Predicting Urinary Tract Infections With Interval Likelihood Ratios

Tian Liang, MD,[a,b] Silvia Schibeci Oraa, MD,[a,b] Naomi Rebollo Rodríguez, MD,[a,b] Tanvi Bagade, MD,[a,b] Jennifer Chao, MD,[a,b] Richard Sinert, DO[a,b]

abstract

BACKGROUND: Protocols for diagnosing urinary tract infection (UTI) often use arbitrary cutoff values of urinalysis components to guide management. Interval likelihood ratios (ILRs) of urinalysis results may improve the test's precision in predicting UTIs. We calculated the ILR of urinalysis components to estimate the posttest probabilities of UTIs in young children.

METHODS: Review of 2144 visits to the pediatric emergency department of an urban academic hospital from December 2011 to December 2019. Inclusion criteria were age <2 years and having a urinalysis and urine culture sent. ILR boundaries for hemoglobin, protein, and leukocyte esterase were "negative," "trace," "1+," "2+" and "3+." Nitrite was positive or negative. Red blood cells and white blood cells (WBCs) were 0 to 5, 5 to 10, 10 to 20, 20 to 50, 50 to 100, and 100 to 250. Bacteria counts ranged from negative to "loaded." ILRs for each component were calculated and posttest probabilities for UTI were estimated.

RESULTS: The UTI prevalence was 9.2%, with the most common pathogen being *Escherichia coli* (75.2%). The ILR for leukocyte esterase ranged from 0.20 (negative) to 37.68 (3+) and WBCs ranged from 0.24 (0–5 WBCs) to 47.50 (100–250 WBCs). The ILRs for nitrites were 0.76 (negative) and 25.35 (positive). The ILR for negative bacteria on urinalysis was 0.26 and 14.04 for many bacteria.

CONCLUSIONS: The probability of UTI in young children significantly increases with 3+ leukocyte esterase, positive nitrite results, 20 to 50 or higher WBCs, and/or many or greater bacteria on urinalysis. The probability of UTI only marginally increases with trace or 1+ leukocyte esterase or 5 to 20 WBCs. Our findings can be used to more accurately predict the probability of true UTI in children.

[a]*The State University of New York Downstate Medical Center, Brooklyn, New York; and* [b]*New York City Health and Hospitals/Kings County, Brooklyn, New York*

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Address correspondence to Tian Liang, MD, Division of Pediatric Emergency Medicine, Department of Emergency Medicine, New York City Health and Hospitals/Kings County, 451 Clarkson Ave, CG-27A, Brooklyn, NY 11201. E-mail: tianzliang@gmail.com

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WHAT'S KNOWN ON THIS SUBJECT: Although urinalysis components often contain multiple result values (negative, trace, 1+, 2+, 3+), their likelihood ratios in predicting urinary tract infection (UTI) were historically calculated as dichotomized variables, only indicating the presence or absence of each component.

WHAT THIS STUDY ADDS: We report interval likelihood ratios of each urinalysis component result for estimating UTI probability. Our findings can be used with existing tools for UTI evaluation to help more accurately diagnose true disease in young children.

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Urinary tract infections (UTIs) are a common cause of fever in young children who present to the emergency department (ED).[1] Evaluating for UTIs in this age group remains a challenge because of the nonspecific clinical presentation.[2] The overall prevalence of UTI in febrile infants and young children is ~5% to 7%.[3–5] Early detection and treatment of UTI in children is important to minimize the risk of kidney injury.[6–8]

Urinalysis components such as leukocyte esterase, nitrites, white blood cells (WBCs), and bacteria can help diagnose patients with UTI.[3,6] No individual component of urinalysis is both highly sensitive and specific.[6] Leukocyte esterase is the most sensitive single test but has limited specificity.[6] Nitrites are highly specific for UTI, but a "negative" nitrite result cannot be used to rule out infection.[6] WBCs and bacteria in urinalysis have sensitivities and specificities ranging from 73% to 83% in predicting infection.[6]

Urinalysis-driven protocols in the management of UTI exist to minimize delays in treatment and to promote antibiotic stewardship.[6,9,10] Many of these protocols use arbitrary cutoff values of urinalysis components to guide management.[10,11] In previous studies, researchers have reported operating characteristics of urinalysis components as dichotomized variables (eg, negative or "positive" instead of negative, "trace," "1+," "2+," or "3+") even if they contain >2 possible values.[6,12] Interval likelihood ratios (ILRs) of urinalysis components when combined with the pretest probability of disease may improve the estimation of UTI probability. We calculated the ILR of urinalysis components to estimate the posttest probabilities of UTIs in children <2 years of age.

METHODS

Population

We performed a retrospective cross-sectional study of patients seen in the pediatric ED at Kings County Hospital in Brooklyn, New York. Inclusion criteria were children <2 years of age evaluated between December 2011 and December 2019 and having a urinalysis and urine culture sent. Patients were excluded if a urine culture was sent without a urinalysis in the same visit or if urine testing was not sent from the pediatric ED. The provider's clinical decision reasoning to send urine was not used as selection criteria to include the widest range of patient presentations. Urine specimens were sent from the ED to the hospital laboratory through pneumatic tubes. Urinalysis samples are processed immediately 24 hours/day. Urine cultures are plated after receipt during daytime hours, and overnight, they are refrigerated until the morning. The sample size was calculated as 1112 by using 95% confidence, 1.5% margin of error, and 7% prevalence.[5]

Study Definitions

UTI was defined per the American Academy of Pediatrics (AAP) guidelines, which require evidence of pyuria or bacteriuria on urinalysis and >50 000 colony-forming units per mL of a pathogenic bacteria in urine culture from a sterilely obtained sample.[6] Pyuria was defined as ≥5 WBCs per high-power field (HPF) or any level of leukocyte esterase in urinalysis.[6,7] Bacteriuria was defined as the presence of nitrites or any level of bacteria.[6,7] Contaminated cultures were defined by bacteria not commonly considered pathogens or >2 pathogens. We defined a negative UTI result as a urinalysis and urine culture pairing with no urine culture growth, asymptomatic bacteriuria (positive urine culture result with a normal urinalysis), insignificant bacteriuria (abnormal urinalysis with urine culture growing <50 000 colony-forming units per mL), or any samples classified as contaminants (Fig 1).[6,7]

Data Collection

Our study was approved as exempt by The State University of New York Downstate College of Medicine Institutional Review Board with a waiver for informed consent. Urinalysis dipstick and microscopy (centrifuged), urine culture, and demographic data were collected from our electronic medical record. Our sample selection process is outlined in Fig 1. Results for the urinalysis components hemoglobin, protein, and leukocyte esterase were reported by the hospital laboratory as negative, trace, 1+, 2+, and 3+. Nitrite was measured as positive or negative. Red blood cell (RBC) and WBC counts are reported as cells per HPF. Bacteria counts were reported as negative, "rare," "few," "moderate," "many," and "loaded."

Data Analysis

Urinalysis components were separated into interval values outlined in Tables 1 and 2 and ILRs were calculated with 95% confidence intervals (CIs). We calculated ILRs for the following urinalysis components: hemoglobin, protein, leukocyte esterase, nitrites, RBCs, WBCs, and bacteria. ILR boundaries for hemoglobin, protein, leukocyte esterase, nitrites, and bacteria were reported in the electronic medical record. Interval boundaries for RBCs and WBCs in our data set were "0 to 5," "5 to 10," "10 to 20," "20 to 50," "50 to 100," and "100 to 250" cells per HPF, which were derived from the ranges reported by the hospital laboratory. In our hospital, the microscopy is not performed if the urinalysis dipstick is normal. This occurred in 646 tests, and in these cases, the WBC, RBC, and bacteria results were coded as 0 to 5 cells per HPF (WBCs and RBCs) and negative bacteria for the ILR calculations. Of these 646 tests, 28 had positive urine culture results, and as such, because the urinalysis dipstick did not reveal evidence of pyuria or bacteriuria,

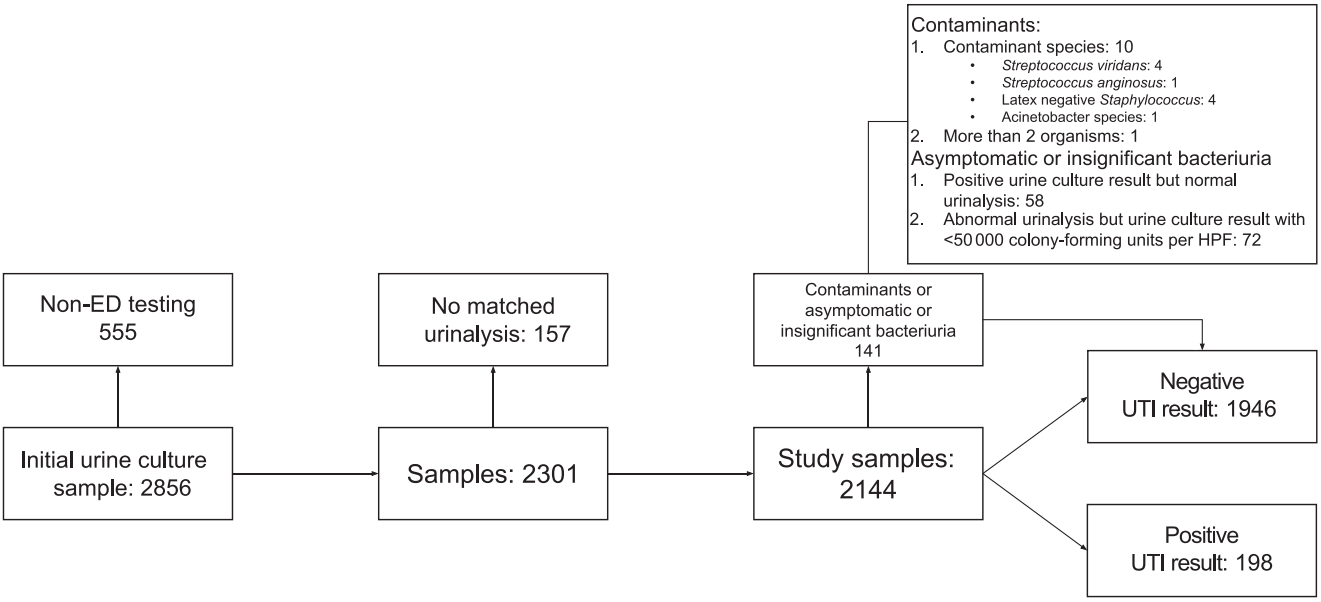

FIGURE 1
Sample selection.

these samples were coded as negative UTI results. The ILR for each interval was calculated according to the standard definition: the ratio of the probability of that urinalysis interval in UTI-positive patients to the probability of that same interval in UTI-negative patients. Finally, we used Bayes' theorem to calculate the posttest probability of UTI by using an ILR for each urinalysis component with the prevalence of UTI as our pretest probability.

RESULTS

Sample Selection

A total of 2856 urine culture samples were sent at our institution for children <2 years of age between December 2011 and December 2019. Of these urine cultures, 555 were not sent from the ED, and 157 additional samples did not have a urinalysis sent at the same visit, leaving 2144 urinalysis and urine culture samples for our analysis. Bacterial contaminants, asymptomatic bacteriuria, or insignificant bacteriuria were found in 59 samples and were coded as negative UTI results (Fig 1).

Patient Population

These 2144 samples represent 1954 individual patients with a median age of 255 days (interquartile range: 93–418 days), of which 52% were female patients. Black patients represented 84.7% of our samples, and 5.7% of our samples were from Hispanic patients. Our UTI prevalence was 9.2% (95% CI, 8.0%–10.5%) (Table 3), which is not significantly different from the prevalence reported in previous literature (7.0%; 95% CI, 5.5%–8.4%).[5]

In Table 3, we compare the demographics between those patients with and without a UTI. Patient sex did not have a significant impact on UTI diagnosis ($P = .16$). In addition, male patients who were diagnosed with UTI were significantly more likely to be uncircumcised compared with male patients who did not have UTI ($P < .001$). Patients with UTI were significantly more likely to be <2 months old compared with patients without UTI ($P < .001$). The subjects' race did not significantly impact the UTI prevalence ($P = .102$). *Escherichia coli* was the most common (75.2%) urinary pathogen, followed by *Klebsiella* (7.1%) and *Enterococcus* (7.1%).

Operating Characteristics of Urinalysis

Using the prevalence of UTI of 9.2% as the pretest probability in our population, we calculated the ILR of leukocyte esterase, hemoglobin, protein, and nitrite in the urinalysis dipstick that may alter our posttest probability of a UTI. The urinalysis dipstick components in Table 1 reveal that 3+ leukocyte esterase increases the probability of having a UTI from 9.2% to 79.2%. The ILR for 3+ leukocyte esterase is significantly higher compared to the ILR for 1+ leukocyte esterase and 2+ leukocyte esterase as shown by the lack of overlap in their CIs. A hemoglobin result of 3+ will increase the probability of a UTI to 9.2% to 29.2%. Our study did not reveal any statistical significance between a hemoglobin result of 2+ when compared to 3+. A protein of 2+ on urinalysis will increase the probability of UTI from 9.2% to 37.4%, whereas a protein of 3+ results in an increase in probability from 9.2% to 55%. However, there is

TABLE 1 ILRs for Urinalysis Dipstick Components

Test and Intervals	ILR (95% CI)	Posttest Probability,[a] %	No. Samples[b]
Leukocyte esterase			
Negative	0.20 (0.15–0.27)	2	1762
Trace	1.86 (1.07–3.23)	15.9	88
1+	2.79 (1.76–4.43)	22	95
2+	7.53 (5.00–11.00)	42.5	83
3+	37.68 (25.00–58.00)	79.2	116
Any leukocyte esterase	7.32 (6.36–8.42)	42.6	382
Hemoglobin			
Negative	0.38 (0.3–0.48)	3.7	1454
Trace[c]	NA[c]	NA[c]	6
1+	1.27 (0.87–1.86)	11.4	227
2+	2.75 (2.06–3.67)	21.8	215
3+	4.08 (3.23–5.16)	29.2	242
Any hemoglobin	2.59 (2.32–2.90)	20.8	690
Protein			
Negative	0.54 (0.45–0.65)	5.2	1473
Trace	0.76 (0.49–1.19)	7.1	264
1+	2.22 (1.71–2.89)	18.4	283
2+	5.90 (4.08–8.53)	37.4	104
3+	12 (5.04–29.00)	54.9	20
Any protein	2.16 (1.90–2.47)	18	671
Nitrite			
Negative	0.76 (0.7–0.82)	7.1	2076
Positive	25.35 (15.00–42.00)	72	68

NA, not applicable.

[a] Prevalence and pretest probability = 9.2%.

[b] Total number of samples = 2144.

[c] LR not calculated for trace hemoglobin because of no positive UTI results with this value in the data set.

no statistical difference between a protein level of 2+ when compared to 3+. The 95% CIs of the 1+ and 2+ protein ILRs do not overlap, indicating that this threshold level of protein on urinalysis is significant in predicting UTI. Lastly, a positive nitrite result on urinalysis will increase the probability of having a UTI from 9.2% to 72%.

The dipstick results with ILR <1 include a negative leukocyte esterase result, which decreases the probability of UTI from 9.2% to 2%. A negative hemoglobin result will result in a posttest probability of 3.7%. No ILR was calculated for trace hemoglobin because there were no positive culture results with this value (only 6 samples were found to have trace hemoglobin). Either a negative or trace protein result will lower posttest probabilities of UTI to 5.2% and 7.1% respectively. Finally, a negative nitrite result will decrease the probability of UTI to 7%.

The urinalysis microscopy components are reported in intervals of WBC, RBC, and bacteria, as shown in Table 2. Significant ILR for WBC is seen for 20 to 50 WBCs per HPF and higher with an ILR of 11.18 resulting in an increase in the posttest probability of UTI from 9.2% to 53.1%. There is no statistical difference between this interval when compared to the 50 to 100 WBCs per HPF interval. The ILR for 100 to 250 RBCs per HPF (6.14) denotes an increase in the probability of UTI from 9.2% to 38.4%; however, there is no statistical difference when this interval is compared to 5 to 10, 10 to 20, 20 to 50, or 50 to 100 RBCs per HPF. A moderate level of bacteria will increase the probability of UTI to 38%; however, this is not statistically significant when compared to loaded bacteria. The bacteria interval that most increased the probability of disease was many, with a posttest probability of 59%. A result of 0 to 5 WBCs per HPF decreases the probability of disease from 9.2% to 2.4%, a result of 0 to 5 RBCs per HPF decreases the probability to 5.1%, and a negative bacteria on microscopy decreases the probability to 2.6% (Table 2). The number of samples corresponding to each urinalysis interval are reported in Tables 1 and 2.

DISCUSSION

We calculated ILRs for urinalysis components in predicting UTI in children <2 years of age. We found that when evaluating a young child for UTI, 3+ leukocyte esterase, positive nitrite results, 3+ protein, ≥20 WBCs per HPF and greater, or many bacteria in the urinalysis significantly increases the posttest probability of true infection. Of all the negative urinalysis results, only a negative leukocyte esterase result conferred a moderate decrease in the posttest probability of UTI (Tables 1 and 2).

TABLE 2 ILRs for Urinalysis Microscopy Components

Test and Intervals	ILR (95% CI)	Posttest Probability,[a] %	No. Samples[b]
WBCs per HPF			
0–5	0.24 (0.19–0.32)	2.4	1689
5–10	1.20 (0.70–2.04)	10.8	129
10–20	1.82 (1.20–2.78)	15.6	147
20–50	11.18 (6.94–18.00)	53.1	62
50–100	15.83 (8.96–28.00)	61.6	47
100–250	47.50 (26.00–87.00)	82.8	70
All ≥5 WBC	5.18 (4.56–5.88)	34.4	455
RBCs per HPF			
0–5	0.53 (0.45–0.62)	5.1	1646
5–10	1.87 (1.26–2.76)	15.9	163
10–20	3.30 (2.43–4.47)	25.1	179
20–50	2.98 (1.85–4.81)	23.2	86
50–100	4.12 (2.19–7.75)	29.5	44
100–250	6.14 (2.83–13.00)	38.4	26
All ≥5 RBC	2.92 (2.51–3.39)	22.8	498
Bacteria			
Negative	0.26 (0.19–0.35)	2.6	1404
Rare	1.38 (1.01–1.90)	12.3	292
Few	1.46 (1.04–2.06)	12.9	247
Moderate	6.05 (4.20–8.72)	38	105
Many	14.04 (8.86–22.00)	58.7	68
Loaded	9.83 (4.75–20.00)	49.9	28
Any bacteria	2.75 (2.51–3.03)	21.8	740

[a] Prevalence and pretest probability = 9.2%.

[b] Total number of samples = 2144.

In contrast to our ILR calculations, authors of previous research[10–14] have only described the likelihood ratios of urinalysis components as dichotomized variables (eg, negative versus positive leukocyte esterase results in urinalysis dipstick or 0–5 WBCs per HPF versus >5 WBCs per HPF on urinalysis microscopy) in predicting childhood UTI. Although the AAP requires evidence of pyuria or bacteriuria on urinalysis to diagnose a UTI, we questioned the utility of a marginally positive result such as trace leukocyte esterase or rare bacteria in revealing true infection.[6]

ILRs >10 or <0.10 provide strong evidence to rule in or rule out disease, respectively, whereas ILRs between 5 and 10 or 0.1 and 0.5 provide moderate evidence to alter posttest probability.[15,16] In past studies and systematic reviews, researchers have calculated positive likelihood ratios (+LRs) for leukocyte esterase, nitrites, WBCs, and bacteria on urinalysis for diagnosing UTI.[10,14] In 2018, Shaikh et al[10] found that having trace or higher levels of leukocyte esterase in urinalysis had a +LR of 12.9 (95% CI, 10.5–16) and Whiting et al,[14] in a 2005 systematic review, found a pooled positive leukocyte esterase +LR to be 5.5 (95% CI, 4.1–7.3). This compares similarly to our +LR of 7.32 (95% CI, 6.36–8.42) for any level of leukocyte esterase found on urinalysis. Within our ILR data, only a leukocyte esterase result of 2+ (ILR = 7.53) or 3+ (ILR = 37.68) meaningfully increases the posttest probability of UTI. Trace or 1+ leukocyte esterase on urinalysis in our study only increased the posttest probability by a small amount (Table 1).

In 2018, Shaikh et al[10] also published interval odds ratios for trace, 1+, 2+, and 3+ leukocyte esterase and found that there is a significant increase in odds ratio between 1+ and 2+ leukocyte esterase (odds ratio 37.5 [95% CI, 20.2–69.7] vs 214 [95% CI, 98.0–468]). We found a similar increase in ILR between 1+ and 2+ leukocyte esterase in our results (ILR 2.79 [95% CI, 1.76–4.43] vs 7.53 [95% CI, 5–11]).

The presence of nitrites on urinalysis has a significant +LR in both our study and in previous research.[10,14] Our +LR for nitrites is 25.35 (95% CI, 15–42) and is similar to those reported by researchers in previous literature.[10,11,13,14] We also found a moderate ILR for 2+ protein (5.90) and significant ILR for 3+ protein (12) for predicting UTI. The 95% CI for 3+ protein is wide, likely because of the low number of samples with this value (20), and overlaps with the 95% CI for 2+ protein, indicating there is not a significant difference between these 2 results. Proteinuria is associated with symptomatic UTI in adults,[17] and our findings suggest that 3+ protein on urinalysis can help predict UTI in young children. Trace or 1+ protein on urinalysis did

TABLE 3 Comparison of UTI-Positive and UTI-Negative Patients

Patient Characteristics	UTI-Positive	UTI-Negative	*P*
Total, *N* = 2144 (100%), *n* (%) (95% CI)	198 (9.2) (8.0–10.5)	1946 (90.8) (89.5–92.0)	—
Sex, *n* of *n*, % (95% CI)			
Male	105 of 198, 53.0 (45.8–60.1)[a]	924 of 1946, 47.5 (45.2–49.7)	.16
Circumcision, *n* of *n*, % (95% CI)			
Yes	19 of 105, 18.1 (11.3–26.8)[b]	475 of 924, 51.4 (48.1–54.7)	<.001
No	70 of 105, 66.7 (56.8–75.6)[b]	263 of 924, 28.5 (25.6–31.5)	—
Unknown	16 of 105, 15.2 (9.0–23.6)	186 of 924, 20.1 (17.6–22.9)	—
Age, *n* of *n*, % (95% CI)			
0–2 mo	52 of 198, 26.3 (20.3–33.0)[b]	356 of 1946, 18.3 (16.6–20.1)	<.001
2–12 mo	116 of 198, 58.6 (51.4–65.5)[b]	946 of 1946, 48.6 (46.4–50.9)	—
12–24 mo	30 of 198, 15.2 (10.5–20.9)[b]	644 of 1946, 33.1 (31.0–35.2)	—
Race, *n* of *n*, % (95% CI)			
Black	156 of 198, 78.8 (72.4–84.3)[a]	1664 of 1946, 85.5 (83.9–87.0)	.102
Hispanic	20 of 198, 10.1 (6.3–15.2)[a]	102 of 1946, 5.2 (4.3–6.3)	—
Asian American or Pacific Islander	4 of 198, 2.0 (0.6–5.1)[a]	33 of 1946, 1.7 (1.2–2.4)	—
White	2 of 198, 1.0 (0.1–3.6)[a]	17 of 1946, 0.9 (0.5–1.4)	—
American Indian	1 of 198, 0.5 (0.0–2.8)[a]	6 of 1946, 0.3 (0.1–0.7)	—
Other	15 of 198, 7.6 (4.3–12.2)[a]	124 of 1946, 6.4 (5.3–7.6)	—
Urine pathogen, *n* of *n*, % (95% CI)			
E coli	149 of 198, 75.3 (68.6–81.1)	—	—
Klebsiella species	14 of 198, 7.1 (3.9–11.6)	—	—
Enterococcus species	14 of 198, 7.1 (3.9–11.6)	—	—
Enterobacter species	3 of 198, 1.5 (0.3–4.4)	—	—
Other[c]	18 of 198, 9.1 (5.5–14.0)	—	—

—, not applicable.

[a] Nonsignificant.

[b] $P < .05$.

[c] *Citrobacter* species, *Proteus* species, *Morganella* species, *Pseudomonas*, and/or *Staphylococcus aureus*.

not significantly increase the posttest probability of UTI.

The ILR for any hemoglobin on a urinalysis dipstick ranged from 1.27 for 1+ hemoglobin to 4.08 for 3+ hemoglobin. No ILR of hemoglobin in our results would lead to a significantly altered posttest probability of UTI. Our combined +LR for any level of hemoglobin on the dipstick for predicting UTI is 2.59 (Table 1), which is similar to previous studies (2.3).[14]

Overall likelihood ratios and ILRs were also calculated for urinalysis microscopy (Table 2). For WBC results, our combined likelihood ratio for ≥5 WBCs per HPF is 5.18, which compares similarly to systematic review data by Whiting et al[14] (pooled +LR 5.9; 95% CI 4.1–8.5) and is lower than data from Shaikh et al[10] in 2018, in which his calculated +LR for ≥10 WBCs per mm^3 is 10.1 (95% CI, 8.11–12.5). This difference could be explained by urine processing methods. Whereas Shaikh et al[10] in 2018 calculated the WBC +LR using uncentrifuged urine (unit = cells per mm^3), our study and some studies reviewed by Whiting et al[14] used centrifuged urine (unit = cells per HPF) for WBC counts. Uncentrifuged urine microscopy has historically been shown to be more accurate in diagnosing UTI compared to centrifuged urine.[18]

Evidence of pyuria on urinalysis microscopy in children is generally defined as >5 WBCs per HPF.[6,7,13,19–21] Some algorithms for febrile infants use >10 WBCs per HPF as high-risk criteria for infection.[22,23] Our results reveal that neither 5 to 10 WBCs per HPF nor 10 to 20 WBCs per HPF, when present on urinalysis microscopy, represent significant pyuria (ILRs = 1.20 and 1.82, respectively). Measurements of 20 to 50 WBCs per HPF (ILR = 11.18) or higher on urinalysis microscopy significantly increase the posttest probability of UTI.

Our overall likelihood ratio of the presence of bacteria on urinalysis microscopy is 2.75. Moderate, many, and loaded levels of bacteria all had an ILR >5. The ILR for many bacteria is higher than loaded bacteria levels in our study, which is likely because of the sample size and the low numbers of urinalysis with these results (only 28 samples with loaded bacteria). Bacterial microscopy results of rare or few did not have significant ILRs. Whiting et al[14] reported a pooled bacteria microscopy +LR of 14.7 (95% CI, 8.6–24.9) with the caveat that there was significant heterogeneity between the studies.

The likelihood ratio for the presence of ≥5 RBCs per HPF on urinalysis microscopy is 2.92. Neither Shaikh et al[10] in 2018 nor Whiting et al[14] reported +LR of RBCs in predicting UTI. Only 100 to 250 RBCs per HPF had an ILR >5. However, there is overlap between the 95% CIs in each RBC interval, so it is unlikely that any level of RBC found on urinalysis microscopy significantly increases the

posttest probability of UTI in a young child.

For negative likelihood ratios (−LRs) of urinalysis components, our data reveal that no single result significantly decreases the posttest probability of UTI. The −LR for leukocyte esterase is moderate at 0.20 and similar to the value found in the systematic review by Whiting et al[14] (0.26; 95% CI, 0.18–0.36) but not as strong as the −LR for leukocyte esterase calculated by Shaikh et al[10] (0.07; 95% CI, 0.05–0.1). Our −LR for nitrites on urinalysis is 0.76 and higher than those calculated by Shaikh et al[10] (0.65; 95% CI, 0.61–0.69) and Whiting et al[14] (0.51; 95% CI, 0.43–0.60). The −LR for hemoglobin is 0.38 and is lower than the 1 study reviewed by Whiting et al[14] (0.84). The −LR for protein in our sample size was small (0.54) and similar to 2 studies reviewed by Whiting et al[14] (0.78 and 0.96). Shaikh et al[10] did not calculate −LR for hemoglobin or protein in urinalysis.

Our −LR for negative WBC count results on urinalysis microscopy (0.24) is similar to those calculated in previous studies (0.27; 95% CI, 0.2–0.37).[14] The −LR for a negative bacteria result (0.26) is similar to the pooled −LR calculated by Whiting et al[14] (0.19; 95% CI, 0.14–0.24). Neither Shaikh et al[10] nor Whiting et al[14] published −LR for RBC on urinalysis microscopy.

The prevalence of UTI in our study population is higher than the prevalence reported by Shaikh et al[5] in a 2008 meta-analysis (9.2%; [95% CI, 8.0%–10.5%] vs 7.0% [95% CI 5.5%–8.4%]). Although this difference is not statistically significant because of overlapping 95% CIs, our urinalysis ILR posttest probability estimates depend on the calculated prevalence, and these probabilities may change when applied to another patient population with a different pretest probability of disease.

CONCLUSIONS

When we use our ILR and Bayes' theorem, the probability of UTI significantly increases with 3+ leukocyte esterase, positive nitrite results, 3+ protein, 20 to 50 or higher WBCs per HPF, and many bacteria on urinalysis. The probability of UTI only moderately decreases with negative leukocyte esterase results in urinalysis. Antibiotics are frequently prescribed empirically for evidence of pyuria on urinalysis while awaiting culture results in acute care settings.[24,25] The AAP defines "significant pyuria" as ≥5 WBCs per HPF or any level of leukocyte esterase in urinalysis.[7] Our results suggest that pyuria <20 WBCs per HPF or 2+ leukocyte esterase or bacteriuria less than moderate bacteria on urinalysis is unlikely to be clinically useful in predicting a positive urine culture result and a diagnosis of UTI. These findings can be used in conjunction with existing tools for UTI evaluation to more accurately estimate the probability of disease or decrease the probability of infection to the point of possibly delaying antibiotics until the urine culture results are finalized.

Regarding the limitations of this study, our electronic medical record system did not list the method of collection of urine for our population, although our usual practice for obtaining urine to evaluate for infection in children <2 years of age is sterile bladder catheterization. In addition, there is no protocol in place at our institution to use urine bags to obtain specimens under any circumstances.[26,27] Circumcision status was not listed on all male patients, which could affect demographics and other results.

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ABBREVIATIONS

AAP: American Academy of Pediatrics
CI: confidence interval
ED: emergency department
HPF: high-power field
ILR: interval likelihood ratio
RBC: red blood cell
UTI: urinary tract infection
WBC: white blood cell
−LR: negative likelihood ratio
+LR: positive likelihood ratio

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