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Authors

Wang, Yvette L

Lee, Begem

Zimmerman, Elise

et al.

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RESEARCH ARTICLE

Discontinuing Antibiotics for Contaminant Urine Cultures in a Pediatric Emergency Department

Yvette L. Wang, MD,[1,2] Begem Lee, MD,[1,3] Elise Zimmerman, MD, MS,[1,2] Tatyana G. Mills, MD,[1,3] Amy W. Bryl, MD[1,2]

ABSTRACT

OBJECTIVES: In the pediatric emergency department (ED), patients are diagnosed with urinary tract infections (UTIs) and prescribed antibiotics based on urinalysis results while awaiting urine cultures (UCs). If UCs are not consistent with UTIs, antibiotics can be discontinued. Previously, our ED physicians did not contact patients with contaminant UCs, and antibiotics were continued unnecessarily. For patients diagnosed with UTIs but having contaminant UCs, we aimed to increase the percentage of antibiotics discontinued from 3% to 75% in 6 months.

METHODS: Interventions focused on physician education, physician feedback, and training Resource Nurse Line staff to contact families regarding UCs. Outcome measures were the percentage of patients with contaminant UCs who had antibiotics discontinued and the average antibiotic duration for patients with contaminant UCs. Process measures included the percentage of patients who providers called. Balancing measures included the percentage of patients who had antibiotics discontinued and returned to the ED within 7 days with persistent urinary symptoms. We used statistical process control to examine changes in measures over time.

RESULTS: The percentage of patients with antibiotics discontinued increased from 3% to 61% within 10 months, with this change sustained for an additional 12 months. The average antibiotic duration decreased from 7.3 to 4.5 days. The percentage of patients called increased from 5% to 82%. Of the patients who discontinued antibiotics, 1% returned to the ED and were again diagnosed with UTIs.

CONCLUSIONS: We increased the percentage of patients with contaminant UCs who had antibiotics discontinued and demonstrated sustainability.

[1]Department of Pediatrics, University of California San Diego School of Medicine, La Jolla, California
[2]Division of Emergency Medicine, Rady Children's Hospital San Diego, San Diego, California
[3]Division of Hospital Medicine, Rady Children's Hospital San Diego, San Diego, California

Address Correspondence to: Yvette L. Wang, MD, Division of Emergency Medicine, 3020 Children's Way, MC 5075, San Diego, CA 92123. ylwang@rchsd.org

Dr Wang conceptualized the study, designed the quality improvement (QI) interventions, supervised data collection, analyzed the data, and drafted and critically revised the manuscript. Drs Lee and Bryl conceptualized the study, designed the QI interventions, and critically revised the manuscript. Drs Zimmerman and Mills designed the QI interventions and drafted and critically revised the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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INTRODUCTION

Urinary tract infections (UTIs) account for 5% to 14% of pediatric emergency department (ED) visits.[1,2] Urine cultures (UCs) are the gold standard for diagnosis, with a positive UC defined as at least 100 000 colony-forming units (CFU) per milliliters of a single uropathogen from a clean-catch specimen.[3,4] For catheterized samples, a positive UC is defined as at least 50 000 CFU/mL or 10 000 CFU/mL of a single uropathogen if fever and pyuria are present.[5] Culture counts less than these thresholds and growth of at least 2 organisms suggest contamination. Because UC results are only available after 1 to 2 days, antibiotics are typically started empirically based on clinical history and a screening urinalysis (UA).[6] Owing to the imperfect specificity of UAs, approximately 45% to 50% of patients treated empirically for UTIs in the ED setting have UCs that do not align with the American Academy of Pediatrics (AAP) definition of UTI.[7,8]

Unnecessary antibiotics for these patients can cause adverse effects such as the development of antibiotic resistance.[9] Both the AAP and Infectious Diseases Society of America recommend that antibiotic stewardship strategies include discontinuing unnecessary antibiotics such as those for negative cultures.[10,11] However, antibiotic discontinuation is infrequently attempted in the ED setting.[12–14]

Similar to patients with negative UCs, patients with contaminant UCs likely do not have true UTIs and do not require antibiotics. Over a 12-month period at our institution, 23% of ED patients who were empirically treated for UTIs and met our study's inclusion criteria had contaminant UCs. Although pediatric emergency medicine (PEM) physicians reviewed culture results daily and identified UCs as contaminants, only 3% of children with contaminant UCs were instructed to discontinue antibiotics. In order to improve antibiotic stewardship, we aimed to increase the percentage of patients with contaminant UCs who discontinued antibiotics from 3% to 75% within 6 months.

METHODS

Context and Setting

This study took place in a large, urban, freestanding pediatric ED in the Western United States serving approximately 100 000 patients per year. During the study period, 83.8% of all ED patients listed English as their preferred language, 12.8% preferred Spanish, and 3.4% had other preferred languages. Patients are seen by approximately 80 ED providers, including PEM physicians, pediatricians, and advanced practice providers, in addition to residents (ie, those in emergency medicine, family medicine, and pediatrics).

Approximately 45 core PEM physicians are responsible for reviewing culture results. Each day, the physician on backup call is also tasked with reviewing outstanding ED test results. Outstanding results include imaging, electrocardiograms, blood tests, and all cultures (such as urine, blood, stool, and throat) showing growth. Cultures showing no growth are not routed to the electronic medical record (EMR) results pool. The number of results varies from approximately 30 to 50 per day. Physicians receive credit for 1 hour of clinical time for reviewing results.

Defining a Target Population and Planning Interventions

We had previously formed a team of PEM and pediatric hospital medicine physicians to participate in the AAP's Better Antibiotic Selection in Children quality improvement (QI) collaborative. Inspired by this work, a subset of us formed an interdisciplinary team with nursing and EMR analysts to improve our local practice. Our team reviewed 12 months of baseline data. We defined contaminants as UCs showing mixed flora. At baseline, of patients who were diagnosed with UTIs but did not have UCs representing true pathogens, 71% had mixed flora, whereas 12% had low growth, and 17% had no growth. Using Pareto principles to focus on the largest area of opportunity, we decided to address contaminant UCs.

Given the concern that certain higher-risk patients may have adverse consequences from discontinuing antibiotics, we excluded patients who were immunocompromised, specifically patients with underlying immunodeficiencies or those on chemotherapy, or those who had underlying renal or urologic disorders. Given the difficulty in interpreting partially treated UCs, we excluded patients who were on antibiotics at the time of UC collection. Patients who were prescribed antibiotics for another infection such as pneumonia in addition to a UTI were excluded, as antibiotic therapy was still warranted. Admitted patients were also excluded, as the inpatient team was expected to follow-up on culture results.

We performed a targeted needs assessment with an Ishikawa diagram, which demonstrated barriers, including not having a standardized process for managing UC results and perceptions of not having enough time to review cultures. We then constructed a key driver diagram addressing these barriers (Figure 1).

Interventions

We tested 3 categories of interventions over 17 months: (1) PEM Physician and Patient Education, (2) PEM Physician Feedback, and (3) Collaboration with the Resource Nurse Line.

PEM Physician and Patient Education

In order to address the identified barriers, we focused our educational efforts on ensuring awareness of our QI initiative and enhancing efficiency in managing culture results. We presented this initiative at our ED division meeting and in our ED newsletter in November 2021. As part of our initial interventions, we presented local data on the number of patients with contaminant UCs continuing antibiotics unnecessarily. We communicated that our local infectious disease specialists concurred that antibiotic treatment was unnecessary for these patients. From November 2021 to February 2022, we sent weekly emails to physicians scheduled for culture review, reminding them to discontinue antibiotics for patients with contaminant UCs.

Although not directly part of the QI project, we also provided education to enhance the accuracy of physician diagnosis of UTIs. In February 2022, we presented an existing guideline outlining the criteria for ordering microscopy and cultures based on urine dipstick results. In May 2022, to assist physicians in interpreting UAs, we

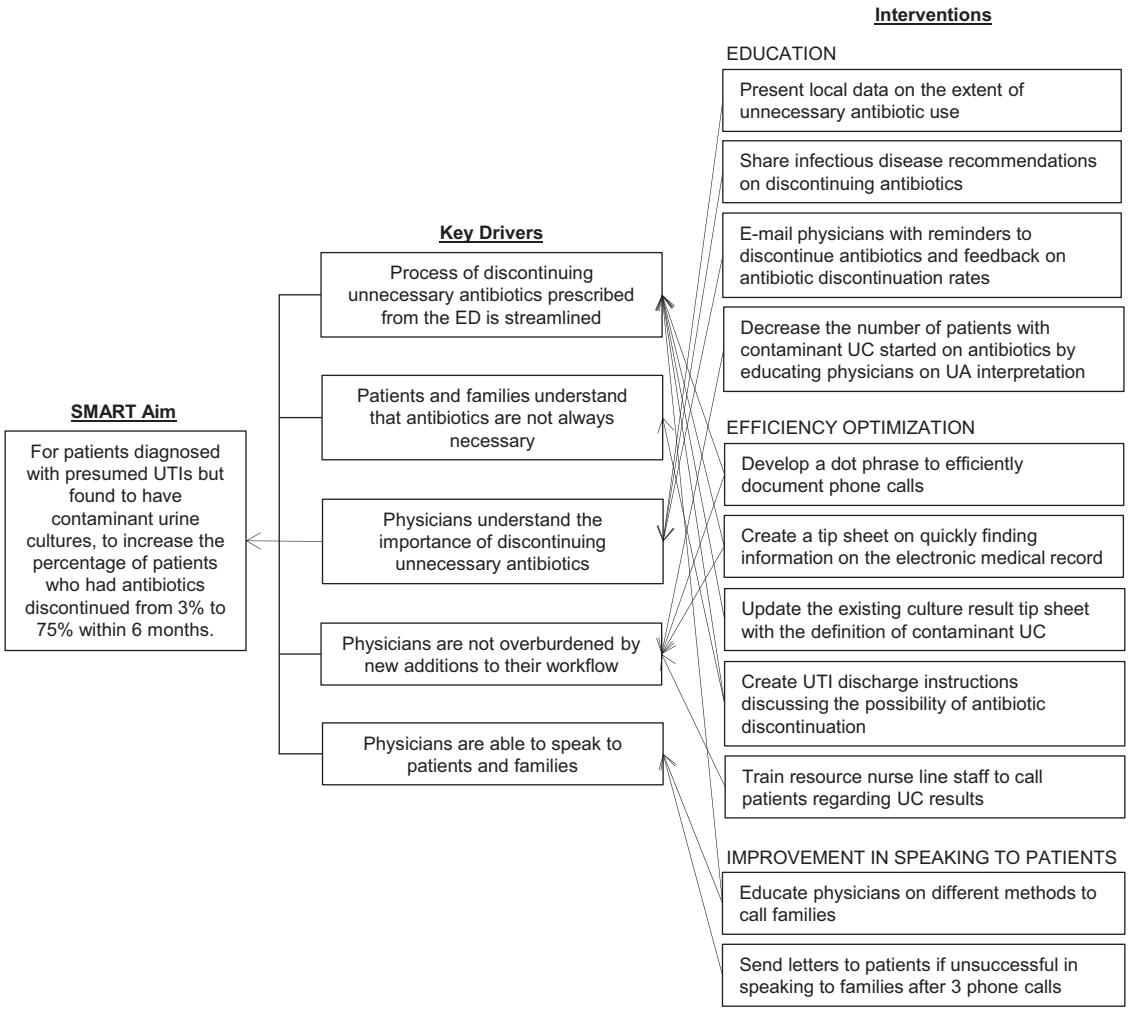

FIGURE 1. Key driver diagram summarizing the key drivers and interventions.
Abbreviations: ED, emergency department; SMART, specific, measurable, attainable, relevant, time based; UA, urinalysis; UC, urine culture; UTI, urinary tract infection.

presented literature elucidating the utility of urine dipsticks and microscopy.[15]

At the start of our initiative, we created an educational tip sheet bundle to improve efficiency and streamline the process of reviewing results. Because our physicians typically contact patients remotely, we included methods of calling families such as using a phone application that allows physicians to use personal cellular phones to call families while displaying the hospital phone number on caller identification. Another tip sheet described means of quickly finding information, including contact information and discharge prescriptions, in the EMR. We updated an existing culture result tip sheet to include definitions of UCs representing true pathogens and contaminant UCs. Finally, we created EMR dot phrases to efficiently document results and phone calls.

In order to notify families of a potential call regarding UC results, we formulated standardized UTI discharge instructions. These instructions conveyed that a urine sample was sent for a UC to confirm whether the child had a UTI and whether antibiotics were still indicated. Instructions were provided in English and Spanish, addressing the predominant languages within our demographic. In December 2021, we integrated these instructions into the EMR, guiding physicians on their inclusion within a patient's discharge instructions.

PEM Physician Feedback

Although we noted immediate improvement in antibiotic discontinuation following the implementation of our QI initiative, in reviewing our data, we found that there were specific physicians who either never or only sporadically called families. Prior division QI projects had demonstrated changes in physician practice in response to individual feedback. Therefore, in April 2022, we reinstated our previous weekly emails to physicians scheduled for culture review, including individual feedback on antibiotic discontinuation rates. This physician-specific feedback continued through June 2022.

Collaboration With the Resource Nurse Line

Despite providing physician-specific feedback, certain physicians did not reliably call families regarding contaminant UCs. In individual conversations with these physicians, a common theme was that this was time-consuming when they were already spending more than the amount of clinical time that they received to review results. In order to address this concern, we partnered with our hospital's existing Resource Nurse Line to create a new workflow of resource line nurses calling patients regarding UC results. This process "went live" in August 2022. For patients prescribed antibiotics for contaminant UCs, PEM physicians wrote a result note stating that he or she recommended discontinuing antibiotics and forwarded this note to the Resource Nurse Line. Resource line nurses then called families regarding the results. If multiple attempts to speak to the family were unsuccessful, resource line nurses mailed a letter instructing the family to call back regarding a test result.

Study of Interventions

Patient lists for the baseline, intervention, and sustainability periods were obtained from EMR analysts. Using the *International Classification of Diseases, 10th Revision* diagnosis codes N39.0 (ie, UTI, site not specified), N30.0 (ie, acute cystitis), N30.9 (ie, cystitis), N10 (ie, acute pyelonephritis), and N15.1 (ie, renal and perinephric abscess), we obtained a list of ED patients diagnosed with UTIs and their UC results. A team member reviewed records for all patients with contaminant UCs. The lead author independently confirmed that all patients met eligibility criteria. We reviewed records monthly during the intervention period (November 2021 through August 2022). We also reviewed records monthly at the start of the sustainability period (September 2022 through March 2023) but obtained additional data retrospectively (April 2023 through August 2023) to show continued sustainability.

Measures

Outcome Measures

Our primary measure was the percentage of patients who were prescribed antibiotics for UTIs with contaminant UCs who were successfully contacted by the ED and indicated that they would stop antibiotics. Voicemails were not considered as successful antibiotic discontinuation unless confirmed with a subsequently documented phone conversation or follow-up visit. Another outcome measure was the total antibiotic duration for patients with contaminant UCs. For patients who indicated that they would discontinue antibiotics, we calculated the antibiotic duration using the ED discharge time as the antibiotic start time and the time of the phone conversation as the antibiotic stop time. Although some patients received a first dose of antibiotics in the ED, antibiotics were typically given immediately prior to ED discharge. For patients who did not stop antibiotics, we used the total duration that was prescribed.

Process Measures

Our process measure was the percentage of patients who the ED called regarding contaminant UCs. We defined this as any documented phone call, regardless of whether the physician or resource nurse spoke to the family.

Balancing Measures

Balancing measures included the percentage of patients who discontinued antibiotics and returned to the ED within 7 days for persistent symptoms and the number of phone calls per day that PEM physicians and resource line nurses made regarding contaminant UC results. We included fever, abdominal pain, flank pain, vomiting, dysuria, hematuria, and urinary frequency in our definition of "persistent symptoms".

Analysis

We used Microsoft Excel and QI Macros to create statistical process control charts and followed established rules for interpreting control charts.[16] For our primary outcome measure and additional measures of percentages, we used p-charts. We used Xbar-S charts to investigate changes in antibiotic duration and the number of calls made. Gender and preferred language distributions were compared using a χ^2 test, whereas age distributions were compared using a *t* test. These statistical analyses were calculated using IBM SPSS Statistics for Macintosh, version 28.0 (IBM Corp).

Ethical Considerations

Our institution's institutional review board designated this study as not human-subjects research and granted it a QI exemption.

RESULTS

During our QI initiative, an average of 108 patients per month were diagnosed with UTIs. Twenty-five percent of patients diagnosed with UTIs had contaminant UCs (Supplemental Figure 1). Demographic characteristics of ED patients who were and were not called regarding contaminant UC results during our initiative are displayed in Table 1. There were no statistically significant differences in age, sex, or preferred languages of these patients. Although we aimed to complete our project in 6 months, we did not achieve our aim at the end of this period and, therefore, chose to continue improvement efforts for an additional 4 months.

TABLE 1. Demographic Characteristics of Patients with Contaminant UCs Called and Not Called During the Quality Initiative

Patient Characteristics	Patients Called Regarding UC Results, n = 463	Patients Not Called Regarding UC Results, n = 129	*P* Value
Age, y, mean ± SD	6.4 ± 4.5	7.0 ± 5.3	0.232
Sex, % female	93.5	89.9	0.164
Preferred language, %			0.519
English	79.5	81.4	
Spanish	16.8	17.0	
Other	3.7	1.6	

Abbreviation: UC, urine culture.

Outcome Measures

Immediately after presenting our project and educating ED providers, we observed special cause variation in our antibiotic discontinuation pattern. We achieved a centerline (CL) shift for our primary measure, increasing the percentage of patients who had antibiotics discontinued by the ED from 3% to 61% (Figure 2). Changes were sustained for 12 months from our last intervention. The average duration of antibiotics for patients with contaminant UCs decreased from 7.3 to 4.5 days (Figure 3), with this shift similarly occurring immediately after project initiation. We observed an expected increase in SD as patients stopped antibiotics earlier rather than completing a full 7- to 10-day course. During this initiative, no other system changes would have affected our results.

Process Measures

Immediately after presenting our project, we observed special cause variation in the percentage of patients with contaminant UCs called by the ED. We achieved a CL shift, with the percentage of patients called increasing from 5% to 73%. Once we started collaborating with the Resource Nurse Line in August 2022, we observed a second CL shift, with the percentage of patients called increasing from 73% to 82% (Figure 4).

Reasons for Antibiotic Continuation

Reasons that antibiotics were continued fell into the following categories: (1) The physician interpreted the result as a contaminant but did not document a phone call; (2) The physician or resource line nurse called but did not speak to the family, eg, leaving a voicemail without receiving a call back; (3) The patient's family expressed discomfort with discontinuing antibiotics; (4) The physician decided that antibiotics were warranted based on UA results and/or patient symptoms; and (5) The physician did not successfully forward the result to the Resource Nurse Line. Physicians and resource line nurses either not calling or not succeeding in speaking to families accounted for 68% (44% and 24%, respectively) of unnecessarily continued antibiotics during our intervention and sustainability periods. After initiating Resource Nurse Line callbacks, the percentage of continued antibiotics attributed to patients not being called, including physicians unsuccessfully forwarding results, decreased from 49% to 40% (Supplemental Figure 2).

Balancing Measures

During the QI initiative, 17 out of 363 (4.7%) patients who discontinued antibiotics returned to the ED with persistent symptoms. A total of 6 patients returned with continued abdominal pain, 6 with

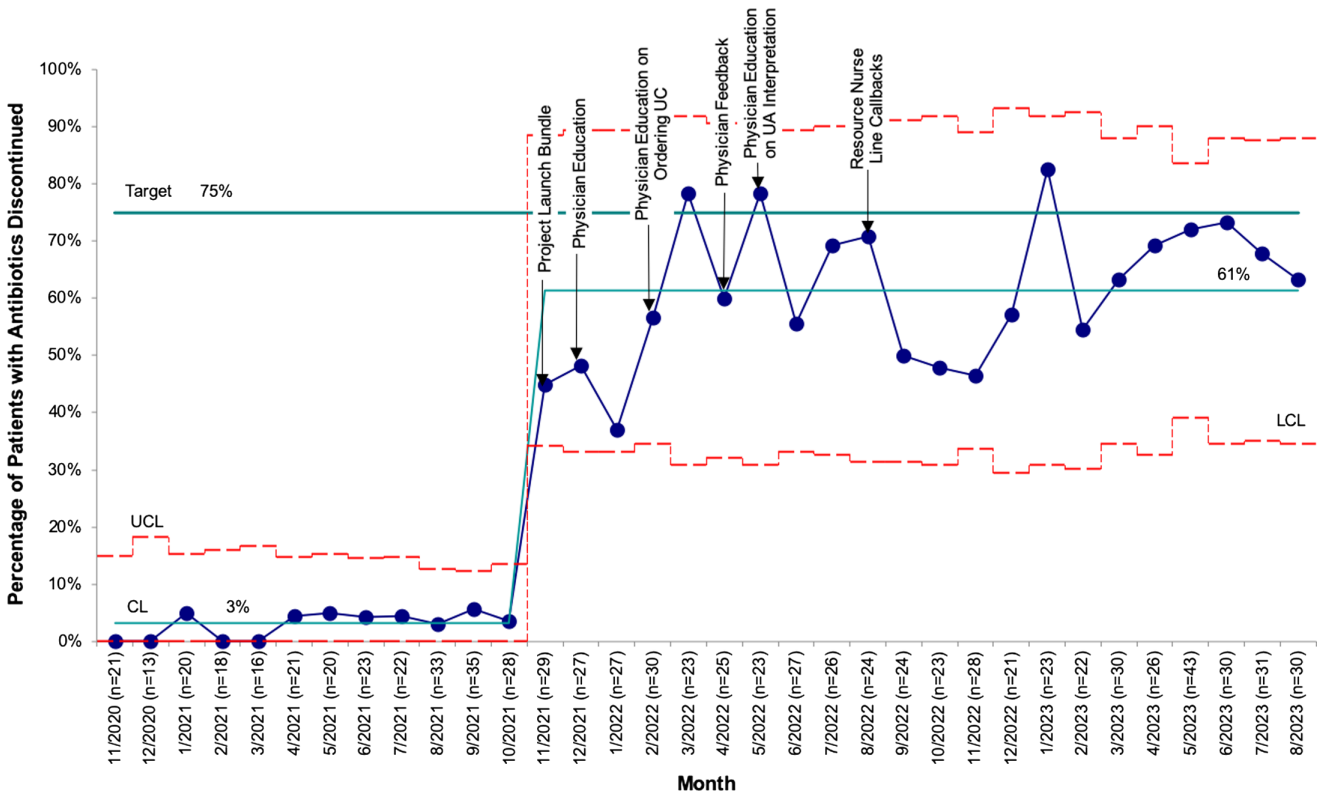

FIGURE 2. P-chart displaying the percentage of patients with contaminant UCs who had antibiotics discontinued per month. The project launch bundle included physician education on the initiative, publication of tip sheets and UTI discharge instructions, and weekly reminder emails.

Abbreviations: CL, centerline; LCL, lower control limit; UA, urinalysis; UC, urine culture; UCL; upper control limit; UTI, urinary tract infection.

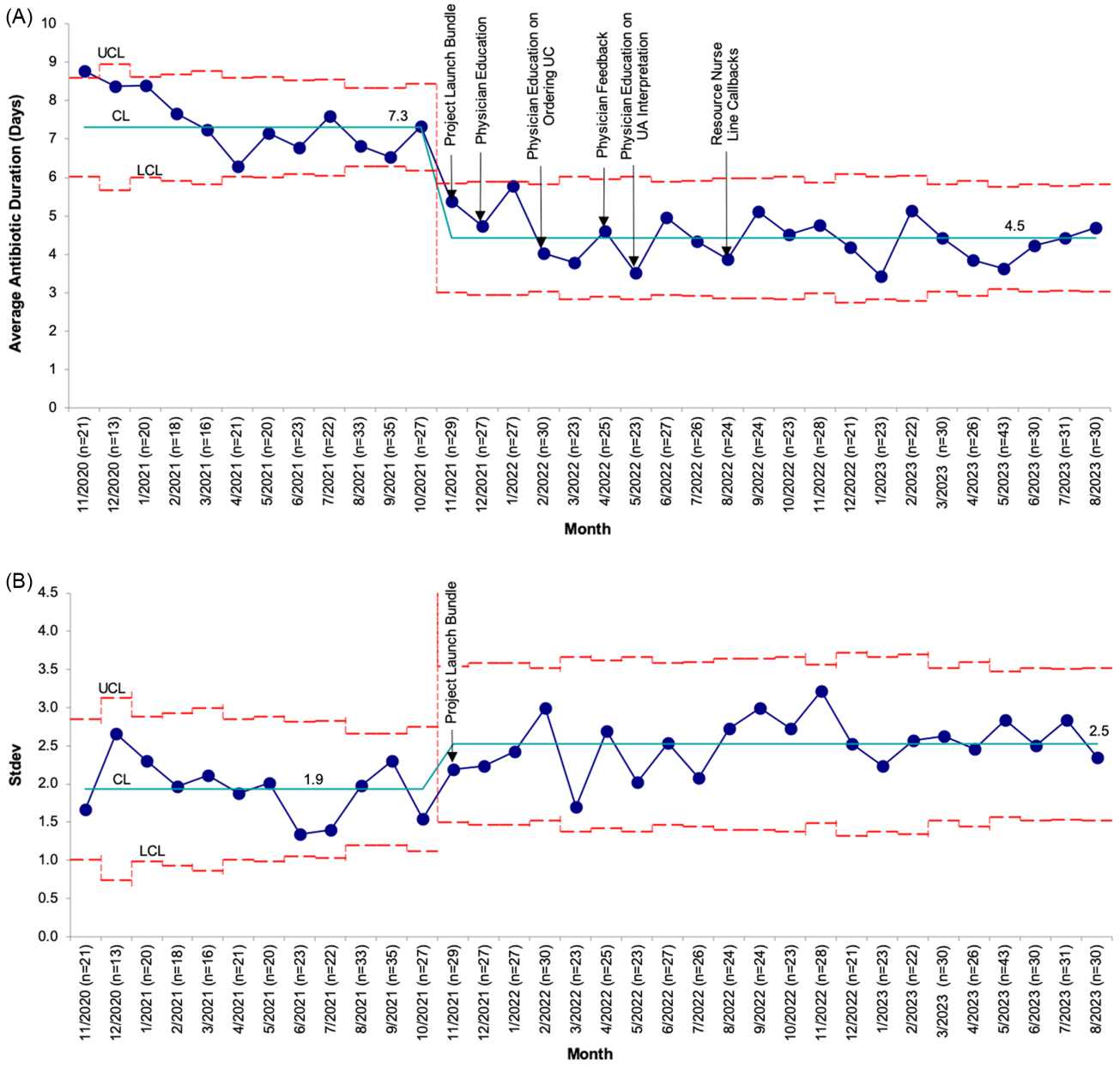

FIGURE 3. (A) Xbar and (B) S chart displaying the average antibiotic duration for patients with contaminant UCs per month. Abbreviations: CL, centerline; LCL, lower control limit; Stdev, standard deviation; UA, urinalysis; UC, urine culture; UCL; upper control limit.

fever, 2 with vomiting, 2 with dysuria, and 1 with flank pain. Most patients (13 out of 17, 76.5%) who returned to the ED were diagnosed with other conditions, including constipation, viral illnesses, vulvovaginitis, bowel obstruction, and Kawasaki disease. Of these returning patients, 4 (4 out of 17, 23.5%) were again discharged with a diagnosis of UTI, 2 of whom had UCs representing true pathogens during their return visits. The average number of phone calls per day that PEM physicians and resource line nurses made regarding contaminant UC results increased from 0 to 1 call per day (Supplemental Figure 3). There was an expected increase in SD as physicians and nurses started calling families. This increase in the number of phone calls per day corresponded to the first project announcement in November 2021.

DISCUSSION

Despite not achieving our aim of discontinuing antibiotics for 75% of patients with contaminant UCs, we increased our antibiotic discontinuation rate from 3% to 61%. We saw immediate improvement with physician education and weekly reminder emails at the start of our QI initiative. Although our educational interventions were successful,

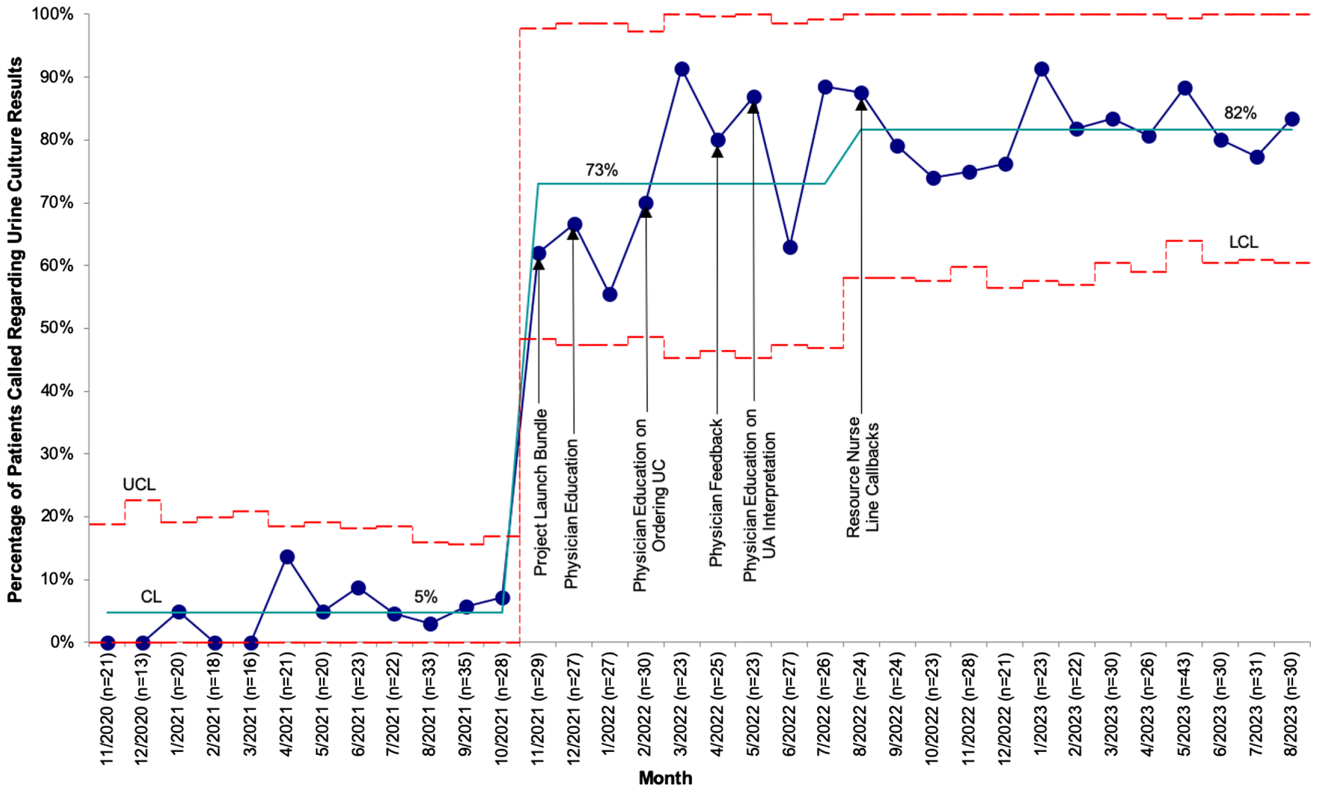

FIGURE 4. P-chart displaying the percentage of patients with contaminant UCs called regarding these results per month. Abbreviations: CL, centerline; LCL, lower control limit; UA, urinalysis; UC, urine culture; UCL; upper control limit.

multiple studies have described that education, although necessary, is usually ineffective in producing sustained improvement.[17] Having leadership support is an essential component for success in QI.[18] We hypothesize that presenting this project as one promoted by both division and hospital leadership contributed to the positive effect seen with education.

Physician-specific feedback did not lead to additional improvement in our antibiotic discontinuation rate. A commonly used QI strategy, audit and feedback is most effective when it includes action plans and clear targets for change, is provided by a supervisor or colleague, and is given more than once.[19,20] We strived to optimize this intervention by having a physician colleague deliver weekly email feedback, including information on physician and goal antibiotic discontinuation rates. We had already sent ED physicians weekly reminder emails for several months prior to providing individual feedback. Email fatigue, in addition to high pediatric ED volumes, may have diminished the expected effect of physician-specific feedback.

Although we attribute our initial improvement to formalizing an antibiotic discontinuation process, we believe we created sustainable change by partnering with the Resource Nurse Line. The process of forwarding results and delegating phone calls to resource line nurses enabled physicians to address contaminant UCs efficiently rather than not acknowledging these results owing to lack of time. The increased percentage of families called with the collaboration with the Resource Nurse Line supports this hypothesis. Although this increase in phone calls did not result in a similar increase in our antibiotic discontinuation rate, this intervention was still helpful in making families aware of their children's results and allowing them to make an informed decision regarding their children's care. This intervention was also positively received by the ED physician team, who found the additional support helpful in efficiently addressing outstanding test results.

This study demonstrates that unnecessary antibiotics can be successfully discontinued in a pediatric ED setting. These results are similar to, but more modest than, prior studies by Saha et al and Ostrow et al on discontinuing antibiotics from Urgent Care and ED settings, respectively.[21,22] Although not a major intervention in these prior studies, both included a process change of creating a dedicated nursing position to review outstanding test results, with significant changes in antibiotic discontinuation and family callbacks seen after implementation of this role. We did not have a similar dedicated nursing role, instead initially relying on our physician group to contact families as part of their assigned rotating result review responsibilities. We demonstrated improvement at the start of our project, suggesting that an antibiotic discontinuation procedure can be successfully implemented in other institutions lacking the resources for a dedicated nursing role. However, our partnership with the

Resource Nurse Line led to an increase in the percentage of patients called and was invaluable in ensuring the sustainability of our initiative. Although physicians expressed concerns that calling patients with contaminant UCs would be time-consuming, our observation that this initiative resulted in 1 additional phone call per day suggests that this did not impose an excessive burden on ED physicians and resource line nurses. Our study also demonstrates that discontinuing antibiotics is a safe practice, with a low rate of return ED visits among patients who had antibiotics discontinued.

At 25%, our proportion of contaminant UCs was higher than that described in previous studies by Alghounaim et al and Watson et al, who reported that 4.4% and 7% of UC grew mixed flora, respectively.[7,8] However, Neto et al reported a higher contamination rate of 26.7%.[14] A 2008 study of 127 laboratories in the United States and Canada found that, although the median urine contamination rate was 15%, contamination rates in certain laboratories were as high as 75%, with postcollection processing, specifically specimen refrigeration, having a significant effect on contamination rates.[23] The majority of our contaminant UCs were from voided specimens. One reason for our high contamination rate may be that these urine samples often remain at room temperature, at the bedside, for long periods of time before they are sent to the laboratory for culture.

There were several limitations to our study. First, although physicians and resource line nurses documented when caregivers agreed to discontinue antibiotics, we cannot be certain that they did so as instructed. Therefore, we may have overestimated the effect of our interventions. Second, we used a narrow definition of contaminant UCs, including only mixed flora and not cultures with low growth of a single organism. We used this definition because ED physicians might be hesitant, for example, to discontinue antibiotics for a patient with urinary symptoms and a clean-catch urine specimen showing growth of 75 000 CFU/mL of a single uropathogen. However, patients with UCs demonstrating low bacterial growth may similarly not have had true UTIs. Our definition captured the majority of patients, as the percentage of patients with low growth was small, at 12.7%. Furthermore, UCs with no growth were not included, as these results are not routed to the pool of outstanding ED test results. This group comprised 17.9% of patients without culture-confirmed UTIs. There were also patients diagnosed with UTIs who did not have a UC sent, preventing us from confirming the accuracy of this diagnosis. Third, we only captured return visits to our institution and institutions enrolled in Care Everywhere, a system in which we can view outside records in the EMR. However, as the only freestanding pediatric ED in the county, these patients most likely would have returned to our care.

CONCLUSIONS

Using QI methodology, we increased our antibiotic discontinuation rate for patients with contaminant UCs from 3% to 61% and sustained this change for 12 months. Our next improvement steps will focus on improving our urine collection and processing procedures to decrease the number of contaminant UCs.

ABBREVIATIONS

AAP: American Academy of Pediatrics
CFU: colony-forming units
CL: centerline
EMR: electronic medical record
ED: emergency department
PEM: pediatric emergency medicine
QI: quality improvement
UA: urinalysis
UC: urine culture
UTI: urinary tract infection

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