Issue 3 • Volume 8

Individual QI projects from single institutions

OPEN

Utilizing Clinical Decision Support in the Treatment of Urinary Tract Infection across a Large Pediatric Primary Care Network

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Abstract

Introduction: Cystitis and pyelonephritis are common bacterial infections in infants and children, and initial treatment is usually empirical. Antimicrobial stewardship advocates using narrow-spectrum antibiotics with consideration for local resistance patterns. Narrow-spectrum antibiotic use is critical in addressing the global issue of bacterial antimicrobial resistance, associated with approximately 5 million annual deaths. **Methods:** The antimicrobial stewardship committee developed a guideline for diagnosing and managing urinary tract infections and distributed it to all primary care providers. A standardized order set provided clinical decision support regarding appropriate first-line antibiotic therapy. A chief complaint of dysuria prompted the use of the order set. Prescription rates for the most common antimicrobials were tracked on a control chart. **Results:** From March 2018 through March 2020, there were 4,506 antibiotic prescriptions for urinary tract infections. Utilization of the recommended first-line therapy, cephalexin, increased from 27.5% to 74.8%. Over the same period, trimethoprim-sulfamethoxazole, no longer recommended due to high local resistance, decreased from 31.8% to 8.1%. Providers have maintained these prescribing patterns since the conclusion of the project. **Conclusion:** Using clinical decision support as a standardized order set can sustainably improve the use of first-line antimicrobials for treating pediatric urinary tract infections. *(Pediatr Qual Saf 2023;8:e655; doi: 10.1097/pq9.0000000000000655; Published online May 22, 2023.)*

INTRODUCTION

Urinary tract infection (UTI) is one of the common bacterial causes of febrile illness in infants and children.[1] *Escherichia coli* is the etiologic pathogen in more than 80% of infections; *Klebsiella*, *Enterobacter*, and *Enterococcus* species each contribute a small percentage, respectively. Clinical practice guidelines recommend urinalysis and urine culture in infants and young children with fever and no apparent source of infection.[2] Older children with dysuria, urgency, and/or urinary frequency should also be tested. Treatment is often initiated based on presenting signs and symptoms and a positive urinalysis for leukocyte esterase and/or nitrites. Antimicrobial selection is simplified when culture and sensitivities are available. However, because culture results often take 48 hours, initial treatment is often empirical. Rates of *Escherichia coli* resistance to ampicillin and trimethoprim-sulfamethoxazole have increased over the previous decades, with significant geographic variability.[3] Therefore, many institutions have established recommendations for treating UTIs based on local antimicrobial sensitivity patterns inferred from their antibiogram.

Unfortunately, creating a guideline is not sufficient to change practice. Up to 36% of children with bacterial infections and up to 70% of children with viral infections still receive inappropriate antibiotics.[4] Most inpatient institutions have antimicrobial stewardship programs, which is true for less than 10% of ambulatory practices.[5] Clinical decision support (CDS) delivers the right information to the right person at the right time to improve care. It includes formats such as alerts, documentation templates, and order sets. Stewardship programs have reduced antibiotic utilization and improved guideline adherence through effective CDS.[6] Standardized order sets have improved prescribing for UTIs in pediatric

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To cite: Karas DR, Upadhyayula S, Love A, Bigham MT. Utilizing Clinical Decision Support in the Treatment of Urinary Tract Infection across a Large Pediatric Primary Care Network. Pediatr Qual Saf 2023;8:e655.

Received for publication January 4, 2023; Accepted April 27, 2023.

Published online May 22, 2023

DOI: 10.1097/pq9.0000000000000655

emergency departments. Still, few studies focus on pediatric primary care.[7]

In 2018, over 2000 primary care patients at our organization were given antimicrobials for treating UTIs, including cystitis and pyelonephritis. Trimethoprim-sulfamethoxazole was prescribed for thirty-three percent of patients. Cephalexin was used 27% of the time, and 22% received cefdinir. Amoxicillin accounted for 8% of prescriptions, and nitrofurantoin, ciprofloxacin, amoxicillin-clavulanate, and levofloxacin were each prescribed less than 5% of the time.

The local Antimicrobial Stewardship Committee monitors and informs the use of antibiotics across the institution. They identified that 44% of *Escherichia coli* isolates were resistant to ampicillin, and 18% were resistant to trimethoprim-sulfamethoxazole, indicating that many patients were treated with ineffective antibiotics. Conversely, 96% of isolates were sensitive to cefazolin. Additionally, many patients were receiving broad-spectrum antimicrobials unnecessarily. The local antibiogram and the prescribing patterns revealed an opportunity to provide optimization and standardization of antimicrobial prescribing across the primary care network.

We developed a quality improvement project to improve the use of recommended first-line antimicrobials for treating UTIs. The team identified cephalexin as the appropriate first-line treatment due to its narrow spectrum and efficacy against common urinary pathogens. We sought to increase the utilization of cephalexin from 27% to 70% by the project's conclusion. This quality improvement project was exempt from institutional review board oversight due to the nonexperimental nature of the work.

METHODS

Akron Children's Hospital has a network of 30 primary care locations across 15 counties, with a total panel size of over 220,000 patients and over 450,000 visits annually. Informed by baseline 2018 data on the management of UTI derived from our shared electronic health record (EHR) (Epic, Epic Systems Corp, Verona, Wis.), we assembled a multidisciplinary improvement team. The improvement team included primary care pediatricians, pediatric infectious disease physicians, a clinical pharmacist, clinical informaticists, EHR builders, laboratory personnel, and nurses. The team utilized the Model for Improvement to guide the work.[8] After identifying multiple key drivers, the team chose interventions that focused on provider education, prescriber feedback, and the development of EHR-based CDS tools.

The Antimicrobial Stewardship Committee developed local UTI treatment guidelines that recommended cephalexin be used first-line for managing uncomplicated cystitis and pyelonephritis. The use of trimethoprim-sulfamethoxazole was reserved for patients with a true allergy to cephalosporins. Primary care providers participated in a multimodal education strategy that included email, staff meeting presentations and discussions, and access to hospital intranet guidelines.

Epic allows for the creation of standardized order sets. These order sets can group relevant diagnoses, laboratory tests, imaging orders, medications, and follow-up appointments in one location. Order sets were previously built for numerous common pediatric disorders and are suggested for use by providers based on the patient's chief complaint. Providers use these order sets over 99% of the time to select appropriate diagnoses, orders, and service levels for their visits. Therefore, we expected that adding CDS for UTIs would help improve prescribing practices.

The new order set contained a link to the local treatment recommendations as well as a link to the American Academy of Pediatrics' "Urinary Tract Infection: Clinical Practice Guideline for the Diagnosis and Management of the Initial UTI in Febrile Infants and Children 2 to 24 Months."[2] Additionally, providers had access to UTICalc (University of Pittsburgh, Pa.), a UTI probability calculator.[9] The AAP Clinical Practice Guideline was retired and UTICalc replaced race with other variables after our study period.[10] Our order set links to the most recently published version.

Key elements of the order set and accompanying CDS are shown in Figure 1. Common diagnoses were available for selection. Recommended antimicrobials for uncomplicated cystitis and pyelonephritis were listed along with their indications and appropriate dose, frequency, and duration. When selecting liquid formulations, Epic calculates the correct dose based on the patient's weight up to the maximum dose.

Data Analysis

Epic's robust, self-service reporting tool, SlicerDicer, provided all data. All ambulatory prescriptions have an associated diagnosis. For example, patients with antimicrobial prescriptions linked to a UTI were identified using ICD-10-CM codes for cystitis, UTI, and pyelonephritis. We excluded diagnoses related to pregnancy, catheters, sexually transmitted infections, and nonbacterial causes. Prescriptions for azithromycin, cefaclor, cefadroxil, cefixime, cefuroxime, clindamycin, and penicillin accounted for less than 1% of prescriptions each and were excluded from the analysis. Antimicrobial use was aggregated monthly and tracked on a control chart.

RESULTS

Between 3/1/2018 and 2/28/2019, there were 2055 outpatient prescriptions for patients diagnosed with UTIs. The order set went live in March 2019. Over the following 12 months, there were 2284 prescriptions for UTI. Demographic information can be found in Table 1. After the order set's implementation, cephalexin's use increased from 27.5% to 74.8%. Concurrently, the use of trimethoprim/sulfamethoxazole decreased from 31.8% to 8.1%. Control charts with annotated interventions are shown in Figures 2 and 3, respectively. The control charts

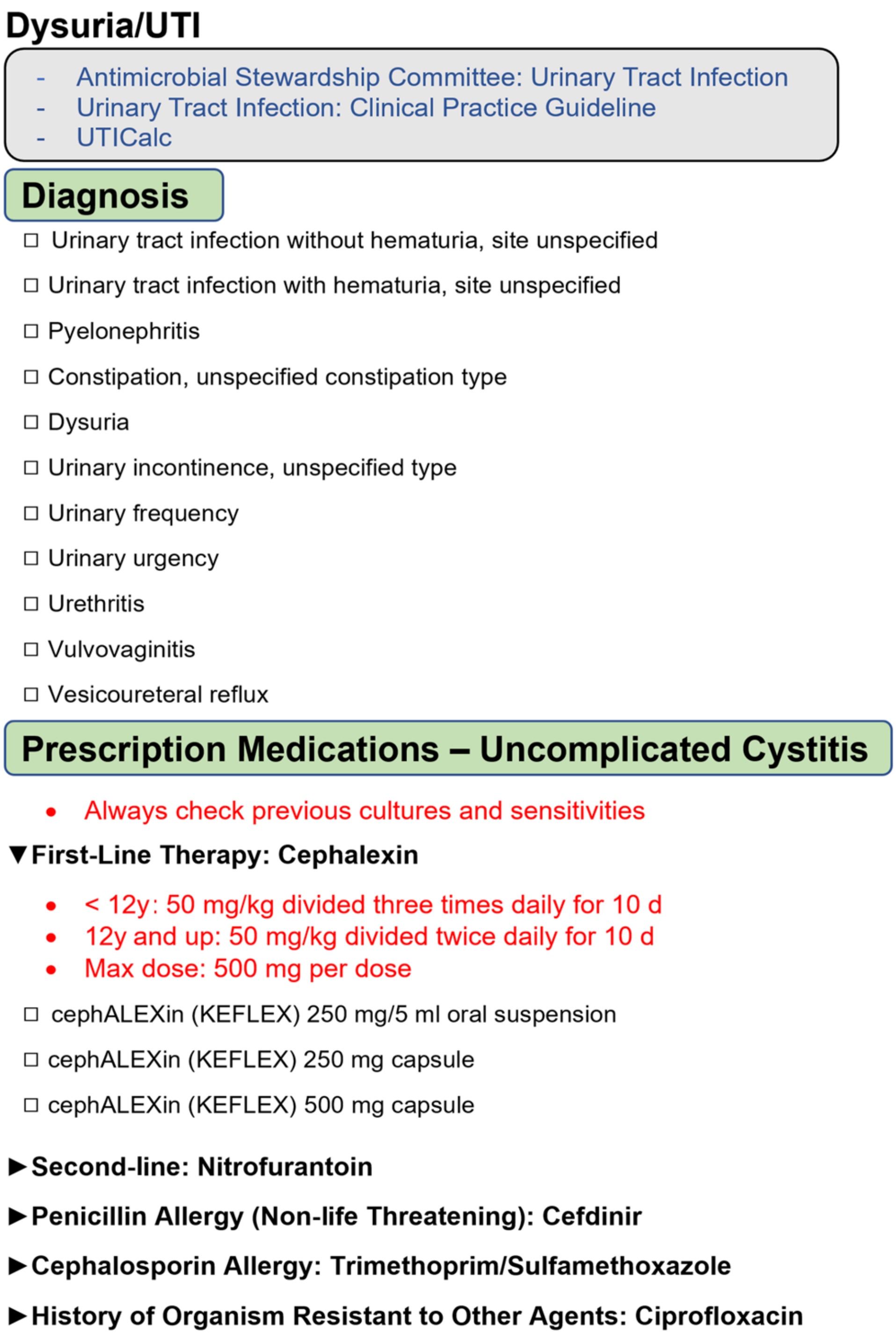

Fig. 1. Dysuria/UTI order set with CDS.

Table 1. Demographics for Patients Treated with Antimicrobials for UTI 1 Year Preintervention (3/2018–2/2019) and 1 Year Postintervention (4/2019–3/2020)

	Preintervention (n = 2055)	Postintervention (n = 2284)
Men (%)	102 (5.0%)	115 (5.0%)
Women (%)	1953 (95.0%)	2169 (95.0%)
White (%)	1790 (87.1%)	2009 (88.0%)
Black (%)	209 (10.2%)	207 (9.1%)

track the average prescribing rates for each antimicrobial and demonstrate a statistically significant shift that coincides with the intervention. Prescribing rates for the most commonly prescribed antimicrobials are in Table 2. Amoxicillin, which had the highest rates of resistance, had a 72% reduction in use. There was no significant change in the prescribing rate for nitrofurantoin, the second-line treatment. The improvement in appropriate utilization has been maintained through June 2022.

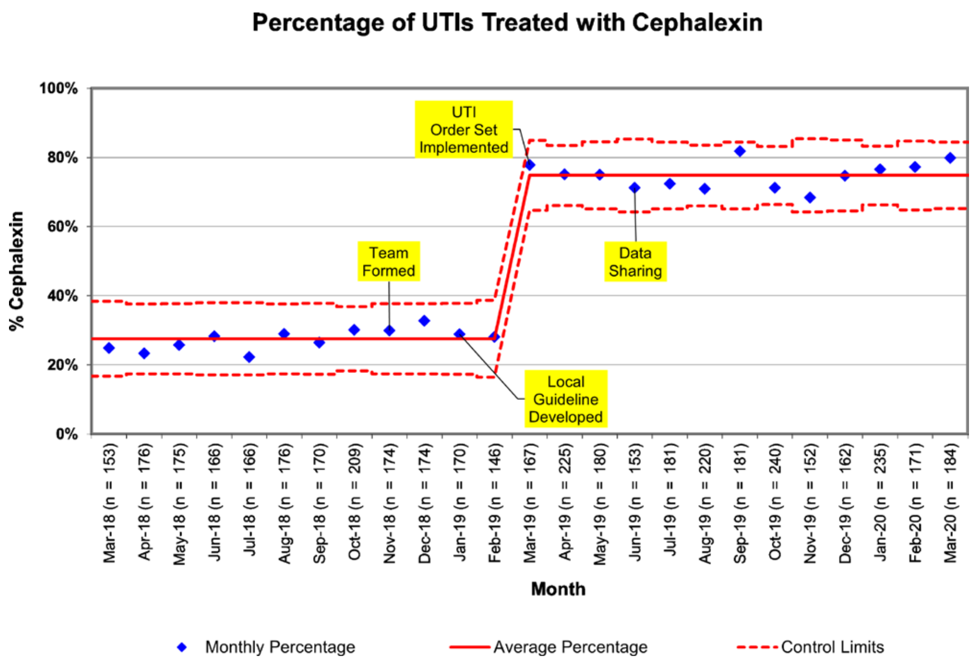

Fig. 2. Control chart depicting the percentage of patients diagnosed with UTI treated with cephalexin. Annotations identify the timing of key interventions.

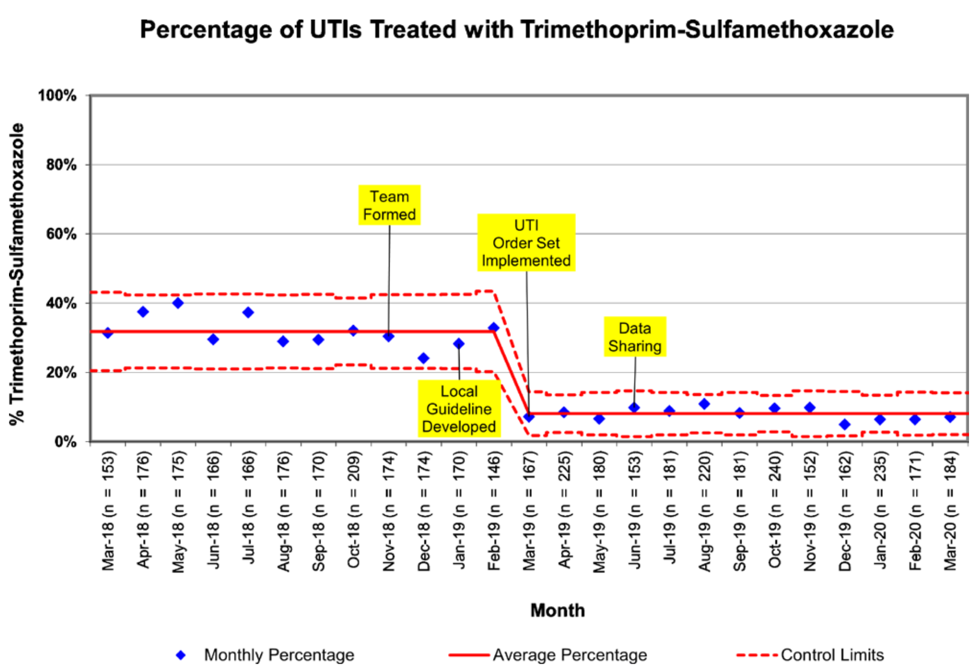

Fig. 3. Control chart depicting the percentage of patients diagnosed with UTI treated with trimethoprim-sulfamethoxazole. Annotations identify the timing of key interventions.

DISCUSSION

We successfully achieved the goal of greater than 70% utilization of the recommended first-line antimicrobial for treating UTIs and have maintained that rate since the conclusion of the quality improvement project. This improvement was achieved by implementing EHR CDS tools. Although tracking treatment failures can be challenging, the significantly reduced use of ineffective antibiotics will likely result in improved outcomes. In addition, these data suggest that using standardized, diagnosis-specific order sets to manage common pediatric illnesses can significantly improve compliance with local and national guidelines.

In the EHR era, CDS has accelerated the adoption of best practices. For example, Davidson et al. demonstrated how CDS could increase screening rates for lead exposure

Table 2. Antimicrobial Prescribing for UTI 1 Year Preintervention (3/2018–2/2019) and 1 Year Postintervention (4/2019–3/2020)

	Preintervention (n = 2055)	Postintervention (n = 2284)
Cephalexin (%)	566 (27.5%)	1703 (74.6%)
Trimethoprim/ sulfamethoxazole (%)	654 (31.8%)	186 (8.1%)
Cefdinir (%)	447 (21.8%)	119 (5.2%)
Amoxicillin (%)	174 (8.5%)	55 (2.4%)
Nitrofurantoin (%)	76 (3.7%)	108 (4.7%)
Ciprofloxacin (%)	43 (2.1%)	23 (1.0%)
Other (%)	95 (4.6%)	90 (3.9%)

in a pediatric primary care network.[11] However, the impact of CDS systems on antibiotic stewardship has been mixed. One study examining antimicrobial prescribing in three emergency departments found that CDS did not statistically impact appropriate prescribing.[12] Conversely, implementing a CDS system for diagnosing and managing pneumonia in ten emergency departments in Utah showed that providers accepted the antibiotic recommendations 93% of the time.[13] Data regarding the impact of CDS on antibiotic prescribing in ambulatory pediatric settings are more limited. Uhl et al successfully increased the use of short-duration therapy for acute otitis media in pediatric urgent care clinics using a discharge template.[14] Although further research is required to identify the most effective ways to deliver CDS in various settings, solutions that fit established workflows, like order sets, show promise.

As healthcare conditions become more complex, leveraging CDS in the patient-care environment is crucial. We have shown that CDS can impact clinician choice of antimicrobials. Similar tools could be leveraged for antimicrobial stewardship and standardization of management of a broad range of common medical conditions. From a return-on-investment perspective, using narrow-spectrum antibiotics would afford direct cost savings, which could be substantial at the population level, not to mention the indirect costs related to decreasing the burden of *Clostridium difficile* infections and drug-resistant organisms resulting from the use of broad-spectrum antibiotics.

LIMITATIONS

This work occurred in a multi-site practice with a shared EHR. Our ambulatory providers utilize diagnosis-specific order sets with CDS for many common pediatric conditions. Successful implementation could be more complicated for organizations with multiple EHR systems, inconsistent use of order sets, or limited informatics or antimicrobial stewardship support. Providers are not required to use order sets, so CDS may not be exclusively responsible for improvement. In addition, this improvement project focused solely on the choice of therapy for UTI and did not look at the appropriateness of therapy based on culture results. Also, we could not identify if the patients filled prescriptions, and we did not track treatment failures.

ACKNOWLEDGMENT

The authors thank Hanna Lemerman, MD, MPH and Kelly Williamson, PharmD, BCIDP for their contributions.

DISCLOSURE

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

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