

Evaluation of the diagnostic performance of the urine dipstick test for the detection of urinary tract infections in patients treated in Kenyan hospitals

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Abstract

Introduction. Culture is the gold-standard diagnosis for urinary tract infections (UTIs). However, most hospitals in low-resource countries lack adequately equipped laboratories and relevant expertise to perform culture and, therefore, rely heavily on dipstick tests for UTI diagnosis.

Research gap. In many Kenyan hospitals, routine evaluations are rarely done to assess the accuracy of popular screening tests such as the dipstick test. As such, there is a substantial risk of misdiagnosis emanating from inaccuracy in proxy screening tests. This may result in misuse, under-use or over-use of antimicrobials.

Aim. The present study aimed to assess the accuracy of the urine dipstick test as a proxy for the diagnosis of UTIs in selected Kenyan hospitals.

Methods. A hospital-based cross-sectional method was used. The utility of dipstick in the diagnosis of UTIs was assessed using midstream urine against culture as the gold standard.

Results. The dipstick test predicted 1416 positive UTIs, but only 1027 were confirmed positive by culture, translating to a prevalence of 54.1%. The sensitivity of the dipstick test was better when leucocytes and nitrite tests were combined (63.1%) than when the two tests were separate (62.6 and 50.7%, respectively). Similarly, the two tests combined had a better positive predictive value (87.0%) than either test alone. The nitrite test had the best specificity (89.8%) and negative predictive value (97.4%) than leucocytes esterase (L.E) or both tests combined. In addition, sensitivity in samples from inpatients (69.2%) was higher than from outpatients (62.7%). Furthermore, the dipstick test had a better sensitivity and positive predictive value among female (66.0 and 88.6%) than male patients (44.3 and 73.9%). Among the various patient age groups, the dipstick test's sensitivity and positive predictive value were exceptionally high in patients ≥ 75 years old (87.5 and 93.3%).

Conclusion. Discrepancies in prevalence from the urine dipstick test and culture, the gold standard, indicate dipstick test inadequacy for accurate UTI diagnosis. The finding also demonstrates the need for urine culture for accurate UTI diagnosis. However, considering it is not always possible to perform a culture, especially in low-resource settings, future studies are needed to combine specific UTI symptoms and dipstick results to assess possible increases in the test's sensitivity. There is also a need to develop readily available and affordable algorithms that can detect UTIs where culture is not available.

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Keywords: dipstick test; urine culture; urinary tract infections; nitrites; leucocytes esterase.

Abbreviations: LMIC, low- and middle-income country; NPV, negative predictive value; PPV, positive predictive value; RBC, red blood cell; UTI, urinary tract infection; WBC, white blood cell.

A supplementary material file is available with the online version of this article.

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DATA SUMMARY

Data regarding the nitrite test, leucocyte esterase, blood and white cell count were entered into the Epicollect data management tool. An Excel sheet was generated from Epicollect (uploaded as supplementary materials, available in the online version of this article) and exported to SPSS to calculate prevalence, sensitivity, specificity, and positive and negative values using urine culture results as the gold standards. Graphs were generated with Microsoft Excel.

INTRODUCTION

Urinary tract infections (UTIs) are among the most common community-acquired bacterial infections globally [1]. While most UTIs are associated with mild and brief morbidity characterized by dysuria, lower abdominal pain and frequent urination, these symptoms are a nuisance to many. Furthermore, if not treated promptly, the disease can progress to cause a more severe infection in the kidney. Despite a timely and accurate diagnosis of UTI being the baseline for disease management, most healthcare facilities in low- and middle-income countries (LMICs) lack the capacity necessary to conduct culture, the gold standard test [2]. Therefore, treatment of UTIs in these countries is often based on symptoms and results of urine dipstick tests [3]. The urine dipstick method is easy and inexpensive to perform. It produces results quickly (approximately 5 min), making it popular in many hospitals in Kenya, as in many LMICs. Unfortunately, most healthcare facilities in Kenya do not have a microbiology laboratory, nor do they have the capacity to perform urine cultures. The logistics of setting up such facilities, especially in grass root healthcare facilities that are often the first contact point for many patients, are problematic due to a lack of infrastructure capacity. The technical aspect of test performance, the complexity of analysis and the long turnaround time mean that results are rarely available in a timeframe to affect patient management decisions. Despite these considerable technicalities and challenges in culture performance for accurate diagnosis, the continued use and overreliance on dipstick screening remains a significant concern due to its inability to accurately detect and discriminate active UTI cases.

In dipstick diagnostic tests for UTIs, leucocyte esterase (L.E) and nitrites (N) are the essential test parameters [4]. Leucocyte esterase enzymes are released by white blood cells (WBCs) and are an excellent quantitative measure of WBCs in the urinary tract [5]. On the other hand, nitrites (N) detect the presence of bacteria that can convert nitrates to nitrites, especially those belonging to the family *Enterobacteriaceae* [6]. In addition to leucocyte esterase and nitrites, other parameters such as red blood cells (RBCs), proteins and pH can reinforce the UTI dipstick test [5]. For instance, a pH of ≥ 7.2 , though not conclusive, could indicate the presence of urease-producing organisms such as *Klebsiella* and *Proteus* spp. [7]. The presence of urease enzymes in these bacteria leads to ammonia production, which leads to pH elevation [8]. Urine pH depends on diet and, therefore, is not as helpful in the absence of other tests such as arterial blood gas (ABG) and metabolic panels. The presence of blood in the urine may also suggest a bleeding urinary tract due to an active UTI. Additionally, several other factors, including genital and urinary malignancy, kidney stones, nephritic syndrome, huge muscle breakdown (rhabdomyolysis) [5], and contamination with semen and menses in women, may lead to a positive RBC test. Positive protein urine may also suggest post-renal proteinuria, with more than 60% of such cases being positive for UTIs. The present study therefore sought to evaluate the utility of urine dipstick tests in UTI diagnosis compared to the standard culture method.

METHODOLOGY

Study overview

The present study was part of the large 'HATUA Consortium'. HATUA is an East African consortium that used a mixed methods research design to holistically determine drivers of antimicrobial resistance using UTI as the flag disease. This 5 year study was conducted between 2018 and 2022 in Kenya, Uganda and Tanzania (<https://gtr.ukri.org/projects?ref=MR%2FS004785%2F1>). A subset of the study's objectives was to evaluate the diagnostic performance of the urine dipstick test as a proxy for UTI diagnosis using culture as the gold standard.

Study design

To evaluate the accuracy of the urine dipstick test for UTI diagnosis, a cross-sectional hospital-based study design was used to recruit 1898 patients using a purposive sampling approach.

Participant recruitment

Participants presenting with abdominal pain, burning sensation, discharge, frequent urination and/or fever symptoms were recruited for the study by doctors and clinical officers at various healthcare facilities in Kenya. Potential participants who failed to meet the empiric UTI diagnosis criteria determined by the study doctor and who did not consent were excluded.

Study site

The study was implemented in eight healthcare facilities in the Central, Eastern and Nairobi regions of Kenya (Fig. 1).

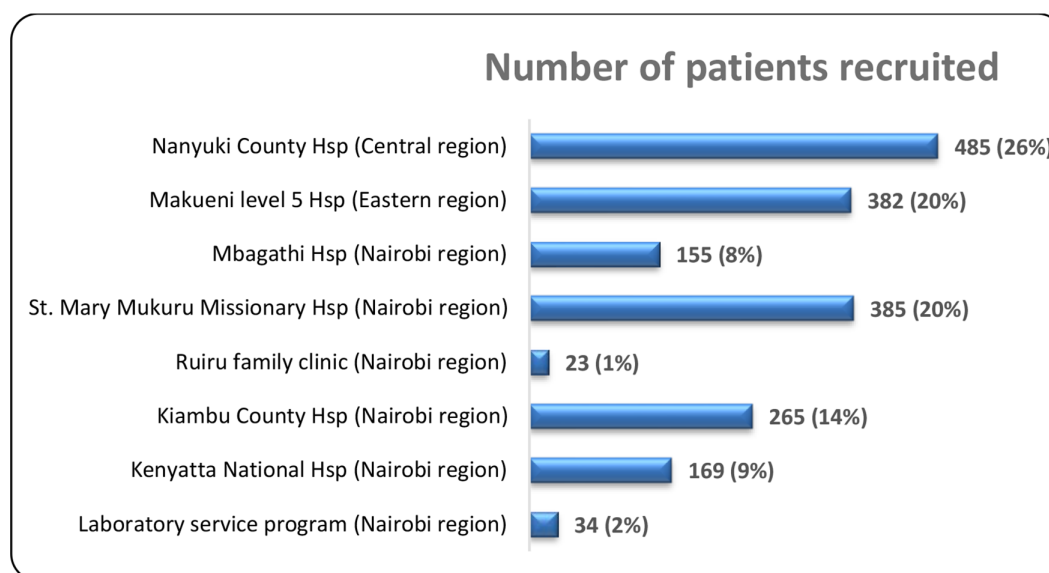


Fig. 1. Details of patients recruited for the present study. The HATUA study Kenya chapter had three sampling regions: former Nairobi, Central region, and Eastern province. The study recruited 1,898 patients in eight healthcare facilities within the three regions. The Nairobi region had the highest number of patients recruited (54%), followed by Central (26%) and Eastern (20%).

Sample processing

Approximately 10 ml of a midstream urine sample was collected in a sterile container and processed within 10 min at the study sites. A urine culture was done before dipping the urine stick to prevent contamination. The strip (ACON Laboratories) was dipped into urine and immediately removed, followed by a wait period of 1–2 min (according to the manufacturer's instructions). Although conventionally RBCs are not considered in the UTI dipstick test, we screened for them to assess their usability. L.E and RBCs were recorded as negative, trace, 1+ (small), 2+ (moderate) or 3+ (large), while nitrites (N) were recorded as negative or positive. A test was considered positive when the specimen presented N or L.E activity greater than or equal to a trace amount of leucocytes.

All urine samples, including those with negative dipstick test screening, were cultured on cysteine lactose electrolyte-deficient (CLED), blood agar (BA) and mannitol salt ager (MSA) (Oxoid) using the quadrant culture method and incubated at 37 °C for 18–24 h. Testing all samples collected was crucial in detecting UTI cases that may have been missed by dipstick test screening. A monoculture growth with a colony count of $\geq 10^4$ c.f.u. ml⁻¹ was treated as a confirmed positive UTI case, while a culture with more than one colony type and growth of $< 10^4$ c.f.u. ml⁻¹ was considered a contaminant [9]. Contaminated cultures or those without microbial growth were classified as negative for UTI.

Ethics statement

Prior to the study's commencement, ethical approval was sought from the Kenya Medical Research Institute Scientific Ethical Review Committee (No. KEMRI/SERU/CMR/P00112/3865), National Commission for Science, Technology and Innovation (NACOSTI) and Health facilities, included in the study. The study and its intended objectives were introduced to the participants at the study site, and written consent was obtained voluntarily. Assent and consent were obtained for participants aged 13–17 years, while only consent was obtained for the guardians of participants younger than 13 years. Married participants under the age of 18 years, were deemed to be minor adults, capable of consenting.

RESULTS

Dipstick and culture results

This study recruited 1707 (89.9%) adult outpatients, 123 (6.5%) adult inpatients, 47 (2.5%) child outpatients and 21 (1.1%) child inpatients. The minimum age of the patients was 1 year, the maximum was 102 years, and the mean was 30.7 years with a median of 28 years. The study analysed 1898 urine samples from in- and outpatients of all ages. Nitrite and leucocyte tests together predicted UTI positivity in 1416 of 1898 samples. However, culture confirmed 1027 of 1898 suspected UTI cases, translating to a test population prevalence of 54.1% (Table 1). A total of 133 (27.6%) predicted to be UTI-negative by dipstick test were positive by culture, while 36.9% predicted to be positive were either contaminants or showed no growth on the medium.

Table 1. Comparative analysis of the dipstick test and culture with regard to accuracy of UTI diagnosis

		UTI status by culture			Total
		Contaminants	No growth	UTI	
UTI status by dipstick	Negative	105 21.8%	244 50.6%	133 27.6%	482
	Positive	182 12.9%	340 24.0%	894 63.1%	
Total		287 15.1%	584 30.8%	1027 54.1%	1898

Table 1 assesses the accuracy of the dipstick screening test in detecting UTIs against the culture-based method.

Urine dipstick test sensitivity and specificity

The nitrite test had the lowest ability to accurately detect a positive UTI case (sensitivity, 50.7%). Simultaneously, the nitrite test's specificity (89.8%) was higher than that of the leucocyte esterase test (68.5%) and the combined results of the two tests (72.4%). The specificity of the dipstick test was better when leucocytes and nitrite tests were combined (63.1%) than when the two tests were separate (Fig. 2). The RBC test for UTI screening had the lowest sensitivity at 32.9%.

Positive and negative predictive value of UTI screening with the dipstick test

The nitrite test had the lowest analytical ability to detect a positive UTIs accurately, with a positive predictive value (PPV) of 19.8% (Fig. 3). However, the nitrite test had a better ability to accurately detect a true negative UTIs (97.4%) than either the leucocyte test alone (40.9%) or both tests combined (40.1%). On the other hand, the leucocyte and nitrite tests combined had an enhanced ability to accurately detect a positive UTI (87%) than either test alone. The leucocyte test had a higher PPV (84%) than the nitrite test (19.8%). The RBC test had a better PPV than the nitrite test (40.9% vs. 19.8%) and better negative predictive value (NPV) than the L.E test (49.5% vs. 40.9%).

UTI diagnosis analysis across study variables

The dipstick test based on either the nitrite or L.E test had a better sensitivity in samples from inpatients (69.2%) than from outpatients (62.7%; Table 2). However, the specificity and ability of the dipstick test to accurately predict a positive test were

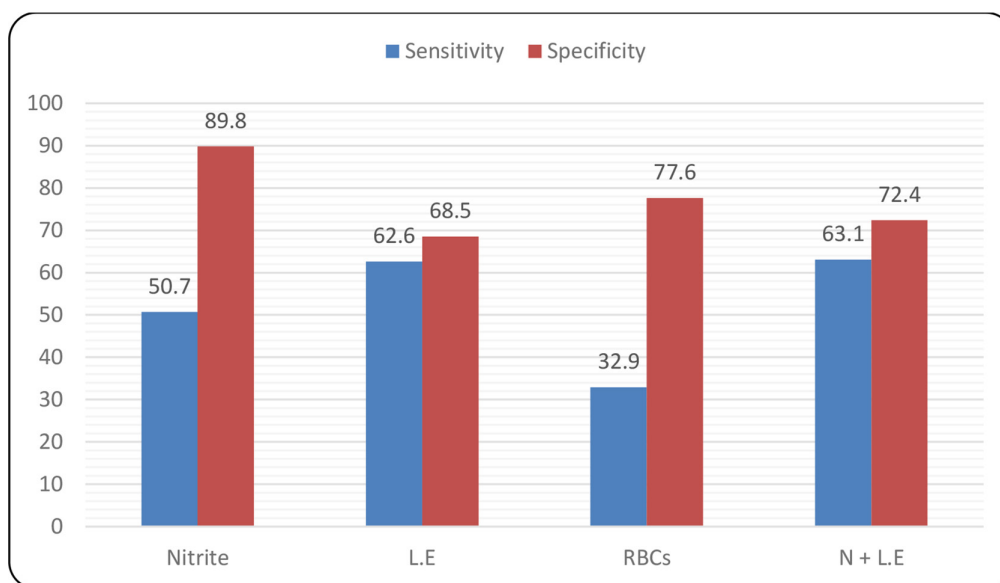


Fig. 2. Represent sensitivity and specificity scores for various dipstick test parameters vital in UTI screening. A high sensitivity score indicates that a test can accurately identify a positive case, while a high specificity score indicates that it can accurately identify a negative case.

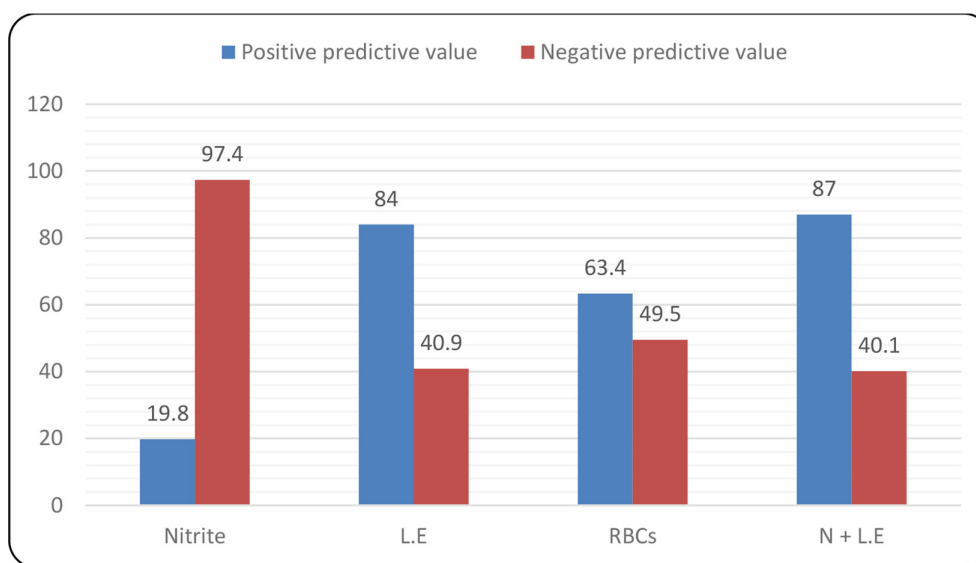


Fig. 3. Shows positive and negative predictive values for various dipstick test parameters vital in UTI screening using the dipstick test. The predictive values indicate the tests' ability to determine the true result predicted as positive or negative. A high value indicates a better ability, while a low value indicates poor ability.

Table 2. Sensitivity, specificity, and positive and negative predictive values for the dipstick test across the various study variables

Variable	N	UTI status		Sensitivity	Specificity	Positive predictive value	Negative predictive value	
		Negative	Positive					
Patient category	Inpatient	144	60	84	69.2	60.4	75	53.3
	Outpatient	1754	811	943	62.7	73.9	88.1	39.1
Patient type	Adult inpatient	123	54	69	66.3	62.8	76.8	50
	Adult outpatient	1707	796	911	62.5	74.2	88	39.4
	Child inpatient	21	6	15	90.1	50	66.7	83.3
	Child outpatient	47	15	32	70.7	50	90.6	20
Gender	Female	1550	634	916	66	67.4	88.6	33.9
	Male	348	237	111	44.3	82.2	73.9	56.5
Age group (years)	<18	79	28	51	71.9	54.5	80.4	42.9
	18–24	493	207	286	64.9	71.3	90.6	32.4
	25–34	837	401	436	60.7	72.9	86.7	38.9
	35–44	294	146	148	63.1	74.7	83.1	50.7
	45–54	96	48	48	58.6	73.1	85.4	39.6
	55–64	44	24	20	60	73.4	75	58.3
	65–74	35	12	23	74.2	100	100	33.3
	≥75	20	5	15	87.5	75	93.3	60

Table 2 shows the accuracy of the dipstick test in urinary tract infections (UTI) diagnosis across various patient variables against the gold standard, culture. Both nitrite or positive tests were used to calculate the tests' sensitivity, specificity, PPV, and NPV. Values for Sensitivity, Specificity, Positive predictive value, and Negative predictive value are expressed as percentages.

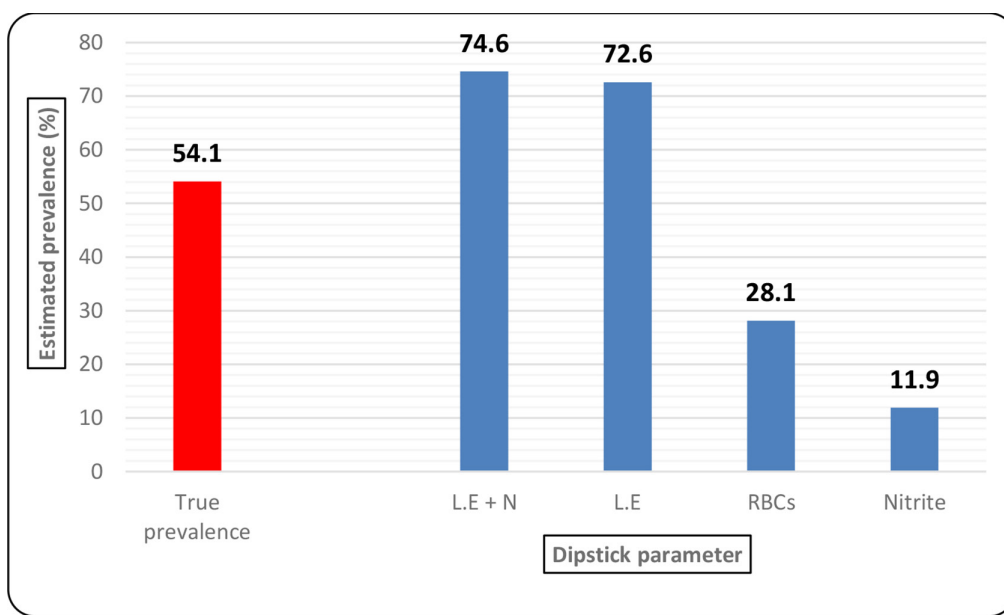


Fig. 4. Estimated prevalence with the nitrate, L.E, RBC and N+L.E tests

better in samples from outpatients (73.9 and 88.1%, respectively) compared with inpatients (60.4 and 75.0%). The dipstick test was better able to detect UTIs among child patients (inpatients at 90.1% and outpatients at 70.7%) than among adult patients (inpatients at 66.3% and outpatients at 62.5%). On the other hand, the test had a better sensitivity and PPV among female (66.0 and 88.6%) patients compared to their male counterparts (44.3 and 73.9%). However, the test specificity and NPV were better among the male (82.2 and 56.5%) than the female patients (67.4 and 33.9%). Among the various patient age groups, sensitivity and PPV of the dipstick test were exceptionally high in patients ≥ 75 years old (87.5 and 93.3%) and those aged 65–74 years (74.2 and 100%). However, despite a specificity of 100% among those aged 65–74 years, the dipstick test had a low ability to accurately detect a true negative (33.3%) in this age group. Table 2 details the dipstick test's sensitivity, specificity, and PPV and NPV across the various study variables.

UTI prevalence estimates based on dipstick test parameters

When either L.E or nitrite positivity was used to screen for UTIs, a total of 1416 tests were deemed positive, translating to an estimated prevalence of 74.6%, which is higher than the 54.1% true prevalence. The L.E test (72.6%) also overestimated the prevalence. Nitrite (11.9%) and RBC test (28.1%) prevalence were less than the actual prevalence (Fig. 4).

DISCUSSION

Whereas the dipstick test is a readily available and cheap proxy test for UTI diagnosis, variability raises concerns about its accuracy in UTI diagnosis. For instance, the present study's dipstick sensitivity and specificity of 63.1 and 72.4% differ from the 51 and 83% reported by Bhansali [10] in a similar study in India [10]. Similarly, positive (65%) and negative (73%) predictive values in Bhansali's (2020) study also differ from the 87.0 and 40.1% recorded in our study. The variability in the dipstick UTI screening test can be caused by the patient selection criteria, urine type and time of sample collection, the experience of the lab staff, and the time taken to read the results [11].

The nitrite test has also shown variability across studies. According to Ballazreg *et al.*, the nitrite test had a sensitivity of 48% and specificity of 95%, which varies from 50.9 and 89.8% in the present study [12]. In the present study, the nitrite test had the lowest sensitivity compared to the leucocyte esterase (L.E) (50.7% vs. 62.6%) test and both tests combined (50.7% vs. 63.1%). In addition, the nitrite test also had the lowest PPV (19.8%), which mirrored the findings of Ballazreg's study. Gram-positive bacteria do not produce nitrite reductase enzyme, making the nitrite test unreliable in detecting UTIs caused by these bacteria. Furthermore, the decreased excretion of nitrites in urine lowers pH, which can also cause a low sensitivity for the nitrite test, which explains the present study's findings [13]. The sensitivity of the nitrite test may also be impacted by the time of sample collection. The conversion of nitrate to nitrite (nitrification) requires time (at least 4 h) and therefore a midstream sample collected during the first void in the morning is likely to yield a better sensitivity [14]. Therefore, this could also explain the recorded low sensitivity of the nitrite test, considering the present study did not have a standard sample

collection time. The nitrite test's low sensitivity shows that this test alone is insufficient in screening for possible UTIs. By contrast, the nitrite test has been shown to have better specificity and NPVs, a finding reflected in the current study (89.8 and 97.4%) [11, 12]. These results indicate that the nitrite test is a better parameter detecting true negative UTIs caused by Gram-negative bacteria in the absence of a culture test.

Often, the L.E test has a better sensitivity than the nitrite test. The L.E sensitivity of 57.6% reported by Prah *et al.* [15], 92% by Suresh *et al.* [16] and 62.7% by Mohanna *et al.* [17] were all higher than the nitrite test, which is similar to the present study [15–17]. Most infections elicit an immune response and production of WBCs, which could explain why leucocyte esterase was a better UTI predictor. Nonetheless, nitrite and L.E tests combined were a better UTI predictor, with the highest sensitivity and PPV than either of the separate tests. The relatively low sensitivity of the L.E test may be attributed to factors such as low bacterial counts in urine, elevated specific gravity and glycosuria [18].

Dipstick test results have also been shown to vary in the different study populations. For instance, in the elderly population, the dipstick test is deemed unreliable and often leads to elevated false positive UTI diagnoses [19]. This could explain why the dipstick test had an over 90% PPV in patients older than 65 years. Therefore, the dipstick test can be misleading in empirical treatment of the elderly, as asymptomatic bacteria are common in these patients and may not require antibiotic treatment [20]. On the other hand, the dipstick test has been found to be comparatively more reliable in the middle-aged population [21]. This is contrary to the present study's findings, which indicates dipstick test performance was better in patients >75 years old with sensitivity and PPV of 87.5 and 93.3% compared to 63.1 and 83.1% in patients between 35 and 44 years. The dipstick test is also considered to be unreliable in UTI diagnosis in children due to sample contamination and the inability to allow adequate incubation time for nitrate-to-nitrite conversion [22]. This could explain the comparatively low specificity and NPV of 54.5 and 42.9% in participants below 18 years. Dipstick screening was more sensitive in female patients (66.0%) but more specific in males (82.2%), and similar results have been noted in previous studies [12, 23].

The blood cells test as a predictor of UTI had a sensitivity of 32.9%, lower than the 63.9% reported by Mambatta *et al.* [24] [24]. In addition, the RBC test had the lowest sensitivity at 32.9%, which indicates that RBCs represent a poor indicator of active UTIs. This confirms that the array of confounding factors of haematuria makes RBC screening in urine unreliable for UTI diagnosis.

The prevalence of UTI based on dipstick parameters (74.6%) was higher than the 54.1% observed by the gold standard. The discrepancy in prevalence was also observed when the nitrite test (11.9%) and leucocyte esterase (72.6%) were used separately. The above findings align with those of Deepthi *et al.*, who reported UTI prevalence of 21.15%, 30.76%, 36.53% and 38.46% by the nitrite, L.E, culture and dipstick tests, respectively, in a study in India [25]. Although not within the scope of the current study, over-estimation of UTI prevalence means incorrect diagnoses and unnecessary prescriptions to treat UTI-like symptoms. The dipstick test UTI misdiagnosis could be attributed to factors such as patients' antimicrobial medication at the time of sampling, urinary tract inflammation or sexually transmitted infection [26].

CONCLUSION

A combination of relevant dipstick parameters overestimate the prevalence of UTIs. This could result in unnecessary prescription and over-prescription of antimicrobials. On the other hand, using crucial urine dipstick parameters for UTI diagnoses, such as nitrite, as demonstrated in the present study, could lead to UTI underestimation and under-prescription. The findings therefore strongly imply the need to perform urine culture for accurate UTI diagnosis. Thus, further research using emerging rapid UTI culture methods is required. However, the practicality of performing culture in settings that lack the infrastructure capacity makes accurate UTI diagnosis a challenge. Similar future studies can combine specific UTI symptoms and dipstick results to assess possible increases in the test's sensitivity. There is also a need to develop readily available and affordable algorithms that can detect UTIs where culture is not available.

STRENGTH OF THE STUDY

The large sample size used in the study allows for a more precise prevalence estimate. In addition, the culture of all urine samples allows for more precise estimation and detection of possible UTIs that the dipstick test screening would otherwise miss.

STUDY LIMITATIONS

Distinguishing between a true UTI pathogen and a contaminant in a polymicrobial culture presents a major challenge and may lead to biased interpretation of the results. Despite a patient having a positive urine dipstick test, antibiotic use may suppress bacterial growth, resulting in a negative result or growth below the UTI threshold. In the present study, antimicrobial

intake at the time of recruitment was not an exclusion factor, which may have led to disparities in UTI prevalence by dipstick and culture.

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Author contributions

J.M. was part of the bacteriology investigation team and drafted the present manuscript. J.M. reviewed the initial draft and edited the paper. F.M., S.K., J.K., F.W. and F. M. were instrumental in the study's methodology formulation and investigation. O.K. led the data analysis team. J.K. was the team lead and principal co-investigator of the HUTUA Kenyan chapter. J.K., B.A., S.M., W.S., S.H.G. and M.H. were part of the team that conceptualized and wrote the study proposal. M.H. was the MRC grant recipient and HATUA principal investigator.

Conflicts of interest

The author(s) declare that there are no conflicts of interest

References

- Majumder MMI, Mahadi AR, Ahmed T, Ahmed M, Uddin MN, *et al.* Antibiotic resistance pattern of microorganisms causing urinary tract infection: a 10-year comparative analysis in a tertiary care hospital of Bangladesh. *Antimicrob Resist Infect Control* 2022;11:156.
- Dacombe R, Bates I, Bhardwaj M, Wallis S, Pulford J. Fleming fund: supporting surveillance capacity for antimicrobial resistance an analysis of approaches to laboratory capacity strengthening for drug resistant infections in low and middle income countries; (n.d.)
- Murgia *Let al.* Management of urinary tract infections: problems and possible solutions. In: *Urinary Tract Infection - The Result of the Strength of the Pathogen, or the Weakness of the Host*. 2017.
- Fernandes DJ, D. JM, Castolino DN. Utility of dipstick test (nitrite and leukocyte esterase) and microscopic analysis of urine when compared to culture in the diagnosis of urinary tract infection in children. *Int J Contemp Pediatr* 2017;5:156.
- Fan S-L, Bai S. Urinalysis. In: *Contemporary Practice in Clinical Chemistry*. 2020. pp. 665–680.
- Dadzie I, Quansah E, Puopelle Dakorah M, Abiade V, Takyi-Amuah E, *et al.* The effectiveness of dipstick for the detection of urinary tract infection. *Can J Infect Dis Med Microbiol* 2019;2019:8642628.
- Lai H-C, Chang S-N, Lin H-C, Hsu Y-L, Wei H-M, *et al.* Association between urine pH and common uropathogens in children with urinary tract infections. *J Microbiol Immunol Infect* 2021;54:290–298.
- Chen C-Y, Chen Y-H, Lu P-L, Lin W-R, Chen T-C, *et al.* Proteus mirabilis urinary tract infection and bacteremia: risk factors, clinical presentation, and outcomes. *J Microbiol Immunol Infect* 2012;45:228–236.
- Primack W, Bukowski T, Sutherland R, Gravens-Mueller L, Carpenter M. What urinary colony count indicates a urinary tract infection in children? *J Pediatr* 2017;191:259–261..
- Bhansali AJ, Inbaraj LR, George CE, Norman G. Can urine dipstick test be an alternative to detect urinary tract infection in limited resource setting? - A validity study from Bangalore, India. *J Family Med Prim Care* 2020;9:561–566.
- Bafna P, Deepanjali S, Mandal J, Balamurugan N, Swaminathan RP, *et al.* Reevaluating the true diagnostic accuracy of dipstick tests to diagnose urinary tract infection using Bayesian latent class analysis. *PLoS One* 2020;15:e0244870.
- Bellazreg F, Abid M, Lasfar NB, Hattab Z, Hachfi W, *et al.* Diagnostic value of dipstick test in adult symptomatic urinary tract infections: results of a cross-sectional Tunisian study. *Pan Afr Med J* 2019;33:131.
- Coulthard MG. Using urine nitrite sticks to test for urinary tract infection in children aged <2 years: a meta-analysis. *Pediatr Nephrol* 2019;34:1283–1288.
- Mahyar A, Ayazi P, Froozesh M, Daneshi-Kohan M-M, Barikani A. Can urinary nitrite results be used to conduct antimicrobial option for urinary tract infection in children? *Iran J Pediatr* 2012;22:237–240.
- Prah JK, Amoah S, Ocansey DWK, Arthur R, Walker E, *et al.* Evaluation of urinalysis parameters and antimicrobial susceptibility of uropathogens among out-patients at University of Cape Coast Hospital. *Ghana Med J* 2019;53:44–51.
- Suresh J, Krishnamurthy S, Mandal J, Mondal N, Sivamurukan P. Diagnostic accuracy of point-of-care nitrite and leukocyte esterase dipstick test for the screening of pediatric urinary tract infections. *Saudi J Kidney Dis Transpl* 2021;32:703–710.
- Mohanna AT, Alshamrani KM, SaemAldahar MA, Kidwai AO, Kaneetah AH, *et al.* The sensitivity and specificity of white blood cells and nitrite in dipstick urinalysis in association with urine culture in detecting infection in adults From October 2016 to October 2019 at King Abdulaziz Medical City. *Cureus* 2021;13:e15436.
- Bacărea A, Fekete GL, Grigorescu BL, Bacărea VC. Discrepancy in results between dipstick urinalysis and urine sediment microscopy. *Exp Ther Med* 2021;21:538.
- Rousham E, Cooper M, Petherick E, Saukko P, Oppenheim B. Overprescribing antibiotics for asymptomatic bacteriuria in older adults: a case series review of admissions in two UK hospitals. *Antimicrob Resist Infect Control* 2019;8:71.
- Biggel M, Heytens S, Latour K, Bruyndonckx R, Goossens H, *et al.* Asymptomatic bacteriuria in older adults: the most fragile women are prone to long-term colonization. *BMC Geriatr* 2019;19:170.
- Joseph A. The diagnosis and management of UTI in >65s: to dipstick or not? The argument against dipsticks. *Infect Prev Pract* 2020;2:100063.
- Coulthard MG. Using urine nitrite sticks to test for urinary tract infection in children aged <2 years: a meta-analysis. *Pediatr Nephrol* 2019;34:1283–1288.
- Middelkoop SJM, van Pelt LJ, Kampinga GA, Ter Maaten JC, Stegeman CA. Influence of gender on the performance of urine

- dipstick and automated urinalysis in the diagnosis of urinary tract infections at the emergency department. *Eur J Intern Med* 2021;87:44–50.
24. **Mambatta AK, Jayarajan J, Rashme VL, Harini S, Menon S, et al.** Reliability of dipstick assay in predicting urinary tract infection. *J Family Med Prim Care* 2015;4:265–268.
25. **Fernandes DJ, D. JM, Castelino DN.** Utility of dipstick test (nitrite and leukocyte esterase) and microscopic analysis of urine when compared to culture in the diagnosis of urinary tract infection in children. *Int J Contemp Pediatr* 2017;5:156.
26. **Behzadi P, Behzadi E, Pawlak-Adamska EA.** Urinary tract infections (UTIs) or genital tract infections (GTIs)? It's the diagnostics that count. *GMS Hyg Infect Control* 2019;14:Doc14.

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Peer review history

VERSION 2

Editor recommendation and comments

<https://doi.org/10.1099/acmi.0.000483.v2.2>

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Jana Katharina Schniete; Leibniz Universitat Hannover Naturwissenschaftliche Fakultat, Institut fuer Mikrobiologie, Herrenhaeuser Strasse 2, Geb 4104, GERMANY, Hannover

Date report received: 10 May 2023

Recommendation: Accept

Comments: This is a study that would be of interest to the field and community. Thank you for the detailed and substantial revision of your manuscript. I have found two minor inconsistencies that I would like you to address- in line 159 I think you mean "consent" and not "concept" and in line 249 it should be "caused by these bacteria" and "not caused these bacteria"

Reviewer 1 recommendation and comments

<https://doi.org/10.1099/acmi.0.000483.v2.1>

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Date report received: 08 May 2023

Recommendation: Accept

Comments: 1. Methodological rigour, reproducibility and availability of underlying data-- yes the method is well written 2. Presentation of results-- is good 3. How the style and organization of the paper communicates and represents key findings 4. Literature analysis or discussion -- has improved 5. Any other relevant comments

Please rate the manuscript for methodological rigour

Good

Please rate the quality of the presentation and structure of the manuscript

Good

To what extent are the conclusions supported by the data?

Strongly support

Do you have any concerns of possible image manipulation, plagiarism or any other unethical practices?

No

Is there a potential financial or other conflict of interest between yourself and the author(s)?

No

If this manuscript involves human and/or animal work, have the subjects been treated in an ethical manner and the authors complied with the appropriate guidelines?

Yes

Author response to reviewers to Version 1

Reviewers. comments	Authors response
Reviewer 1	
How you discriminated between contamination and infection	Addressed, Line 151- 155
Lack of urine culture details, advantages and drawbacks or limitations.	Comprehensive details of culture results are captured in another manuscript. It's therefore inappropriate to repeat the same here since this paper's focus was to evaluate urine dipstick test performance
The authors ignored the inclusion criteria of the enrolled patients	Addressed, Line 129 -133
The discussion section is lacking. I would strongly advise the authors to rewrite it.	Entire discussion now rewritten
Reviewer 2	
How long did it take after sample collection before the Urine test was done? time is taken to process the sample? Ie between the time of urine collection and urine test/culture as timing can affect the result as well.	Addressed, Line 138 -146
How was the culture done? was it done from the dipstick sample or different sample was used? can you clarify that in the sample processing section	Addressed, Line 147 -155
why did you decide to choose monoculture, what happens if you have 2 different colonies The result sections	UTIs indicated by monocultures. Polycultures are an indication of contamination.
What was your criteria for the contaminant of the dipstick	This was indicated by a polyculture growth
Did you only test for one type of urine dipstick or more? and Why	The dipsticks used were from one company and did not use difference companies since the study was not interested in comparing performance of different brands
Typo and structural errors	The numerous mistakes pointed have been addressed

VERSION 1**Editor recommendation and comments**

<https://doi.org/10.1099/acmi.0.000483.v1.5>

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Jana Katharina Schniete; Edge Hill University, Biology, St Helens Road, UNITED KINGDOM, Ormskirk

Date report received: 21 November 2022

Recommendation: Minor Amendment

Comments: This study would be a valuable contribution to the existing literature. This is a study that would be of interest to the field and community. The reviewers have highlighted minor concerns with the work presented. Please ensure that you address their comments.

Reviewer 2 recommendation and comments

<https://doi.org/10.1099/acmi.0.000483.v1.3>

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Date report received: 16 November 2022

Recommendation: Minor Amendment

Comments: The manuscript entitled "Evaluation of the Diagnostic Performance of urine dipstick test for Detection of urinary tract infections in patients treated in Kenyan hospital" contains interesting results in the field and it is in line with the scope of journal studies. The paper needs modification according to the following comments: Please add years of study setup in abstract. Line 66; Moreover, culture is often less preferred by "my" change to "many" Line 72; leukocytes esterase and nitrates are the essential test parameters "and" are often used inseparably. Will change the word "and" to "Which" Line 76-77 Not clear, what do you mean by "strengthen the UTI dipstick test" Line 82 "Genital" should be lowercase "genital" Sample processing How long did it take after sample collection before the Urine test was done? time is taken to process the sample? ie between the time of urine collection and urine test/culture as timing can affect the result as well. How was the culture done? was it done from the dipstick sample or different sample was used? can you clarify that in the sample processing section? Line 116 statement no clear Line 123 why did you decide to choose monoculture, what happens if you have 2 different colonies The result sections. Line 135 It is difficult to understand What was your criteria for the contaminant of the dipstick Did you only test for one type of urine dipstick or more? and Why Figure 3.2 Legend interpretation; 4 - All urine dipstick parameters for UTI, does this include nitrate, LE and RBCs if yes why did you separate those. If No then please clarify Line 216 need reference

Please rate the manuscript for methodological rigour

Satisfactory

Please rate the quality of the presentation and structure of the manuscript

Good

To what extent are the conclusions supported by the data?

Strongly support

Do you have any concerns of possible image manipulation, plagiarism or any other unethical practices?

No

Is there a potential financial or other conflict of interest between yourself and the author(s)?

No

If this manuscript involves human and/or animal work, have the subjects been treated in an ethical manner and the authors complied with the appropriate guidelines?

Yes

Reviewer 1 recommendation and comments

<https://doi.org/10.1099/acmi.0.000483.v1.4>

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Date report received: 20 October 2022

Recommendation: Minor Amendment

Comments: The manuscript entitled " Evaluation of the Diagnostic Performance of urine dipstick test for Detection of urinary tract infections in patients treated in Kenyan hospitals " is succinct, well written, and structured but it has some minor concerns: There are insufficient details of the used methods to produce a more contextualized and scientific manuscript e.g. standard microbiological procedures used for urine culture and characterization of isolates. The authors ignore the isolated bacteria. How you discriminated between contamination and infection? Lack of urine culture details, advantages and drawbacks or limitations. -The authors ignored the inclusion criteria of the enrolled patients. The type of infection whether it was hospital or community acquired (HAI OR CAI??). -The discussion section is lacking. I would strongly advise the authors to rewrite it.

Please rate the manuscript for methodological rigour

Good

Please rate the quality of the presentation and structure of the manuscript

Very good

To what extent are the conclusions supported by the data?

Strongly support

Do you have any concerns of possible image manipulation, plagiarism or any other unethical practices?

No

Is there a potential financial or other conflict of interest between yourself and the author(s)?

No

If this manuscript involves human and/or animal work, have the subjects been treated in an ethical manner and the authors complied with the appropriate guidelines?

Yes

SciScore report

<https://doi.org/10.1099/acmi.0.000483.v1.1>

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iThenticate report

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