Improving Antibiotic Prescribing for Pediatric Urinary Tract Infections in Outpatient Settings

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OBJECTIVES: To determine if a multicomponent intervention was associated with increased use of first-line antibiotics (cephalexin or sulfamethoxazole and trimethoprim) among children with uncomplicated urinary tract infections (UTIs) in outpatient settings.

METHODS: The study was conducted at Kaiser Permanente Colorado, a large health care organization with ~127 000 members <18 years of age. After conducting a gap analysis, an intervention was developed to target key drivers of antibiotic prescribing for pediatric UTIs. Intervention activities included development of new local clinical guidelines, a live case-based educational session, pre- and postsession e-mailed knowledge assessments, and a new UTI-specific order set within the electronic health record. Most activities were implemented on April 26, 2017. The study design was an interrupted time series comparing antibiotic prescribing for UTIs before versus after the implementation date. Infants <60 days old and children with complex urologic or neurologic conditions were excluded.

RESULTS: During January 2014 to September 2018, 2142 incident outpatient UTIs were identified (1636 preintervention and 506 postintervention). Pyelonephritis was diagnosed for 7.6% of cases. Adjusted for clustering of UTIs within clinicians, the proportion of UTIs treated with first-line antibiotics increased from 43.4% preintervention to 62.4% postintervention (P < .0001). The use of cephalexin (first-line, narrow spectrum) increased from 28.9% preintervention to 53.0% postintervention (P < .0001). The use of cefixime (second-line, broad spectrum) decreased from 17.3% preintervention to 2.6% postintervention (P < .0001). Changes in prescribing practices persisted through the end of the study period.

CONCLUSIONS: A multicomponent intervention with educational and process-improvement elements was associated with a sustained change in antibiotic prescribing for uncomplicated pediatric UTIs.

In children and adolescents, urinary tract infections (UTIs) are a frequent cause of oral antibiotic use.¹–³ Rising antimicrobial resistance⁴,⁵ and recognition of potential acute⁶,⁷ and long-term⁸,⁹ individual- and population-level negative effects from antibiotics have increased attention on judicious antibiotic use, broadly termed “antimicrobial stewardship.”¹⁰,¹¹ Stewardship entails using an antibiotic only when necessary and, when one is warranted, choosing the correct antibiotic for the recommended duration and dose.¹⁰–¹² For pediatric UTIs, the Centers for Disease Control

abstract

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Dr Daley contributed to the study design, reviewed and interpreted analytic results, drafted the initial manuscript, and reviewed and revised the manuscript; Drs Arnold Rehring and Steiner conceptualized and designed the study, reviewed and interpreted analytic results, and reviewed and revised the manuscript; Ms Glenn led the data collection, contributed to analyses, and reviewed and revised the manuscript; Ms Reifler conducted analyses and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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and Prevention and others have recommended selecting initial antibiotic therapy based on local sensitivity patterns, which may promote use of narrower-spectrum antibiotics. Treatment duration may also be reduced because systematic reviews have supported treating cystitis in older children with shorter antibiotic courses.

Changing clinicians’ antibiotic prescribing practices can be challenging; barriers to change include lack of awareness of new evidence, competing clinical demands, and concern about treatment failure. Although clinician education is often used to promote practice change, reliance on didactic educational sessions typically produces little or no sustainable change. Multicomponent strategies that integrate educational interventions with process-improvement approaches, such as clinical decision support, may be needed.

Kaiser Permanente Colorado (KPCO), a large health care system with an internal education department, aims to improve quality of care for its members through organization-wide dissemination of best practices. In early 2017, a gap analysis at KPCO identified unwarranted practice variation in the treatment of pediatric UTIs, including frequent use of broad-spectrum antibiotics. Concurrently, KPCO clinician-educators were collaborating with subject-matter experts to produce new local clinical practice guidelines for pediatric UTI management. To promote guideline adoption and improve care, we conducted a multicomponent educational and process-improvement intervention. Our primary objective was to determine if the intervention was associated with increased use of first-line antibiotics among children and adolescents with acute uncomplicated UTIs.

**METHODS**

**Study Setting**

This study was conducted in KPCO, an integrated health care system that, in 2017, provided health insurance and care to >670,000 members in Colorado, of whom ~127,000 were <18 years of age. Outpatient care is provided at 27 primary care facilities. KPCO offers traditional health maintenance, deductible, State Children’s Health Insurance Program, and Medicaid plans. KPCO uses the Epic (Epic Systems Corporation, Verona, WI) electronic health record (EHR) to document clinical care. The study observation period was January 1, 2014, to September 30, 2018.

**Overview of Study Design**

After identifying unwarranted practice variation across KPCO in pediatric UTI management, we developed several educational and process-improvement interventions targeted at key drivers of prescribing practices (shown in Fig 1). Most activities described in Fig 1 were implemented on a single day, April 26, 2017. The study design was an interrupted time series used to compare antibiotic prescribing for UTIs across multiple calendar quarters before versus after the implementation date.

**Multicomponent Educational and Process-Improvement Intervention**

In April 2017, new local clinical practice guidelines regarding pediatric UTIs were released. Developed at Children’s Hospital Colorado by a multidisciplinary team that included clinician-educators from KPCO, the guidelines were based on American Academy of Pediatrics recommendations, systematic reviews, and expert opinion. On the basis of local bacterial susceptibility patterns, either cephalaxin or sulfamethoxazole and trimethoprim was recommended as initial therapy. For children 60 days to <3 years of age, a 10-day course was recommended for all UTIs. For children 3 to <18 years of age, a 3-day course was recommended for cystitis and a 10-day course for pyelonephritis.

We timed the intervention to correspond to the guidelines’ release. As shown in Fig 1, educational activities included a live, case-based, 2-hour session accessible by

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**FIGURE 1**

A key driver diagram illustrating the primary and secondary project aims, the key drivers contributing to achieving the aims, and the educational and process improvement interventions implemented. AAP, American Academy of Pediatrics.
videoconference at all 27 KPCO clinics. To facilitate engagement, session moderators used audience-response polling systems and encouraged attendees to ask questions by video or text. We identified clinicians who attended the 2-hour session through paper sign-in logs and online postsession evaluations.

Several process-improvement activities were conducted concurrent with the educational activities (Fig 1). On April 26, 2017, a hyperlink to the guidelines was added to KPCO’s searchable online repository, a condition-specific order set based on the guidelines was added to the EHR, and the UTI order set was made available to family medicine clinicians. Previously, the EHR had defaulted to an adult-oriented order set for clinicians in family medicine. From the pediatric UTI order set, clinicians could check a box to order a first-line antibiotic with a specified duration and dose.

Identification of UTIs

We identified all children and adolescents diagnosed with a first UTI during the study period. We excluded UTIs in patients with complex renal, urologic, or neurologic conditions (based on diagnoses from the Pediatric Medical Complexity Algorithm); recurrent UTIs in the same individual (regardless of the time between distinct UTIs); UTIs diagnosed without an in-person visit; and UTIs from inpatient and emergency or urgent care settings. The definition of a UTI, based on the Randomized Intervention for Children with Vesicoureteral Reflux study and clinical practice guidelines, required pyuria or nitrite positivity (urine dipstick leukocyte esterase test result of ≥1, dipstick results nitrite-positive, or urine microscopy with ≥5 white blood cells per high-power field) and a positive urine culture result (≥50 000 colony-forming units of a uropathogen). The urine culture was excluded if >1 organism was identified, the specimen was contaminated, or the specimen was obtained by urine bag. To assess data quality, we manually reviewed 50 UTIs identified as pathogens (ie, antibiotic sensitivities were tested) or nonpathogens (ie, no sensitivities tested). Data accuracy was confirmed in 100% of reviewed records. A case was designated as pyelonephritis if a pyelonephritis-specific diagnosis code (International Classification of Diseases, Ninth Revision and International Classification of Diseases, Tenth Revision codes 590 and N10, respectively) was identified within 3 days of the urine culture date or if pyelonephritis was listed on the antibiotic prescription. If no diagnosis for pyelonephritis was found, the case was classified as cystitis.

Measures

The primary outcome was selection of a first-line oral antibiotic (ie, cephalaxin or sulfamethoxazole and trimethoprim) as initial therapy for a suspected UTI. The antibiotic choice was empirical because it was made before urine culture results were available. Drug allergies were not considered when assessing the primary outcome because an allergy to both first-line antibiotics would be uncommon. As a secondary outcome, we assessed treatment duration for the initial antibiotic. Two balancing measures were assessed: (1) the proportion of urine culture isolates resistant to either first-line oral antibiotic and (2) the proportion of subjects with a subsequent encounter (ie, a revisit) for a UTI in outpatient, emergency, or inpatient settings within 7 days of the initial diagnosis date.

Analytic Methods

A statistical process control chart was developed, with upper and lower confidence limits set at ±3 SDs about the mean measure by calendar quarter. Because most intervention activities were performed on a single day, we divided the observation time into pre- (January 1, 2014, to April 25, 2017) and postintervention (April 26, 2017, to September 30, 2018) periods. Using χ² tests, we compared the demographic and clinical characteristics of children with an incident UTI in the pre- versus postintervention periods. We compared the proportion of UTIs treated with a first-line oral antibiotic between the pre- and postintervention periods in fixed-effect and hierarchical models. To address the nonindependence of multiple observations clustered within the same clinician, clinician was modeled as a random effect with an exchangeable correlation structure. We assessed secular trends by calendar quarter during the pre- and postintervention periods within models and compared nested models with and without secular trends using the likelihood ratio test. Adjustment for and interactions between chronic condition status, age group, and UTI diagnosis (cystitis or pyelonephritis) were tested. Additionally, we examined whether clinician educational session attendance had a differential effect on the use of first-line antibiotics through modeling an interaction and in stratified models. Finally, we repeated the cluster-adjusted model in subanalyses restricted to clinicians who treated ≥1 UTIs in both the pre- and postintervention periods.

We also examined the duration of antibiotic use in days using a linear hierarchical model and controlling for within-clinician clustering of UTIs. Antibiotic duration was included for all antibiotics, regardless of whether a first-line agent was used. For duration analyses, we excluded the small number of cases (n = 43) for which no antibiotic was prescribed within 3 days of the index visit date. We used α = .05, 2-sided, to determine statistical significance. SAS
prescribed for 2.0% of cases. No antibiotic was
organism identified was Escherichia coli. Pyelonephritis was diagnosed for 7.6% of cases. No antibiotic was
of cases. The
most common organism identified was Escherichia coli. Pyelonephritis was diagnosed for 7.6% of cases. No antibiotic was
for 2.0% of cases. The
demographic and clinical characteristics of UTI cases diagnosed in the pre- versus postintervention periods were similar (data not shown).

**Antibiotic Choice in Unadjusted Analyses**
The proportion of UTIs treated with first-line oral antibiotics plotted by calendar quarter is presented in Fig. 2. The use of first-line antibiotics ranged from 40.9% to 56.6% per quarter preintervention and from 63.3% to 76.9% per quarter postintervention. When accounting for a main effect (ie, whether prescribing changed from the pre- to postintervention period), the linear trend by quarter was $-0.0002 (P = .98)$ and the interaction of trend by quarter with the main effect was $-0.0058 (P = .75)$. Because the secular trends were close to 0, they were not retained in models used to compare pre- and postintervention antibiotic prescribing.

We also examined use of first-line antibiotics stratified by age and UTI diagnosis, shown in Table 2. Overall, 49.8% of UTIs preintervention compared with 70.6% postintervention were treated with first-line antibiotics. Differences were observed for all age groups, whether diagnosed with pyelonephritis or cystitis. The largest absolute change was observed for treatment of pyelonephritis in children 60 days to <3 years: 11.4% preintervention compared with 83.3% postintervention received first-line antibiotics.

**Antibiotic Choice in Adjusted Analyses**
Within-clinician clustering accounted for 0.17 of the variance in first-line antibiotic choice. By adjusting for the clustering of UTIs within treating clinicians, the proportion of UTIs treated with first-line antibiotics increased from 43.4% preintervention to 62.4% postintervention ($P < .0001$).

We also examined change in use of specific antibiotics while adjusting for clustering (Fig 3). The use of cefalexin, a first-line antibiotic, increased from 28.9% preintervention to 53.0% postintervention ($P < .0001$). The use of cefixime, a second-line antibiotic, decreased from 17.3% preintervention to 2.6% postintervention ($P < .0001$). The use of sulfamethoxazole and trimethoprim also decreased, composing 14.4% of antibiotics preintervention compared with 7.4% postintervention ($P < .01$).

In a multivariate model that included adjustment and interactions for age group, UTI diagnosis, and within-provider clustering of UTIs, the use of first-line antibiotics remained significantly higher in the postintervention period ($P < .001$). Medical complexity was not included in the model because it was not significantly associated with first-line antibiotic use.

**Characteristics of Subjects With UTIs**
The characteristics of children and adolescents with UTIs are presented in Table 1. The vast majority of UTIs were in girls, and 16.8% of the cohort had a noncomplex chronic condition, most frequently asthma or depression. The most common organism identified was Escherichia coli. Pyelonephritis was diagnosed for 7.6% of cases. No antibiotic was prescribed for 2.0% of cases. The

**Research Ethics**
The project was determined to be exempt from human subjects research oversight as a quality initiative, and informed consent was not required.

**RESULTS**

**Clinicians Providing Outpatient Care to Pediatric Patients**
In March 2017, a total of 372 clinicians at KPCO provided primary care to pediatric patients, including 188 family physicians, 82 pediatricians, 43 nurse practitioners, and 59 physician assistants. On the basis of sign-in logs and session evaluations, 181 clinicians (48.7%) attended the live educational session. There were 351 clinicians who treated at least 1 UTI during the study period, with each clinician treating a median of 3 (interquartile range 1–7; range 1–31) UTIs.

**Identification of Incident UTIs**
Among children and adolescents 60 days to <18 years of age, we identified 2795 UTIs meeting our case definition during the study period. Of these, 653 cases were excluded as recurrent, leaving a total of 2142 incident outpatient UTIs. Of these, 1636 UTIs were diagnosed during the preintervention period and 506 were diagnosed during the postintervention period.

**Characteristics of Subjects With UTIs**
The characteristics of children and adolescents with UTIs are presented in Table 1. The vast majority of UTIs were in girls, and 16.8% of the cohort had a noncomplex chronic condition, most frequently asthma or depression. The most common organism identified was Escherichia coli. Pyelonephritis was diagnosed for 7.6% of cases. No antibiotic was prescribed for 2.0% of cases. The

version 9.4.1 (SAS Institute, Inc, Cary, NC) was used for analyses.
Analyses Among Clinicians Treating UTIs Preintervention and Postintervention

To control for differences in prescribing practices among clinicians treating UTIs in only 1 time period, we conducted a subanalysis restricted to the 137 clinicians who treated UTIs in both the pre- and postintervention periods. First-line antibiotics were prescribed for 50.8% of UTIs preintervention versus 70.4% of UTIs postintervention ($P < .0001$).

Change in Antibiotic Duration Preintervention Versus Postintervention

Among all children and adolescents with an incident UTI, the adjusted average duration of antibiotic therapy was longer in the preintervention period (mean 7.34 days, SE 0.10) compared with the postintervention period (mean 5.98 days, SE 0.14; $P < .001$). Among children and adolescents 3 to <18 years of age not diagnosed with pyelonephritis, the adjusted proportion prescribed antibiotics for $\leq$5 days increased from 26.1% preintervention to 68.6% postintervention ($P < .0001$).

Balancing Measures

The proportion of urine culture isolates resistant to either first-line antibiotic ranged from 0.0% to 10.6% per quarter in the preintervention period and from 1.4% to 10.0% per quarter in the postintervention period. The mean proportion of resistant isolates was similar in the preintervention period compared with the postintervention period (5.8% vs 5.9%; $P = .94$). Return visits within 7 days for a UTI were uncommon; the proportion of subjects with a revisit was higher in the preintervention period compared with the postintervention period (1.7% vs 0.4%; $P = .03$).

DISCUSSION

To improve quality of care and encourage antibiotic stewardship,10,11 we implemented a multicomponent intervention focused on outpatient management of acute uncomplicated UTIs. We timed educational and process-improvement activities to correspond with the release of new clinical guidelines.27 Compared with clinician prescribing practices before the intervention, we found that clinician use of first-line oral antibiotics for treatment of pediatric UTIs increased substantially after the intervention. Use of a narrow-spectrum antibiotic, cephalaxin, increased, whereas use of a broad-spectrum antibiotic, cefixime, decreased. The change in practice was immediate, was sustained for 1 year after the intervention, and was seen in all age groups of interest. Additionally, the average antibiotic treatment duration decreased after the intervention. To our knowledge, there have been few studies in which researchers have attempted to improve antibiotic prescribing practices for pediatric UTIs in outpatient settings. Poole

TABLE 1 Demographic and Clinical Characteristics of Children and Adolescents With a First UTI During the Study Observation Period (January 2014 to September 2018)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total No. cases</strong></td>
<td>2142 (100.0)</td>
</tr>
<tr>
<td><strong>Age at time of UTI diagnosis</strong></td>
<td></td>
</tr>
<tr>
<td>60 d to &lt;36 mo</td>
<td>285 (13.3)</td>
</tr>
<tr>
<td>3 to &lt;12 y</td>
<td>983 (45.9)</td>
</tr>
<tr>
<td>12 to &lt;18 y</td>
<td>874 (40.8)</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>2057 (96.0)</td>
</tr>
<tr>
<td>Male</td>
<td>85 (4.0)</td>
</tr>
<tr>
<td><strong>Race and/or ethnicity</strong></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>582 (26.2)</td>
</tr>
<tr>
<td>Non-Hispanic Asian American</td>
<td>68 (3.2)</td>
</tr>
<tr>
<td>Non-Hispanic African American</td>
<td>98 (4.6)</td>
</tr>
<tr>
<td>Non-Hispanic white</td>
<td>1135 (53.0)</td>
</tr>
<tr>
<td>Other race and/or ethnicity</td>
<td>101 (4.7)</td>
</tr>
<tr>
<td>Missing race and/or ethnicity</td>
<td>178 (8.3)</td>
</tr>
<tr>
<td><strong>Chronic conditions based on PMCA31,32</strong></td>
<td></td>
</tr>
<tr>
<td>No complex or chronic conditions</td>
<td>1783 (83.2)</td>
</tr>
<tr>
<td>Noncomplex chronic condition</td>
<td>359 (16.8)</td>
</tr>
<tr>
<td><strong>Health insurance type</strong></td>
<td></td>
</tr>
<tr>
<td>Traditional health maintenance</td>
<td>649 (30.3)</td>
</tr>
<tr>
<td>Deductible</td>
<td>744 (34.7)</td>
</tr>
<tr>
<td>Children’s Health Insurance Program</td>
<td>152 (7.1)</td>
</tr>
<tr>
<td>Publica</td>
<td>516 (24.1)</td>
</tr>
<tr>
<td>Other</td>
<td>81 (3.8)</td>
</tr>
<tr>
<td><strong>Urinalysis and microscopy results</strong></td>
<td></td>
</tr>
<tr>
<td>Leukocyte esterase 1+ or greater</td>
<td>1629 (76.1)</td>
</tr>
<tr>
<td>Nitrite-positive</td>
<td>1047 (48.9)</td>
</tr>
<tr>
<td>$\geq$5 white blood cells per high-powered field</td>
<td>1971 (92.0)</td>
</tr>
<tr>
<td><strong>Uropathogen identified</strong></td>
<td></td>
</tr>
<tr>
<td><em>E. coli</em></td>
<td>1859 (86.8)</td>
</tr>
<tr>
<td>Proteus spp</td>
<td>77 (3.6)</td>
</tr>
<tr>
<td>Klesbiella spp</td>
<td>48 (2.2)</td>
</tr>
<tr>
<td><em>Enterococcus</em> spp</td>
<td>19 (0.9)</td>
</tr>
<tr>
<td><em>Enterobacter</em> spp</td>
<td>15 (0.7)</td>
</tr>
<tr>
<td>Others2</td>
<td>124 (5.8)</td>
</tr>
<tr>
<td>Diagnosed with pyelonephritis</td>
<td>162 (7.6)</td>
</tr>
<tr>
<td>No antibiotic prescribed $\geq$3 d of index date</td>
<td>43 (2.0)</td>
</tr>
</tbody>
</table>

PMCA, Pediatric Medical Complexity Algorithm.

a Medicaid and other public health insurance programs.

b Column percentages sum to 100% because positivity on 1 of any of these results qualified as meeting the UTI case definition.

c Other uropathogens included *Citrobacter* species, *Morganella* morganii, *Pseudomonas* aeruginosa, group B *Streptococcus*, *Staphylococcus* species, and *Serratia* marcescens.
et al introduced an EHR-based pediatric UTI algorithm and order set with mandatory computer training in urgent and emergency care settings; cephalexin use increased from 19.2% of prescriptions before to 79.6% after the intervention. A study of UTIs among adolescents and adults in a single emergency department documented improved prescribing after implementation of education plus audit and feedback. Similarly, Walters et al demonstrated improvements in UTI management in a pediatric emergency department after multiple quality improvement cycles. None of these studies included primary care settings. Most other studies of outpatient antimicrobial stewardship have been focused on respiratory infections. Rather than conducting multiple plan-do-study-act cycles, we implemented 1 organization-wide intervention with many interrelated components. Consequently, it is not possible to determine which components were associated with the improvements observed. The educational components were developed by using educational best practices, in which programs are multimodal, longitudinal, interactive, and reflective of learner priorities. However, practice change was also observed among clinicians who did not attend the live educational session, suggesting that other mechanisms of change were involved. Creation of a UTI-specific order set closely aligned with the guidelines may have been important, particularly if the order set was perceived by clinicians as trustworthy, intuitive, and easy to locate in the EHR. However, we were unable to assess whether the UTI-specific order set was used to order antibiotics.

This study is subject to several limitations. First, the interrupted time-series design prevents us from inferring that the intervention caused the observed change in practice, and it is possible that secular trends in antibiotic prescribing accounted for the change observed. However, several factors support the observed association: (1) the intervention occurred over a short period of time, with intervention timing controlled by guest on July 15, 2021www.aappublications.org/news Downloaded from www.aappublications.org/news by guest on July 15, 2021

The Use of First-line Oral Antibiotics for Treatment of Acute Uncomplicated UTIs, Stratified by Type of UTI Diagnosed and Age Group

<table>
<thead>
<tr>
<th>Diagnosisa</th>
<th>Age Group</th>
<th>Preintervention</th>
<th>Postintervention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. Cases</td>
<td>Proportion Prescribed First-line Antibiotic, %</td>
<td>No. Cases</td>
</tr>
<tr>
<td>Any diagnosis</td>
<td>All ages</td>
<td>1636</td>
<td>49.8</td>
</tr>
<tr>
<td>Cystitis</td>
<td>All ages</td>
<td>1516</td>
<td>52.5</td>
</tr>
<tr>
<td></td>
<td>60 d to &lt;3 y</td>
<td>186</td>
<td>43.6</td>
</tr>
<tr>
<td></td>
<td>3 to &lt;12 y</td>
<td>732</td>
<td>68.0</td>
</tr>
<tr>
<td></td>
<td>12 to &lt;18 y</td>
<td>588</td>
<td>36.3</td>
</tr>
<tr>
<td>Pyelonephritis</td>
<td>All ages</td>
<td>120</td>
<td>15.0</td>
</tr>
<tr>
<td></td>
<td>60 d to &lt;3 y</td>
<td>35</td>
<td>11.4</td>
</tr>
<tr>
<td></td>
<td>3 to &lt;12 y</td>
<td>26</td>
<td>19.2</td>
</tr>
<tr>
<td></td>
<td>12 to &lt;18 y</td>
<td>59</td>
<td>15.3</td>
</tr>
</tbody>
</table>

First-line oral antibiotics were either cephalexin or sulfamethoxazole and trimethoprim. The model was not adjusted for clustering of UTIs within treating clinicians.

A case was designated as pyelonephritis if the diagnosis code for pyelonephritis was associated with an outpatient encounter or antibiotic prescription; if no diagnosis for pyelonephritis was found, the case was classified as cystitis.
by the project team; (2) first-line prescribing rates were stable before the intervention; (3) a marked change was observed immediately after the intervention; (4) multiple time points, each with a large sample size, were available before and after the intervention; and (5) the UTI case mix did not differ between time periods. A recent systematic review found that in 82% of published studies of antimicrobial stewardship, authors used nonexperimental designs, suggesting that similar feasibility constraints are present in other settings.

Second, misclassification of case status, exposures, outcomes, or covariates could have biased the findings. We used a strict case definition, and we did not ascertain how frequently UTIs were diagnosed and treated without a supporting urinalysis or urine culture results. It is possible that the antibiotics identified within 3 days of a positive urine culture result were prescribed for a different infection or multiple concurrent infections. We might have misclassified some pyelonephritis cases as cystitis; this misclassification would have particularly affected the duration analysis. It is possible that clinicians attended the educational session but did not sign in or complete the postsession evaluation.

A final limitation pertains to generalizability and the translation of findings to other organizations. Although replicating the entire intervention would require substantial coordination, adapting parts of the intervention to other settings may be feasible and productive. For example, developing a UTI-specific EHR order set is relatively straightforward. Partnering with a local academic children’s hospital, as we did, may facilitate tailoring the order set to local antimicrobial susceptibilities and yield educational opportunities. Embedding hyperlinks to guidelines within an EHR may also be feasible.

CONCLUSIONS

A multicomponent intervention focused on pediatric UTI management was associated with immediate and sustained changes in antibiotic prescribing in primary care settings. Consistent with the goals of antimicrobial stewardship, the observed changes included increased use of narrow-spectrum antibiotics and shorter treatment duration when indicated. Despite the limitations inherent in a nonexperimental study design, the methods and interventions developed in the current study may be informative to other learning health systems and other content areas when conducting organization-wide quality improvement initiatives.
ACKNOWLEDGMENTS
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ABBREVIATIONS
EHR: electronic health record
KPCO: Kaiser Permanente Colorado
UTI: urinary tract infection


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