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Antimicrobial susceptibility and risk factors of uropathogens in symptomatic urinary tract infection cases at Dessie Referral Hospital, Ethiopia

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Abstract

Background Urinary tract infection (UTI) is one of the most common bacterial infections encountered by clinicians in developing countries, affecting the urethra, bladder, and kidneys. It is a prevalent infectious disease among outpatients and hospitalized patients, leading to morbidity and mortality. Antibiotic resistance among uropathogens varies geographically, but empirical treatment is common in our study area. Therefore, this study aimed to evaluate antimicrobial susceptibility and risk factors of uropathogens in symptomatic UTI cases at Dessie Referral Hospital in northeast Ethiopia.

Methods A hospital-based cross-sectional study design was utilized to examine 256 participants with urinary tract complaints from February 1, 2024, to May 30, 2024. Consecutive convenience sampling was used to select participants. Midstream urine samples were collected, and bacteriological tests, including culture, Gram stain, biochemical tests, and antimicrobial susceptibility tests, were conducted following standard procedures. The data were entered into EpiData version 3.1 and analyzed using SPSS version 20 software. Bivariate and multivariate logistic regressions were carried out to identify potential risk factors associated with urinary tract infection.

Results The overall prevalence of bacteriuria was 22.7%. *Escherichia coli* (*E. coli*) accounted for the highest proportion 21(30.4%), followed by Coagulase-negative *Staphylococcus* (CoNS) at 15(21.7%) and *Klebsiella* spp 12(17.4%). Most Gram-positive bacteria were susceptible to gentamicin 19(90.5%) but less sensitive to trimethoprim-sulfamethoxazole 16(76.2%) and nitrofurantoin 18(85.7%). High resistance rates were observed for penicillin 9(60%) and cefoxitin 14(66.7%). On the other hand, amikacin (83.3%), gentamicin (81.3%), and nitrofurantoin (89.7%) were effective against Gram-negative bacteria. Resistance to tetracycline and ampicillin was reported at 53.8% against both groups of bacteria. Female sex (AOR = 4.21; 95% CI = 1.43–8.29, $P = 0.002$), diabetes mellitus (AOR = 14.786; 95% CI = 3.91–70.72, $P = 0.001$), and human immunodeficiency virus positivity (AOR = 5.273; 95% CI = 2.596–17.410, $P = 0.002$) were identified as significant risk factors for bacteriuria.

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Conclusion The prevalence of UTI among syptomatic patients was 22.7%. *E. coli* and coagulase negative *Staphylococcus* were the predominant isolates. The identified bacteria were resistant to commonly use antimicrobials. Therefore, there should be continuous surveillance of UTI and antimicrobial susceptibility testing to minimize urinary tract infection and antibiotic resistance in our study setting.

Keywords Antimicrobial susceptibility, Uropathogen, Risk factors, UTI, Ethiopia

Background

The bacterial growth in the typically sterile urinary tract (kidney and bladder), is known as a urinary tract infection (UTI). It can vary from the asymptomatic presence of bacteria in the urine to a sever kidney infection that can lead to sepsis [1, 2]. UTI is one of the most common bacterial infections among hospitalized and outpatient patients with a significant negative impact on morbidity and mortality [3, 4]. It can be either asymptomatic or symptomatic and is usually categorized by the site of infection: bladder (cystitis), kidney (pyelonephritis), or urine (bacteriuria). Complicated UTI is diagnosed in abnormal genitourinary tracts caused by indwelling urethral catheters [5]. However, uncomplicated UTI occurs in a normal genitourinary tract without instrumentation [6]. Therefore, UTI can affect people of all age groups [7].

In 2019, over 404.6 million individuals experiencedUTI, with nearly 236,786 deaths attributed to UTI, resulting in 5.2 million disability adjusted life year (DALY) [54]. The age-standardized mortality rate (ASMR) also increased from 2.77/100,000 to 3.13/100,000, globally [55]. UTI can be caused by a various microbe such as *Escherichia coli* (*E. coli*) and *Enterobacteriaceae*, accounting for approximately 75% of cases. *Enterococcus faecalis* (*E. faecalis*) and highly resistant gram-negative rods like *Pseudomona* species, are commonly found in cmplicated UTI, and hospitalized patients. Factors like age, sex, catheter use, hospitalization, and prior antibiotic exposure can influence the prevalence of uropathogens [8–10]. However, frequent empirical treatment of UTI has been linked to increase antimicrobial resistance [11–14].

In developing countries, antimicrobial resistance presents a significant challenge in treating infectious diseases including UTI [15]. Furthermore, antimicrobials are oftenmisused without prescriptions leading to empirical treatments that can contribute to antimicrobial resistance in Ethiopia [15, 16]. Therefore, empirical treatment for UTI may exacerbate cause antimicrobial resistance over time [17, 18]. The prevalence of antimicrobial resistance varies geographically and UTI treatments emphasizing the importance of tailoring treatment based on local etiology and antimicrobial susceptibility profile [19].

Empirical treatment is common but healthcare providers may lack a basic understanding of UTI epidemiology and risk factors and antimicrobial resistance of uropathogens which can vary geographically. Additionally, there is the lack of studies conducted in our study setting. Therefore, this study aims to evaluate the antimicrobial susceptibility and risk factors of uropathogens in symptomatic UTI cases at Dessie Referral Hospital, northeast Ethiopia.

Materials and methods

Study design, period and setting

A hospital based cross-sectional study was conducted at Dessie Referral Hospital (DRH) in Dessie Town, Ethiopia, from February 1, 2024 to May 30, 2024. Dessie is the capital city of the South Wollo Zone of the Amhara Region located in north-central Ethiopia at a latitude and longitude of 11°8′N 39°38′E, with an elevation ranging between 2,470 and 2,550 m above sea level. Dessie is approximately 400 km away from Addis Ababa, the capital city of Ethiopia.

According to the Dessie town health administrative office, there are 16 governmental health institutions in the town including 1 comprehensive specialized hospital, 1 general hospital, 8 health centers, 3 private general hospitals and 6 higher private clinics in addition to DRH. DRH serves approximately 12 million people living in the catchment with an average daily patient flow of 600 and a staffs of 800 of whom around 600 are health professionals. The hospital has 600 beds, 8 wards, and various outpatient departments (OPDs) such as adult, pediatric, emergency, and TB & HIV as well as providing services like laboratory, pharmacy, and imaging (X-ray, ultrasound, and CT scan). Therefore, patients presenting at these OPDs with suspected UTI cases were treated after investigation.

Population

The source population consisted of all symptomatic UTI patients who presented at Dessie Referral Hospital in Dessie, northeast Ethiopia. The study population, however, was composed of patients experiencing symptomatic UTI who attended Dessie Referral Hospital and consented to participate in the study during the designated period.

Sample size and sampling technique

The sample size was determined using the single population proportion calculation. This was based on the prevalence of symptomatic UTI (21.1%) among patients at Mekelle University in northern Ethiopia which is located approximately 250 km from the study site [20].

The sample size was calculated by assuming a 95% confidence interval (z = Za/2 = 95%=1.96), and a margin of error (d = 5%=0.05) as follows:

$$N = \frac{(Z_{a/2})^2 \times p(1-p)}{d^2} = \frac{(1.96)^2 \times 0.211 \times (1-0.211)}{(0.05)^2} = 256$$

Therefore, the consecutive convenience sampling technique was used to select a minimum of 256 study participants.

Eligibility criteria

Patients who were able to provide a urine sample were included in this study. However, symptomatic UTI patients who had received antibiotic therapy within two weeks prior to data collection or patients who were unwilling to participate were excluded.

Data collection and processing

The lead investigator along with a qualified BSc nurse collected the data. They used, a structured, pretested Amharic version questionnaire to collect sociodemographic data through face to face interviews with study participants or their parents immediately after obtaining consent or assent. The questionnaire included demographic information (age, sex, etc.), other crucial clinical data (patient history) and related factors. Skilled nurses collected the clinical data. Before conducting the interviews, the parents or study participants were provided with adequate explanation on the purpose of study.

Laboratory data collections

Urine specimen collection and transportation

All research participants were encouraged to use sterile, screw-capped, wide-mouth, leak-resistant containers to collect midstream urine during the sociodemographic data-collection process. Within 15 to 30 min at the latest, these urine samples were delivered to the Wollo University microbiology laboratory, where they were processed within two hours of collection.

Bacterial isolation

The collected samples were inoculated on cysteine lactose electrolyte-deficient agar (CLED) (Oxoid, Ltd., England) medium using a calibrated inoculating wire loop with 0.001 ml. The culture plates were then incubated for 24 h at 35–37 °C in an aerobic atmosphere. For further identification, pure colonies were subcultured onto 5% sheep blood agar (Oxoid, England), mannitol salt agar (MSA), or MacConkey agar (Oxoid, England) after detecting 10^5 colony-forming units per milliliter (CFU/ml) [21]. Uropathogens were isolated and identified using standard morphological, cultural, and biochemical techniques following the National Committee for Clinical Laboratory Standard Criteria (NCCLS) [49] once 10^5 CFU/ml were found in the culture of properly collected midstream urine sample [22]. Gram staining and colony shape were initially used to identify the bacteria. Biochemical tests were then performed on pure cultures based on Gram reaction results. Klinger iron agar, lysine iron agar, urease, motility, nutritional broth, and the citrate utilization test were utilized to identify gram-negative bacteria. Gram-positive cocci were differentiated based on their response to coagulase and catalase tests. A coagulase test was used to distinguish *Staphylococcus aureus* from other *Staphylococci* while a catalase test was also used to differentiate *Staphylococcus* from *Streptococcus* [23].

Antibiotic susceptibility testing

The Kirby–Bauer disc diffusion technique was utilized to assess antimicrobial susceptibility following the Clinical and Laboratory Standards Institute (CLSI, 2019) guidelines [24]. A pure colony was suspended in sterile normal saline and adjusted to the 0.5% MacFarland standard. The suspension was then inoculated onto Mueller-Hinton agar (MHA), antibiotics were applied, and the mixture was incubated at 35–37 °C for 24 hours. The antibiotics used included Ampicillin (10 µg), gentamicin (10 µg), amoxicillin clavulanate (20/10 µg), piperacillin-tazobactam (100/10 µg), ceftriaxone (30 µg), amikacin (30 µg), ciprofloxacin (5/50 µg), trimethoprim-sulfamethoxazole (1.25/23.75 µg), penicillin (30 µg), nitrofurantoin (300 µg), and cefoxitin (30 µg). The isolates were classified as sensitive, intermediate, or resistant using CLSI 2019 guideline [24].

Quality control

To ensure accuracy in word meanings, structured questionnaires were initially written in English, translated into Amharic, and then back into English. A bachelor science (BSc) nurse was trained to collect clinical and sociodemographic data, and around thirteen (5%) of the questionnaires were tested at Borue Meda Primary Hospital. Following localy validated standard operating procedures, all media were autoclaved aseptically as per the manufacturer's instructions. A 5% batch of culture medium was then incubated for 24 h at 35–37 °C to confirm sterility. All materials, tools, and processes were properly regulated in accordance with the pre analytical and post-analytical phases of quality assurance integrated into the microbiological laboratory's standard operating procedures (SOPs) which were locally validated. Additionally, to ensure the consistency in materials, techniques, results, performance of the media and antimicrobial potency in laboratory procedures was assessed by inoculating with known control strains of *Escherichia* *coli* ATCC 25,922, *K. pneumonia* ATCC 700,603, and *S. aureus* ATCC 25,923 [24].

Data analysis

EpiData 3.1 was used for data entry, and analyzed using Statistical Package for Social Sciences (SPSS) version 20. Descriptive statistics were used to estimate the prevalence of antibiotic resistance and uropathogens. To identify the factors associated with UTI among symptomatic patients, multivariate logistic regression was performed by including the variables with $p < 0.25$ from the bivariate logistic regression. A *p*- value < 0.05 was considered as a statistically significant association.

Table 1 Socio-demographic characteristics and clinical features of study participants attending Dessie Referral Hospital, North East Ethiopia

Variables	Categories	Total (*n* = 256) Frequency (no)	Percent (%)
Sex	Male	99	38.7
	Female	157	61.3
Residents	Urban	124	48.4
	Rural	132	51.6
Age	0–14	11	4.3
	15–24	29	11.3
	25–64	158	61.7
	> 64	58	22.7
Marital status	Married	171	67.2
	Single	45	17.6
	Divorced	17	6.6
	windowed	22	8.6
Educational status	Illiterate	110	43.0
	Primary school	50	19.5
	Secondary school	56	21.9
	College/university	40	15.6
Patient settings	Out patient	228	89.1
	In-patient	28	10.9
Pervious history of UTI	Yes	89	34.8
	No	167	65.2
History of Hospitalization (Hospital stay)	< 3 days	229	89.5
	≥3 days	27	10.5
Pervious history of antibiotics use for UTI	Yes	78	30.5
	No	178	69.5
Surgical Procedure	Yes	24	9.4
	No	232	90.4
Patients with UTI complaints	Yes	256	100
	No	00	00
Vomiting	Yes	224	87.5
	No	32	12.5
Dysuria	Yes	178	69.5
	No	78	30.5
Abdominal pain	Yes	56	21.8
	No	200	78.3
Flank pain	Yes	155	60.5
	No	101	39.5
Fever	Yes	101	39.5
	No	155	60.5

Ethical considerations

The College of Medicine and Health Sciences, Wollo University Institutional Review Board, provided ethics approval (reference number Reg168/11), and Dessie Referral Hospital granted permission in formal letter. In accordance with the Declaration of Helsinki [56] written informed consent or assent was obtained from every study participants. The data from study participants were kept confidential and anonymous. Participants who tested positive for bacterial pathogens were treated with the recommended standard antibiotics as prescribed by physician.

Operational definitions

Antimicrobial susceptibility Isolated bacteria that are inhibited by the usual achievable concentration of antimicrobial agent when the recommended dosage is used for the site of infection.

Mid-stream urine sample: a urine sample obtained from the middle part of the urine flow (clean catch urine sample).

Symptomatic urinary tract infection: infection in any part of the urinary system, the kidney, bladder or urethra.

Multidrug-resistant (MDR) isolates: are those isolates that are resistant to two or more classes of antimicrobials simultaneously.

Results

Sociodemographic characteristics and clinical features of the study participants

The current study involved the recruitment of 256 individuals. Among these, 157 (61.3%) were female, and 132 (51.6%) lived in rural areas. The participants ages ranged from one year to one hundred years, with a mean age of 40.73 years (standard deviation, SD = 18.079). Eleven participants (4.3%) were under 14 years old, while the majority 158 (61.7%) fell between 25 and 64 years old. In this study, 228 (89.1%) of the symptomatic UTI patients were outpatients with a symptomatic UTI, and the majority 167 (65.2%) had no prior history of UTI (Table 1).

Prevalence of bacterial urinary tract infections

Out of a total 256 urine specimens, the overall prevalence of significant bacteriuria (SBU) was 58 (22.7%) with a 95% confidence interval ranging from 20.4 to 32.2% and the rests 198(77.3%) are non significant bacteriuria (NSBU) (Fig. 1).

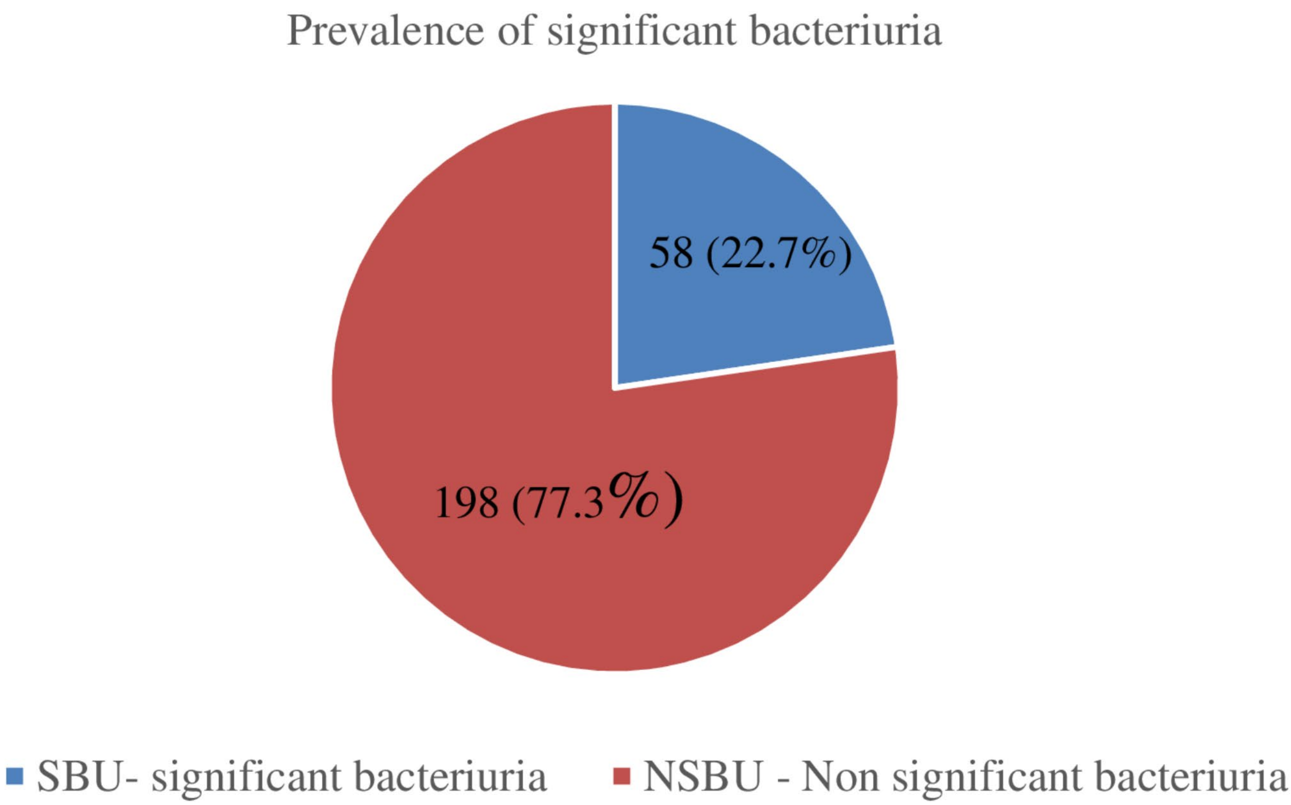

Fig. 1 Prevalence of significant bacteriuria among UTI cases at Dessie Referral Hospital, Northeast Ethiopia

Among the 58 specimens with significant bacteriuria, approximately 69 bacteria were isolated; 69.6% of the isolates were Gram-negative while the remaining 30.4% were Gram-positive bacteria. The proportion of *E. coli*, CONS, *Klebsiella* spp., *S.aureus, and P. aeruginosa* are 21 (30.4%), 15 (21.7%), 12 (17.4%), 6 (8.7%), and 5 (7.25%), respectively. Additionally, the proportions for *Citrobacter* species 5 (7.25%), *Proteus* species 4 (5.8%) and *Serratia* species 1 (1.4%) are presented below (Fig. 2).

Antimicrobial susceptibility profiles

The result of antimicrobial susceptibility testing for Gram-negative bacteria ($n = 48$) isolated from urine cultures of UTI-compliant patients against selected antimicrobial agents are presented in Table 2. The identified bacteria were found to be susceptible to Amikacin (83.3%), Gentamicin (81.5%), Imipenem(77.8%), and Nitrofurantoin(89.7%). Among those gram negative isolates, *E. coli* was susceptible to amikacin 15 (71.4%), gentamycin 15 (71.4%), trimethoprim-sulfamethoxazole 17 (81.0%) and nitrofurantoin 18 (85.7%) but high resistance rate was recorded to ampicillin 11 (52.4%), augmentin 11(52.4%) and Tetracycline 13 (61.9%). *Klebsiella* species were also susceptible to amikacin 10 (83.3%), Gentamycin 11 (91.7%), trimethoprim-sulfamethoxazole 8 (66.7%), imipenem 10 (83.3%). In contrast, *Klebsiella* species were resistant to ampicillin 2 (16.7%) tetracycline 4 (33.3%) and ciprofloxacin 5 (47.7%). Similarly, *Citrobacter* species showed 3(60.0%) of resistance rate to piperacillin tazobactam, ciprofloxacin, and tetracycline. However, a 100% of resistance rate was also observed among three isolates such as *P. vulgaris, P. mirabilis,* and *Serratia* species for various antimicrobial classes as shown bellow (Table 2).

On the other hand, Gram-positive isolates showed susceptibility to Gentamicin 19(90.5%), Trimethoprim-sulfamethoxazole 16(76.2%), Tetracycline 13(61.9%), and Nitrofurantoin 18(85.7%) although resistance to Penicillin 9(60%) and Cifoxitin 14(66.7%) was recorded (Table 3). The present findings demonstrated multi drug resistance (MDR) strains in both Gram-negative 33(68.75%) and Gram-positive 12(57.1%) isolates. Among gram negative isolates, *E. coli* 18(85.7%), *P. vulgaris* 2(100%), *Klebsiella* species 8(67%), *Citrobacter* Species 3(60%) *and Serratia* species 1(100%) are MDR. While, CONS 9(60%) and *S. aureus* 3(50%) are MDR as shown below (Table 4).

Factors associated with utis among symptomatic patients

Among all independent variables (P value < 0.25) in the bivariate logistic regression and those entered ito multivariate logistic regression analysis, sex, diabetes mellitus and HIV positivity were identified as associated risk factors with bacteriuria. As a result, females were

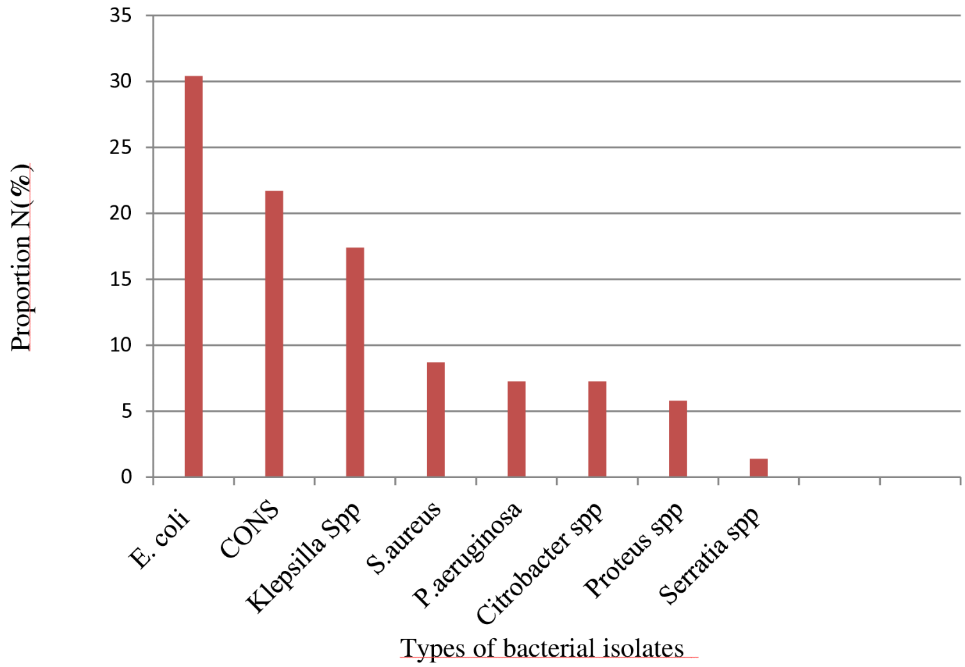

Fig. 2 Distribution of bacterial isolates among UTI patients in Dessie Referral Hospital, North East Ethiopia

found to be 4.21 times more likely to be affected by UTI (AOR = 4.21; 95% CI = 1.43–8.29, P = 0.002) than males. Similarly, study participants with diabetes mellitus (AOR = 14.786; 95% CI = 3.91–70.72, P = 0.001), and HIV positive (AOR = 5.273, 95% CI = 2.596–17.410, P = 0.002) were also found to have 14.786 and 5. 273 times higher risk of UTI among symptomatic patients, respectively (Table 5).

Discussion

One of the most common reasons people seek medical care in our study area is bacterial UTI. Identifying the type of organisms that cause the illness and selecting an appropriate antimicrobials are crucial effectively managing patients with bacterial UTI [25]. In this study, the overall prevalence of bacteriuria was 22.7% with a 95% confidence interval ranging from 20.4 to 32.2%. This prevalence is consistent with studies conducted in Central America (30%) [26], Uganda (32.2%) [27], Kenya (29%) [28], Mekelle University (21.1%) [20], Addis Ababa (23.32%) [29], Harar (27.9%) [30] and Dessie (22.7-31.4%) [31, 32].

The current prevalence of UTI was lower compared to prevalence reports from Bangladesh (42.66%) [33], Latin America (96.07%) [34], Iran (34.2%) [35], Indonesia (37.33%) [36], Pakistan (34.6%) [37], Nigeria (43%) [38], Shashemene (90.1%) [39] and the University of Gondar (39.5%) [40]. In contrast, the prevalence rate of UTI obtained in this study was much higher than a report from Kiohat (11.6%) [42], Ethiopia (20.16%) [43] and Jemma University (9.2%) [25]. Geographical disparities, health education strategies, the population's irrational use of antibiotics, host factors, and behaviors such as community social norms and personal cleanliness standards might all contribute to this discrepancy.

Like previous studies reported from various countries such as Bangladesh (5.3–93.2%) [33, 44], Saudi Arabia (100%) [45], Iran (83.2%) [41], Kohat Teaching Hospital (79.3%) [42], Pakistan (94%) [37], Ethiopia (2.6–80.2%) [29, 3043], Gondar University Hospital (71.5%) [40] and Dessie (87.7%) [32], our findings show that Gram-negative bacteria accounted for 69.6% of isolates. Additionally, the results revealed that *E. coli* (30%) was the most common isolate, which is consistent with studies reported from Bangladesh (59.30-64.20%) [33, 44], America (56–66%) [26, 34], India (92.85%) [46], Kohat Teaching Hospital (41.4%) [42], Uganda (41.9%) [27], Kenya (55%) [28], Ethiopia (16.4%) [43], Addis Ababa (44.62%) [29], Harar (48.5%) [30], Shashemene (39.3%) [39], and Gondar University Hospital (46%) [40], This may be indicate of fecal contamination and reflect poor personal hygiene.

This study revealed that coagulase-negative staphylococcus (21.7%) was the second most prevalent which is comparable to other study in Kenya (20.9%) [28] but greater than earlier studies in Iran (3.2%) [35]. Nonetheless, our finding of CoNS was smaller than reported in Addis Ababa (46.06%) [29]. This difference may be due to geographical variation, inadequate hygiene, sample size, and diagnostic methodology heterogeneity causing disparities in isolation.

Klebsiella spp. (17.4%) was also in line with the study reported from Nigeria (18.6%) [27], Central America

Table 2 Antimicrobial susceptibility profiles for Gram-negative bacterial with symptomatic UTI patients in Dessie Referral Hospital, Northeast Ethiopia

Gram negative bacterial		Antibiotics susceptibility profiles *N* (%)										
		AM	**AP**	**GEN**	**AUG**	**TZP**	**CRO**	**SXT**	**IM**	**TE**	**NIF**	**CIP**
E.coli (*n* = 21)	S	15(71.4)	10 (47.6)	15(71.4)	8(38.1)	11(52.4)	8(38.1)	17(81.0)	15(75.4)	6(28.6)	18(85.7)	11(52.4)
	I	3(14.3)	0	5(23.8)	2(9.5)	4(19.0)	6(28.6)	0	3(14.3)	2(9.5)	1(4.8)	2(9.5)
	R	3(14.3)	11(52.4)	1(4.8)	11(52.4)	6(28.6)	7(33.3)	4(19.0)	3(14.3)	13(61.9)	2(9.5)	8(38.1)
P. vulgaris (*n* = 2)	S	2(100)	0	2(100)	1(50.0)	0	0	-	-	-	-	0
	I	0	0	0	0	1(50.0)	0					0
	R	0	2(100)	0	1(50.0)	1(50.0)	2(100)					2 (100)
Klebsiella. spp (*n* = 12)	S	10(83.3)	-	11(91.7)	-	7(58.3)	4(33.3)	8(66.7)	10 (83.3)	7(58.3)	12(100)	6(50.0)
	I	0		0		2(16.7)	4(33.3)	3(25)	0	1(8.3)	0	1(8.3)
	R	2(16.7)		1(8.3)		3(25)	4(33.3)	1(8.3)	2(16.7)	4(33.3)	0	5(47.7)
P. mirabilis (*n* = 2)	S	2(100)	1(50)	2(100)	1(50)	2(100)	0	-	0	-	-	1(50)
	I	0	0	0	0	0	0		0			0
	R	0	1(50)	0	1(50)	0	2(100)		2(100)			1(50)
P.aeruginosa (*n* = 5)	S	5(100)	-	4(80.0)	-	1(20.0)	-	-	5(100)	-	-	3(60.0)
	I	0		1(20.0)		1(20.0)			0			1(20.0)
	R	0		0		3(60.0)			0			1(20.0)
Citrobacter spp (*n* = 5)	S	5(100)	-	4(80.0)	-	1(20.0)	3(60.0)	2(40.0)	5(100)	1(20.0)	5(100)	1(20.0)
	I	0		0		1(20.0)	0	0	0	0	0	1(20.0)
	R	0		1(20.0)		3(60.0)	2(40.0)	3(60.0)	0	4(80.0)	0	3(60.0)
Serratia (*n* = 1)	S	1(100)	1(100)	1(100)	1(100)	0	0	-	-	1(100)	0	0
	I	0	0	0	0	0	0			0	0	0
	R	0	0	0	0	1(100)	1(100)			0	1(100)	1(100)

Note: Am = amikacin, AP = ampicillin, GEN = gentamicine, AUG = augmantin, TZP = piperacillin Tazobactam, CRO = ceftriaxone, TE = tetracycline, SXT = trimethoprim-Sulfamethoxazole, IM = imipenem, NIF = Niterofurantoin, CIP = ciperofiloxacin.

Table 3 Antimicrobial susceptibility profiles of gram positive bacterial isolates from symptomatic UTI patients in Dessie Referral Hospital, Northeast Ethiopia

Isolated GPB		Antibiotics susceptibility profiles *N* (%)						
		GEN	SXT	TE	NIF	*P*	CIP	FOX
CONS (*n* = 15)	S	13(86.7)	11(73.3)	9(60.0)	13(86.7)	4(26.7)	7(46.7)	2(13.3)
	I	0(0)	2(13.3)	2(13.3)	0(0)	2(13.3)	3(20.0)	4 (26.7)
	R	2(13.3)	2(13.3)	4(26.7)	2(13.3)	9(60.0)	5(33.3)	9(60.0)
S. aureus (*n* = 6)	S	6(100)	5(83.3)	4 (66.70	5(83.3)	-	5(83.3)	1(16.7)
	I	0(0)	1(16.7)	0(0)	0(0)		1(16.7)	0(0)
	R	0(0)	0(0)	2(33.3)	1(16.7)		0(0)	5(83.3)
Total (*n* = 21)	S	19 (90.5)	16(76.2)	13(61.9)	18(85.7)	4(26.7)	12(57.1)	3(14.3)
	I	0(0)	3(14.3)	2(9.5)	0(0)	2(13.3)	4(19.1)	4(19.0)
	R	2(9.5)	2(9.5)	6(28.6)	3(14.3)	9(60.0)	5(23.8)	14(66.7)

Note: GEN = Gentamicin, SXT = Trimethoprim-Sulfamethoxazole, TE = Tetracycline, NIF = Nitrofurantoin, P = Penicillin, Fox = Cifoxiten, CIP = Ciperofilocacillin, GPB = Gram positive bacteria.

Table 4 Multidrug resistance rates of isolated bacteria from symptomatic UTI patients in Dessie Referral Hospital, Northeast Ethiopia

Isolated bacteria species	MDR strains		Total *N* (%)
	Yes *N* (%)	No *N* (%)	
E.coli	18(85.7)	3(14.3)	21(100)
P.vulgaris	2(100)	0(0)	2(100)
Klebsiella. Spp	8(67)	4(33.3)	12(100)
P.mirabilis	1(50)	1(50)	2(100)
P.aeruginosa	0(00)	5(100)	5(100)
Citrobacter. Spp	3(60)	2(40)	5(100)
Serracia spp	1(100)	0(0)	1(100)
S.aureus	3(50)	3(50)	6(100)
CONS	9(60)	6(40)	15(100)
Gram negative	33(68.75)	15(31.25)	48(100)
Gram positive	12(57.1)	9(42.9)	21(100)

Key: MDR- Multidrug resistance, Spp- species, CONS- coagulase Negative staphylococcus, N- number, %- Percent

(18%) [26] and Addis Ababa (16.81%) [29]. However, it is higher than findings reported in Bangladesh (5.53%) [33], Latin America (7%) [34], India (1.78%) [46], Indonesia (9.38%) [36], Ethiopia (10.1%) [43], Harrar (15.5%) [30], Shashemene referral hospitals (8.4%) [39], and University of Gondar (10%) [40] This discrepancy may be due to geographical location, poor hygienic practices, and sample size variation.

The other common isolate was *P. aeruginosa* (7.25%), similar to the results of a study conducted in Dessie [4.1%] [32], but higher than those reported in Bangladesh (2.01%) [33], Latin America (4.6%) [34], Saudi Arabia (2.6%) [45], Iran (3.2%) [35], India (1.78%) [46] and Ethiopia (1.7%) [43]. The proportion of *Citrobacter* (6.7%) in our study was similar to the reported result from Ethiopia (2.2%) [43], Shashemene (5.2%) [39], University of Gondar (6%) [40] and Dessie (2%) [32]. In contrast, this finding was lower than that reported in Indonesia (9.38%) [42], This discrepancy may be due to geographical location, poor hygienic practices, the irrational use of antibiotics, the high prevalence of *P. aeruginosa* among patients in other countries, sample size, and methodological variability.

According to antimicrobial susceptibility profies of isolates, *E. coli* showed high level of resistance to ampicillin (52.4%), tetracycline (61.9%), and amoxicillin clavulante (52.4%). Consistent studies have reported ampicillin resistance at 53.6% in Latin America [34], 81.22%) in Addis Ababa [29], 62.2% in University of Gondar [40] and 92.6% in Dessie [32]. However, our study found that nitrofurantoin (85.7%), gentamicin (71.4%), amikacin (71.4%), and imipenem (75.4%) were effective against *E. coli*. Similarly, nitrofurantoin sensitivity was reported in Bangladesh (84.9%) [46], Indonesia (77.67%) [36], Central America > 90% [26] and Dessie (100%) [32],

Klebsiella species were susceptible to amikacin (83.3%), gentamicin (91.7%), pipracillin tazobactam (58.3%), trimethoprim-sulfamethoxazole (66.7%), imipenem (83.3%), tetracycline (58.3%), and nitrofurantoin (100%). However, about 47.7% of *Klebsiella* species were -resistant to ciprofloxacin, similar to data reported in Saudi Arabia (48%) [45]. Additionally, *Proteus* spp are resistant to imipenem (100%), ceftriaxone (100%), ampicillin, amoxicillin clavulante, and ciprofloxacin (50–100%), similar to the 84.6% ciprofloxacin resistance reported in Latin America [34]. Serratia spp. in our study were 100% resistant to ciprofloxacin, ceftriaxone, pipracillin tazobactam, and nitrofurantoin. This resistance may be due to under use or self-prescription of these antibiotics, inappropriate use of antimicrobials, a lack of laboratory diagnostic tests, repeated use, or prolonged exposure of uropathogens to the antibiotics used to treat UTI in the study setting.

Staphylococus aureus showed a high degree of resistance to cefoxitin (83.3%) but it demonstrated sensitivity.to ciprofloxacin (83.3%), gentamicin (100%), trimethoprim-sulfamethoxazole (83.3%), and nitrofurantoin (83.3%) as observed at the University of Gondar [40]. Among all bacterial uropathogens (n = 69), 45 (65.2%) of the isolates exhibited multiple drug resistance. Similarly,

Table 5 Factors associated with urinary tract infection among symptomatic UTI patients, at Dessie Referral Hospital, North East Ethiopia from February 1st, 2024 to May 30th, 2024

Variables	Categories	Significant bacteriuria		Crude-OR(95% CI	*P*-Value	AOR(95% CI)	*P*-value
		Yes (%)	No (%)				
Sex	Male	20(19.6)	82(80.4)	1	0.005	4.21 (1.43–8.29)	0.002**
	Female	38(21.8)	136(78.2)	1.360(0.728–2.540)			
Residence	Rural	25 (17.7)	116(82.3)	2.630(1.344–7.153)	0.034	0.873(0.406-1.881)	0.730
	Urban	33(23.9)	105(76.1)	1			
Marital status	Single	10(22.2)	35(77.8)	1	0.027*	0.718(0.236-2.189)	0.560
	Married	34(19.9)	137(80.1)	2.865(0.383–1.953)	0.059*	2.986(0.605-14.749)	0.179
	Divorced	8(47.1)	9(52.9)	3.314(0.956–11.490)	0.135*	0.548(0.101-2.955)	0.484
	Widowed	6(27.3)	16(72.7)	1.338(0.401–4.467)			
Surgical procedure	Yes	13(54.2)	11(45.8)	4.943(1.985–2.311)	0.001*	6.263(2.306–17.011)	0.190
	No	45(19.4)	187(80.6)	1			
Hx of antibiotic use for UTI	Yes	22(28.2)	56(71.8)	1.602(1.852–3.014)	0.144*	1.263(0.569–2.807)	0.566
	No	36(20.2)	142(79.8)	1			
HIV	Yes	6(28.6)	15(71.4)	4.686(1.187–9.524)	0.003*	5.273 (2.596–17.410)	0.002**
	No	52(22.1)	183(77.9)	1			
Diabetes	Yes	9(47.4)	10(52.6)	14.786(3.091–70.729)	0.001*	14.786 (3.91–70.72)	0.001**
	No	49(20.8)	187(79.2)	1			
Hx of catheterization	Yes	10(45.5)	12(54.5)	3.565(1.369–9.283)	0.009*	1.897 (0.605–5.95)	0.272
	No	48(20.5)	186(79.5)	1			
improper urine retention	Yes	21(17.2)	101(82.8)	2.534(1.288-0.990)	0.046*	0.607 (0.304-1.211)	0.157
	No	37(27.6)	97(72.4)	1			

Note: Hx = history, COR = crude odd ratio, AOR = Adjusted odd ratio, OPD = outpatient, IPD = inpatient, HIV = Human immunodeficiency virus, UTI = Urinary tract infection, 1 = reference, * = variables subjected to multivariable logistic regression, ** = signifcantly associated variab

MDR rates for Gram negative (73%) and Gram-positive (68.75%) isolates were reported from Mekelle University [20], and gram-positive (80.0%) and gram-negative (87.0%) isolates in Hara [30]. Factors such as inappropriate use of antibiotics, inadequate environmental conditions, an increasing trend of MDR strains over time, and variations in the study population may all contribute to this discrepancy.

Regarding associated factors, the risk of developing UTI was 14.786 times greater in patients with diabetes mellitus (AOR = 14.786; 95% CI = 3.91–70.72, $P = 0.001$) compared to non diabetic patients. This finding is consistent with studies conducted in Jugal hospitals in Harar, Ethiopia [30] and Uganda [27]. HIV positive patients had a 5.273 fold increased risk of UTI compared to HIV negative patients, which aligne with studies reported in Nigeria [47, 50] and India [48] due to the comorbidity of diabete mellitus and HIV suppressing individual's immunological status. Furthermore, females were more affected (4.21 folds) by UTI than males as seen in studies reported from Saudi Arabia [51], Uganda [52], and Arba Minch Hospital [53], This is because females have shorter urethras, which increases the prevalence of UTIs in females through ascending infection. The limitations of this study were that MIC or E test was not performed for carbapenemase and extended-spectrum β-lactamase to assess antibiotic susceptibility profiles. The absence of molecular testing for bacterial detection at the species level and convenience sampling had the potential to result in a biased sample a convenient sample may only include certain types of individuals.

Conclusion

The prevalence of UTI among syptomatic patients was 22.7%. *E. coli* and coagulase negative Staphylococcus were the predominant isolates. The identified bacteria were resistant to commonly use antimicrobials. Therefore, there should be continuous surveillance of UTI and antimicrobial susceptibility testing to minimize urinary tract infection and antibiotic resistance in our study setting.

Abbreviations

AST	Antibiotic susceptibility test
ATCC	American Type Culture Collection
BAP	Blood agar plate
CFU	Colony forming unit
CI	Confidence interval
CLED	Cysteine lactose-deficient medium
COR	Crude odd ratio
CLSI	Clinical and Laboratory Standards Institute
CSA	Central statistical agency
IDSA	Infectious Disease Society America
KIA	Kelnger iron agar
MDR	Multidrug resistance
MSU	Midstream urine
NCCCS	National Committee for Clinical Laboratory Standard Criteria
NICE	National Institute for Health and Clinical Excellence
QC	Quality control
SOP	Standard operating procedure
Spp	Species
SPSS	Statistical Package for Social Sciences

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Author contributions
In addition to participating in the original article drafting process and creating tables and figures, WYS contributed to the ideation, inquiry, methodological design, data collection, analysis, and interpretation. EK made a significant contribution to the conceptualization, design, data collection, analysis, and interpretation of this work. WD contributed to the approval of the submitted version. DK also contributed to the creation of the manuscript and provided critical revisions for significant intellectual content. Nonetheless, the final version of the paper was authorized for publication by all the authors.

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Data availability
The results of this study are generated from the data collected and analyzed based on stated materials and methods. All data concerning this study are available upon request from Destaw Kebede (corresponding author; mobile +251911594675, email: kebededestaw1@gmail.com).

Declarations

Ethics approval and consent to participate
The College of Medicine and Health Sciences, Wollo University Institutional Review Board, provided ethics approval (Reference number Reg168/11), and Dessie Referral Hospital provided a letter of permission. In accordance with the Declaration of Helsinki, written informed consent or assent was also acquired from every research participant. Additionally, all research participants were volunteers, and their identities were coded rather than named to maintain their confidentiality. Finally, any noteworthy bacterial findings were linked to hospital physicians for further treatment based on antibiotic profiles.

Consent for publication
Written informed consent for publication was obtained from study participants (or their parent or legal guardian in the case of children under 18years).

Competing interests
The authors declare no competing interests.

Clinical trial number
Not applicable.

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