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Bacterial etiologies, antibiotic susceptibility patterns and risk factors among patients with ear discharge at the University of Gondar Hospital, Northwest Ethiopia

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ABSTRACT

Objective: To determine the etiologic agent, antibiotic susceptibility patterns and possible risk factors among patients who had ear infection.
Methods: A cross-sectional study was conducted between February 2014 and June 2014 at the University of Gondar Hospital, Northwest Ethiopia among patients with ear discharge. Data were collected by using a semi-structured questionnaire. Ear discharge was inoculated on blood agar, chocolate agar and MacConkey agar plates. Standard procedures were used for identification of etiologic agents. Antibiotic susceptibility tests were performed on Mueller-Hinton agar. Data were entered and analyzed by using SPSS version 20 and $P < 0.05$ was considered statistically significant.
Results: Out of 167 patients, 97 (58.1%) were males. The mean age of the study participants was 23.3 years with the age ranging form 4 months to 78 years. Among the 167 study participants with ear discharge, 154 (92.2%) were showed bacterial growth. Gram-negative bacteria were commonly isolated from 100 (58.5%) participants. Of the 167 ear infection cases, 68.9% and 31.1% were from patients with chronic and acute otitis media, respectively. A total of 125 (73.1%) and 46 (24.9%) bacterial isolates were recovered from patients with chronic otitis media and acute otits media, respectively. The most commonly isolated Gram-positive bacterium was *Staphylococcus aureus* [43 (25.1%)]. Among the Gram-negative isolates, *Proteus* species [43 (25.1%)] were the most common isolate. Age and sex had statically significant association with ear infection ($P = 0.013$). Multidrug resistances were observed in 100% and 88.4% Gram-positive and Gram-negative bacterial isolates, respectively.
Conclusions: The prevalence of Gram-negative bacteria was high. *Staphylococcus aureus*, *Proteus* and *Pseudomonas* species were the most predominant. Alarmingly high rates of multiple drug resistance to majority of the commonly used antimicrobial agents were found. Therefore, treatment of ear infection should be based on culture and susceptibility test.

1. Introduction

Otitis media (OM), a kind of ear infection being the most common and occurring mostly in children, is an inflammatory disease of the mucosal lining of the middle ear caused by pathogenic micro-organisms[1]. In developing countries, the natural course of the disease is different, leading further complications due to the low socio-economic status, overcrowding, poor hygiene and inadequate health care, and recurrent upper respiratory tract infection[2] increases the complications of OM[3]. Global burden of chronic suppurative otitis media (CSOM) ranges from 65–330 million individuals and 60% of them had hearing impairment. The World Health Organization categorizes countries into low (1%–2%) and high (3%-6%) prevalence of CSOM. Ethiopia belongs to the last group[4]. OM is more prevalent among children than adults because the children's Eustachian tube is more horizontal and shorter with a

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The study protocol was performed according to the Helsinki declaration and approved by the Ethical Review Committee of School of Biomedical and Laboratory Sciences, Collage of Medicine and Health Sciences, University of Gondar. Informed written consent was obtained from each study participant and their family or guardian for children.
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more flaccid cartilage which can easily impair its opening[5,6].

The etiologies of acute otitis media (AOM) are multi-factorial. Both viruses and bacteria are concerned with the ordinary respiratory bacteria often preceded by a viral infection[7]. These are respiratory pathogens that may have been insufflated from the nasopharynx into the middle ear through the Eustachian tube during upper respiratory tract infections[8]. In CSOM, the commonest organisms isolated include *Pseudomonas aeruginosa*, *Escherichia coli* (*E. coli*), *Staphylococcus aureus* (*S. aureus*), *Streptococcus pyogenes* (*S. pyogenes*), *Proteus mirabilis* (*P. mirabilis*) and *Klebsiella* species[9].

Various antibiotics, including tetracycline, chloramphenicol and penicillin are effective in treating OM. However, the current appearance of *Streptococcus pneumoniae* (*S. pneumoniae*) resistant for penicillin and the rising frequency of beta-lactamase producing strains of *Haemophilus influenzae* (*H. influenzae*) and *Moraxella catarrhalis* are concern regarding the use of amoxicillin as the traditional first line treatment for younger children with OM[10]. The high prevalence of OM and the increasing incidence of bacterial resistance to antibiotics necessitating continuous reevaluation of bacterial susceptibility to commonly used antibiotics is necessary[11]. The morbidity due to ear infection in Ethiopia is high and much attention is required in this regard.

Different epidemiological data from Ethiopia and elsewhere showed that the load due to ear infection in terms of physician visits, medications, absences from work and school was very high, indicating that for this problem it needs more attention. Therefore, this study was undertaken to analyze the prevalence of bacterial etiologic agents, antimicrobial susceptibility patterns and risk factors among patients with ear infections visiting ear, nose, and throat (ENT) clinics of University of Gondar Hospital, Northwest Ethiopia.

2. Materials and methods

2.1. Study design, area and period

A hospital-based cross-sectional study was conducted from February 2014 to June 2014. University of Gondar Hospital served for over six million people. The hospital served as a teaching as well as patient-care providing center for the region. It is one of the largest hospitals in the region. It has an intensive care unit with 18 beds and 13 wards with 518 beds including one ENT clinic. The ENT clinic gives service for about 2640 patients per year.

2.2. Study population

The study populations were all patients with ear discharge attending at the ENT clinic of University of Gondar Hospital during the study period.

2.3. Data collection and laboratory processing

2.3.1. Socio-demographic and clinical data

Socio-demographic data such as age, sex, residence and possible risk factors such as history of previous ear infections, upper respiratory tract infections, hearing loss, recurrent tonsillitis, and introduction of foreign bodies were collected from each study participant by using structured questionnaire conducted by the attending trained nurse.

2.3.2. Culture and identification

Ear discharge was obtained from each patient and kept in Amies transport media to maintain the viability of the bacteria until the specimen was processed. The samples were transported within 30 min to the bacteriology laboratory in the biomedical complex at the School of Biomedical and Laboratory Sciences. Specimens were inoculated directly on to blood, chocolate and MacConkey agar (Oxoid Limitd). The blood and MacConkey agar plates were incubated in aerobic and chocolate agar in microaerophilic atmosphere using a candle atmosphere using a candle jar at 37 °C for 24–48 h.

Then, culture media were inspected for the growth of bacteria. Organisms were identified by their characteristic appearance on their respective media, Gram staining reaction and biochemical reactions using the standard method[12]. Members of the family Entrobacteriaceae were identified by using a series of biochemical tests such as carbohydrate fermentation, gas production, H_2S production, citrate utilization, urease production and lysine decarboxylation. For Gram-positive catalase, coagulase, bacitracin and optochin susceptibility test were used.

2.3.3. Antimicrobial susceptibility testing

Antimicrobial susceptibility testing was performed for all isolates according to criteria of the National Committee for Clinical Laboratory Standards by the disk diffusion method. A set of antibiotic discs (Oxoid, England) were then delivered on the surface of Muller-Hinton plate. The antimicrobials agents tested were in the following concentrations: ampicillin[11], amoxicillin-clavulanic acid (30 µg), ceftriaxone (30 µg), ciprofloxacin (5 µg), chlooramphenicol (30 µg), erythromycin (15 µg), gentamicin (10 µg), kanamycin (30 µg), oxacillin (5 µg), penicillin (10 IU), streptomycin (10 µg), trimethoprim-sulphamethoxazole (25 µg) and vancomycin (30 µg). Penicillin, vancomycin, erythromycin and oxacillin were tested only for Gram-positive bacteria[13].

2.4. Quality control

Reference strains of *E. coli* (ATCC25922) and *S. aureus* (ATCC25923) were used to cheek the performance of culture media and antimicrobial susceptibility discs[12].

2.5. Statistical analysis

Data were checked, sorted, categorized and coded manually. The data were entered to SPSS version 20 statistical software for analysis purpose. Data cleaning was done before analysis. Frequencies and cross tabulations were used to summarize categorical variables. Both bivariate and multiple logistic regressions were employed to assess the association between outcome and explanatory variables. $P < 0.05$ at 95% confidence interval (*CI*) was considered statistically significant.

2.6. Ethical considerations

Ethical clearance was obtained from the Ethical Review Committee of School of Biomedical and Laboratory Sciences, Collage of Medicine and Health Sciences, University of Gondar, Permission letter was obtained from University of Gondar Hospital. Consent was secured from each study participant and their family or guardian for children.

3. Results

3.1. Socio-demographic information

Out of the 167 patients, 97 (58.1%) were males resulting in an overall male to female ratio of 1.3:1. The mean age of the patients was 23.3 year. The ages of participants ranged from 4 months to 78 years. Nearly a third, 60 (35.9%), of the patients were younger than 15 years. The majority of the study participants, 126 (75.4%) lived in urban area (Table 1).

Table 1

Socio-demographic characteristics of patients with ear discharge at Gondar University Hospital, Gondar, Northwest Ethiopia from February 2014 to June 2014.

Socio-demographic characteristics		Number	Percentage
Sex	Male	97	58.1
	Female	70	41.9
Age (year)	< 15	60	35.9
	15–40	81	48.5
	> 40	26	15.6
Residence	Urban	126	75.4
	Rural	41	24.6

3.2. Magnitude of bacterial etiologic agents and clinical feature of participants

Out of the 167 study participants with ear discharge, 154 (92.2%) were showed bacterial growth. More than half of the isolates, 100 (58.5%) were Gram-negative bacteria, the rest, 71 (41.5%) were Gram-positive. A total of 171 bacterial pathogens were recovered from 167 discharges inoculated. Seventeen (10.2%) of the discharge showed mixed growth, while 137 (82.0%) showed single bacterial growth. The rest 13 (7.8%) had no bacterial growth (Table 2).

Ear discharge was the commonest clinical finding observed in 167 patients investigated for ear infections with AOM and CSOM (100%), followed by history of previous ear infection (68.9%), hearing problem (56.9%) and otalgia (ear pain) (31.1%). The ear problem was unilateral (right = 63 or left ear = 58) in 121 (72.5%) and bilateral (both ears) in 46 (27.5%) patients. The most common type of ear discharge was purulent 160 (95.8%) and bloody 7 (4.2%). Among the 167 ear infection cases, 68.9% and 31.1% accounted for chronic otitis media (COM) and AOM, respectively. One hundred twenty five (73.1%) and forty-six (26.9%) bacterial isolates were recovered from patients with COM and AOM, respectively. Among the Gram-positive isolates, *S. aurues* was the leading cause of both AOM and COM. Among the Gram-negative isolates, *Proteus* species were the most common isolates (Table 3).

Table 2

Bacterial etiologic agents among patients with ear discharge attending at Gondar University Hospital, Gondar, Northwest Ethiopia from February 2014 to June 2014.

Bacterial isolated		Number	Percentage
Gram-positive	*S. aureus*	43	25.1
	Staphylococcus epidermidis (*S. epidermidis*)	10	5.8
	Enterococcus spp.	11	6.4
	S. pneumoniae	4	2.3
	S. pyogenes	3	1.8
Gram-negatives	*P. mirabilis*	24	14.0
	Pseudomonas spp.	23	13.5
	Proteus vulgaris (*P. vulgaris*)	16	9.4
	Klebsiella pneumoniae (*K. pneumoniae*)	12	7.0
	Providencia rettgeri (*P. rettgeri*)	3	1.8
	Klebsiella ozaenae (*K. ozaenae*)	9	5.3
	Klebsiella oxytoca (*K. oxytoca*)	4	2.3
	Citrobacter spp.	5	2.9
	E. coli	2	1.2
	Enterobacter cloacae (*E. cloacae*)	1	0.6
	H. influenzae	1	0.6
	Total	171	100.0

Table 3

Bacterial etiologic agents among patients with ear discharge at Gondar University Hospital, Gondar, Northwest Ethiopia from February 2014 to June 2014 [*n* (%)].

Bacterial isolate	AOM	COM	Total
S. aureus	11 (23.9)	32 (25.6)	43 (25.1)
P. mirabilis	3 (6.6)	21 (16.8)	24 (14.0)
Pseudomonas spp.	2 (4.3)	21 (16.8)	23 (13.5)
P. vulgaris	5 (10.9)	11 (8.8)	16 (9.4)
K. pneumoniae	2 (4.3)	10 (8.0)	12 (7.0)
S. epidermidis	6 (13.0)	4 (3.2)	10 (5.8)
Enterococcus spp.	6 (13.0)	5 (4.0)	11 (6.4)
K. ozaenae	3 (6.6)	6 (4.8)	9 (5.3)
P. rettgeri	1 (2.2)	2 (1.6)	3 (1.8)
S. pneumoniae	4 (8.7)	0 (0.0)	4 (2.3)
S. pyogenes	2 (4.3)	1 (0.8)	3 (1.8)
E. coli	0 (0.0)	2 (1.6)	2 (1.2)
E. cloacae	0 (0.0)	1 (0.8)	1 (0.6)
Citrobacter spp.	0 (0.0)	5 (4.0)	5 (2.9)
H. influenzae	0 (0.0)	1 (0.8)	1 (0.6)
K. oxytoca	1 (2.2)	3 (2.4)	4 (2.3)
Total	46 (26.9)	125 (73.1)	171 (100.0)

3.3. Possible risk factors of ear discharge

Both bivariate and multivariate logistic regression analyses were done to assess the possible risk factors of infections among ENT patients. Statistical significant associations were observed between sex and age. Males were 21 times more likely to have bacterial ear infection as compared to females [adjusted odds ratios = 21.200 (1.910–23.570)]. Those who had ages under 15 years were 4.3 times more likely to expose and those aged between15 and 40 years were reduced the risk of ear infection by 99% as compared to those who have age over 40 years [(adjusted odds ratios = 4.300 (0.084–222.000) and 0.010 (0.000–0.220)], respectively. However, residence, chronic tonsillitis, upper respiratory tract infection, history of previous ear infection, long-term usage of antibiotic and the introduction of foreign bodies were not statistically significant with ear discharge (Table 4).

3.4. Antimicrobial resistance patterns of bacterial isolates

The antimicrobial resistance patterns of the Gram-positive (n = 71) and Gram-negative bacterial isolates (n = 100) from ear infection against 13 and 9 antimicrobial agents were presented in Tables 5 and 6, respectively. The predominant isolate, *S. aureus* revealed high level of resistant to penicillin 38 (88.4%) and for ampicillin 41 (95.3%). All Gram-positive isolates showed 100.0% multiple drug resistance (resistance to two or more drugs). All of the isolates of *S. aureus* 43 (100%) were sensitive to ciprofloxacin and one isolate of *S. aureus* was resistant to chloramphenicol.

The second predominant isolate, *Protues* spp. (n = 40) showed resistance to ampicillin 31 (77.5%), amoxicillin 20 (50.0%), chloramphenicol 19 (47.5%), kanamycin 7 (17.5%), streptomycin 21 (52.5%) and trimethoprim-sulfamethoxazole 3 (7.5%). The Gram-positive isolates were 100.0%, 97.5% and 86.5% susceptible to ceftriaxone, ciprofloxacin and gentamicin, respectively. Out of the 100 Gram-negative isolates, 80.0% strains were also identified as multiple drug resistant. In general, ceftriaxone, ciprofloxacin and gentamicin were the most effective drugs against Gram-positive and Gram-negative bacteria (Tables 5 and 6).

3.5. Multidrug resistance

Multidrug resistance to or more antibiotics was observed in 71 (100%) and 80 (80%) of Gram-positive and Gram-negative bacteria, respectively (Tables 7 and 8). The overall prevalence of multidrug resistance in both groups was 151 (88.3%).

In general, ceftriaxone, ciprofloxacin and gentamicin were the most effective drugs against the tested Gram-positive and Gram-negative bacteria.

Table 4

Risk factors for bacterial with ear infection among patients with ear discharge attending at Gondar University Hospital, Gondar, Northwest Ethiopia from February 2014 to June 2014.

Risk factors		Bacterial infection		Total	Crude odds ratio (95% *CI*)	AOR (95% *CI*)
		Yes	No			
Age	< 15	59	1	60	4.200 (0.426–56.800)	4.300 (0.084–222.000)
	15–40	70	11	81	0.530 (0.110–2.560)	0.010 (0.000–0.220)*
	> 40	24	2	26	1	1
Sex	Male	92	5	97	2.710 (0.870–8.490)	21.200 (1.910–23.570)*
	Female	61	9	70	1	1
Residence	Urban	117	9	126	0.550 (0.170–1.750)	2.410 (0.320–17.930)
	Rural	36	5	41	1	1
Previous ear infection	Yes	110	5	115	0.217 (0.070–0.680)	0.720 (0.013–38.850)
	No	43	9	52	1	1
Upper respiratory tract infection	Yes	22	5	27	3.300 (1.010–10.790)	0.730 (0.059–8.890)
	No	131	9	140	1	1
Recurrent tonsillitis	Yes	6	5	11	13.600 (3.470–53.260)	0.340 (0.001–1.510)
	No	147	9	156	1	1
Introduction of foreign body to the ear	Yes	22	6	28	4.460 (1.410–4.110)	0.180 (0.010–3.380)
	No	131	8	139	1	1
Long-term antibiotic usage	Yes	106	6	112	0.333 (0.109–1.012)	3.143 (0.379–26.070)
	No	47	8	55	1	1
Duration of infection	2 weeks	43	9	52	1	1
	> 2 weeks	110	5	115	4.605 (1.460–14.520)	4.901 (0.160–147.870)
Hearing problem	Yes	90	5	95	0.389 (0.124–12.160)	2.129 (0.290–15.570)
	No	63	9	72	1	1

*: The presence of significance association.

Table 5

Antimicrobial resistance patterns of Gram-positive bacteria isolates among patients with ear discharge attending at Gondar University Hospital, Gondar, Northwest Ethiopia from February 2014 to June 2014.

Antibiotics tested	Number of resistance isolate [n (%)]					Total [n (%)]
	S. aurues (n = 43)	*Entrocuccus* spp. (n = 11)	*S. epidermidis* (n = 10)	*S. pneumoniae* (n = 4)	*S. pyogenes* (n = 3)	
Penicillin	38 (88.4)	10 (90.9)	9 (90.0)	2 (50.0)	2 (66.7)	61 (85.9)
Ampicillin	41 (95.3)	6 (54.5)	2 (20.0)	2 (50.0)	2 (66.7)	61 (85.9)
Amoxicillin	30 (69.8)	3 (30.0)	2 (50.0)	2 (50.0)	0 (0.0)	37 (52.1)
Ceftriaxone	13 (30.2	0 (0.0)	1 (10.0)	4 (100.0)	3 (100.0)	21 (29.5)
Ciprofloxacin	0 (0.0)	6 (54.5)	5 (50.0)	0 (0.0)	0 (0.0)	12 (14.9)
Chloramphenic	1 (2.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.4)
Erythromycin	38 (88.4)	0 (0.0)	9 (90.0)	3 (75.0)	2 (66.7)	47 (66.2)
Gentamicin	19 (44.1)	0 (0.0)	4 (40.0)	3 (75.0)	0 (0.0)	13 (18.3)
Kanamycin	15 (34.9)	11 (100.0)	3 (30.0)	1 (25.0)	2 (66.7)	32 (45.1)
Oxacillin	18 (41.9)	11 (100.0)	4 (40.0)	4 (100.0)	0 (0.0)	37 (52.2)
Streptomycin	28 (65.2)	11 (100.0)	3 (30.0)	4 (100.0)	3 (100.0)	49 (69.0)
Cotrimoxazole	9 (20.9)	1 (9.1)	7 (70.0)	4 (100.0)	3 (100.0)	24 (33.8)
Vancomycin	19 (44.1)	1 (9.1)	7 (70.0)	1 (25.0)	3 (100.0)	31 (43.7)

Table 6

Antimicrobial resistance patterns of Gram-negative bacteria isolates among patients with ear discharge attending at Gondar University Hospital, Gondar, Northwest Ethiopia from February 2014 to June 2014.

Bacterial isolates	Number of resistance to antimicrobial agents [*n* (%)]								
	AMP	AMC	CRO	CPR	C	CN	K	S	SXT
P. mirabilis (*n* = 24)	17 (70.8)	12 (50.0)	0 (0.0)	0 (0.0)	8 (33.3)	0 (0.0)	3 (12.5)	10 (41.7)	1 (4.2)
P. aeruginosa (*n* = 23)	23 (100.0)	21 (91.3)	13 (56.0)	5 (21.7)	19 (82.6)	3 (13.0)	20 (86.5)	20 (86.9)	15 (65.2)
P. vulgaris (*n* = 16)	14 (87.5)	8 (50.0)	0 (0.0)	1 (6.2)	11 (75.0)	5 (31.3)	4 (25.0)	11 (68.7)	2 (12.5)
K. pneumoniae (*n* = 12)	12 (100.0)	12 (100.0)	5 (41.7)	0 (0.0)	8 (66.7)	2 (16.7)	6 (50.0)	9 (75.0)	5 (41.6)
K. ozane (*n* = 9)	9 (100.0)	9 (100.0)	1 (11.1)	1 (8.3)	3 (33.3)	1 (11.1)	4 (44.4)	0 (0.0)	2 (22.2)
Citrobacter spp. (*n* = 5)	5 (100.0)	5 (100.0)	5 (100.0)	0 (0.0)	3 (60.0)	0 (0.0)	2 (40.0)	5 (100.0)	5 (100.0)
K. oxytoca (*n* = 4)	2 (50.0)	2 (50.0)	2 (50.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (100.0)	4 (100.0)	2 (50.0)
P. ritigri (*n* = 3)	3 (100.0)	3 (100.0)	3 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (100.0)	0 (0.0)
E. coli (*n* = 2)	2 (100.0)	2 (100.0)	0 (0.0)	0 (0.0)	2 (100.0)	2 (100.0)	1 (50.0)	2 (100.0)	1 (50.0)
E. cloacae (*n* = 1)	1 (100.0)	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
H. influenzae (*n* = 1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Total (*n* = 100)	88 (88.0)	75 (75.0)	29 (29.0)	7 (7.0)	55 (55.0)	13 (13.0)	44 (44.0)	64 (64.0)	33 (33.0)

AMP: Ampicillin; AMC: Amoxicillin-clavulanic acid; CRO: Ceftriaxone; CPR: Ciprofloxacin; C: Chloramphenicol; CN: Gentamicin; K: Kanamycin; S: Streptomycin; SXT: Trimethoprim-Sulphamethoxazole.

Table 7

Multidrug resistance patterns of Gram-positive bacteria isolated among patients with ear discharge at the Gondar University Hospital, Northwest Ethiopia from February 2014 to June 2014.

Bacterial isolates	Antimicrobial susceptibility [*n* (%)]						
	R0	R1	R2	R3	R4	R5	R6
S. aureus (*n* = 43)	0 (0.0)	0 (0.0)	0 (0.0)	7 (16.3)	5 (11.6)	15 (34.9)	16 (47.5)
S. epidermidis (*n* = 10)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	6 (60.0)	2 (20.0)	2 (0.2)
S. pneumonia (*n* = 4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (25.0)	1 (25.0)	2 (0.5)
Entrocuccus spp. (*n* = 11)	0 (0.0)	0 (0.0)	0 (0.0)	3 (27.3)	1 (9.1)	6 (54.5)	1 (9.0)
S. pyogenes (*n* = 3)	0 (0.0)	0 (0.0)	1 (33.3)	0 (0.0)	1 (33.3)	1 (3.3)	0 (0.0)
Total (*n* = 71)	0 (0.0)	0 (0.0)	1 (1.4)	10 (14.1)	14 (19.7)	25 (35.2)	21 (29.5)

R0–R6 means certain bacterial isolate is resistance for 0-6 different drugs.

Table 8

Multidrug resistance patterns of Gram-negative bacteria isolated among patients with ear discharge at Gondar University Hospital, Northwest Ethiopia from February 2014 to June 2014.

Organism isolated	Antibiogram patterns [*n* (%)]							
	R0	R1	R2	R3	R4	R5	R6	R7
E. coli	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (100.0)	0 (0.0)
Pseudomonas spp.	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (4.3)	6 (26.1)	7 (30.4)	9 (39.1)
P. mirabilis	1 (4.2)	4 (16.7)	15 (62.5)	1 (4.2)	1 (4.2)	2 (8.3)	0 (0.0)	0 (0.0)
P. vulgaris	0 (0.0)	4 (25.0)	1 (6.2)	2 (12.5)	2 (12.5)	5 (31.2)	2 (12.5)	0 (0.0)
P. rettgeri	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)
K. pneumoniae	0 (0.0)	0 (0.0)	0 (0.0)	2 (16.7)	4 (33.3)	2 (16.7)	2 (16.2)	2 (16.7)
K. ozaenae	0 (0.0)	0 (0.0)	1 (11.1)	5 (55.6)	3 (33.3)	0 (0.0)	0 (0.0)	0 (0.0)
Citrobacter spp.	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	5 (100.0)	0 (0.0)
K. oxytoca	0 (0.0)	0 (0.0)	0 (0.0)	2 (50.0)	0 (0.0)	2 (50.0)	0 (0.0)	0 (0.0)
H. influenzae	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
E. colace	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Total	2 (2.0)	8 (8.0)	18 (18.0)	12 (12.0)	14 (14.0)	17 (17.0)	18 (18.0)	11 (11.0)

R0–R7 means certain bacterial isolate resistance to 0, 1, 2, 3, 4, 5, 6 and 7 antimicrobials.

4. Discussion

Many studies indicate that OM is an important public health problem especially in children and it is the most common indication for antibiotics prescribing[6]. The rate of bacterial isolation in discharging ear in our study was 91.6%. Similar results also reported in Addis Ababa (96.6%)[14] and Nigeria (76.1%)[15].

The clinical findings of patients with ear infection (predominantly CSOM), the peak-age prevalence (mostly children younger than 15 years of age) in our study (Table 4) are similar to findings of previous studies done in Ethiopia[16]. In developed countries, however, AOM was more commonly seen than CSOM[17]. This disparity partly may be explained by the lack of health awareness in the community, inadequate health infrastructure, and limited access to medical care and lack of specialists in developing countries.

Different studies indicate that OM is an important public health problem affecting all age groups and sexes. It is the most frequent disease for a child to visit a physician[18] and age has been considered a predisposing factor for ear infection, especially in children ($P < 0.0001$)[19]. In the same way in this study, 35.9%

of OM patients were children less than 15 years old which is comparable to 45% and 46% reported in Ethiopia[20] and Nigeria[21], respectively. This indicates that children were more prone to have ear infections. The high prevalence may be related to different factors such as anatomy of the eustachian tubes which are short, broad and straight nature allowing the bacteria into the middle ear. Additionally, the nutritional status of the children and other health problems like upper respiratory tract infections which are important for contribution of middle ear bacterial infection are high in young children because of immature immunity[21].

In the present investigation, significant ear infection was detected in 58.1% *vs.* 41.9% (P = 0.013) (Table 4) in male and female patients, respectively. Similar findings have been reported in studies conducted in Gondar University Teaching Hospital, Ethiopia (63.7% *vs.* 36.3%) (P = 0.017)[18] and Nigeria[19]. To the contrary study done in Sudan, females were more affected by ear discharge. This may be due to the difference between ear cleaning habit of the males and females. In some traditions, females use cotton swabs to clean their ears and this may contribute for the introduction of microorganisms from the external surface to the middle ear[22]. However, in some other studies[23], there is no difference on the prevalence of ear infections between males and females.

Different studies showed that the etiologic agents of ear infection accounted for mainly to Gram-negative bacteria[24]. Similarly, the majority of the ear infection in the present study were caused by Gram-negative bacteria (58.4%) which is also similar to previous studies that have been conducted in Gondar (56.9%)[23] and Addis Ababa (60.5%)[14] and Nigeria [224 (65.9%)][15]. In the present study, the majority of the patients 137 (89%) had single bacterial infection, which is similar to the previous retrospective report from Gondar University Hospital, Ethiopia [185 (90.7%)][18] and other studies in Ethiopia [650 (88%) and 135 (79.5%)] respectively[20], including Nigeria [413 (72.6%)][15].

In this study, the predominant bacterial isolates were *S. aureus* [43 (25.1%)], followed by 40 (23.4%) and 22 (13.5%) of *Proteus* spp. and *Pseudomonas* spp. This was in line with previous study done in Ethiopia, 47 (31.2%), 40 (26.5%) and 21 (13.9%) of *S. aureus*, *Proteus* spp. and *Pseudomonas* spp., respectively[14]. However, in contrast with the previous report from Gondar University Hospital, Ethiopia, 27.5% *Proteus* spp., followed by 26.5% *S. aureus*[18] and again elsewhere *Pseudomonas* spp. followed by *S. aureus* in Nigeria[19] and Turkey[25] (37.3% and 30.4%, 23% and 18%, respectively) were the most dominant. These patterns of bacterial isolates change through time due to differences in climate and geographical variations in different countries.

In this prospective study, *S. epidermidis* accounted for 6%. This finding is comparable with previous reports from Gondar[23] and Addis Ababa[14], which accounted for 4.2% and 3%, respectively. These were considered as contaminants in this study since the normal bacterial flora of the external ear canal is predominately *S. epidermidis*[5]. But the isolation rate was lower than a previous study in Gondar which is 11.2%[18] and Nigeria which is 47.8%[5]. This low rate of bacterial isolation in the present study may be due to the differences of the quality of ear infection specimens, bacteriological techniques and may be due to the differences in climate and geographical variations in different countries.

In this study, the susceptibility pattern of *S. aureus* isolates demonstrated 100% susceptable to ciprofloxacin and low level resistance to gentamicin, and ceftriaxone. This result is in agreement with a study done in Ethiopia[9]. The present study showed 6.34% *Entrococcus* spp. The emergence of *Entrococcus* spp. may pose therapeutic problems.

The study also provides insights into the susceptibility profile of bacteria isolated from ear discharge. Our results showed that Gram-positive bacteria isolated from ear infections showed low resistance rates (< 60%) to ceftriaxone, ciprofloxacin, chloramphenicol, gentamicin, kanamycin, streptomycin and trimethoprim-sulphamethoxazole and Gram-negative amoxicillin clavulinic acid (60%–80%), and ampicillin (> 80%) intermediate level of resistance and high level of resistance, respectively. In addition, ampicillin and penicillin showed (> 80%) high level of resistance for Gram-positive (Tables 5 and 6). Gram-positive bacteria showed low-level resistance to erythromycin, vancomycin and oxacillin and penicillin. This is in agreement with previous study done in Ethiopia[14], where most of the isolates showed low resistance retes (< 60%) to amoxicillin-clavulinic acid, ceftriaxone, ciprofloxacin, chloramphenicol, gentamicin, kanamycin, streptomycin and trimetoprim-sulphamethoxazole and intermediate level of resistance (60%–80%) to ampicilln. Gram-positive bacteria showed low-level resistance to erythromycin, vancomycin and methicillin and intermediate level of resistance to penicillin. However, there are reports from different parts of the world with high resistance to these antimicrobial agents except for gentamicin[25]. This difference in the susceptibility profile might be due to the frequency of usage of these agents for the treatment of ear infections in different geographic locations. In the present study, ceftriaxone, gentamicin and ciprofloxacin were the most effective drugs as compared to other drugs tested against the Gram-positive and Gram-negative bacteria (Tables 5 and 6). This is comparable with other studies done in Ethiopia[20]. This may be due to the infrequent prescription of these drugs in Ethiopia. In this study, multidrug resistances (resistant to two or more drugs) were observed in Gram-positive (100%) and Gram-negative bacteria (88.4%). Comparable results also seen in similar study in Gondar Ethiopia with 88% Gram-positive and 66.7% Gram-negative bacteria[24]. It is a known fact that microbial drug resistance is a growing global problem.

In conclusion, the prevalence of bacterial isolates accounted for 91.6% of the patients included in the study. Majority of the isolates were Gram-negative from discharging ear. *S. aureus*, *Pseudomonas* spp. and *Proteus* spp, were the most common isolated pathogens. Being male and age less than 15 years were factors associated with ear infection.

Majority of the bacterial isolates had multiple antibiotic resistant patterns. Hence, antibiotics susceptibility test is mandatory before prescribing any antibiotics. Ceftriaxone, ciprofloxacin and gentamicin were the most effective drugs against the Gram-positive and Gram-negative bacteria.

Conflict of interest statement

We declare that we have no conflict of interest.

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