Open Forum Infectious Diseases

BRIEF REPORT

Clinician Testing and Treatment Thresholds for Management of Urinary Tract Infection

Andrea Harris,[1] Lisa Pineles,[2] Jonathan D. Baghdadiv,[2] Larry Magder,[2] Gurpreet Dhaliwal,[3,4] Deborah Korenstein,[5] Anthony D. Harris,[2,6] and Daniel J. Morgan[2,6]

[1]University of Maryland School of Medicine, Baltimore, Maryland, USA, [2]Department of Epidemiology and Public Health, University of Maryland School of Medicine, Baltimore, Maryland, USA, [3]Medical Service, Veterans Affairs (VA) San Francisco Health Care System, San Francisco, California, USA, [4]Department of Medicine, University of California San Francisco, San Francisco, California, USA, [5]Division of General Internal Medicine, Memorial Sloan Kettering Cancer Center, New York, New York, USA, and [6]Medical Service, Veterans Affairs (VA) Maryland Health Care System, Baltimore, Maryland, USA

Greater understanding of clinical decision thresholds may improve inappropriate testing and treatment of urinary tract infection (UTI). We used a survey of clinicians to examine UTI decision thresholds. Although overestimates of UTI occurred, testing and treatment thresholds were generally rational, were lower than previously reported, and differed by type of clinician.

Unnecessary antibiotic treatment for suspected urinary tract infection (UTI) is common [1]. Efforts to reduce unnecessary antibiotic treatment for UTI include limiting urine culture testing to appropriate patient presentations, in which UTI is reasonably likely [2]. Understanding how and when clinicians decide to test for and prescribe inappropriate antibiotics for UTI can identify opportunities for stewardship. The diagnosis of UTI requires dysuria, urinary frequency or urgency, or suprapubic or flank pain [1].

Clinical decision making using a threshold model was described >40 years ago [3]. The threshold model describes a probability of disease at which a clinician will test for the disease, and a higher probability at which a clinician will treat the disease. Below the testing threshold, neither testing nor treatment is indicated. Above the treatment threshold, only treatment is indicated as the clinician is confident the patient has the disease. The decision to test for or treat disease depends on the patient's likelihood of having the disease and the clinician's threshold for action. Decisions to test or treat may be informed by the expectation of benefit from testing or treatment, the risk of harm, and the preferences and attitudes of the clinician [3, 4]. A patient with probability of UTI below the testing threshold should not undergo urine culturing.

There is limited research on testing and treatment thresholds. Studies have calculated decision thresholds for various illnesses by giving a scenario and a predetermined probability of disease to a group of clinicians and asking how many would test or treat at a given numerical likelihood [5–7]. No studies have determined thresholds using clinician-estimated probabilities for a clinical case. Testing thresholds have rarely been examined, and there is no literature that has evaluated testing thresholds for UTI. One study reported a UTI treatment threshold of 64%, defining treatment threshold as the probability of disease at which half of primary care clinicians would treat for UTI with antibiotics. However, the vignette in this study assessed treatment only after a test result and did not include an option to not test for UTI. In addition, no literature has examined differences in thresholds associated with clinician characteristics [6]. We examined clinician test and treatment thresholds in a real-life clinical scenario of low-likelihood UTI among primary care clinicians. We compared testing and treatment thresholds between clinicians based on training, years in practice, study site, medical specialty, and numeracy.

METHODS

We used a survey that was administered between 1 June 2018 and 26 November 2019, to primary care clinicians in 8 US states. Institutional review board approval was obtained at each of 3 coordinating sites [8]. The survey asked clinicians to estimate the probability of UTI in a 65-year-old man with foul-smelling urine and no pain or difficulty with urination where a urine dipstick shows only trace blood. Practitioners were asked whether they would order a urine culture based on this scenario, the probability of disease with a positive urine culture, and whether they would treat the patient with antibiotics. Demographic information was collected from clinicians who completed the survey.

Thresholds were derived from the survey data at the probability estimate when >50% of surveyed practitioners chose that they would order the test or treatment (eg, cross a threshold), consistent with previously published literature on test and treatment thresholds [5]. To estimate the disease probability threshold associated with a 50% probability of being likely to test for UTI, we used a method similar to that used by Ebell et al [5]. Briefly, we fit a logistic regression model with dependent variable equal to the binary variable (likely to test), and

Received 16 June 2023; editorial decision 19 August 2023; accepted 30 August 2023; published online 31 August 2023

Correspondence: Andrea Harris, MS, University of Maryland School of Medicine, 655 W Baltimore St, Baltimore, MD 21201 (harris.andrea.w@gmail.com).

Open Forum Infectious Diseases®

© The Author(s) 2023. Published by Oxford University Press on behalf of Infectious Diseases Society of America. This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs licence (https://creativecommons.org/licenses/by-nc-nd/4.0/), which permits non-commercial reproduction and distribution of the work, in any medium, provided the original work is not altered or transformed in any way, and that the work is properly cited. For commercial re-use, please contact journals.permissions@oup.com

https://doi.org/10.1093/ofid/ofad455

predictor equal to the pretest probability of disease. We then inverted the resulting equation to determine the pretest threshold probability corresponding to a 50% probability of being likely to test. The confidence intervals (CIs) for this threshold were found by using bootstrap samples. We performed this analysis for the entire sample for both testing and treatment thresholds, and separately for various subgroups of clinicians.

Institutional review board approval was obtained at each of 3 participating sites (Baltimore, Maryland; San Antonio, Texas; and Portland, Oregon). Verbal informed consent with a waiver of documentation was approved at all sites, and consent was obtained from all participants.

RESULTS

In total, 585 of 723 physicians, nurse practitioners (NPs), and physician assistants (PAs) responded to the survey, of whom 551 answered all questions, for a response rate of 76.2%.

Testing Thresholds

Overall, 338 clinicians (61%) indicated that they would test with a urine culture in this scenario. Based on clinician estimates of the probability of UTI, the probability at which ≥50% of clinicians would order a urine culture was 19.1% chance of UTI (95% CI, 15.4%–22.7%) (Table 1).

There were significant differences in testing threshold by years in practice and training. Clinicians in practice longer had lower thresholds for testing ($P = .03$): physicians practicing <3 years had an average testing threshold of 24.3% (95% CI, 18.0%–30.3%); those practicing 3–9 years, 13.3% (6.8%–19.5%); and those practicing ≥10 years, 13.6% (4.9%–20.8%). Both NPs/PAs and attending physicians had lower thresholds for testing than resident physicians ($P < .001$). The testing threshold was 2.5% (95% CI, .0%–9.4%) for NP/PAs, 24.9% (20.3%–29.4%) for resident physicians, and 14.4% (7.9%–20.9%) for attending physicians.

Treatment Thresholds

Following a positive urine culture, 392 clinicians (71%) indicated that they would treat for UTI with antibiotics. The overall treatment threshold following positive urine culture was estimated to be a 42.3% chance of disease (95% CI, 37.7%–46.9%) (Table 1).

Clinicians in practice longer had lower thresholds for treatment with antibiotics ($P = .007$); physicians practicing <3, 3–9, or ≥10 years had treatment thresholds of 49.4% (95% CI, 42.8%–56.0%), 38.7% (30.5%–46.8%), and 31.0% (19.9%–42.1%), respectively. Both NPs/PAs and attending physicians had lower thresholds for treatment than resident physicians

Table 1. Testing and Treatment Thresholds and Likelihood of Testing and Treating for Urinary Tract Infection, by Respondent Characteristics

Respondent Characteristic	Testing Threshold (95% CI), %[a]	*P* Value[b]	No. (%) Likely to Test	*P* Value[c]	Treatment Threshold (95% CI), %[d]	*P* Value[b]	No. (%) Likely to Treat	*P* Value[b]
Overall (N = 553)	19.1 (15.4–22.7)	…	338 (61)	…	42.3 (37.7–46.9)	…	392 (71)	
Time in practice, y								
<3 (n = 240)	24.3 (18.0–30.3)	.03	137 (58)	.19	49.4 (42.8–56.0)	.007	153 (64)	.0009
3–9 (n = 160)	13.3 (6.8–19.5)		104 (65)		38.7 (30.5–46.8)		116 (73)	
≥10 (n = 145)	13.6 (4.9–20.8)		95 (66)		31.0 (19.9–42.1)		119 (82)	
Training								
NP/PA (n = 61)	2.5 (0–9.4)	<.001	50 (82)	.001	22.4 (0–48.2)	<.001	55 (90)	<.0001
Resident physician (n = 290)	24.9 (20.3–29.4)		163 (57)		48.6 (43.8–55.4)		180 (63)	
Attending physician (n = 202)	14.4 (7.9–20.9)		125 (62)		32.9 (25.4–40.4)		157 (78)	
Site								
Pacific NW (n = 112)	22.4 (14.5–30.4)	.28	50 (45)	<.001	37.2 (27.6–46.9)	.46	73 (65)	.153
Mid-Atlantic (n = 305)	17.6 (10.5–24.7)		190 (63)		44.7 (38.7–50.7)		215 (71)	
South Texas (n = 136)	11.3 (3.7–18.8)		98 (73)		43.9 (33.4–54.4)		104 (76)	
Practice type								
Family medicine (n = 138)	12.9 (3.7–22.1)	.17	97 (70)	.006	36.0 (24.7–47.3)	.13	118 (86)	<.0001
Internal medicine (n = 315)	23.2 (17.7–28.7)		171 (55)		46.8 (41.0–52.6)		194 (62)	
Other (n = 35)	20.8 (9.4–32.4)		19 (54)		34.9 (16.9–53.4)		23 (66)	
Numeracy score (range, 0–3)								
Low (0–1) (n = 64)	13.6 (1.8–25.4)	.28	42 (67)	.03	31.3 (14.5–48.1)	.19	50 (78)	.030
Medium (2) (n = 172)	13.4 (3.7–23.2)		114 (66)		40.5 (30.8–50.1)		131 (76)	
High (3) (n = 307)	20.8 (16.1–25.0)		173 (57)		45.2 (2.9–39.6)		202 (66)	

Abbreviations: CI, confidence interval; NP, nurse practitioner; NW, Northwest; PA, physician assistant.

[a]Probability at which 50% of respondents would test.

[b]*P* values based on bootstrap standard errors.

[c]P values based on χ^2 test.

[d]Probability at which 50% of respondents would treat.

($P < .001$); the treatment thresholds for NP/PAs, resident physicians, and attending physicians, respectively, were 22.4% (95% CI, 0%–48.2%), 48.6% (43.8%–55.4%), and 32.9% (25.4%–40.4%).

DISCUSSION

Across a population of primary care clinicians in 8 US states, we found that clinicians on average would test with a 19% chance of UTI and treat with a 42% chance of UTI. Variation in thresholds was noted by type of clinician, years in practice, and geographic location.

We found support for the threshold approach to clinical decision making, with clinicians ordering a urine culture with a lower chance of disease (19%) than the chance of disease at which they would treat (42%). There is no previous data on testing thresholds for UTI. The treatment threshold that we found (42%) is lower than the previously reported threshold of 64% [5]. This figure comes from the single previous study of UTI thresholds [5]. Their higher estimate may be due to their method of providing a case with pregenerated numerical probabilities instead of requiring clinicians to make estimates. It remains unclear whether clinicians actively assign a probability of disease and then make decisions based on probability or decide based on gestalt for a case and then estimate the probability after the decision.

The treatment thresholds reported by average participants in our study are in line with guidance for treating UTI [9]. However, it is notable that this scenario of possible UTI described a clinical scenario of asymptomatic bacteriuria (ASB) for which antibiotic treatment is inappropriate. Overall, 71% of clinicians would inappropriately prescribe antibiotics in this scenario, implying that while clinicians have appropriate thresholds for UTI, their initial estimate of probability of UTI in this case was far too high. This is likely related to inadequate understanding of the definition of UTI: the patient in this scenario did not have any symptoms that would have led to a diagnosis of UTI, nor any clinical background to indicate testing for ASB. Recognition of true UTI symptoms, rather than commonly associated findings such as urine odor, is important for reducing inappropriate treatment of ASB.

We found significant variation in testing and treatment thresholds related to years in practice. We could not determine whether this was due to time in practice versus practices being different at the time of training. The diagnosis of ASB is relatively new, and more recent graduates are more familiar with it. There was also significant variation between types of practitioners, with NP/PAs having notably lower thresholds for both testing and treatment (and being more likely to treat). This may reflect differences in education and indicates a potential area for improvement. Advanced practice providers may also face pressure to operate more conservatively so as not to miss a significant finding that physicians could argue they didn't test for because of professional judgment.

This study had limitations, including using a single scenario of ASB to assess testing and treatment thresholds for UTI. However, given the high estimates of probability of UTI, it appears that most clinicians perceived the scenario as UTI, allowing for the calculation of testing and treatment thresholds. The study asked clinicians to assign probabilities of disease while simultaneously deciding whether to treat. Respondents may be reporting a probability that matches their decision to treat, rather than first assigning a probability of disease.

In conclusion, we assessed primary care clinicians' testing and treatment thresholds for UTI. A large proportion of clinicians indicated that they would inappropriately treat this case of ASB with antibiotics. Treatment was associated with overly high estimates of UTI, while thresholds for testing and treatment appeared rational. Better clinician understanding of the initial likelihood of UTI and consideration for decision thresholds for testing and treatment is key for improving antibiotic overuse.

Acknowledgments

Financial support. This work was supported by the National Library of Medicine, National Institutes of Health (New Innovator Award DP2LM012890 to D. J. M.).

Potential conflicts of interest. D. J. M. reports funding from the Centers for Disease Control and Prevention; the Health Services Research and Development Services, Department of Veterans Affairs; and the Agency for Healthcare Research and Quality, all unrelated to the current work. All other authors report no potential conflicts.

References

1. Nicolle LE, Gupta K, Bradley SF, et al. Clinical practice guideline for the management of asymptomatic bacteriuria: 2019 update by the Infectious Diseases Society of America. Clin Infect Dis **2019**; 68:e83–e110.
2. Claeys KC, Blanco N, Morgan DJ, Leekha S, Sullivan KV. Advances and challenges in the diagnosis and treatment of urinary tract infections: the need for diagnostic stewardship. Curr Infect Dis Rep **2019**; 21:11.
3. Pauker SG, Kassirer JP. The threshold approach to clinical decision making. N Engl J Med **1980**; 302:1109–17.
4. Scherer LD, Caverly TJ, Burke J, et al. Development of the medical maximizer-minimizer scale. Health Psychol **2016**; 35:1276–87.
5. Ebell MH, Locatelli I, Senn N. A novel approach to the determination of clinical decision thresholds. Evid Based Med **2015**; 20:41–7.
6. Ebell MH, Locatelli I, Mueller Y, Senn N, Morgan K. Diagnosis and treatment of community-acquired pneumonia in patients with acute cough: a quantitative study of decision thresholds in primary care. Br J Gen Pract J R Coll Gen Pract **2018**; 68: e765–74.
7. Alencastro LD, Locatelli I, Clair C, Ebell MH, Senn N. Correlation of clinical decision-making with probability of disease: a web-based study among general practitioners. PLoS One **2020**; 15:e0241210.
8. Morgan DJ, Pineles L, Owczarzak J, et al. Accuracy of practitioner estimates of probability of diagnosis before and after testing. JAMA Intern Med **2021**; 181: 747–55.
9. Saint S, Scholes D, Fihn SD, Farrell RG, Stamm WE. The effectiveness of a clinical practice guideline for the management of presumed uncomplicated urinary tract infection in women. Am J Med **1999**; 106:636–41.