

ORIGINAL ARTICLE

BACTERIAL PROFILE, ANTIBACTERIAL SUSCEPTIBILITY PATTERN AND ASSOCIATED FACTORS AMONG WOMEN ATTENDING ANTENATAL AND POST-NATAL HEALTH SERVICES AT THE UNIVERSITY OF GONDAR TEACHING HOSPITAL, NORTHWEST ETHIOPIA.

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ABSTRACT

Background: Bacterial infections are an important cause of maternal morbidity and mortality especially in resource limited countries such as Ethiopia. The major bacterial infections include urinary tract infections, septicemia and endometritis. Antibiotic resistant bacterial pathogens have become a growing problem worldwide and pose a serious threat to vulnerable populations, including mothers. However, studies which address the problem in the Ethiopian setting are scarce.

Objective: To assess the bacterial profile, antibacterial susceptibility pattern and associated factors among mothers attending antenatal and postnatal care health services.

Methods: A cross-sectional study was conducted on 222 study participants at the University of Gondar Teaching Hospital from January 1 to May 31, 2016. Clinical specimens such as urine, blood and cervical discharge specimens were collected from patients and antimicrobial susceptibility tests conducted following standard procedures. Data were entered and analyzed with SPSS version 20. Bivariate and multivariate logistic regression models were applied in data analysis.

Results: Out of 222 specimens collected, 57(25.7%) bacterial species were isolated. The predominant bacterial isolates from urine culture were *Escherichia coli* (24/47; 51.1%) and *Staphylococcus aureus* (16/47;34%). From blood cultures, *Staphylococcus aureus* (2/8; 25%), *Coagulase negative staphylococci* (2/8;25%), *Klebsiella pneumoniae* (2/8;25%) and *Streptococcus pyogenes* 2/8(25%) were isolated. *Neisseria gonorrhoea* (2/27;7.4%) was isolated from cervical discharge cultures. The majority of the isolates were resistant to amoxicillin and ampicillin but susceptible to ceftriaxone. Many multidrug resistant bacterial species were isolated. Being in the first trimester of pregnancy and having a history of diabetes mellitus were strongly associated with the presence of bacterial infections.

Conclusion: The overall prevalence of bacterial infections was high with many being resistant to commonly prescribed antimicrobial agents. This calls for an urgent need to conduct screening of bacterial infections in both antenatal as well as postnatal women.

Keywords: antibiotic susceptibility pattern, bacterial profile, associated factors

INTRODUCTION

Bacterial infection is an important cause of maternal morbidity and mortality. The most common infections during pregnancy and following delivery include urinary tract infections (UTI), septicemia and endometritis (1-4). UTI is a common urinary tract problem among pregnant women. Its complication usually begins at about the sixth week of pregnancy and peaks between the twenty-second to twenty-fourth week due to urethral dilatation, increased bladder volume, decreased bladder and urethral tone, all of which contribute to increased urinary stasis.

Up to 70% of pregnant women develop glucosuria which encourages bacterial growth in the urine. The highest incidence of UTI occurs in women of child bearing age and this has been linked to sexual activity and aging (5). The predominant organisms that cause UTI are *Escherichia coli* (*E. coli*), *Staphylococcus aureus* (*S. aureus*), *Klebsiella pneumoniae* (*K. pneumoniae*), *Pseudomonas aeruginosa* (*P. aeruginosa*), *Proteus* spp, *Streptococcus faecalis* and *Enterobacter* spp (6). *E. coli* and *S. aureus* are major pathogens that have been associated with UTI and they underpin the empiric choice of antibiotics (7).

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Sepsis is the consequence of the body's inflammatory response to bacterial endotoxins and exotoxins. Pregnant and postpartum women are particularly vulnerable to developing severe sepsis because of their high susceptibility to bacterial infection due to changing physiology, biochemistry and immune response during pregnancy (8). This leads to an ascending postnatal infection of the genital tract, due to onset of the rupture of membranes or prolonged labour (9, 10). It was a major cause of peripartum morbidity and mortality throughout the pre-antibiotic era (11). Still, it is an important cause of maternal mortality in developing countries, and younger mothers have a higher risk, because of their higher rates of contamination with bacteria (12, 13). The major pathogens that cause sepsis are *Group A Streptococcus (GAS)*, *E. coli*, *S. aureus*, *S. pneumoniae*, methicillin-resistant *S. aureus* (MRSA), *Clostridium septicum (C. septicum)* and *Morganella morganii (M. morganii)* (14).

Endometritis an infection of the lining of the uterus, due to the rise of vaginal flora through the cervix and into the uterus. In the vagina, there is an overgrowth of pathogenic bacteria, which results in the reduction of hydrogen peroxide-producing lactobacilli. This condition aggravates preterm delivery, low birth weight and late onset postnatal endometritis in mothers. The most commonly isolated organisms include *N. gonorrhoeae*, *Ureaplasma urealyticum (U. urealyticum)*, *Peptostreptococcus*, *Gardnerella vaginalis (G. vaginalis)*, *Bacteroides*, *Group B Streptococcus (GBS)*, and *Chlamydia* (15). Currently drug resistant pathogens are an increasing problem worldwide (16). The rates of MRSA and Gram negative cephalosporin-resistant (extended-spectrum beta-lactamase) infections have increased globally by 2.1% and 12% for UTI, respectively (17, 18, 19). Generally, around the time of childbirth, bacterial infections are the leading causes of maternal mortality, accounting for about one tenth of the global burden of deaths (20). Annually, it leads to an estimated 358,000 deaths in the world of which 99% occur in developing countries. Sub Saharan Africa alone accounts for half of the deaths in developing countries. Apart from death, women who experience peripartum infections are prone to severe morbidity and long-term disabilities such as chronic pelvic pain, fallopian tube blockage and secondary infertility (21, 22, 23, 24). In the literature, pre and postnatal maternal infections have been associated with several risk factors, such as malnutrition, diabetes, obesity, severe anemia, premature rupture of membranes, multiple per vaginal examinations, manual removal of the placenta, caesarean section, use of steroids and the lack of pre-incision antimicrobial care (25).

Screening and treatment of bacterial infections during the pre and postnatal periods have improved maternal health outcomes and reduced the prevalence of drug resistant pathogens. However, there is a scarcity of studies in the medical literature from developing countries such as Ethiopia which report on the bacterial profile and antibiotic susceptibility patterns of bacteria isolated from prenatal and post-natal women.

MATERIALS AND METHODS

A cross sectional study was conducted from January 1 to May 31, 2016 at the University of Gondar Teaching Hospital of Amhara region. The study population consisted of all mothers who presented with different clinical complaints in either the antenatal or postnatal periods. A total of 222 individuals suspected for urinary tract infection, septicemia or endometritis who self-reported to the hospital during the study period were examined. Convenient sampling technique was used to select the study participants from the University of Gondar Teaching Hospital antenatal and postnatal clinic. All mothers who presented consecutively during the study period were included in the study.

Socio-demographic variables such as age, residence, marital status, educational level, occupation, and other relevant clinical data such as gravidity, trimester, parity, and mode of delivery were collected using a structured questionnaire. The specimens were collected by physicians using standard procedures for collecting urine, blood and cervical discharge samples after obtaining written ethical clearance from the ethical review committee of the School of Biomedical and Laboratory Sciences of Gondar University. Informed written consent was obtained from study participants after explaining the purpose of the study to them. Each specimen was collected based on the patient's clinical history and clinical complaints to physicians. A 0.001 ml of urine sample was inoculated onto Cysteine Lysine Electrolyte Deficient medium (CLED). The inoculated CLED was incubated for 18-24 hours at 37°C, then checked for significant bacterial growth (10^5 CFU/ml of urine). Colonies which had a significant growth on CLED were sub-cultured onto MacConkey agar (MAC), 5% blood agar plates (BAP) (Oxoid), Mannitol salt agar (MSA) (Oxoid) and incubated for 18-24 hours at 37°C aerobically [26]. Ten milliliters of blood was collected from both arms of study participants, (5 ml from each arm) and transferred into two bottles containing sterile tryptone soya broth (Oxoid, LTD).

A minimum of 1 to 10 blood-to-broth ratio was maintained. The blood culture broths were incubated at 37°C and checked for signs of bacterial growth daily up to 7 days. Bottles were examined for the visible evidence of bacterial growth such as turbidity, hemolysis, and presence of gas bubbles. Bottles which showed signs of growth were subcultured onto BAP, MAC, and MSA at 37°C for 24-48 hours aerobically while chocolate agar plates (CAP) were incubated at 37°C for 24-48 hours with 10% carbon dioxide (CO₂). Blood culture broths with no bacterial growth were subcultured onto BAP, CAP, MSA and MAC plates, before being reported as negative (26). Gram staining was performed to differentiate Gram positive and Gram-negative bacteria.

Biochemical tests were conducted to specifically identify different pathogenic bacterial species from positive culture media. The collected cervical swabs were inoculated onto non-selective CAP and selective agar modified Thayer-Martin medium (MTMM) since some fastidious bacterial species are more susceptible to concentrations of vancomycin, colistin, nystatin and trimethoprim lactate (VCNT) which are used in the selective media. The inoculated plates were incubated at 37°C for 72 hours with 10% CO₂ by using a candle jar (26). Subsequently oxidase test and Gram stains were performed. *N. gonorrhoeae* was differentiated from other *Neisseria* species by its characteristic of producing acid only from glucose.

Identification of bacteria was based on colony morphology and Gram reactions. Biochemical characteristics such as Catalase, Coagulase, Novobiocin, Bacitracin and Optochin sensitivity test results were used to identify Gram positive pathogenic bacteria. Triple sugar iron agar TSI, indole test, motility test, urea test, hydrogen sulphide production (H₂S), citrate test, Lysine decarboxylase (LDC) and oxidase tests were used for identification of Gram negative bacteria. All identified clinical strains were subjected to in vitro susceptibility testing using the Kirby Bauer disk diffusion method as described in Clinical Laboratory Standard Institute (CLSI) (2016) guidelines and interpreted accordingly (26).

The antibiotic discs used for UTI were norfloxacin (10µg), nitrofurantoin (300µg), ciprofloxacin (5µg), trimethoprim-sulfamethoxazole (1.25/23.75µg), tetracycline (30µg), amoxicillin (10µg), ampicillin (10µg), ceftriaxone (30µg), gentamycin (10µg) and amikacin (30µg). Antibiotic discs used for septicemia caused by Gram-positive bacteria were penicillin (10IU), cloxacillin (30µg) and clindamycin (2µg).

Gentamycin (10µg), nalidixic acid (30µg), ciprofloxacin (5µg) and amikacin (30µg) were used for Gram negative organisms. Certain antibiotics such as amoxicillin (10µg), ampicillin (10µg), cefoxitin (30µg), cefixime (5µg), ceftriaxone (30 µg), trimethoprim-sulfamethoxazole (1.25/23.75 µg), ceftazidime (30 µg) were used to test the antibiotic susceptibility profile of both Gram positive and Gram negative organisms. Antibacterial susceptibility tests for gonococci were conducted on Muller Hinton Agar (MHA) containing 5% sheep blood for the following antimicrobial agents: tetracycline (30µg), penicillin (10 IU), ciprofloxacin (5µg), ceftriaxone (30µg), spectinomycin (100µg). Plates were incubated at 37°C for 18- 24hours with 10% CO₂.

Data were entered and statistically analyzed by SPSS version 20 software. Bivariate and multivariate logistic regressions models were applied to determine possible associated factors with bacterial infections. Odds ratio was used as a measure of the strength of association and reported with 95% confidence intervals (95%CI) to determine statistically significant factors associated with presence of bacterial infection. P value ≤ 0.05 was considered to be statistically significant.

In order to maintain the quality of the data and laboratory tests, data collectors and laboratory assistants were trained. Daily collected data was recorded and compiled. All steps in data collection and recording were monitored. The reagents were checked for expiry date and appropriate storage under recommended temperature and humidity conditions. Standard operating procedures were prepared and strictly followed. The quality of culture media and antimicrobial susceptibility testing were checked by using quality control standard strains of *E. coli* (ATCC 25922), *S. aureus* (ATCC 25923), *E. faecalis* (ATCC 29212) and *K. pneumoniae* (ATCC®BAA1705). McFarland standards (0.5% BaSO₄) were used to standardize the inoculum density of bacterial suspensions for susceptibility testing. The acceptance range of optical density of the 0.5% McFarland standards was 0.08-0.1 (CLSI, 2016).

RESULTS

Socio demographic, obstetric, and clinical variables

A total of 222 women with symptoms of bacterial infections during the antenatal and postnatal periods were investigated in this study. The mean age of the study participants was 27 (±5.56) years, and ranged from 15-44 years.

The majority of the study participants were urban dwellers (66.7%), Orthodox Christian (92.8%), married (95%) and housewives (56.8%). In the present study 162 (73%) of the women were on antenatal care (ANC) follow up; of these 68 (42%)

were in their third trimester of pregnancy. Sixty (27%) of the participants were on postnatal care follow up and were admitted after delivery (**Table 1**).

Table 1: Sociodemographic, obstetric and clinical variables from women attending antenatal and postnatal services at the University of Gondar Teaching Hospital January 1, 2016–May 31, 2016. (N=222*).

Characteristics		Number (%)
Age (years)	15-24	71(32%)
	25-34	123(55.4%)
	35-44	28(12.6%)
Residence	Urban	148(66.7%)
	Rural	74(33.3%)
Religion	Orthodox	206(92.8%)
	Muslim	14(6.3%)
	Other	2(0.9%)
Marital status	Married	211(95%)
	Single	11(5%)
Educational level	Illiterate	101(45.5%)
	Primary school(1-8)	22(9.9%)
	Secondary school	37(16.7%)
	Higher education	62(27.9%)
Occupational status	Housewife	126(56.8%)
	Self-employed	26(11.7%)
	Government employee	55(24.8%)
	Private employee	6(2.7%)
	Student	4(1.8%)
	Daily laborer	5(2.2%)
Gravidity	1-3	171(77%)
	4-6	41(18.5%)
	7-9	10(4.5%)
Parity	Nulliparous	65(29.3%)
	Primiparous	71(32%)
	Multiparous	86(38.7%)
Trimester (n=162)	1st	38(23.5%)
	2nd	56(34.5%)
	3rd	68(42%)
Prolonged labour (n=60)	Yes	25(41.7%)
	No	35(58.3%)
Premature rupture of membrane (n=60)	Yes	22(36.7%)
	No	38(63.3%)
Mode of delivery (n=60)	Vaginal delivery	32(53.3%)
	Cesarean delivery	25(41.7%)
	Instrumental delivery	3(5%)
Place of delivery (n=60)	Health institution	45(75%)
	Home	15(25%)
	Yes	12(5.4%)
HIV/AIDS	No	214(96.4%)
	Yes	8(3.6%)

*Except where indicated otherwise

Isolation of pathogenic bacteria from different infection sites

A total of 134 urine, 61 blood and 27 cervical discharge samples were collected from patients in our study. The choice of which specimen to collect was determined by the chief complaint of the presenting women at the University of Gondar Teaching Hospital during the study period. From these suspected clinical specimens, bacterial infection was present in urine samples from 47(35.1%) individuals. Likewise, the presence of bacterial infection was confirmed in 8(13.1%) blood samples and in 2(7.4%) cervical discharge samples. Overall, pathogenic bacteria were isolated in 57(25.7%) of the women. Of these, 47 (35.1%) were isolated from UTI suspected participants, 8(13.1%) and 2(7.4%) were isolated from blood and from cervical discharge samples respectively.

The prevalence of bacteria differed based on the sample type; for instance a high proportion (61.7%) of Gram negative bacteria were isolated from urine. On the other hand, a higher rate of Gram positive bacteria was isolated from blood infections (75%). The predominant bacterial isolates from urine culture were *E. coli* (24/47; 51.1%), *S. aureus* (16/47;34%), *K. pneumoniae* (2/47;4.3%) and CoNS (2/47;4.3%) . On the other hand, the most common bacterial isolates identified from blood culture were *S. aureus* (2/8;25%), CoNS (2/8;25%), *K. pneumoniae* (2/8;25%), and *S. pyogenes* (2/8;25%). *N. gonorrhoeae* was the only pathogenic bacteria isolated from cervical discharge samples (2/2; 100%) (Figure 1).

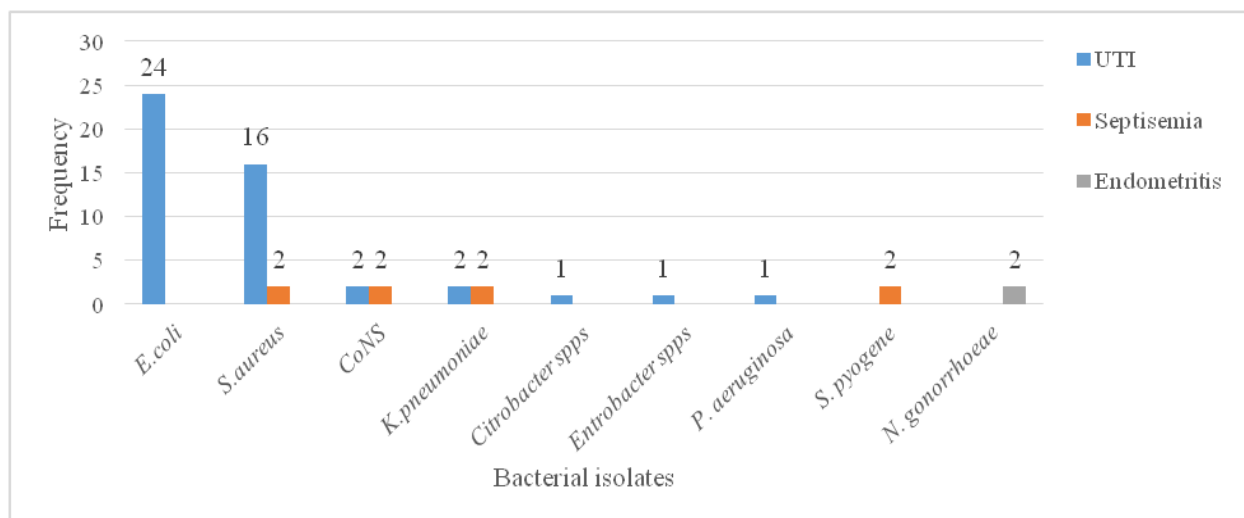


Figure 1. Profile and frequency of bacterial isolates from mothers during antenatal and postnatal period at University of Gondar teaching Hospital from January 1, 2016 –May 30, 2016.

Antibacterial susceptibility pattern for bacterial isolates from urine samples

Antibacterial susceptibility testing was done for pure isolates obtained from urine samples. All pathogens isolated from urine were susceptible to amikacin (100%) and most to norfloxacin (86.5%), nitrofurantoin (80.8%), and ceftriaxone (69.2%). Among Gram negative bacteria, all *K. pneumoniae* isolates were resistant to ampicillin and amoxicillin (100%). *E. coli* isolates were resistant to amoxicillin (58.3%), and trimethoprim-sulphamethoxazole (41.7%) (Table 2).

Likewise, most Gram positive isolates such as *S. aureus* were resistant to trimethoprim-sulphamethoxazole (75%), tetracycline (68.8%), amoxicillin (50%), and ampicillin (47.7%). CoNS isolates were resistant to tetracycline (50%), amoxicillin (50%), ampicillin (50%), trimethoprim-sulphamethoxazole (50%), gentamicin (50%) and ciprofloxacin (50%) (Table 2).

Table 2: Antibacterial susceptibility pattern of Gram negative and Gram positive UTI causing bacterial pathogens from women attending antenatal and postnatal services at the University of Gondar Teaching Hospital from January 1 – May 31, 2016.

Bacterial isolate	Antibacterial susceptibility pattern [Number (%)]										
		AMP	AM O	CRO	CIP	SXT	NIT	NOR	AMK	GEN	TTC
E.coli(n=24)	S	10 (41.7)	12 (50)	17 (70.8)	21 (87.5)	14 (58.3)	19 (79.2)	22 (91.2)	24 (100)	18 (75)	12 (50)
	R	14 (58.3)	12 (50)	7 (29.2)	3 (12.5)	10 (41.7)	5 (20.8)	2 (8.8)	0(0)	6(25)	12 (50)
K .pneumonia e(n=2)	S	0(0)	0(0)	2 (100)	2 (100)	1(50)	2 (100)	2(100)	2(100)	2 (100)	1(50)
	R	2 (100)	2 (100)	0(0)	0(0)	1(50)	0(0)	0(0)	0(0)	0(0)	1(50)
Citrobacter (n=1)	S	1 (100)	1 (100)	1 (100)	1 (100)	1 (100)	1 (100)	1(100)	1(100)	1 (100)	1 (100)
	R	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Pseudomonas (n=1)	S	0(0)	0(0)	1 (100)	1 (100)	1 (100)	1 (100)	1(100)	1(100)	0(0)	0(0)
	R	1 (100)	1 (100)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	1 (100)	1 (100)
Enterobacter spp..(n=1)	S	1 (100)	0(0)	1 (100)	1 (100)	1 (100)	1 (100)	1(100)	1(100)	0(0)	0(0)
	R	0(0)	1 (100)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	1 (100)	1 (100)
S. aureus (n=16)	S	8(50)	9 (52.3)	14 (87.5)	10 (62.5)	4(25)	13 (81.3)	13 (81.3)	16 (100)	12 (75)	5 (31.2)
	R	8(50)	7 (47.7)	2 (12.5)	6 (37.5)	12 (75)	3 (18.7)	3(18.7)	0(0)	4(25)	11 (68.8)
CoNS(n=2)	S	1(50)	1(50)	2 (100)	1(50)	1(50)	2 (100)	2(100)	2(100)	1(50)	1(50)
	R	1(50)	1(50)	0(0)	1(50)	1(50)	0(0)	0(0)	0(0)	1(50)	1(50)
[Total(n=47)	S	21 (44.6)	23 (49)	40 (85)	37 (78.7)	23 (49)	39 (83)	42 (89.4)	47 (100)	34 (72.3)	20 (42.6)
	R	26 (55.4)	24 (51)	7(15)	10 (21.3)	24 (51)	8(17)	5(10.6)	0(0)	13 (27.7)	27 (57.4)

AMP=Ampicillin; AMO=Amoxicillin; NIT=Nitrofurantoin; NOR=Norfloxacin; CIP=Ciprofloxacin; SXT=Trimethoprim-sulphamethoxazole; CRO=Ceftriaxone; GEN= Gentamicin; AMK=Amikacin; TTC= tetracycline

CoNS= Coagulase -negative staphylococcus; S= Susceptible; R= Resistant

Antibacterial susceptibility pattern for bacterial isolates from blood samples

The majority of Gram positive bacterial isolates from blood were resistant to ceftazidime (83.3%) and trimethoprim-sulphamethoxazole (66.7%).

On the other hand, most of them were susceptible to clindamycin (83.3%), ceftriaxone (83.3%), amoxicillin (66.7%), ampicillin, (66.7%) and cefixime (66.7%). Among Gram negative bacteria all *K. pneumoniae* isolates were resistant to ampicillin, amoxicillin, trimethoprim-sulphamethoxazole and ceftazidime (100%). On the other hand, all *K. pneumoniae* isolates were susceptible to ciprofloxacin, ceftriaxone, amikacin and cefixime (100%) (Table 3).

Table 3: Antibacterial susceptibility pattern of Gram positive bacterial pathogens causing septicemia in women attending antenatal and postnatal services at the University of Gondar Teaching Hospital, from January 1, 2016 – May 31, 2016.

Bacterial isolate		Antibacterial susceptibility pattern									
		AMO	AMP	CRO	P	CAZ	SXT	CXM	CXC	DA	CXT
S. aureus (n=2)	S	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)
	R	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)	1(50)
CoNS (n=2)	S	1(50)	1(50)	1(50)	2(100)	0(0)	0(0)	0(0)	1(50)	2(100)	2(100)
	R	1(50)	1(50)	1(50)	0(0)	2(100)	2(100)	2(100)	1(50)	0(0)	0(0)
S. pyogenes (n=2)	S	2(100)	2(100)	2(100)	2(100)	0(0)	1(50)	2(100)	2(100)	2(100)	1(50)
	R	0(0)	0(0)	0(0)	0(0)	2(100)	1(50)	0(0)	0(0)	0(0)	1(50)
Total (n=6)	S	4(66.7)	4(66.7)	4(66.7)	5(83.3)	1(16.7)	2(33.3)	3(50)	4(66.7)	5(83.3)	4(66.7)
	R	2(33.3)	2(33.3)	2(33.3)	1(16.7)	5(83.3)	4(66.7)	3(50)	2(33.3)	1(16.7)	2(33.3)

AMO=Amoxicillin; AMP=Ampicillin; P=Penicillin; CAZ= Ceftazidime;SXT=Trimethoprim-sulphamethoxazole; CXM=Cefixime; CXC=Cloxacillin; DA=Clindamycin; CXT=Cefoxitin; CoNS= Coagulase-negative staphylococcus; S=Susceptible; R= Resistant.

Antibacterial susceptibility pattern for bacterial isolates from cervical discharge samples

N. gonorrhoeae was the only pathogenic bacterial isolate from cervical discharge samples. All isolates of *N. gonorrhoeae* were resistant to tetracycline (100%) and partially resistant to penicillin (50%), ceftriaxone (50%) and spectinomycin (50%). However all the *N. gonorrhoeae* isolates were sensitive to ciprofloxacin (100%).

Multidrug resistance of isolated bacterial pathogens

Taking all the bacterial isolates from the different biological samples into account, multidrug resistance (defined as resistance to ≥ 2 drugs of different classes) was observed in 54.5% and 95.8% of Gram negative and Gram positive bacteria respectively (**Table 4**).

Risk factors associated with presence of bacterial infections

In the bivariate logistic analysis, demographic and clinical factors such as age, occupation, marital status, religion, level of education, gravidity and parity were not significantly associated with having bacterial infection.

On the other hand, place of residence, being in the third trimester of pregnancy as well as a previous history of diabetes mellitus were strongly associated with having bacterial infection. (**Table 5**).

Table 4: Multidrug resistance (MDR) of bacterial isolates from women attending antenatal and postnatal services at the University of Gondar Teaching Hospital from January 1, 2016 – May 31, 2016.

Antibiograms	Bacterial isolates					
	E.coli (=24)	K. pneu- moniae (n=4)	Citro- bacter (n=1)	Entero- bacter (n=1)	P. aerugi- nosa(n=1)	N. gonor- rheae (n=2)
AMX,TTC	1(4.2%)	-	-	-	-	-
AMX,CRO	1(4.2%)	-	-	-	-	-
AMX,SXT,GEN,TTC	1(4.2%)	-	-	-	-	-
AMP,CRO,SXT,NOR,GEN ,TTC	1(4.2%)	-	-	-	-	-
AMX,CRO,SXT,TTC	2(8.4%)	-	-	-	-	-
AMP,SXT,NOR,GEN,TTC	1(4.2%)	-	-	-	-	-
AMX,SXT.TTC	1(4.2%)	2(50%)	-	-	-	-
AMX,CPR,SXT,NIT,TTC	1(4.2%)	-	-	-	-	-
SXT,GEN	1(4.2%)	-	-	-	-	-
AMX,CRO,SXT,GEN,TTC ,NIT	1(4.2%)	-	-	-	-	-
AMX,NIT	1(4.2%)	-	-	-	-	-
CPR,SXT,NIT, GEN, TTC	1(4.2%)	-	-	-	-	-
CPR, CRO, NIT	-	-	-	1(100%)	-	-
AMX, GEN, TTC	-	-	-	-	1(100%)	-
AMX, CRO, GEN, TTC	-	-	-	-	-	1(50%)
P, CRO, TTC	13(54.2%)	2(50%)	-	1(100%)	1(100%)	1(50%)
Total =18(54.5%)						
Antibiograms for Gram positive bacteria	S. aureus (n=18)	CoNS (n=4)	S. pyo- genes (n=2)			
AMX, SXT,GEN, TTC	1(5.5%)	-	-			
AMX,CPR,SXT,NOR,NIT, GEN,TTC	1(5.5%)	1(25%)	-			
AMX,CRO,CPR,SXT,GEN ,TTC	1(5.5%)	-	-			
CPR,SXT,NOR,NIT	1(5.5%)	-	-			
AMP,CPR,SXT,NOR,TTC	1(5.5%)	-	-			
AMP,CPR,SXT,NOR,GEN ,TTC	1(5.5%)	-	-			
AMX, TTC	1(5.5%)	-	-			
AMX, CPR, SXT, TTC	2(11.1%)	-	-			
CPR, SXT, TTC	1(5.5%)	-	-			
CRO, SXT, TTC	1(5.5%)	-	-			
SXT, TTC	1(5.5%)	-	-			
CPR, TTC	1(5.5%)	-	-			
AMX, CPR, SXT, NIT, GEN	1(5.5%)	-	-			
AMX, CPR, GEN, TTC	1(5.5%)	-	-			
AMX, CRO, SXT	2(11.1%)	-	-			
AMP, SXT, CAZ, DA	-	1(25%)	-			
AMP, CAZ	-	1(25%)	-			
AMP, CAZ, CXC, SXT	-	1(25%)	-			
CRO, SXT, CXC	-	-	2(100%)			
Total =23(95.8%)	17(94.4)	4(100%)	2(100%)			

Table 5: Bivariate and multivariate analysis to assess factors associated with bacterial infections in women attending antenatal and postnatal services at the University of Gondar Teaching Hospital, January 1, 2016 – May 31, 2016.

Characteristics		Culture Positive No (%)	Negative No (%)	Bivariate analysis COR (95%CI)	Multivariate analysis AOR (95%CI)	p-value
Age (years) (N=222)	15-24	16(28.1)	55(33.3)	1		
	25-34	33(57.9)	90(54.6)	0.87(0.315-2.422)		
	35-44	8(14)	20(12.1)	1 (0.41-2.716)		
Residence (N=222)	Urban	45(79)	103(62.4)	2 (1.037- 4.315)	3.032(1.05-8.729)	0.040*
	Rural	12(21)	62(37.6)	1		
Occupation (N=222)	Self-employed	39(68.4)	128(77.6)	1		
	Government	18(31.6)	37(22.4)	0.54(0.124 - 2.315)		
Education (N=222)	Illiterate	23(40.4)	78(47.3)	0.66(0.323- 1.35)		
	Primary	3(5.3)	17(10.3)	0.42(0.11- 1.595)		
	Secondary	11(19.3)	26(15.8)	1.002(0.413- 2.43)		
	Higher education	20(35)	44(26.7)	1		
Marital status (N=222)	Married	52(91.2)	159(96.4)	0.37(0.109-1.273)		
	Single	5(8.8)	6(3.6)	1		
Trimester (n=162)	1st	14(13.7)	24(43.75)	3.6(1.6-8.24)	5.8 (1.67-20.16)	0.006*
	2nd	42(45.1)	14(21.9)	0.6(0.28-1.41)	0.367 (0.12-1.12)	0.078*
	3rd	46(41.1)	22(34.4)	1	1	
Gravidity (N=222)	1-3	44(77.2)	127(77)	0.78(0.194-3.166)		
	4-6	10(17.5)	31(17.8)	0.656(0.14-3.066)		
	7-9	3(5.3)	7(4.2)	1		
Parity (N=222)	Nulliparous	18(31.6)	47(28.5)	1		
	Primiparous	16(28)	55(33.3)	1.114(0.538- 2.307)		
	Multiparous	23(40.4)	63(38.2)	0.779(0.369- 1.646)		
Diabetes mellitus (N=222)	No	50(87.7)	160(97)	1	1	
	Yes	7(12.3)	5(3)	4.267(1.524-11.942)	5.498(1.820-16.610)	0.003*

AOR=adjusted odds ratio; COR=crude odds ratio; 1=reference group; 95% CI=95% confidence interval.

Multivariate analysis was carried out on covariates which showed significant association with bacterial infection in the bivariate analysis at a p-value of ≤ 0.2 . The backward stepwise regression was employed for controlling the confounding effect. Being an urban dweller, in the first trimester of pregnancy and having a history of diabetes mellitus were highly associated with the presence of bacterial infections ($p \leq 0.05$). Moreover, women who were in their first trimester were 4.8 times more likely to develop bacterial infections as compared to those in their second trimester (AOR= 4.8;95% CI:1.841-12.761, $p=0.001$). Likewise, women with diabetes mellitus (DM) were 5 times more likely to develop a bacterial infection as compared to those without DM (AOR= 5;95%CI:1.621-16.620, $p=0.003$) (Table 5).

DISCUSSION

The present study has identified the bacteria believed to be responsible for causing a range of clinical manifestations that are indicative of bacterial infections in mothers attending antenatal and post-natal health services. In this study, the overall prevalence of bacterial infection during the antenatal and postnatal period was 25.7%, indicating that pregnant women, as well as women who have delivered, continue to be vulnerable to contracting bacterial infections. This could have adverse repercussions on the health of neonates. Thus the current findings have important public health significance. The findings in the present study mirror findings reported from other studies from Ethiopia and elsewhere (27, 28, 29, 30, 31).

In this study, the prevalence of symptomatic UTI was 35.1% which is comparable to studies reported from Addis Ababa (31.6%) and also India (36.1%) (27, 31) but higher than in reports from Gondar (17.9%), Bahir Dar (18.9%), Dire Dawa (17%), Tanzania (17.9%) and another study from India (20.1%) (33, 34,35,36, 37). However a study from Nigeria has reported a much higher prevalence of symptomatic UTI (55%) (38).

The various estimates could reflect differences in sample size, laboratory methods employed and geographical location. *E. coli*, *S. aureus*, *CoNS*, *K. pneumoniae*, *Citrobacter* spp, *Enterobacter* spp, and *P. aeruginosa* were the most common bacterial pathogens causing UTI in pregnant women in this study which agrees with reports by other investigators (5, 6, 33, 34, 35).

The most common bacterial isolates from urine samples were Gram negative bacterial pathogens, which is also consistent with what is reported in the literature (5, 30, 35). In our study, the second most predominant isolate was *S. aureus* which is similar to what has been observed in other studies conducted in Ethiopia (5, 34, 35).

In this study, 13.1% of pathogenic bacteria were identified from blood samples. This finding is lower than reports from other studies conducted in Ethiopia (19.7%, 8.8%, 28%, 24%) (39- 42), Sudan (72.6%) (28) and the Netherlands (46%) (29). The possible explanation for the differences in bacterial prevalence between the different studies could be the sample size used, blood culture system, duration of study time, seasonal variation, nature of patient populations, and differences in infection control practices of the different hospitals (41,42).

In the current study, 75% and 25% of the blood infections were due to Gram positive and Gram negative bacteria respectively. The preponderance of infections from blood cultures were also due to Gram positive bacteria in other studies from different parts of Ethiopia which included Jimma, Mekele and Gondar (39,40,41,42). In this study, *S. aureus*, *CoNS*, *S. pyogenes* and *K. pneumoniae* were identified from blood samples. More or less similar observations have been recorded in different studies and countries (39, 40, 41, 42). In the present study, *S. aureus* was isolated in similar proportions as other bacteria (25%). In contrast, *S. aureus* was the predominant isolate in other studies from Ethiopia (39, 40).

Out of the 27 cervical discharge samples, *N. gonorrhoea* was isolated from 7.4% of the women, which concurs with data from Sub Saharan African countries (43, 44, 45). However, our result was lower than the findings from Gambella and another study from Gondar which reported 11.3% and 38.4% prevalence of *N. gonorrhoea* respectively (46). This variation may be due to the difference in the diagnostic methods used to detect *N. gonorrhoea* infection. The study cited previously from Gondar used syndrome-based diagnosis and not laboratory confirmation of the etiologic agent, possibly resulting in an over estimation (47).

In this study, Gram-negative bacterial isolates were found to be sensitive to potent antibiotics such as amikacin, norfloxacin, ciprofloxacin, and others, similar to reports from other studies in Ethiopia (33,34). However, as long as there continues to be a high rate of irrational antibiotic usage, as well as poor adherence to prescribed treatment plans, these antibiotics may no longer be effective to treat infections caused by bacterial pathogens.

On a positive note, in the present study, *S. aureus* isolates were wholly susceptible to amikacin. Three other antibiotics (ceftriaxone, nitrofurantoin and norfloxacin) were reasonably effective to treat *S. aureus* infections (88.2%, 76.5%, and 76.5% respectively). This finding was in line with studies from Dire Dawa (35) and Tanzania (51). A study from Iran reported a lower efficacy of these antibiotics to treat *S. aureus* infections (52) while an Indian study found these antibiotics to be very effective (31). In the present study, *E. coli* showed significant resistance to amoxicillin (58.3%), comparable to findings from Bahir Dar (34) and Nigeria (38). Likewise most Gram positive isolates such as *S. aureus* showed significant resistance to trimethoprim-sulphamethoxazole (76.5%) and tetracycline (70.6%). CoNS showed a significant level of resistance to tetracycline (66.7%), amoxicillin (66.7%), ampicillin (66.7%), trimethoprim-sulphamethoxazole (66.7%) and gentamicin (66.7%), which was more or less comparable to findings from Nigeria (38) and India (48).

Different antibacterial susceptibility patterns were observed for bacterial isolates from blood. *S. aureus* was resistant to methicillin in the present study. In this study, we screened for MRSA using Cefoxitin which has been reported to be a surrogate marker for MRSA. The presence of MRSA in pregnant women may cause sepsis that could be transmitted to the fetus (14). *K. pneumoniae* isolates from blood were resistant to ceftazidime and trimethoprim-sulphamethoxazole, amoxicillin and ampicillin. The increased resistance of blood isolates in this study may be a signal of indiscriminate and continuous usage of sub-therapeutic doses of commonly available drugs in the public health sector (39, 40). This could very well challenge the management and treatment of patients.

N. gonorrhoeae was highly resistant to tetracycline and penicillin. This finding is similar to previous reports in Ethiopia and other countries 929, 44, 46, 53, 54, 55, 56). In our study, *N. gonorrhoeae* was sensitive to ciprofloxacin, contrary to findings from studies in Bahir Dar and Gambella, Ethiopia (44, 46). However, a low level of susceptibility to ceftriaxone was reported in our study. The introduction of syndromic management for sexually transmitted infections (STIs), and the use of fluoroquinolones and cephalosporin to treat such infections is fairly routine, although there is always the risk that this could create a selective advantage for bacteria which are resistant to these antimicrobial agents (44).

The findings from this study are alarming because they point to the resistance of bacteria to commonly used antimicrobial agents in a resource limited country such as Ethiopia where there are few alternatives for the management of gonorrhoea. The occurrence of untreated and complicated gonorrhoea may fuel the transmission of HIV and other STIs.

In the current study, a significant level of multidrug resistance (resistance to ≥ 2 classes of drugs) was noted. From the total number of isolates, 54.5% and 95.8% of Gram negative and Gram positive bacteria, respectively, exhibited multidrug resistance. This situation raises serious concerns and suggests the existence of a high resistance gene pool, perhaps due to gross misuse and inappropriate usage of antimicrobial agents (57). Taken together, these findings clearly show how resistant strains are expanding at an alarming rate in the area. With this trend an antibiotic which was effective only one year ago, might be rendered useless in a year's time. This creates a huge burden, especially for people living in resource limited countries where many are not assured of getting their daily food, let alone afford expensive medications such as new antibiotics. All this places an unbearable strain on health care provision in poor countries.

In addition to identifying bacterial etiological agents and their pattern of susceptibility to existing antibiotics, the present study also sought to determine what association exists, if any, between the different socio-demographic and clinical parameters, and the development of bacterial infection in the women studied. In this study, the prevalence of bacterial infection was associated with residence ($p=0.040$), being higher in urban dwellers. Obstetric parameters such as being in the first trimester of pregnancy had 4.8 times increased odds of developing a bacterial infection compared to women in their second trimester ($p=0.001$). This finding was in line with a study reported from India (31). This could be attributed to the physiological changes which occur in relation to early pregnancy (hormonal, immune shift, reduced proportion of lactobacillus in the vaginal flora) (37). Among the clinical variables, there was a strong association of developing bacterial infection in the antenatal and postnatal period in patients with diabetes mellitus (DM) ($p=0.003$). This is consistent with findings from a study in the USA (58). The same reasons as those mentioned above could play a role here also, as patients with DM have a higher likelihood to develop different clinical complications that promote bacterial infections.

Conclusion

The overall prevalence of bacterial infections was high among women who attended antenatal and postnatal care in the study area. Most of the bacterial isolates were resistant to the most commonly prescribed antibiotics. This finding highlights the significant threat posed by the rise in antibiotic resistance, especially for such vulnerable population groups. Therefore, treatment of bacterial infections in the study area needs to be guided by antimicrobial susceptibility testing. An effective surveillance system needs to be instituted to monitor trends in antimicrobial resistance. At the same time prudent use of existing antibiotics is warranted to avoid further escalation of the problem. Longitudinal studies are recommended to track development of bacterial resistance resulting from usage of antimicrobials and also to determine further risk factors which predispose women in antenatal or postnatal care, to acquire bacterial infections that could be detrimental for them and their infants.

ACKNOWLEDGEMENTS

The study was funded by the Ministry of Health through the Clinical Research Capacity Building program at the Armauer Hansen Research Institute (AHRI). We would like to acknowledge study participants for their participation in the study. We are grateful to Dr. Dawit Kassahun (Gynecologist) for his support during specimen collection and management of patients. We would also like to acknowledge the Department of Medical Microbiology for availing necessary materials to conduct this study. Finally, we want to thank the Armauer Hansen Research Institute, the Federal Ministry of Health and the Amhara Regional Health Bureau for allowing us to conduct the study as well as for their technical, material and financial support.

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