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MAJOR ARTICLE

Point-of-Care Multiplex NAAT for Acute Pharyngitis in the Urgent Care: Detection Patterns, Associated Antimicrobial Prescribing, and Stakeholder Perceptions

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Background. Pharyngitis is a frequent cause of urgent care (UC) visits. The SPOTFIRE Sore Throat (SPOTFIRE ST) panel is a Clinical Laboratory Improvement Amendments–waived point-of-care test capable of detecting 14 common bacterial and viral pathogens from an oropharyngeal swab. We evaluated detection characteristics, antimicrobial prescribing, and clinician and patient perceptions associated with SPOTFIRE ST testing.

Methods. We conducted a prospective, single-center study at an academic UC clinic. Eligible participants included 1–2-year-olds with fever, 3–17-year-olds with acute pharyngitis, and adult patients with acute pharyngitis and either immunocompromising or comorbid conditions. Clinical variables were collected, and specimens were tested according to SPOTFIRE ST instructions. Clinicians completed a pre-implementation survey, and clinicians and patients completed a postimplementation survey to assess perceptions and satisfaction with the test.

Results. At least 1 detected pathogen occurred in 149/200 (74.5%) patients. Compared with adults, pediatric patients had higher detections (85% vs 60%; $P < .001$), statistically significantly higher detections of specifically Group A *Streptococcus*, influenza B, and *M. pneumoniae*, and higher detections of a pathogen with specific antimicrobial treatment (68% vs 28%; $P < .001$). Antibiotics were prescribed in only 7% of cases when a virus was detected. Stakeholders reported high satisfaction with SPOTFIRE ST testing and thought it useful in guiding clinical decisions.

Conclusions. SPOTFIRE ST testing demonstrated a high proportion of detections with distinct differences between pediatric and adult patients with acute pharyngitis. The detection characteristics and high satisfaction indicate that this test is likely to be valued by clinicians and patients and may improve clinical assessment and antimicrobial prescribing.

Clinical Trials Registration. ClinicalTrials.gov identifier. NCT06713642.

Keywords. pharyngitis; SPOTFIRE ST; stewardship; urgent care.

Acute pharyngitis is one of the most common reasons for urgent care (UC) visits in the United States. It is estimated to account for ~15 million visits annually or 2% of all ambulatory appointments [1–3]. While the majority of acute pharyngitis cases are caused by viral pathogens, an estimated 20%–30% are due to *Streptococcus pyogenes* (Group A *Streptococcus* [GAS]) in pediatric populations and 5%–10% in adults [4, 5]. Antibiotic therapy is often indicated for patients with GAS, making identification of the underlying pathogen essential for guiding appropriate antibiotic use [6]. However, clinical methods to reliably differentiate between bacterial and viral pharyngitis have yet to be established, which has led to variable clinical practices, including implementation of scoring systems (eg, Centor, McIsaac) and rapid antigen detection test (RADT) diagnostics [5, 7–9]. While both may be done at the point of care (POC), they have limited sensitivity, prompting the recommendation for a secondary throat culture in pediatric patients [5]. Nucleic acid amplification tests (NAATs) have higher sensitivity and specificity, obviating the need for subsequent testing, but are less available and less timely than RADTs in most urgent care centers [10]. Indeed, testing is frequently not performed in patients with acute pharyngitis, which leads to inappropriate antibiotic prescribing [5, 11, 12].

Diagnostic uncertainty and perceived risks of untreated GAS infection are clear limitations in the evaluation of acute

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pharyngitis in a UC setting. Clinical Laboratory Improvement Amendments (CLIA)–waived, rapid, multiplex NAATs aim to fill this gap. These tests can be performed at the POC, allowing use outside of a traditional clinical diagnostic laboratory.

The BIOFIRE SPOTFIRE Sore Throat (SPOTFIRE ST) panel is a multiplex, CLIA-waived, POC NAAT that can be rapidly administered in a UC setting using a standard oropharyngeal swab. It detects 14 of the most common bacterial and viral pathogens associated with acute pharyngitis (https://www.biomerieux.com/us/en/our-offer/clinical-products/biofire-spotfire-system.html). In this study, we implemented the SPOTFIRE ST test and assessed target patient populations, characterized detection patterns, evaluated associated antimicrobial prescribing behaviors, and examined stakeholder perceptions and satisfaction in the UC setting.

METHODS

Study Design and Setting

We conducted a prospective, single-center observational study from December 2, 2024, through March 30, 2025, at a Midwestern, urban, academic UC clinic that provides >30 000 patient visits annually. Three distinct phases of the study included a pre-implementation survey of clinicians, implementation of SPOTFIRE ST testing with data collection from patient participants, and a postimplementation survey of patients and clinicians. The study was approved by the institutional review board, and written informed consent was obtained from participants.

Participants

In the first phase of study, we elicited feedback from clinicians via a voluntary electronic survey. Participants included all UC clinicians employed by UW Health, as identified through the UW Health provider database. Each clinician was sent, by email, a secure URL link to a survey. They had 3 weeks to complete the survey, and a reminder email was sent at 1-week intervals. Response was voluntary. The survey contained questions related to their demographics, 2 Likert-scale questions to elicit experience and perceptions regarding diagnostic testing for pharyngitis, and 2 rank-order questions. The last 2 items asked participants to rank-order 7 target patient populations based on who they thought would most benefit from a rapid, POC, multiplex diagnostic NAAT for pharyngitis (ie, SPOTFIRE ST). This provided the basis for target patient populations to implement SPOTFIRE ST testing for the next phase. There was additionally a rank-order question to determine which clinical factors were most important in their decision-making process to test a patient for streptococcal pharyngitis.

In phase 2, SPOTFIRE ST testing was implemented in 4 target groups identified in phase 1: (1) ages 3–17, (2) ages 1–2 with fever and/or sore throat, (3) patients with chronic comorbidities, and (4) immunocompromised patients (primary/secondary immune-deficiency condition based on chart review of their problem list, systemic corticosteroids of ≥20 mg prednisone per day, cyclophosphamide, rituximab, azathioprine, methotrexate, calcineurin inhibitors, JAK inhibitors, TNF-α inhibitors, interleukin inhibitors, integrin inhibitors, organ or stem cell transplantation, solid tumor or hematological malignancy on active therapy). Eligible participants had ≤7 days of symptoms; toddlers did not require localized pharyngitis symptoms.

Patients were excluded from the study if they (1) had anatomic anomalies that would prohibit safely collecting a pharyngeal swab, (2) had symptom onset >7 days before UC arrival, (3) were already on an antiviral or antibiotic medication, and/or (4) previously participated in the study during their current illness, defined as previously tested with SPOTFIRE ST with a lack of complete resolution of symptoms. Potential participants were screened prospectively by study staff. Any patient belonging to 1 of the above groups with a presenting chief complaint of sore throat/pharyngitis was approached by a study team member who introduced the study, gave a description of the SPOTFIRE ST test and study procedures, and determined eligibility. Patients who expressed an interest in participation underwent written informed consent to perform an oropharyngeal swab and SPOTFIRE ST testing according to standard procedures. Patients were compensated $25 for their participation in this phase.

In the final phase of the study, both patient participants (or their legal guardians) and clinicians were sent surveys to obtain their perceptions about the test, testing process, results, future implementation, and use in standard clinical workflows. Participants included all UC clinicians employed by UW Health, as identified through the UW Health provider database. Clinicians received an email containing a secure URL link to the survey, with a 3-week window for completion; reminder emails were sent at 1-week intervals. Patients were also sent a secure URL link to complete confidential surveys by their preferred contact method of email or text message. A single reminder was sent to encourage completion. The clinician survey consisted of 9 Likert-scale questions and 1 rank-order survey question assessing whether perceptions had changed regarding which patient populations might benefit most from the test. The patient survey consisted of 9 questions in total, including 8 Likert-scale items. Both surveys had an open-ended comment section for respondents to share voluntary feedback regarding their experience, perceptions, and opinions on SPOTFIRE ST testing. Participation was voluntary throughout the entirety of the study, and participants were able to refuse or drop out at any point.

Intervention

Patients who met criteria underwent specimen collection via swabbing of the posterior oropharynx and, if applicable, tonsils according to standard procedures. Study personnel then inserted the swabbed specimen into a prefilled, closed circuit reagent cartridge per SPOTFIRE ST instructions. The fully automated

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process provided the molecular detection results within ~15 minutes. Results were recorded, and print copies of the result were provided to the participant and their clinician.

Data Collection

Clinical data were recorded by patients and research staff at the time of the visit using a standardized data collection form. Data were provided by the patient and extracted from the electronic health record. Data collected included demographic information, smoking history, duration (days) of current illness, self-identified severity, exposure to someone who was ill with similar illness and whether a diagnosis was known for that individual, self-identified need for antibiotic prescription, school or work attendance, and current symptoms. Data were collected before testing and recorded in REDCap (Research Electronic Data Capture, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA), an online HIPAA-compliant, institutional review board–approved data collection tool [13]. Survey data (for phases 1 and 3) were also collected using REDCap.

Outcomes

Primary outcomes included identifying target intervention groups from clinician surveys, describing SPOTFIRE ST detections, and analyzing associated antimicrobial prescribing patterns. Treatable viral pathogens were defined as influenza A/B, and treatable bacterial pathogens as GAS, *Mycoplasma pneumoniae*, and *Chlamydia pneumoniae*. Group C/G *Streptococcus* was excluded due to lack of a local outbreak and its known presence as normal oropharyngeal flora [6]. Secondary outcomes evaluated clinician and patient perceptions, satisfaction, clinical impact, and concerns based on Likert-scale responses and summarizing free-text voluntary comments.

Data Analysis

Descriptive statistics summarized central tendencies and proportions. Categorical variables were compared using chi-square tests. Rank-order responses were analyzed with Plackett-Luce models. For the first part of this analysis, results were collated and the average ranking was calculated. We then evaluated the data to assess the relative log-worth of each item being ranked in the survey. Separate models were fitted for each ranking question. Inference was conducted using comparison intervals of the relative log-worth values for each item. Items whose intervals did not overlap were considered statistically different. The comparison intervals were constructed using quasi-standard errors, which allows for determination of inference at the 95% level for all possible contrasts of comparisons. For visualization, 1 item per question was randomly selected as the reference. All analyses were conducted in R, version 4.4.0 [14]. The *PlackettLuce* package was used to fit the regression models, and quasi-standard errors were calculated using the *qvcalc* package [15, 16]. All other survey questions were summarized by descriptive statistics, including distribution of responses and summarizing recurring, voluntary comments from clinicians and patients.

RESULTS

Pre-implementation Clinician Surveys

A total of 52 out of 100 UC clinicians completed the pre-implementation survey. Demographic characteristics and survey responses are summarized in Table 1 and Figure 1. Among respondents, 27 (52%) were physicians (MD or DO), and 25 (48%) were Advanced Practice Providers (APPs; Nurse Practitioners or Physician Assistants). Most participants were full-time clinicians with training and experience in Family Practice or UC, and their primary appointment was in the UC setting. All respondents reported at least a moderate level of familiarity with rapid streptococcal antigen testing, with nearly all respondents (96%) rating its utility as very or extremely useful in the UC setting (Supplementary Figures 1 and 2). In rank-order responses, clinicians identified children aged 3–17 years, immunocompromised patients, toddlers (1–2 years), and patients with medical comorbidities as the 4 highest-priority groups for SPOTFIRE ST testing (Figure 1, top panel). In contrast, infants under 1 year old and healthy adults were perceived as less likely to benefit from this testing. When determining which patients to test for streptococcal pharyngitis, clinicians

Table 1. Summary of UC Clinician Characteristics and Responses to Pre-implementation Survey (n = 52)

Variable	No. (%)
Age, median (range), y	44.5 (29–73)
Female gender	36 (69)
Caucasian	49 (94)
Years in practice, median (range)	10 (1–46)
Degree	
MD or DO	27 (52)
Advanced Practice Provider (NP or PA)	25 (48)
Full-time employment (ie, 100% FTE)	29 (56)
Primary appointment in UC	39 (75)
Medical training/experience	
Family practice and/or urgent care	39 (75)
Pediatrics	9 (17)
Other	5 (8)
Please rate your understanding of rapid strep testing	
Advanced	21 (40)
Moderate	31 (60)
Limited	0 (0)
Please rate the usefulness of rapid strep testing in UC settings	
Extremely useful	22 (42)
Very useful	28 (54)
Moderately useful	2 (4)
Slightly useful	0 (0)
Not useful at all	0 (0)

Abbreviations: DO, Doctor of Osteopathic Medicine; FTE, full-time employment; MD, Doctor of Medicine; NP, Nurse Practitioner; PA, Physician's Assistant; UC, urgent care.

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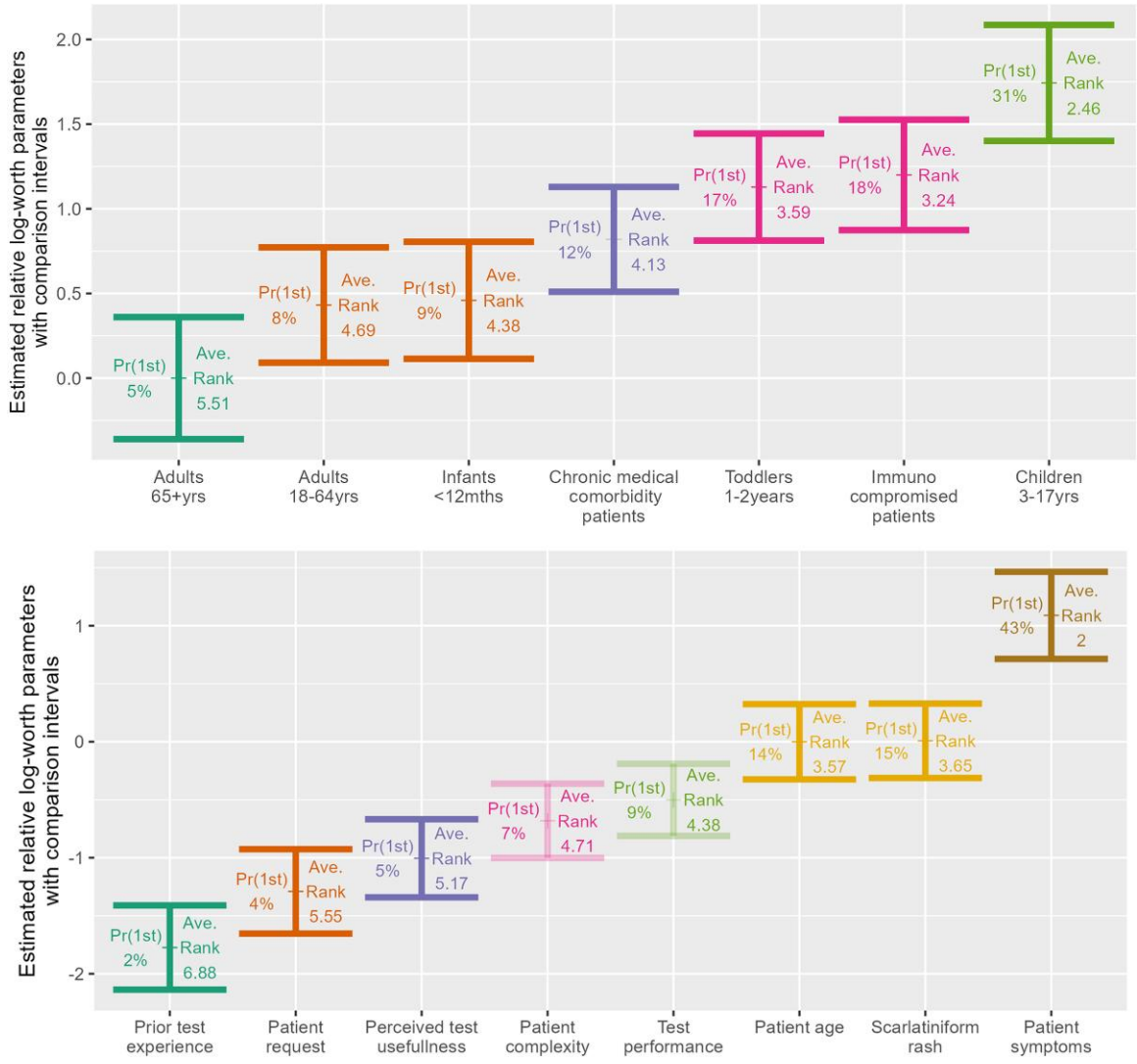

Figure 1. Regression results for the pre-implementation rank-order questions including which populations are more likely to benefit from SPOTFIRE ST (top) and which factors are most important in deciding who to test for streptococcal pharyngitis (bottom). The y-axis is the estimated log-worth value from Plackett-Luce modeling. Also listed for each item is the probability the item was ranked first (Pr(1st)) and the average rank score (from 1 to 7).

prioritized clinical signs and symptoms (eg, Centor criteria), the presence of a scarlatiniform rash, and patient age. Factors such as personal preferences regarding specific tests, prior experience with a given test, and patient requests were considered less influential in decision-making (Figure 1, bottom panel).

Patient Population

A total of 371 patients presented to urgent care with sore throat (and/or fever among those aged 1–2 years); 232 met eligibility criteria, and 200 were enrolled (86.2%). Characteristics of enrolled patients are shown in Table 2. The cohort included more pediatric (58.5%) than adult patients (41.5%), with a median age of 15.3 years. Most were female (55.5%) and identified as White/Caucasian (83.5%). Symptoms had a mean duration of 3.0 days and were typically rated as mild to moderate. Common associated symptoms included cough, rhinorrhea, sinus congestion, and headache (>50%). At enrollment, before evaluation or testing, 82% (152/185) of respondents believed there was at least a 50% likelihood that they or their child required antibiotics.

Pathogen Detection by Multiplex NAAT Testing

SPOTFIRE ST testing detected at least 1 pathogen in 149 (74.5%) participants, including single-pathogen detections in 99 (49.5%) and ≥2 pathogens in 50 (25.0%) (Table 3). GAS and influenza A were the most common (22.5% and 21.5%, respectively). Pediatric patients were significantly more likely than adults to have a positive test (84.6% vs 60.2%; $P < .001$) and were more likely to have multiple pathogens detected (37.6% vs 7.2%; $P < .001$). Individual pathogen detections also varied between age groups (Table 3). Higher rates of

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Table 2. Summary of Baseline Demographic and Clinical Characteristics of Study Cohort (n = 200)

Variable	No. (%)
Enrollment group[a]	
Ages 1–2 y (12–35 mo old) with fever	7 (3.5)
Ages 3–17 y with acute pharyngitis	110 (55.0)
Any age with IC conditions/medication with acute pharyngitis	20 (10.0)
Any age with comorbidities with acute pharyngitis	98 (49.0)
Age, median (range), y	15.3 (1–85)
Age group	
Pediatric (<18 y)	117 (58.5)
Adult (≥18 y)	83 (41.5)
Gender	
Female	111 (55.5)
Male	86 (43.0)
Nonbinary	2 (1.0)
Prefer not to answer	1 (0.5)
Race	
American Indian/Alaskan Native	3 (1.5)
Asian	19 (9.5)
Black or African American	17 (8.5)
Native Hawaiian or Pacific Islander	4 (2.0)
White/Caucasian	167 (83.5)
Prefer not to answer	4 (2.0)
Attend daycare	23 (11.5)
Attend school (in-person)	106 (53.0)
Attend work (in-person or hybrid)	70 (35.0)
Tobacco use or secondhand exposure	12 (6.0)
Days of illness before UC presentation, mean (95% CI)	3.0 (2.8–3.3)
Severity of illness (self-reported)	
Mild	39 (19.5)
Moderate	137 (68.5)
Severe	20 (10.0)
Unreported	4 (2.0)
Exposure to someone else who is ill	36 (18.0)
Received flu vaccine for current year	111 (55.5)
Received COVID-19 vaccine within last 12 mo	87 (43.5)
Presenting symptoms (other than sore throat)	
Fever	88 (44.0)
Chills	68 (34.0)
Cough	134 (67.0)
Wheezing	20 (10.0)
Shortness of breath	28 (14.0)
Runny nose (rhinorrhea)	105 (52.5)
Sinus congestion	102 (51.0)
Eye inflammation (conjunctivitis)	2 (1.0)
Loss of smell	7 (3.5)
Loss of taste	7 (3.5)
Tiredness/feeling run down (malaise)	74 (37.0)
Muscle pains (myalgias)	42 (21.0)
Joint pains (arthralgias)	15 (7.5)
Ear pain	42 (21.0)
Headache	105 (52.5)
Diarrhea	9 (4.5)
Loss of appetite	48 (24.0)
Vomiting	17 (8.5)
Abdominal pain	17 (8.5)
How certain are you that you/your child needs an antibiotic today?	
I am certain an antibiotic is not needed	9 (4.5)
I am pretty sure an antibiotic is not needed, but not certain	24 (12.0)
I am in the middle; I feel there is a 50% chance an antibiotic is needed	104 (52.0)
I am pretty sure an antibiotic is needed, but not certain	36 (18.0)
I am certain an antibiotic is needed	12 (6.0)
Unanswered	15 (7.5)

Abbreviations: COVID-19, coronavirus disease 2019; IC, interstitial cystitis; UC, urgent care.

[a]No. is >200 as patients could be in >1 enrollment group (eg, have comorbid conditions and have immunosuppression).

influenza B, GAS, and *M. pneumoniae* were detected in pediatric patients, whereas other pathogens showed no significant differences. As shown in Table 4, pediatric patients were more likely to have multiple viral infections ($P = .004$) or mixed viral–bacterial detections ($P = .001$), with a trend toward more single bacterial detections ($P = .056$). Adults were more likely to have a single viral pathogen ($P = .024$). Multiple bacterial detections were rare (1/200).

Association Between Pathogen Detection and Antimicrobial Prescribing

A treatable pathogen (influenza A/B, GAS, *M. pneumoniae*, or *C. pneumoniae*) was detected in 103 (51.5%) patients and was more common in pediatric than adult patients (68.4% vs 27.7%; $P < .001$) (Table 5). Despite result availability, antiviral use for influenza was low (32.1%). In contrast, detection of a treatable bacterial pathogen was strongly associated with antibiotic prescribing (95.1%). In contrast, among patients without a treatable bacterial pathogen, antibiotic use was low overall (14.3%, 20/139). Associations between prescribing despite no bacterial pathogen identified were explored, and it was noted that prescribing significantly varied based on presence or absence of a result on the panel even if that result did not indicate a pathogen with specific treatments. For example, antibiotic prescribing was significantly higher with a completely negative panel (ie, nothing detected, 13/51, 25.5%) compared with those with viral detection(s) only (6/86, 7.0%; $P = .002$).

Clinician and Patient Postimplementation Survey Reponses

The postimplementation survey was completed by 33 clinicians, 29 of whom also completed the pre-implementation survey (full results in Supplementary Table 1 and Supplementary Figures 3–10). Key findings included: 81.8% (27/33) reported that the test was easy or very easy to incorporate into workflows; 84.8% (28/33) found it moderately to extremely useful; 97.0% (32/33) considered it more useful than RADT in management decisions; 66.0% (22/33) reported improved antibiotic stewardship; and 93.9% (31/33) indicated that they would likely use SPOTFIRE ST if it became routinely

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Table 3. SPOTFIRE ST Multiplex Detection Results From Study Population Including Comparison Between Adult and Pediatric Patients

Result	Detections, No. (%)	Adult, No. (%)	Pediatric, No. (%)	*P* Value
Positive test	149 (74.5)	50/83 (60.2)	99/117 (84.6)	<.001
Single detection	99 (49.5)	44/83 (53.0)	55/117 (47.0)	.403
≥2 pathogens detected	50 (25)	6/83 (7.2)	44/117 (37.6)	<.001
Adenovirus	7 (3.5)	1/83 (1.2)	6/117 (5.1)	.137
sCoronavirus	27 (13.5)	14/83 (16.9)	13/117 (11.1)	.240
hMetapneumovirus	4 (2.0)	2/83 (2.4)	2/117 (1.7)	.727
Rhinov/enterovirus	28 (14.0)	7/83 (8.4)	21/117 (18.0)	.056
Influenza A[a]	43 (21.5)	14/83 (16.9)	29/117 (24.8)	.179
Influenza B	10 (5.0)	1/83 (1.2)	9/117 (7.7)	.038
Parainfluenza	6 (3.0)	1/83 (1.2)	5/117 (4.3)	.210
RSV	17 (8.5)	6/83 (7.2)	11/117 (9.4)	.587
Group A *Streptococcus*	45 (22.5)	9/83 (10.8)	36/117 (30.8)	.001
Group C/G *Streptococcus*	3 (1.5)	2/83 (2.4)	1/117 (0.9)	.373
C. pneumoniae	3 (1.5)	0/83 (0.0)	3/117 (2.6)	.142
M. pneumoniae	15 (7.5)	1/83 (1.2)	14/117 (12.0)	.004

[a]Influenza A results also include subtypes A/H1–2009 and A/H3.

Abbreviations: hMetapneumovirus, human metapneumovirus; RSV, respiratory syncytial virus; sCoronavirus, seasonal coronavirus.

Table 4. SPOTFIRE ST Multiplex Single and Co-detection Results for Viral and Bacterial Pathogen Detections in Adult and Pediatric Patients

Single vs Co-detections	Adult, No. (%)	Pediatric, No. (%)	*P* Value
Positive for single virus	37/83 (44.6)	34/117 (29.1)	.024
Positive for multiple viruses	1/83 (1.2)	14/117 (12.0)	.004
Positive for single bacteria	7/83 (8.4)	21/117 (18.0)	.056
Positive for multiple bacteria	0/83 (0.0)	1/117 (0.9)	.398
Positive for viral and bacterial pathogens	5/83 (6.0)	29/117 (24.8)	.001

available. Most clinicians preferred testing after check-in but before the face-to-face visit (81.8%). Postimplementation rank-order results for target patient groups were unchanged (Supplementary Figure 11). Voluntary feedback highlighted strong satisfaction with ease efficiency and diagnostic value, alongside concerns about cost/insurance coverage and challenges distinguishing colonization from infection for GAS and Group C/G *Streptococcus*.

Postimplementation surveys were completed by 93% (186/200) of patients or guardians. Responses were overwhelmingly positive (Supplementary Figures 12–20). Key results included: 84.3% (156/185) felt relieved or very relieved after receiving results, 92.4% (171/185) were satisfied or very satisfied with the results, 88.7% (165/186) felt satisfied or very satisfied with the information given from the clinician, 87.1% (162/186) felt satisfied or very satisfied with the treatment(s) given, 89.2% (166/186) found the test useful or very useful to understand their illness, and 93.5% (173/185) were likely or very likely to request the test again for a similar illness. Open-ended voluntary comments emphasized the test's speed, ease of completion, comprehensive nature, and usefulness and desire for broader availability.

DISCUSSION

We describe the evaluation of SPOTFIRE ST, a CLIA-waived, rapid, multiplex POC NAAT for acute pharyngitis, including stakeholder surveys and detection characteristics in a real-world UC environment. Stakeholder perceptions are often lacking from the implementation of new diagnostic tests. Therefore, we initiated our study with a survey of UC clinicians to understand their experience and perceptions about acute pharyngitis evaluation to inform optimal implementation and use of SPOTFIRE ST. Our cohort of urgent care clinicians was experienced and confident in evaluating acute pharyngitis and emphasized the importance of RADT for GAS, reflecting reliance on diagnostic testing in this setting. They also identified the key patient populations most likely to benefit from SPOTFIRE ST testing. Although specific rationales for their rankings were not collected, the results likely reflect the high prevalence of GAS in children, known limitations of current rapid diagnostics, and concern for missed diagnoses in higher-risk groups [17]. Notably, decisions to test for GAS were driven primarily by patient signs and symptoms, with minimal influence from test characteristics.

After implementation of SPOTFIRE ST testing, we demonstrated a high percentage of pathogen detection in patients presenting with acute pharyngitis from target populations, as high as 85% in pediatric patients. While other studies utilizing a pharyngeal swab for multiple-pathogen detection in patients with acute pharyngitis do not exist, previous studies utilizing nasopharyngeal swabs combined with multiplex testing for patients with upper respiratory tract infection evaluation have demonstrated similar percentages of detection, in excess of 80% [18–23]. This high detection percentage, particularly in pediatric patients, makes SPOTFIRE ST an attractive POC test to determine causative pathogens within a time frame that is actionable for UC clinicians. Additionally, >33% of the pediatric patients had >1 pathogen detected, primarily driven by multivirus and virus–bacteria co-detections. This has also been previously demonstrated in pediatric patients with upper and lower respiratory tract infections [22, 24]. Several factors likely contribute to this finding. First, seasonal patterns of respiratory viral activity can heavily influence potential for multidetections. Second, respiratory infections in pediatric patients often occur in quick succession over a typical respiratory viral season [22, 24]. Third, certain respiratory viruses, in particular rhinovirus/enterovirus, coronavirus, and respiratory syncytial virus, can be shed for prolonged periods. Given the high sensitivity of NAAT, it would not be uncommon to detect these viruses for prolonged periods, making overlapping detection more likely [25].

The current lack of sufficiently broad, sensitive, or timely diagnostics available to determine the pathogen for acute

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Table 5. SPOTFIRE ST Detections and Association With Antimicrobial Prescribing

Detections for Treatable Pathogens and Antimicrobial Prescribing	Total, No. (%)	Adult, No. (%)	Pediatric, No. (%)	*P* Value
Treatable (influenza A/B, GAS, *M. pneumoniae, C. pneumoniae*)	103/200 (51.5)	23/83 (27.7)	80/117 (68.4)	<.001
Influenza detected and prescribed antiviral	17/53 (32.1)	6/15 (40.0)	11/38 (28.9)	.437
Treatable bacterial pathogen detection and prescribed antibiotic	58/61 (95.1)	9/10 (90.0)	49/51 (96.1)	.416
Patients without treatable bacterial detection prescribed an antibiotic	20/139 (14.3)	10/73 (13.7)	10/66 (15.2)	.807
Patients prescribed an antibiotic when SPOTFIRE ST panel was completely negative (ie, nothing detected)	13/51 (25.5)[a]	7/33 (21.2)	6/18 (33.3)	.343
Patients prescribed an antibiotic when SPOTFIRE ST panel detected only viral pathogens	6/86 (7.0)[a]	2/38 (5.3)	4/48 (8.3)	.579

Isolated Group C/G *Streptococcus* results (2 instances) were excluded as treatment was considered controversial and not universally indicated.

Abbreviation: GAS, Group A *Streptococcus*.

[a]*P* value .002 for antibiotic prescribing rates between patients with a completely negative panel and those with a viral detection.

pharyngitis creates clinical uncertainty that directly impacts clinician and patient behaviors, perceptions, decision-making, and satisfaction. Diagnostic uncertainty has been linked to patient and clinician dissatisfaction and overprescribing of antibiotics [26–33]. The Pew Charitable Trust has identified diagnostic uncertainty as a fundamental factor in antibiotic overuse (www.pewtrusts.org). The inverse has also been demonstrated, namely that improving diagnostic certainty reduces the frequency of antibiotic prescribing [26, 34, 35]. By detecting 14 of the most common pathogens causing acute pharyngitis, we believe that SPOTFIRE ST testing reduced uncertainty, as illustrated by the comparatively low rate of prescribing antibiotics in patients without a treatable bacterial detection when SPOTFIRE ST testing was used (14.3%). Currently, in the United States, >60% of patients presenting with pharyngitis receive an antibiotic prescription, even though a minority (especially adults) have GAS infection [11, 36, 37]. In a Cochrane review, RADT testing was shown to decrease prescribing from 64% in patients evaluated by clinical methods to 39% in those with RADT performed [37]. While the exact percentage of patients with a documented negative RADT who still receive antibiotics was not precisely quantified in their studies, the gap between prevalence and the antibiotic prescribing rate in the included studies suggests that a substantial number of test-negative patients receive unnecessary antibiotics. In our study, only 14% or patients without a documented bacterial pathogen on SPOTFIRE ST were prescribed an antibiotic. However, a completely negative SPTOFIRE ST panel was associated with significantly higher prescribing rates than a result where a viral etiology was identified. Therefore, there is significant utility of a broad panel that detects etiologies that have no specific treatment (eg, rhinovirus), which still allows clinicians and patients to understand their disease process and avoids unnecessary antibiotics. Residual uncertainty when no pathogen is detected on the panel is likely to remain challenging and represents an important area for future investigation and intervention.

Patient and clinician satisfaction was high on postvisit surveys, which we believe is indicative of the improved diagnostic certainty in a timely manner. Clinician voluntary comments verified that a key benefit of SPOTFIRE ST was diagnostic certainty in a timely manner to allow them more time counseling and making therapeutic decisions. Patients also expressed very high satisfaction, with most comments relating to how easy the sample was to obtain and how impressed they were that they could find out, in most cases, the exact cause of their symptoms. The majority also expressed the wish that this test would become routinely available in the future. The only concerns expressed involved cost and who would be responsible for covering that cost (ie, third-party payers vs patient out-of-pocket cost) and determining differences between infection and colonization.

There are important limitations to acknowledge. First, this was a noncomparative, single-center observational study from a single UC clinic performed during a single respiratory viral season. This imparts potential for convenience sampling bias and limits generalizability to other clinical settings and patient populations. The design also constrains the potential impact on antimicrobial prescribing given seasonal variation including variability in underlying prevalence of detectable pathogens. Second, we examined intrinsic factors that can influence antimicrobial prescribing such as years of experience, degree, and employment characteristics, but each was insufficiently powered. Third, this study was conducted during the global resurgence of *M. pneumoniae*, which likely influenced the number of detections observed. It should also be noted that the need for antimicrobial treatment of this pathogen remains controversial, as the illness may be self-limiting. Finally, we did not assess cost-benefit or other economic impacts.

In summary, we successfully implemented the SPOTFIRE ST test in a UC center utilizing stakeholder feedback on target populations. SPOTFIRE ST demonstrated a very high detection percentage in patients undergoing acute pharyngitis evaluation, and there were distinct detection patterns noted between adult and pediatric patients. Antibiotic prescribing was low for patients who did not have a bacterial target identified, suggesting that this test may improve antibiotic stewardship in the UC setting. Both patients and clinicians expressed positive perceptions, satisfaction, and feedback with SPOTFIRE ST testing.

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Before implementation, economic factors should be determined, and our findings should be verified if applied to other clinical settings or patient populations. Overall, given the broad and rapid detection characteristics of the SPOTFIRE ST test combined with the favorable clinician and patient satisfaction results, this test is likely to be highly appreciated and utilized by patients and clinicians for the evaluation of acute pharyngitis in the UC setting.

Supplementary Data

Supplementary materials are available at *Open Forum 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

Author contributions. Conceptualization and methodology—A.L., B.L., S.B., D.N., J.T.; funding and project administration—A.L., S.B., J.T.; data acquisition and validation—M.G., C.Ha., C.He., E.T., S.W.; analysis—A.L., B.L., S.B., M.G., C.H., D.N., J.T.; draft writing—A.L., B.L., C.Ha., J.T.; manuscript review and editing—A.L., B.L., S.B., M.G., C.Ha., D.N., J.T.

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