Title
Clinician Testing and Treatment Thresholds for Management of Urinary Tract Infection

Journal
Open Forum Infectious Diseases, 10(9)

ISSN
2328-8957

Authors
Harris, Andrea
Pineles, Lisa
Baghdadiv, Jonathan D
et al.

Publication Date
2023-09-01

DOI
10.1093/ofid/ofad455

Peer reviewed

Open Forum Infectious Diseases

BRIEF REPORT

Clinician testing and treatment thresholds for management of urinary tract infection

Andrea Harris, MS[1], Lisa Pineles, MA[2], Jonathan D. Baghdadi, MD, PhD[2], Larry Magder, PhD[2], Gurpreet Dhaliwal, MD[4,5], Deborah Korenstein, MD[6], Anthony D. Harris, MD, MPH[2,3], Daniel J. Morgan, MD, MS[2,3]

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

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, lower than previously reported and differed by type of clinician.

INTRODUCTION

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

Corresponding author: Andrea Harris, 655 W. Baltimore St, Baltimore, MD 21201. Email: harris.andrea.w@gmail.com

DOI: 10.1093/ofid/ofad455

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 over 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 only assessed treatment after a test result and did not include an option to not test for UTI. Additionally, 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 amongst 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 June 1, 2018, and November 26, 2019, to primary care clinicians in 8 U.S. 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 and 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 more than 50% of surveyed practitioners chose that they would order the test or treatment (e.g., 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 Ebell et al.[5] Briefly, we fit a logistic regression model with dependent variable equal to the binary variable (likely to test), and predictor equal to the pre-test 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. Confidence intervals 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.

RESULTS

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

Testing thresholds

Overall, 338 clinicians (61%) indicated 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% confidence interval [CI]: 15.4%, 22.7%; **Table**).

There were significant differences in testing threshold by years in practice and training. Clinicians in practice longer had lower thresholds for testing ($p = 0.026$): 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% (95% CI: 6.8%, 19.5%); and those practicing 10+ years 13.6% (95% CI: 4.9%, 20.8%). NPs/PAs and attending physicians had lower thresholds for testing than resident physicians ($p = 0.0002$): The testing threshold for NP/PAs was 2.5% (95% CI: 0.0%, 9.4%); for resident physicians was 24.9% (95% CI: 20.3%, 29.4%); and for attending physicians was 14.4% (95% CI: 7.9%, 20.9%).

Treatment thresholds

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

Clinicians in practice longer had a lower threshold for treatment with antibiotics ($p = 0.0073$). Physicians practicing <3 years had a treatment threshold of 49.4% (95% CI: 42.8%, 56.0%); those practicing 3-9 years had a threshold of 38.7% (95% CI: 30.5%, 46.8%) and those practicing 10+ years had a testing threshold of 31.0% (95% CI: 19.9%, 42.1%). NPs/PAs and attending physicians had lower thresholds for treatment than resident physicians ($p = 0.0002$): the treatment threshold for NP/PAs was 22.4% (95% CI: 0%, 48.2%), for resident physicians

was 48.6% (95% CI: 43.8%, 55.4%), and for attending physicians was 32.9% (95% CI: 25.4%, 40.4%).

DISCUSSION

Across a population of primary care clinicians in 8 US states, we found 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 geographical 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 we found (42%) is lower than the previously reported threshold of 64%.[5] This figure comes from the single previous study of UTI thresholds.. Their higher estimate may be due to their methodology of providing a case with pre-generated 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 if this was due to time in practice vs. practices being different at 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 to not 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

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 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.

Acknowledgements:

This work was supported by National Institutes of Health National Library of Medicine New Innovator Award to DJM [DP2LM012890]. DJM reports funding from the Centers for Disease Control and Prevention, Department of Veterans Affairs Health Services Research and Development and Agency for Healthcare Research and Quality unrelated to this project.

Potential Conflicts of Interest

The authors declare no conflicts of interest.

Patient consent statement

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.

Table: Testing and treatment thresholds and likelihood of testing and treating for UTI, by respondent characteristics

Clinician Characteristic		Testing threshold* (95% CI)	P-value[1]	Number (%) likely to test	P-value[2]	Treatment threshold** (95% CI)	P-value[1]	Number (%) likely to treat	P-value[2]
Overall	n=553	19.1% (15.4, 22.7)		338 (61%)		42.3% (37.7, 46.9)		392 (71%)	
Years in Practice	<3 (n=240)	24.3% (18.0, 30.3)	0.026	137 (58%)	0.19	49.4% (42.8, 56.0)		153 (64%)	
	3-9 (n=160)	13.3% (6.8, 19.5)		104 (65%)		38.7% (30.5, 46.8)	0.0073	116 (73%)	0.0009
	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)	0.0002	50 (82%)	0.0011	22.4% (0, 48.2)		55 (90%)	
	Resident (n=290)	24.9% (20.3, 29.4)		163 (57%)		48.6% (43.8, 55.4)	0.0004	180 (63%)	<0.0001
	Attending (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)	0.28	50 (45%)	<0.0001	37.2% (27.6, 46.9)		73 (65%)	
	Mid-Atlantic (n=305)	17.6% (10.5, 24.7)		190 (63%)		44.7% (38.7, 50.7)	0.46	215 (71%)	0.153
	South Texas (n=136)	11.3% (3.7, 18.8)		98 (73%)		43.9% (33.4, 54.4)		104 (76%)	
Practice	Fam. Med (n=138)	12.9% (3.7, 22.1)	0.17	97 (70%)	0.0065	36.0% (24.7, 47.3)	0.13	118 (86%)	<0.0001

Type	Int. Med. (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)	0.28	42 (67%)	0.030	31.3% (14.5, 48.1)		50 (78%)	
	Medium (2) (n=172)	13.4% (3.7,23.2)		114 (66%)		40.5% (30.8, 50.1)	0.19	131 (76%)	0.030
	High (3) (n=307)	20.8% (16.1, 25.0)		173 (57%)		45.2% (2.9, 39.6)		202 (66%)	

[1] P-value based on bootstrap standard errors

[2] P-value based on a Chi-Square test

* Probability at which 50% would test

**Probability at which 50% would treat

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 Americaa. *Clin Infect Dis*. Published online March 21, 2019. doi:10.1093/cid/ciy1121
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(4):11. doi:10.1007/s11908-019-0668-7
3. Pauker SG, Kassirer JP. The Threshold Approach to Clinical Decision Making. *N Engl J Med*. 1980;302(20):1109-1117. doi:10.1056/NEJM198005153022003
4. Scherer LD, Caverly TJ, Burke J, et al. Development of the Medical Maximizer-Minimizer Scale. *Health Psychol*. 2016;35:1276-1287. doi:10.1037/hea0000417
5. Ebell MH, Locatelli I, Senn N. A novel approach to the determination of clinical decision thresholds. *Evid Based Med*. 2015;20(2):41-47. doi:10.1136/ebmed-2014-110140
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(676):e765-e774. doi:10.3399/bjgp18X699545
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(10):e0241210. doi:10.1371/journal.pone.0241210
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(6):747-755. doi:10.1001/jamainternmed.2021.0269
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(6):636-641. doi:10.1016/S0002-9343(99)00122-9