Clinical Infectious Diseases

MAJOR ARTICLE

A Statewide Antibiotic Stewardship Collaborative to Improve the Diagnosis and Treatment of Urinary Tract and Skin and Soft Tissue Infections

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Background. Colorado hospitals participated in a statewide collaborative to improve the management of inpatient urinary tract infections (UTIs) and skin and soft tissue infections (SSTIs). We evaluated the effects of the intervention on diagnostic accuracy and antibiotic use.

Methods. The main collaborative outcomes were proportion of UTI diagnoses that met criteria for symptomatic UTI; exposure to fluoroquinolones (UTI only); duration of therapy (UTIs and SSTIs); and exposure to antibiotics with broad gram-negative activity (SSTIs only). Outcomes were compared between pre-intervention and intervention periods overall and by hospital. Secondary analyses were changes in outcome trends by time series analysis.

Results. Twenty-six hospitals, including 9 critical access hospitals, participated in the collaborative. Data were reported for 4060 UTIs and 1759 SSTIs. Between the pre-intervention and intervention periods, the proportion of diagnosed UTIs that met criteria for symptomatic UTI was similar (51% vs 54%, respectively; $P = .10$), exposure to fluoroquinolones declined (49% vs 41%; $P < .001$), and the median duration of therapy was unchanged (7 vs 7 days; $P = .99$). Among SSTIs, exposure to antibiotics with broad gram-negative activity declined (61% vs 53%; $P = .001$) and the median duration of therapy declined (11 vs 10 days; $P = .03$). There was substantial variation in performance among hospitals. By time series analysis, only the declining trend of fluoroquinolone use was significant ($P = .03$).

Conclusions. The collaborative model is a feasible approach to engage hospitals in a common antibiotic stewardship intervention. Performance improvement was observed for several outcomes but varied substantially by hospital.

Keywords. antibiotic stewardship; collaborative methodology; quality improvement; urinary tract infection; skin and soft tissue infection.

Antibiotic stewardship is a cornerstone of the US strategy to combat the crisis of antibiotic-resistant bacteria [1]. For the last decade, the Infectious Diseases Society of America (IDSA), Society for Hospital Epidemiology of America, and Centers for Disease Control and Prevention (CDC) have advocated for antibiotic stewardship programs in all hospitals in order to reduce antibiotic overuse [2–4]. Despite this, overall antibiotic use in US hospitals has not changed in recent years; in fact, use of certain broad-spectrum antibiotics has increased [5]. This suggests that in order to achieve a national reduction in antibiotic use, a larger proportion of hospitals will need to successfully engage in antibiotic stewardship activities.

As of 1 January 2017, the Joint Commission has required that all accredited hospitals have an evidence-based antibiotic stewardship program [6]. A large number of hospitals will therefore be engaging in antibiotic stewardship in the coming years. However, many of these hospitals, particularly rural and critical access hospitals, may not have the necessary expertise or resources to develop such programs [7]. Thus, it is essential to develop approaches to facilitate antibiotic stewardship activities across a spectrum of hospitals with varying resources. This will allow more hospitals to not only meet regulatory mandates but to improve patient safety and address the global threat of antibiotic resistance.

The collaborative model has been successfully used to reduce catheter-related bloodstream and urinary tract infections [8, 9]. In 2015, the Colorado Hospital Association (CHA) established a collaborative to support hospitals in working together on antibiotic stewardship. The initial focus was the implementation of syndrome-specific interventions to improve the management of inpatient urinary tract infections (UTIs) and skin and soft tissue infections (SSTIs). Our objective in this study was to evaluate the effects of the collaborative on prespecified performance metrics.

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Table 1. Characteristics of Hospitals Participating in the Collaborative

Characteristic	Urinary Tract Infection Intervention, n (%) N = 26	Skin and Soft Tissue Infection Intervention, n (%) N = 17
Size		
>100 beds	11 (42)	7 (41)
25–100 beds	6 (23)	4 (24)
<25 beds (critical access hospital)	9 (35)	6 (35)
Teaching status		
Major teaching[a]	2 (8)	0
Minor teaching[b]	8 (31)	4 (24)
Nonteaching	16 (62)	13 (76)
Region		
Front range	10 (38)	6 (35)
Western slope	4 (15)	3 (9)
Southern	7 (26)	4 (24)
Mountain resort	5 (19)	4 (24)
Antibiotic stewardship experience prior to collaborative		
Established ASP	11 (42)	7 (41)
Considering an ASP or ASP in development	15 (58)	10 (59)

Abbreviation: ASP, antibiotic stewardship program.

[a]Member of the Council of Teaching Hospitals of the Association of American Medical Colleges.

[b]Medical school affiliation reported to the American Medical Association or a participating site for an accredited Graduate Medical Education program.

METHODS

Collaborative Structure

CHA is the statewide association that represents more than 100 hospitals and health systems throughout Colorado. Through CHA, Colorado hospitals are committed to improving health and healthcare in the state. Physician consultants assisted CHA in the development of syndrome-specific interventions for UTIs and SSTIs. A steering committee that consisted of a diverse group of stakeholders was organized to develop performance measures, perform quarterly progress reviews, and provide overall guidance during the collaborative. All Colorado hospitals were invited to participate. A signed letter of commitment from hospital leadership expressing support for participation was required. A team lead at each hospital was identified and asked to organize a multidisciplinary team to carry out the intervention; it was recommended that the team lead be either an infectious diseases (ID) physician or pharmacist, when possible.

The primary intervention was implementation of evidence-based guidelines for the diagnosis and treatment of UTIs and SSTIs among adult inpatients (Supplementary Figures 1–4). Hospitals could choose to participate in the intervention for 1 or both infections. For UTIs, the overarching goals were to promote shorter courses of fluoroquinolone-sparing antibiotics and to prevent treatment of asymptomatic bacteriuria. For SSTIs, the goal was to promote shorter courses of antibiotics that target gram-positive pathogens. The guidelines were developed to be generalizable across hospitals; however, teams were encouraged to adapt the guidance as appropriate to their own hospital formulary and resistance patterns. Teams were also encouraged to actively promote uptake of the guidance using strategies feasible and appropriate for their hospital, for example, through education of relevant clinician groups, prospective audit and feedback, or incorporation of recommendations into order sets.

The duration of the intervention period was 18 months. No financial resources were provided to participating hospitals; however, CHA provided a number of services to support teams

Table 2. Demographics and Clinical Characteristics of Patients With Urinary Tract Infection

Characteristic	Baseline, n (%) N = 1530	Intervention, n (%) N = 2530
Age, median (interquartile range)	76 (62–85)	74 (60–84)
Female	1078 (70)	1759 (70)
Type of infection		
Uncomplicated cystitis	83 (5)	184 (7)
Complicated cystitis[a]	1327 (87)	2057 (81)
Catheter-associated UTI	44 (3)	62 (3)
Pyelonephritis	76 (5)	227 (9)
Indwelling catheter	321 (21)	374 (15)
Genitourinary tract abnormality	152 (10)	269 (11)
Prior or recurrent UTI	426 (28)	786 (31)
Dementia	275 (18)	427 (17)
Immunosuppression	105 (7)	141 (6)
History of infection with multidrug-resistant organism[b]	97 (6)	150 (6)
Human immunodeficiency virus infection	12 (1)	4 (0.2)
Long-term care facility resident	253 (17)	386 (15)
Level of care at time UTI diagnosed		
Medical/surgical ward	1310 (86)	2239 (89)
Intensive care unit	219 (14)	289 (12)
Primary service at time UTI diagnosed		
Medicine services/Hospitalist	1369 (89)	2232 (88)
Surgery	72 (5)	110 (4)
Other	89 (6)	188 (7)
Signs or symptoms of UTI		
Fever (≥38.0°C)	413 (27)	892 (36)
Urgency	96 (6)	215 (9)
Frequency	160 (10)	383 (15)
Dysuria	243 (16)	501 (20)
Suprapubic tenderness	118 (8)	263 (10)
Costovertebral angle pain or tenderness	101 (7)	333 (13)
At least 1 sign/symptom	474 (31)	988 (39)
Delirium or other alteration in mental status	455 (30)	800 (32)
Leukocytosis (white blood cells >12 000 cells/mm^3)	863 (57)	1458 (58)
Severe sepsis or septic shock	123 (8)	197 (8)

Abbreviation: UTI, urinary tract infection.

[a]Includes *International Classification of Diseases, 10th Revision, Clinical Modification* codes for unspecified cystitis, urosepsis, and urinary source bacteremia.

[b]Includes extended-spectrum beta-lactamase–producing gram-negative organisms, carbapenem-resistant Enterobacteriaceae, vancomycin-resistant enterococcus, or methicillin-resistant *Staphylococcus aureus*.

throughout the intervention period. This included quarterly performance reports, monthly webinars with pertinent antibiotic stewardship educational content, twice-monthly coaching newsletters, optional site visits, access to local and national antibiotic stewardship experts, and 3 in-person educational meetings.

Study Design

To evaluate the effects of the collaborative intervention, we performed a retrospective quasi-experimental study of patients treated for a UTI or SSTI at participating hospitals. The baseline period prior to the collaborative was 1 January 2014–31 December 2014; the collaborative intervention period was 1 July 2015–31 December 2016.

Study Setting and Population

Twenty-six hospitals participated in the collaborative; all 26 participated in the UTI intervention and 17 also participated in the SSTI intervention. Hospital characteristics are shown in Table 1. They ranged in size from 15 to 567 licensed beds and included both teaching and nonteaching facilities; 9 (35%) were critical access hospitals (<25 beds). The composition of hospital teams is shown in Supplementary Table 1; half of teams included an ID physician or pharmacist.

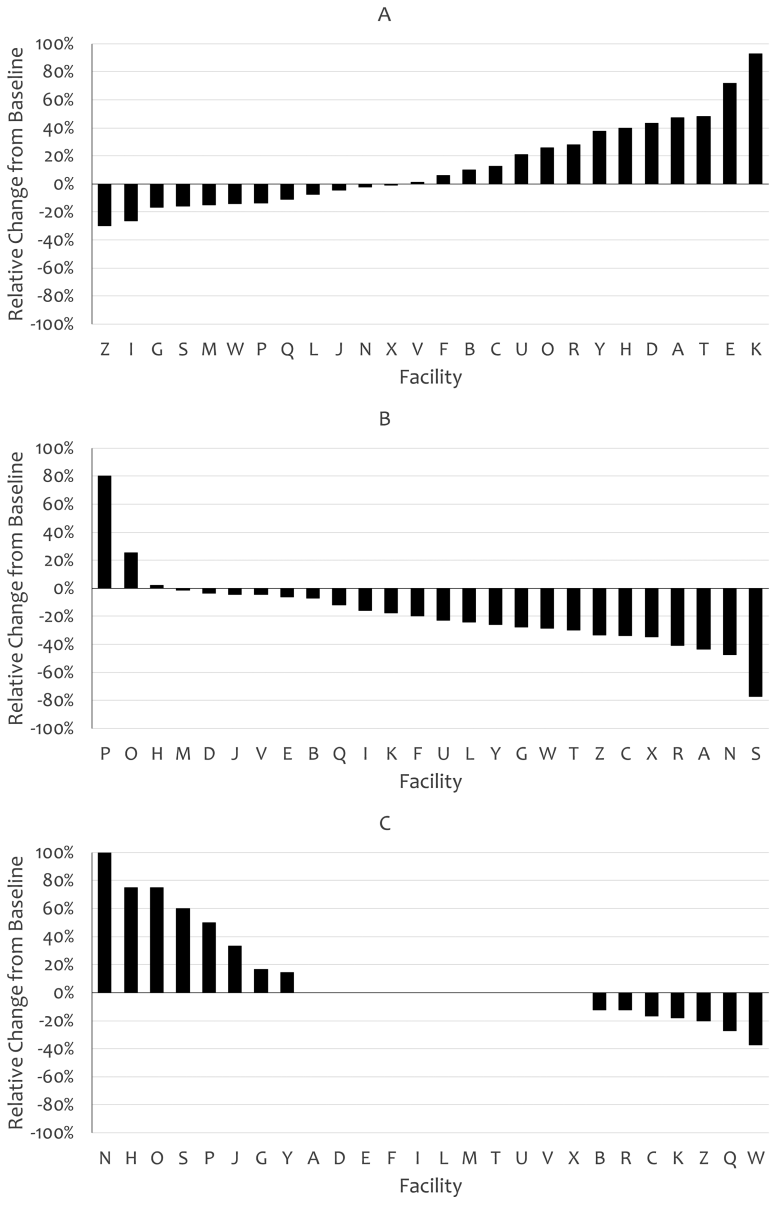

Figure 1. Relative percent change in urinary tract infection (UTI) main outcomes by hospital. *A*, Proportion of diagnosed UTIs meeting Infectious Diseases Society of America criteria for symptomatic UTI (positive change desired). *B*, Exposure to a fluoroquinolone (negative change desired). *C*, Median total duration of therapy (negative change desired).

Data Collection

At each hospital, cases of UTI and/or SSTI in patients aged ≥18 years were identified using *International Classification of Diseases, 10th Revision, Clinical Modification* (ICD-10-CM) codes (ICD-9-CM codes prior to October 2015). Using a structured data collection instrument and standardized definitions of variables, teams were asked to review the medical records of a random sample of cases for clinical information, antibiotic treatment, and outcomes. All data were entered into a central REDCap database [10]. Teams were asked to review 80 cases during the 12-month baseline period and 20 cases during each of the 6 quarters of the intervention. After each intervention quarter, performance reports were provided to teams with data on prespecified outcomes with benchmarking to other collaborative hospitals.

Case Classification

Based on documentation in the medical record, reviewers classified UTIs as simple cystitis, complicated cystitis, catheter-associated UTI, or pyelonephritis. Cases with complicating factors such as percutaneous nephrostomy tubes, renal transplant, urologic or gynecologic surgery, or pregnancy were excluded from further review and analysis. SSTIs were classified as cellulitis with or without purulence, wound infection, or abscess. Cases involving necrotizing or deep tissue infection, infected ulcers or bites, or perineal, odontogenic, or periorbital infections were excluded.

Collaborative Outcomes

For the UTI intervention, the following outcomes and performance targets were established by the steering committee prior to the start of the intervention: 15% increase in the proportion of diagnosed UTIs that met IDSA criteria for symptomatic UTI [11]; 30% decrease in the proportion of patients treated with a fluoroquinolone; and 20% decrease in duration of therapy. For the SSTI intervention, the outcomes and performance targets were 30% decrease in the proportion of patients exposed to antibiotics with a broad spectrum of gram-negative activity, defined as β-lactam/β-lactamase inhibitor combinations, carbapenems, second- through fifth-generation cephalosporins, monobactams, fluoroquinolones, aminoglycosides, tigecycline, and colistin; and 20% decrease in duration of therapy. Prespecified secondary outcomes were rehospitalization within 30 days of discharge and *Clostridium difficile* infection.

Statistical Analyses

We evaluated changes in the main outcomes between the baseline and intervention periods for all hospitals combined and

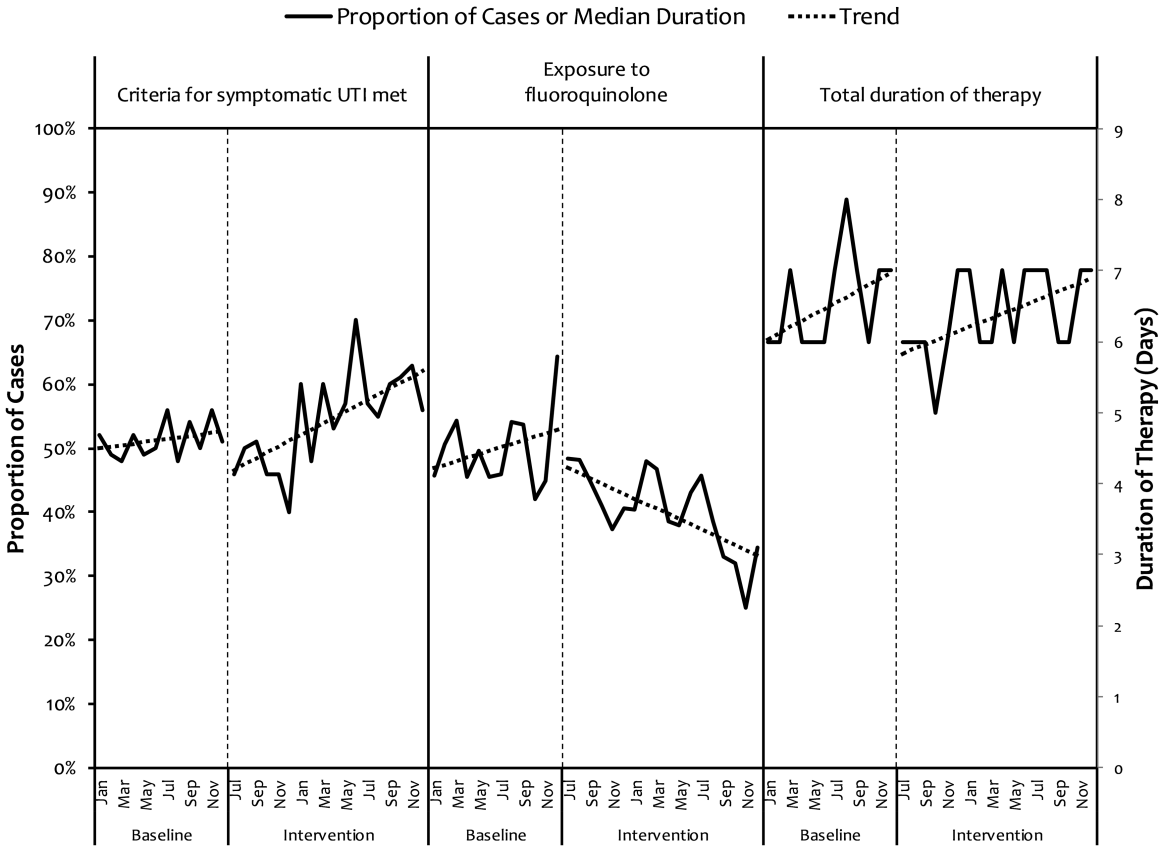

Figure 2. Interrupted time series analysis of main outcomes for urinary tract infection. Abbreviation: UTI, urinary tract infection.

for individual hospitals. As a secondary analysis, we used interrupted time series analysis to evaluate changes in trends in the main outcomes from the baseline to the intervention periods for all hospitals. We used SAS version 9.3 (SAS Institute, Cary, North Carolina) for data analysis. The Colorado Multiple Institutional Review Board approved this study.

RESULTS

Urinary Tract Infections

A total of 4060 UTI cases were submitted: 1530 from the baseline period and 2530 from the intervention period. Overall, the majority of cases were classified as complicated cystitis (3384, 83%). Types of UTIs and patient demographic and clinical characteristics were similar between the periods (Table 2). The majority of patients were managed by a hospitalist or medicine services (3601, 89%). The proportion of cases with a positive urine culture and the types of microorganisms identified were also similar between periods (Supplementary Table 2). *Escherichia coli* was the most commonly identified pathogen.

The main outcomes in relation to the performance targets are shown in Table 3. The proportion of diagnosed UTIs that met IDSA criteria for a symptomatic UTI was not significantly different between the baseline (786, 51%) and intervention periods (1367, 54%; $P = .10$). Exposure to a fluoroquinolone declined from 745 (49%) cases during the baseline period to 1030 (41%) cases during the intervention ($P < .001$). In the inpatient setting, fluoroquinolone use was largely replaced by parenteral cephalosporins (Supplementary Table 3). The median duration of therapy was 7 days in both periods ($P = .99$). For each outcome, there was marked variation in performance among the individual hospitals (Figure 1). By interrupted time series analysis, there was a significant decrease in the trend of fluoroquinolone use between the baseline and intervention periods ($P = .03$; Figure 2). The changes in trends for the proportion of cases meeting IDSA criteria for symptomatic UTI and duration of therapy were not statistically significant.

Skin and Soft Tissue Infections

A total of 1759 SSTI cases were submitted: 722 from the baseline period and 1037 from the intervention period. Overall, the majority were classified as nonpurulent cellulitis (1255, 71%). Types of skin infections and patient demographic and clinical characteristics were similar between periods (Table 4). The majority of patients were managed by a hospitalist or medicine services (1552, 88%). The proportion of cases in which a microorganism was identified by culture and the types of microorganisms were also similar between the 2 periods (Supplementary Table 2). *Staphylococcus aureus* was the most commonly identified pathogen.

The main outcomes in relation to performance targets are shown in Table 3. Overall exposure to an antibiotic with a broad spectrum of gram-negative activity declined from 440 (61%) cases during the baseline period to 551 (53%) cases during the intervention ($P = .001$). Use of cefazolin increased during the intervention (14% vs 22%, $P < .001$), while use of combination therapy at hospital discharged declined (20% vs 14%, $P = .002$; Supplementary Table 3). The total duration of therapy declined from a median of 11 days (interquartile range [IQR], 8–13) to 10 days (IQR, 8–13; $P = .03$). Individual hospital performance for the 2 main outcomes varied markedly (Figure 3). By interrupted time series analysis, the changes in trends between the baseline and intervention periods for the 2 main outcomes were not statistically significant (Figure 4).

Table 3. Main Outcomes in Relation to Performance Targets

Outcome		Baseline	Intervention		
Urinary tract infections	Target Percent Change	N = 1530	N = 2530	Actual Percent Change	*P* Value
Main					
Proportion of diagnosed UTIs meeting criteria for symptomatic UTI	15	786 (51)	1367 (54)	6	.10
Treated with fluoroquinolone	–30	745 (49)	1030 (41)	–16	<.001
Total duration of therapy, median (IQR)	–20	7 (3–10)	7 (4–10)	0	.99
Secondary					
Rehospitalization within 30 days	…	198 (13)	237 (9)	…	.92
Rehospitalization due to UTI	…	53 (3)	89 (4)	…	.24
Clostridium difficile infection	…	33 (2)	56 (2)	…	.91
Skin and soft tissue infections		**N = 722**	**N = 1030**		
Main					
Treated with antibiotic with broad gram-negative activity	–30	440 (61)	551 (53)	–13	.001
Total duration of therapy, median (IQR)	–20	11 (8–13)	10 (8–13)	–9	.03
Secondary					
Rehospitalization within 30 days	…	75 (10)	87 (8)	…	.15
Rehospitalization due to skin infection	…	33 (5)	47 (5)	…	.97
C. difficile infection	…	4 (1)	7 (1)	…	1.00

Abbreviations: IQR, interquartile range; UTI, urinary tract infection.

Table 4. Demographics and Clinical Characteristics of Patients With Skin and Soft Tissue Infection

Characteristic	Baseline, n (%) N = 722	Intervention, n (%) N = 1037
Age, median (interquartile range)	60 (45–75)	60 (45–74)
Male	393 (54)	568 (55)
Type of infection		
Nonpurulent cellulitis	530 (73)	725 (70)
Purulent cellulitis	123 (17)	178 (17)
Cutaneous abscess	58 (8)	100 (10)
Wound infection	11 (2)	34 (3)
Injection drug use	54 (7)	100 (10)
Diabetes mellitus	216 (30)	313 (30)
Human immunodeficiency virus infection	3 (0.4)	8 (1)
History of skin infection	218 (30)	335 (32)
History of methicillin-resistant *Staphylococcus aureus* infection or colonization	63 (9)	98 (9)
Immunosuppression	78 (11)	96 (9)
Anatomical location		
Lower extremity	462 (64)	632 (61)
Upper extremity	158 (22)	236 (23)
Trunk	51 (7)	69 (7)
Head or neck	53 (7)	68 (7)
Buttock	14 (2)	25 (2)
Inguinal/groin	11 (2)	35 (3)
Site of initial hospital care		
Medical/surgical ward	681 (94)	1001 (97)
Intensive care unit	41 (6)	36 (3)
Admitting service		
Medicine services/Hospitalist	652 (90)	900 (87)
Surgery	46 (6)	67 (6)
Other	24 (3)	70 (7)
Fever (≥38.0°C)	152 (21)	203 (20)
Leukocytosis (white blood cells > 12 000 cells/mm^3)	409 (57)	509 (51)
Severe sepsis or septic shock	25 (3)	14 (1)

For both UTI and SSTI, there were no significant differences between periods in secondary outcomes including the proportion of patients rehospitalized within 30 days for any reason, the proportion rehospitalized within 30 days for the same infection, and the proportion who developed *C. difficile* infection (Table 3).

In post hoc analyses, among the 9 critical access hospitals, the relative percent improvement in each of the main outcomes for both UTI and SSTI was larger than that of the noncritical access hospitals (Supplementary Table 4). For hospitals with an ID physician or pharmacist as part of the team, performance as compared with hospitals without an ID expert on the team varied by outcome.

DISCUSSION

This statewide collaborative led to the engagement of a diverse group of 26 hospitals to implement interventions to improve the diagnosis and treatment of UTIs and SSTIs. Although the changes in prescribing for the overall collaborative did not reach prespecified performance targets, clinically relevant improvements for several outcomes were observed, and a number of individual hospitals achieved large improvements.

Our experience shows that the collaborative approach is one potential model to engage and support unaffiliated hospitals with varying experience in antibiotic stewardship to work toward a common stewardship goal. Initially, we chose an intervention focused on syndrome-specific interventions for UTIs and SSTIs for the following reasons: these are 2 of the most common infections treated in hospitals [12]; antibiotic overuse for these infections is widespread and can be improved with interventions at the individual hospital level [13–16]; and broader interventions such as post-prescription review or prior authorization requirements require a larger dedication of resources and were already being performed at some hospitals. We demonstrated that the strategy of disseminating local, evidence-based guidelines; providing implementation coaching and support; and feeding back performance data to hospitals are feasible and potentially effective approaches to antibiotic stewardship on a broad scale.

The financial resources needed to carry out this collaborative were relatively modest in comparison to its scope; total costs of the collaborative work sponsored by CHA were estimated to be $150 000–$175 000 per year. Participating hospitals incurred costs for their staff time, including data collection. Although this study was not designed to compare outcomes among hospital subgroups, it is noteworthy that critical access hospitals appeared to perform better across all outcomes than larger hospitals and that the presence of an ID expert on hospital teams was not consistently associated with better performance. Given that rural and critical access hospitals may be resource constrained and often lack onsite ID expertise [17], this type of collaborative approach may represent a feasible model to provide such hospitals with resources to facilitate effective antibiotic stewardship. These results may have implications for ongoing efforts to scale up antibiotic stewardship in the United States.

As advocated in national guidelines for the treatment of UTIs [11], the intervention had a relatively large impact on reducing fluoroquinolone use. Much of the fluoroquinolone use was replaced by cephalosporins, which in Colorado hospitals tend to have more favorable susceptibility profiles for urinary pathogens. Although the optimal antibiotic selection for inpatient UTIs is not clearly established, these results demonstrate that the collaborative approach can lead to a statewide change in antibiotic selection in a relatively short period of time. This may have implications for other antibiotic classes in which reductions in use are desired. Our results also highlight the ongoing challenge of appropriate diagnosis of UTI and the need for novel interventions to reduce unnecessary treatment of asymptomatic bacteriuria.

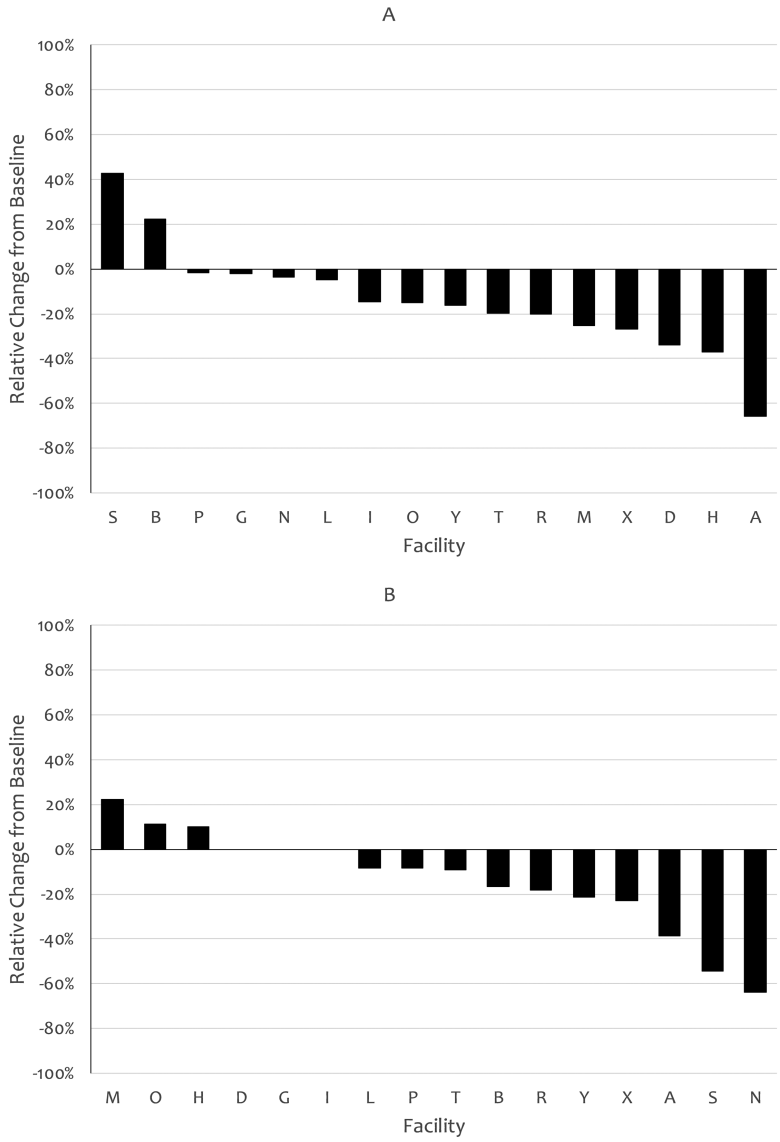

Figure 3. Relative percent change in skin and soft tissue infection main outcomes by hospital. *A,* Exposure to an antibiotic with a broad spectrum of gram-negative activity (negative change desired). *B,* Median total duration of therapy (negative change desired). One of the 17 hospitals did not submit baseline data and thus the percent change could not be calculated.

For most SSTIs, empiric treatment with antibiotics with a broad spectrum of gram-negative activity is not recommended [18]. Although the intervention was associated with a modest overall decline in the use of these agents (13% relative reduction), 7 of the 17 hospitals achieved relative reductions ranging from 20% to 66%. The intervention was also associated with a small but statistically significant decrease in the median duration of therapy (9% relative reduction), while 7 hospitals achieved reductions ranging from 17% to 64%. These findings are consistent with single-center interventions that have improved antibiotic selection and shortened treatment durations for inpatient skin infections [13, 19]. We noted that toward the end of the intervention period, the use of antibiotics with broad gram-negative activity appeared to increase. Without a longer intervention period, it is unclear if this was due to random variation or a true increasing trend; nevertheless, this raises a potential concern about the sustainability of this change in prescribing. Finally, since the vast majority of both UTIs and SSTIs were managed by a hospitalist of medicine services, our data underscore the importance of involving champions from these groups to successfully develop and implement interventions.

The marked variation in the success among hospitals in achieving the intended changes in prescribing (Figures 1 and 3) warrants further discussion. It is important to note that participation in the collaborative was voluntary, activities of hospital teams were not monitored, and no financial resources were provided to individual hospitals. As such, antibiotic stewardship experience, level of engagement, and strength of implementation

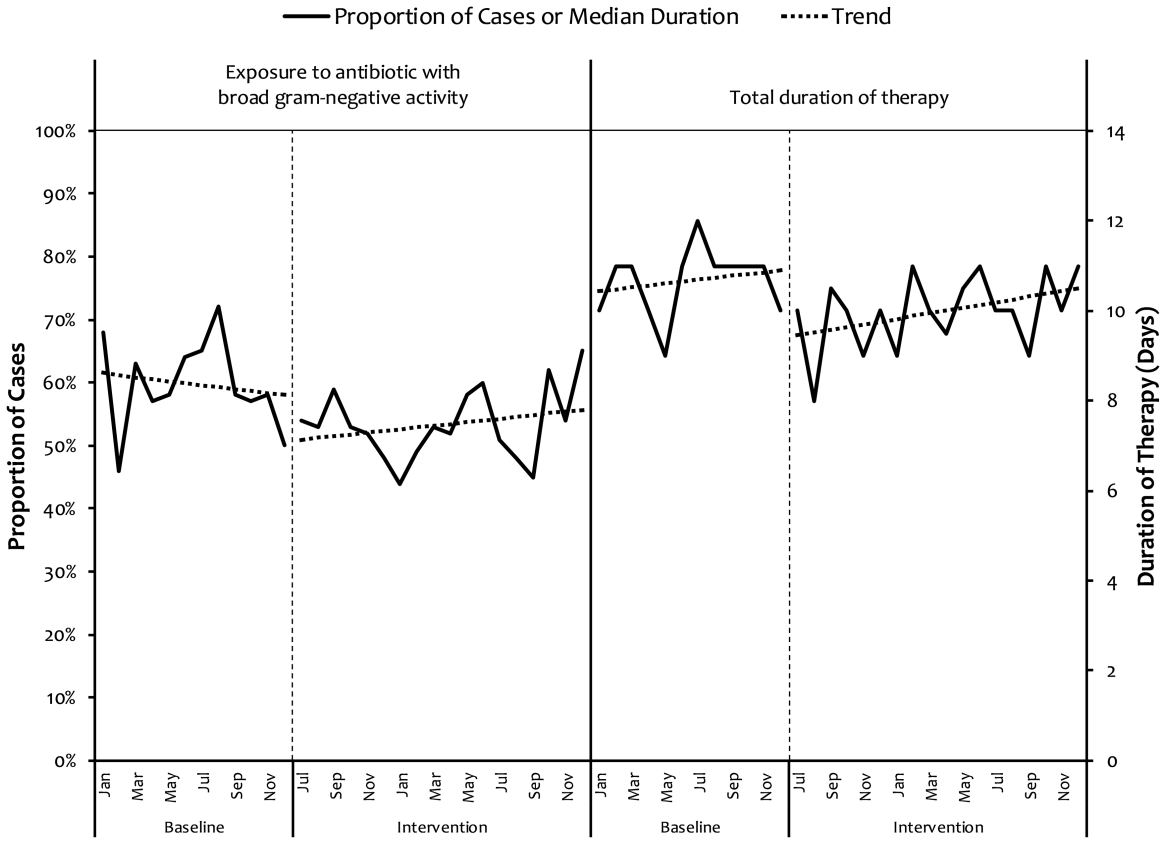

Figure 4. Interrupted time series analysis of main outcomes for skin and soft tissue infections.

of the intervention among the hospital teams varied widely, which may have influenced the success of the intervention at the hospital level. It is notable that a number of hospitals showed dramatic improvements in the intended prescribing behaviors; however, lack of success at some hospitals diluted the apparent overall effectiveness of the intervention. The challenges and barriers to success were likely multifactorial. As examples, 1 hospital noted loss of the physician champion, pharmacist, and nurse leader during the intervention, while another cited resistance from a local pharmacist. In general, our experience highlights that in the collaborative model, it is important to identify and address barriers at the individual hospital level and to incorporate deliverables and milestones to ensure hospitals are accountable to actively participate and demonstrate progress. We also found that the logistical challenges of engaging and supporting rural and critical access hospitals require particular attention. Finally, the differences in outcomes among hospitals highlight the opportunity to learn from the most successful hospitals. As this collaborative predated antibiotic stewardship regulatory requirements, we suspect participation and engagement in an antibiotic stewardship collaborative would be even greater today.

As a large-scale quality improvement initiative, this analysis is subject to a number of limitations. First, given the preintervention post-intervention design, factors other than the intervention may have impacted prescribing practices over the study period. Second, an extensive evaluation of implementation processes was not undertaken; therefore, it is unclear what factors were most highly associated with success at the individual hospital level. Third, medical record abstractors at each site were not formally trained, so variation or inconsistency in data collection may have biased the results. In addition, 1 high-performing hospital was unable to provide data for the final 2 quarters of the intervention because of migration to a new medical record system. Fourth, the prespecified outcomes were only surrogates for improvements in antibiotic use since it was not feasible to assess the appropriateness of antibiotics prescribed in individual cases. Fifth, since UTIs are often secondary diagnoses, antibiotics may have also been prescribed for conditions other than UTIs, potentially biasing our results toward the null. Furthermore, the median duration of therapy for UTIs at baseline was already at the goal of 7 days; thus, there was little room for improvement in this outcome. Finally, in this analysis, we were unable to capture benefits of participating in the collaborative beyond changes in prescribing for UTIs or SSTIs. As an example, half of the hospitals reported developing additional syndrome-specific interventions, and more than half reported implementing at least 1 other type of intervention (eg, 48-hour antibiotic time-out) as a direct result of participating in this collaborative.

Despite the above limitations, this work has a number of strengths. To our knowledge, this is the first report of the application of collaborative methodology to antibiotic stewardship—incorporating measurable performance targets—in a large group of unaffiliated hospitals. Although the overall observed changes in prescribing were modest, it is notable that they were achieved with only modest financial resources and without funding for the participating hospitals. Furthermore, we were able to demonstrate that despite the observed changes in prescribing, hospital readmissions were not increased. Finally, this collaborative provides a platform that may be leveraged for future interventions to impact prescribing at the state level.

In conclusion, a statewide collaborative is a feasible approach to engage unaffiliated hospitals in addressing a common antibiotic stewardship target. Although the performance targets were only partially met, significant improvements in prescribing for several outcomes were achieved, and a number of hospitals had a high degree of success. Future work should include an evaluation of implementation and maintenance strategies associated with successful outcomes.

Supplementary Data

Supplementary materials are available at *Clinical Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Notes

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Potential conflicts of interest. T. C. J., B. C. K., and H. L. W. were consultants for CHA during the intervention. T. H. was an employee of CHA during the intervention, and H. L. W. was a contracted employee of CHA during the evaluation. All remaining authors: No reported conflicts. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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