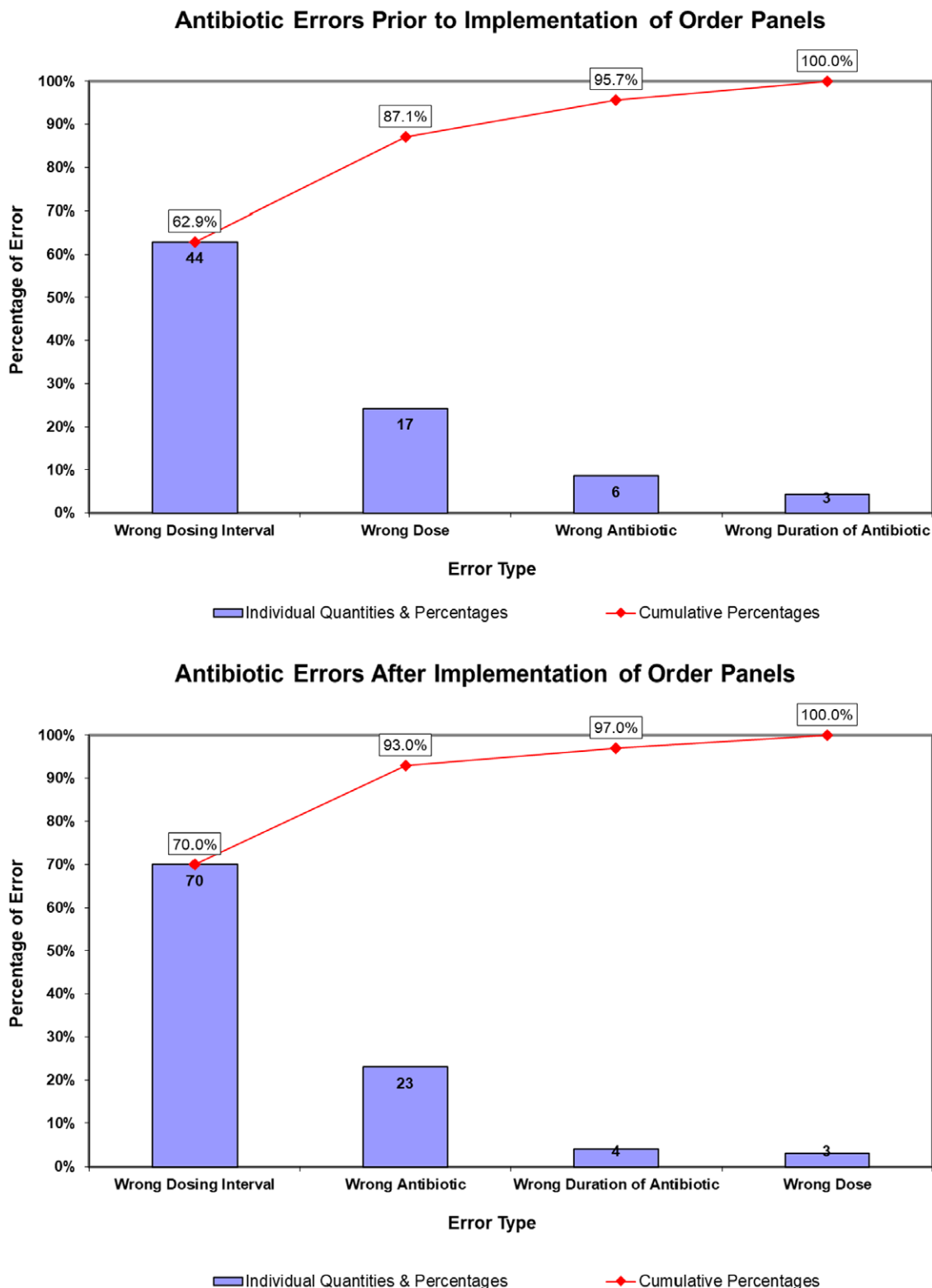


Fig. 3. Pareto charts comparing baseline prescription errors to errors after implementation of order panels.

circumstance may explain some of the incorrect antibiotic selection and antibiotic duration but would be less likely to explain antibiotic dosing and frequency errors.

A final limitation of this project is that we evaluated a process measure of prescription errors and not a specific

outcome measure such as clinical improvement or treatment failure and subsequent need for hospitalization. We also only know what antibiotic was prescribed, and given the pathway recommendations for more frequent dosing of medications such as cephalexin, we do not know if the

patient filled their prescription or if they completed the antibiotic as prescribed, including the appropriate dosing interval and duration of therapy.

Next Steps

The next steps of this project should focus on further integrating the current order panels into the ED system and expanding the order panels to other domains. Further integration of the discharge order panels into the EHR, such as integrated prompts suggesting their use based on discharge diagnosis, would likely lead to increased provider use of the order panels and a further improvement in prescription errors.

Expanding the discharge order panels to other clinical pathways that incorporate outpatient antibiotic management may lead to improved compliance with local pathways or consensus recommendations. Also, this work could be expanded from the ED to the inpatient arena for patients discharged home requiring additional oral antibiotic therapy. This work can also serve as a model for other pathways or clinical conditions where specific outpatient prescription therapy outside of antibiotics is required and would benefit from standardization.

CONCLUSIONS

With the implementation of discharge antibiotic order panels, the percentage of prescriptions with errors for UTI and SSTI improved by 47.1% and 61.8%, respectively, by increasing compliance with institutional clinical pathways. The initial improvement was sustained for 17 months following the order panel implementation. Future work should concentrate on expanding these panels to other pathways and conditions. Also, higher reliability interventions, including EHR prompts to use the order panels, could sustain and increase the scope of the improvement initiative.

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article..

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