




Magnitude of Acute Otitis Media, Bacteriological Profile and Antimicrobial Sensitivity Patterns of Nasopharyngeal Isolates in Children Receiving Care in Moshi Municipality

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Abstract

Background: Acute otitis media (AOM) is among the most common paediatric diseases and a leading cause of morbidity in children. Common etiologic pathogens include non-typable *Haemophilus influenzae*, *Streptococcus pneumoniae*, *Staphylococcus aureus*, *Streptococcus pyogenes*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Moraxella catarrhalis* among others. Evidence shows an increase in cases of antimicrobial resistance when treating for AOM in children, which could be attributed to high rates of empirical treatment for cases of AOM without a clear microbial picture of the otopathogens responsible for the condition. **Methods:** Multi-centre cross-sectional study, carried out between September 2023 to February 2024 at 4 study sites in the outpatient departments. Children under 5 years presenting with AOM during the study period were enrolled. An interview was conducted with parents/caregivers followed by clinical assessment of the children. Nasopharyngeal swabs were obtained from each of these patients and sent to the laboratory for bacterial culture and sensitivity. Data was analysed using SPSS v22. **Results:** A total of 117 children were enrolled in the study from 420 children receiving care during the study period. The magnitude of AOM was 27.9%, with children aged between 13 to 24 months being the most susceptible. Common isolated pathogens included *S. pyogenes*, *E. coli*, *Acinetobacter* spp. and *P. aeruginosa* and *S. aureus*.

Amikacin, Meropenem, Ciprofloxacin and Tazobactam/Piperacillin had the highest rates of susceptibility while Amoxicillin, Ampicillin, Ceftriaxone and Amoxicillin/Clavulanic acid showed high levels of resistance. **Conclusion:** Magnitude of AOM among children is 27.9%. Bacterial pathogens isolated from nasopharyngeal swabs are different from the common etiologic bacteria seen in AOM which could be due to good vaccination coverage of PCV and Pentavalent. Non susceptibility to the commonly used antibiotics indicates the growing rate of antimicrobial resistance. Better pathogen-tailored therapy needs to be implemented to help curb this burden, as well as further investigations on the rising etiologic pathogen.

Subject Areas

Otorhinolaryngology

Keywords

Otitis Media, Acute Otitis Media, Antimicrobial Resistance, Magnitude

1. Introduction

Otitis media is the inflammation of the tympanic membrane and middle ear with a spectrum that includes acute otitis media (AOM), otitis media with effusion (OME) and chronic suppurative otitis media (CSOM) [1]. Globally, around 1.23 billion people are affected by otitis media, ranking it as the fifth global burden of disease and the second cause of hearing loss [2]. Children tend to be the most affected group, with it being among the most common diseases responsible for children receiving antibiotics [3]. Worldwide AOM incidence is estimated at 10,000 per 100,000 individuals [4] with 51% of the incidence in children under 5 years of age. Children under the age of 5 years tend to be prone to most episodes of AOM, due to immaturity of their immune systems, shorter, wider and horizontal nature of the Eustachian tubes, frequent exposure to URTIs and malnutrition. OM was found to be more common in developing countries, namely Sub-Saharan West Africa, Southeast Asia and Oceania [5]. The incidence in these areas is reportedly 2 to 8 times higher than in the rest of the world. In Cameroon, there is a 9.7% prevalence of OM and its sequel in children between the ages of 2 - 3 years [6]. In Kenya, a study showed the overall prevalence among schoolchildren with AOM was 7 of 1000, 15 of 1000 for OME and 15 of 1000 for CSOM [7].

Various pathogenic bacteria like non-typable *Haemophilus influenzae*, *Streptococcus pneumoniae*, *Staphylococcus aureus*, *Streptococcus pyogenes*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Moraxella catarrhalis* have been linked as the etiologic agents of otitis media [8]. Historically, *S. pneumoniae* and *H. influenzae* have been the common causes of AOM with the former generally associated with acute diseases [9]. In Yemen, culture positive bacterial pathogens from middle ear discharge were *S. aureus* (44%), *P. aeruginosa* (12.67%), *Enterococcus* species

(12.67%) and *S. pneumoniae* (10%). The sensitivity to Cefotaxime was high among all the isolates seen [10]. In Romania, analysis was done on cultures of middle ear fluid from children with AOM and found that bacterial causative pathogens were *S. pneumoniae* (72.16%), *H. influenzae* (17.52%), *M. catarrhalis* (2.06%), *P. aeruginosa* (2.06%), *E. coli* (1.03%), *Enterobacter aerogenes* (1.03%). Subsequently, it was found that *S. pneumoniae* had an *in vitro* sensitivity for ceftriaxone, moxifloxacin and vancomycin in all tested strains, *H. influenzae* had all strains sensitive to cefuroxime and ceftriaxone, *E. coli* was sensitive to all antibiotics tested (ampicillin, amoxicillin/Clavulanic acid, cefuroxime, ceftriaxone, gentamicin, amikacin, ciprofloxacin), *P. aeruginosa* was sensitive to all antibiotics (piperacillin/tazobactam, ceftazidime, imipenem, meropenem, gentamicin, ciprofloxacin), while *Enterobacter aerogenes* was sensitive only to piperacillin/tazobactam, carbapenems, amikacin and tetracycline [11]. In Ethiopia, the overall prevalence of bacterial pathogens from OM was 48.5% with the most predominant being *S. aureus* (15.8%), *P. aeruginosa* (10.9%), Viridians streptococcus (9.9%), *S. pneumoniae* (8.9%) and *S. pyogenes* (7.9%). Most of the isolates showed over 75% susceptibility to amoxicillin-clavulanic acid, Cefotaxime, Ciprofloxacin, Cefuroxime and Ceftazidime [3]. In Uganda, the overall nasopharyngeal bacterial carriage prevalence for children under 5 years of age was high at 62%, with individual species isolated including *Strep. pneumoniae* (46%), *H. influenzae* (21%), *M. catarrhalis* (7%) and *S. aureus* (6%). For sensitivity, *S. pneumoniae* was highly susceptible to penicillin and Ceftriaxone (99%), while highly resistant to co-trimoxazole (100%), erythromycin (76%), tetracycline (52%). *H. influenzae* was resistant to co-trimoxazole (100%) and tetracycline (75%), while susceptible to Ciprofloxacin and Cefuroxime, *M. catarrhalis* was resistant to ampicillin, penicillin and co-trimoxazole (100% each) while susceptible to other antibiotics tested, and *S. aureus* was susceptible to chloramphenicol and cefoxitin, while resistant to penicillin (100%), co-trimoxazole, erythromycin and clindamycin [12].

Various measures have been implemented to help curb the impact of AOM in society like educating mothers and healthcare workers on need for early detection and prevention, as well as incorporation of PCV and Pentavalent (*Haemophilus influenzae*) into the national immunization schedule. Despite good vaccination coverage rates, there is still a high number of AOM cases especially among children under 5 years of age in hospitals and health centres, leading to suspicion of a new etiologic pathogen or the possibility of antimicrobial resistance against the commonly used antibiotics. This study therefore aimed to understand the burden of AOM and the antimicrobial susceptibility patterns of the isolated pathogens.

2. Methods

2.1. Study Design and Setting

This was a hospital based cross sectional study involving under 5 years of age in Moshi Municipality presenting with AOM from September 2023 to February 2024.

Four health facilities were purposively selected to cover various tiers of health

care namely: Kilimanjaro Christian Medical Centre (KCMC), St. Joseph Hospital, Majengo and Pasua Health Centres. KCMC is a tertiary care hospital in Northern Tanzania; it serves as a referral, research and teaching hospital, located in the Northeastern part of Tanzania. It caters for four regions in the Northern part of Tanzania, namely, Kilimanjaro, Tanga, Arusha, Manyara with an estimated population of over 10,000,000 people, while also receiving referrals from across Tanzania. It has a bed capacity of 450. St Joseph is a designated District Hospital which has several departments and admits approximately 1787 paediatric patients annually. Majengo Health Centre and Pasua Health Centre are secondary-level health centres. Both serve a considerable number of patients averaging 4920 at outpatient department, 564 in-patients annually at Pasua Health Centre and 5491 outpatients annually at Majengo Health Centre.

2.2. Study Population

All children aged 0 - 59 months presenting with AOM for a period of less than 2 weeks receiving care in the four study sites during the study period were selected. Sample size was estimated per hospital attendances. At least 10 patients were expected from each of the 4 study sites each month. Data was collected for 6 months. Expected sample size was 240.

2.3. Inclusion and Exclusion Criteria

We included all children aged 0 - 59 months presenting with AOM and excluded those whose parent/guardian did not consent to the study.

2.4. Data Collection and Study Variables

A questionnaire was used to collect socio-demographic and clinical data from participants with the aid of research assistants. The outcome variables were AOM, bacteriological profile and antimicrobial sensitivity patterns, while the predictor variables were age, sex, ear pain or tugging, vomiting, irritability, fever. Research assistants were selected from the four study sites and trained on how to detect features of AOM from patient symptoms, then instructed on how to diagnose AOM from signs on otoscopic examination.

A physical examination was done including otoscopy using an otoscope model HS-OT10J. Children found to have AOM had trans nasal swabs taken using flexible, sterile, soft rayon swab type CF101 Rev.00. Briefly, trained research assistants carried this out by gently inserting the swab into the child's nostril and softly advancing to the nasopharynx. The swab was then slowly rotated up and down around the nasopharynx, removed, and stored in Stuart transport media (HiMedia, India) and transported to the department of Clinical Laboratory, Microbiology unit and stored at -20°C until used for bacterial culture and sensitivity.

2.5. Nasopharyngeal Swab Culture

The specimen was inoculated on trypticase soya agar with 5% sheep blood

(HiMedia, India), chocolate agar (HiMedia, India), MacConkey's agar (HiMedia, India). The trypticase soya agar with 5% sheep blood and MacConkey's agar were incubated aerobically, while chocolate agar was incubated under 5% CO₂ atmosphere at 37°C for 24 - 48 h. All positive cultures were identified by colonies morphology/characteristics and Gram-staining reaction. Briefly, for gram negative bacilli were identified by indole production, H₂S production, citrate utilization, motility test, urease test, and oxidase, while for Gram-positive bacteria coagulase, mannitol salt agar, catalase, bacitracin and optochin susceptibility tests.

2.6. Antimicrobial Sensitivity

Antimicrobial susceptibility testing was determined by disk diffusion method according to clinical laboratory standard institute (CLSI, 2023). Bacterial suspension was prepared and was adjusted to a McFarland solution 0.5 and inoculated onto Muller Hinton agar (HiMedia, India). The following antibiotic disc (Oxoid, UK) were used for gram positive bacteria: penicilin G (10U), clindamycin (2 µg) erythromycin (15 µg), vancomycin (30 µg), ciprofloxacin (5 µg), cefoxitin (30 µg) gentamicin (10 µg), while for gram negatives: Ampicillin (10 µg), amoxylin/clavulanate (20/10 µg), gentamicin (10 µg), trimethoprim/sulphamethoxazole (1.24/23.75 µg), ciprofloxacin (5 µg), Ceftriaxone (30 µg), Ceftazidime (30 µg), Amikacin (30 µg) and Meropenem (10 µg).

E. coli ATCC 25922, *P. aeruginosa* (ATCC 27853) and *Staphylococcus aureus* ATCC 25923 was used as reference strains for gram negative and gram-positive bacteria, in quality control of culture media, biochemical identification tests and antimicrobial susceptibility testing.

2.7. Data Analysis

Data was coded and entered into computer using SPSS version 22 for analysis. Descriptive summary statistics for both Categorical and Numerical data was done by their respective measures of central tendency and measures of spread and presented using tables, figures and narrations

3. Results

A total of 420 children under the age of 5 years received care at the four study sites during the study period. Of the 420 children under the age of 5 years, 117 were found to have acute otitis media and were enrolled in our study, giving a magnitude of 27.9%. We failed to meet the estimated sample size due to low turnout during the study period as well few parents/guardians not consenting to the process of data collection. Out of these 117, 13 were from Majengo Health Centre and St. Joseph Hospital each, 43 were from KCMC and 48 were from Pasua Health Centre. The mean age was 26.7 (SD 16.3) months with more than half being males 60/117 (51.3%). Majority reported to be residing in Moshi Rural 70/117 (59.9%) with cow's milk intake being a common form of nutrition 93/117 (79.5%) (See **Table 1**).

Table 1. Socio-demographic characteristics of participants (N = 117).

Characteristics	No.	%
Age (months) (n = 117)		
0 - 12	29	24.8
13 - 24	33	28.2
25 - 36	25	21.4
37 - 48	14	12
49 - 60	16	13.6
Mean (SD)	26.7 (16.3)	
Sex		
Male	60	51.3
Female	57	48.7
Residence		
Moshi rural	70	59.9
Moshi urban	31	26.5
Arusha	14	12
Manyara	1	0.9
Tarakea	1	0.9
Breastfeeding currently		
Yes	42	35.9
No	75	64.1
Cow's milk intake		
Yes	93	79.5
No	24	20.5

Table 2. Bacterial pathogens isolated (n = 117).

Bacterial pathogen	Frequency	%
<i>Acinetobacter</i> species	14	12
<i>Bacillus</i> species	4	3.4
<i>Citrobacter koseri</i>	1	0.9
<i>Citrobacter</i> species	7	6
<i>E. coli</i>	18	15.4
<i>Enterococcus</i> species	4	3.4
MRSA	5	4.3
<i>Pseudomonas aeruginosa</i>	12	10.3
<i>Pseudomonas</i> species	1	0.9
<i>Staphylococcus aureus</i>	6	5.1
<i>Staphylococcus</i> species	1	0.9
<i>Streptococcus pyogenes</i>	39	33.3
<i>Streptococcus</i> species	5	4.3

All the 117 participants had nasopharyngeal swabs taken for culture and sensitivity. Of these, all had bacterial pathogens isolated. 59 (50.4%) of the isolates were Gram positive, while 54 (46.2%) were Gram negative, and 4 (3.4%) had cultured *Bacillus spp* which did not undergo sensitivity. From the isolated pathogens, majority were *Streptococcus pyogenes* 39 (33.3%), followed by *E. coli* 18 (15.4%), *Acinetobacter spp.* 14 (12%) and *Pseudomonas aeruginosa* 12 (10.3%) (See **Table 2**).

Amikacin had the highest rate of susceptibility to the bacteria tested against 48 (90.6%) followed by Ciprofloxacin 55 (82.1%), Meropenem 48 (76.2%) and Tazobactam/Piperacillin 52 (74.3%). Ampicillin 56 (69.1%), Amoxicillin 54 (62.1%) and Amoxicillin/Clavulanic acid 24 (57.1%), showed high rates of resistance (See **Table 3**).

Table 3. Antimicrobial sensitivity patterns of nasopharyngeal isolates.

Antibiotic	Susceptible	Resistant	Intermediate
Ampicillin	25 (30.9%)	56 (69.1%)	0
Amoxicillin	32 (36.8%)	54 (62.1%)	1 (1.1%)
Amoxicillin/Clavulanic acid	17 (40.5%)	24 (57.1%)	1 (2.4%)
Ceftriaxone	46 (48.4%)	47 (49.5%)	2 (2.1%)
Meropenem	48 (76.2%)	15 (23.8%)	0
Cefpodoxime	19 (51.4%)	17 (45.9%)	1 (2.7%)
Cefixime	19 (50%)	19 (50%)	0
Cefalexin	19 (47.5%)	21 (52.5%)	0
Vancomycin	38 (67.9%)	15 (26.8%)	3 (5.4%)
Clindamycin	31 (57.4%)	21 (38.9%)	2 (3.7%)
Amikacin	48 (90.6%)	5 (9.4%)	0
Tazobactam/Piperacillin	52 (74.3%)	18 (25.7%)	0
Ciprofloxacin	55 (82.1%)	7 (10.4%)	5 (7.5%)

Of the most common isolated pathogens, *Strep. pyogenes* was susceptible to vancomycin (64.1%), clindamycin (48.7%), ceftriaxone (41%), and ampicillin and amoxicillin (35.9%). *E. coli* was susceptible to Tazobactam/Piperacillin (94.4%), Meropenem and Amikacin (88.9%) each, Ciprofloxacin (72.2%), Amoxicillin/Clavulanic acid, Cefpodoxime and Ceftriaxone (44.4%) each. *Acinetobacter* species was susceptible to amikacin, ciprofloxacin, meropenem and Tazobactam/Piperacillin at 85.7% for each. *P. aeruginosa* was susceptible to amikacin (91.7%), ciprofloxacin, meropenem and Tazobactam/Piperacillin (83.3%) each. *S. aureus* was susceptible to ciprofloxacin (66.7%), ampicillin and vancomycin (50%) and almost all other antibiotics tested (See **Table 4**).

Table 4. Susceptibility of bacterial pathogens against antibiotics tested.

	Antibiotic used (Susceptible cases)												
	AMC	AMP	AMX	AK	CFDXM	CFXM	CFXN	CIP	CRO	CD	MEM	TZP	VA
<i>Acinetobacter</i> spp (14)			1	12		2		12	9		12	12	
<i>Bacillus</i> spp (4)													
<i>Citrobacter koseri</i> (1)	1		1	1	1	1	1	1				1	
<i>Citrobacter</i> spp (7)	2		2	6	5	5	5	7	4		1	5	
<i>E. coli</i> (18)	8	4	4	16	8	7	7	13	8		16	17	
<i>Enterococcus</i> spp (4)	1	2	2					4			2	2	3
<i>Pseudomonas aeruginosa</i> (12)				11				10			10	10	
<i>Pseudomonas</i> spp (1)				1							1		
<i>Staphylococcus aureus</i> (6)	2	3	2		2	1	1	4	1	2	1	2	3
MRSA (5)						1		1		3			1
<i>Staphylococcus</i> spp (1)	1		1		1		1		1		1	1	1
<i>Streptococcus pyogenes</i> (39)		14	14		1	1	1		16	19	1		25
<i>Streptococcus</i> spp (5)		2	3						3	4			4

AMC: Amoxicillin/Clavulanic acid, **CIP:** Ciprofloxacin, **AMP:** Ampicillin, **CRO:** Ceftriaxone, **AMX:** Amoxicillin, **CD:** Clindamycin, **AK:** Amikacin, **MEM:** Meropenem, **CFDXM:** Cefpodoxime, **TZP:** Tazobactam/Piperacillin, **CFXM:** Cefixime, **VA:** Vancomycin, **CFXN:** Cefalexin.

4. Discussion

This study focused on determining the magnitude of AOM, the bacteriological profile and antimicrobial sensitivity patterns of nasopharyngeal isolates among children receiving care in Moshi Municipality. We found the magnitude of AOM to be 27.9% with children between 13 to 24 months of age being the most susceptible. The most commonly isolated pathogens include *S. pyogenes*, *E. coli*, *Acinetobacter* spp. and *P. aeruginosa*. Sensitivity patterns showed that Amikacin, Meropenem, Ciprofloxacin and Tazobactam/Piperacillin had the highest rates of susceptibility while Amoxicillin, Ampicillin, Ceftriaxone and Amoxicillin/Clavulanic acid showed high levels of resistance.

Our study is different from the magnitude of 0.07% from a study done by Simões *et al.* in 2016 in Kenya among schoolchildren. The difference could be attributed to the difference in study areas as theirs was a community-based study. Similarly, a study done by Libwea *et al.* in 2018 from Cameroon found the prevalence to be 9.7%, likely due to it also being a community-based study. These differences are due to the fact we saw patients who are sick hence sampling was done in diseased population. In USA, Chonmaitree *et al.* found a prevalence of 58% for AOM in 2016. This could be attributed to the longer study duration of 65 months, and a follow up period from when the infants were healthy up to the period they developed AOM. Majority of published studies have focused on ear disease or Chronic Suppurative Otitis Media. Our study is of value as it's the first to be done

in the region. We cannot comment if the magnitude of Acute Otitis Media has increased or not. As of importance, future studies now have baseline information to monitor trend and pattern of the disease.

Our study found majority of the bacterial pathogens isolated were *Streptococcus pyogenes* (33.3%), followed by *E. coli* (15.4%), *Acinetobacter spp.* (12%) and *Pseudomonas aeruginosa* (10.3%) while *Staphylococcus aureus* had a prevalence of 5.1%. *Enterococcus* species had a magnitude of 3.4% while *Pseudomonas* species made up 0.9%. Our findings were similar to those by Ikechukwu *et al.*, 2017 in Nigeria who found *Staph. aureus* at 31.3% and *Pseudomonas aeruginosa* at 22.9%. Likewise, Abera *et al.*, 2011 in Ethiopia found most frequent isolates to be *Staph. aureus* at 24.6%, *Pseudomonas* species at 18%, *E. coli* at 17.7%. Hailegiyorgis *et al.*, 2018 in Ethiopia found isolates including *Staph. aureus* at 15.8%, *Pseudomonas aeruginosa* at 10.9%, *S. pyogenes* at 7.9%, while Tadesse *et al.*, 2019 from Ethiopia found *Staph. aureus* at 27%, *Enterococcus* spp. at 7.2% and *E. coli* at 6.6%. The isolation of *P. aeruginosa* could be related to the ability of the organism to survive in competition with other organisms and resist to antibiotics [13]. Isolating fecal bacteria like *E. coli* might indicate that participants were at risk of infection due to poor hygiene [14].

Differences were noted in studies by Gavrilovici *et al.*, 2022 in Romania where some of the isolates found included *Strep. pneumoniae* at 72.16%, *H. influenzae* at 17.52%, *M. catarrhalis* at 2.06%, which have been the most common perpetrators for the etiology of AOM. Romania has PCV 20 and Pentavalent vaccines in its schedules, the emergence of these high rates compared to ours could be explained by differences in climate (extreme temperatures) which are known to have an effect on organisms as they tend to undergo selection pressure hence changed its phenotype. Aidah *et al.*, 2016 in Yemen found a low prevalence of *Strep. pneumoniae* isolated at 10%, similar to Hailegiyorgis *et al.*, 2018 who found *Strep. pneumoniae* at 8.9%, and Tadesse *et al.*, 2019 who found *H. influenzae* at 9.2%. These findings are different from ours where we didn't find any. Several factors, including environmental and socioeconomic factors, overcrowding conditions, and antibiotic overuse, appear to influence *S. pneumoniae* nasopharyngeal colonization [15]-[17].

Our study found that Amikacin, Meropenem, Ciprofloxacin and Tazobactam/Piperacillin had the highest rates of susceptibility when tested against the pathogens isolated. Aidah *et al.*, 2016 found that *S. aureus* was susceptible to Cefotaxime and Azithromycin (98%), Amoxicillin/Clavulanic acid (92%) and Gentamicin (85%). *P. aeruginosa* was susceptible to Cefotaxime (100%), Azithromycin and Gentamicin (98%). *Enterococcus* species were susceptible to Amoxicillin/Clavulanic acid (85%), Azithromycin (80%), Gentamicin (75%). Gavrilovici *et al.*, 2022 found *E. coli* was susceptible to all antibiotics tested. Abera *et al.*, 2011 in Ethiopia found Ciprofloxacin and Gentamicin had high levels of susceptibility (86.6% - 94.6%). Hailegiyorgis *et al.*, 2018 in Ethiopia also found that most pathogens were susceptible to Amoxicillin/Clavulanic acid, Ciprofloxacin, Ceftazidime

by more than 75%. Tadesse *et al.*, 2019, found that *E. coli* and *Enterococcus* species were resistant Ciprofloxacin, while *S. aureus* showed susceptibility to Ciprofloxacin and Gentamicin. Antimicrobial sensitivity patterns of AOM have been varying over time, possibly attributed to geographical difference, variance in populations studied and the local antimicrobial prescription practices. Resistance patterns shown against some of the commonly used antibiotics could be explained by empirical over-the-counter antibiotic prescription and use, contributing to the resurgence of antimicrobial resistance.

5. Strengths and Weaknesses

This study is the first to highlight the bacteriological profile and sensitivity patterns in relation to AOM in Moshi Municipality. It also covered multiple tiers of health care. Due to the short duration of the study, we were not able to ascertain the seasonal pattern of AOM in our region. Modality of acquiring the nasopharyngeal samples by trans nasal swabs was also a hinderance in having an adequate sample size as some parents/caretakers refused for the procedure to be done to their children.

6. Conclusions

AOM is one of the leading causes of childhood morbidity with children under 5 years of age being the most affected population. The magnitude of AOM was found to be 27.9%, with children between 13 to 24 months being the most affected. A difference from the well-known etiologic pathogens is seen with *S. pyogenes*, *E. coli*, *Acinetobacter* spp., *P. aeruginosa* and *S. aureus* being the most isolated pathogens. Antimicrobial sensitivity patterns showed that Amikacin, Meropenem, Ciprofloxacin and Tazobactam/Piperacillin had the highest rates of susceptibility while Amoxicillin, Ampicillin, Ceftriaxone and Amoxicillin/Clavulanic acid showed high levels of resistance.

There is a need for seasonal variation to be considered to elicit if the isolated pathogens are present throughout the year. Maintenance of high vaccine coverage rates in order to further decrease the occurrence of infections from the well-known etiological pathogens of AOM. Further efforts are required to investigate emerging pathogens and control resistance patterns seen with possible antibiogram data into treatment protocols. This is more relevant to the antibiotics that were found to have high rates of resistance namely Amoxicillin, Ampicillin, Ceftriaxone, and Amoxicillin/Clavulanic acid which are commonly used as options for empirical treatment of AOM cases.

Authors' Contributions

MPK, DNM and DDC designed the study; MPK, AAM, MRM, ANM, JGL, KJM and PPM input in the study design and conduct; MPK data collection; AAM carried out swab bacterial culture and sensitivity testing; MPK, DNM and DDC data analysis; all authors interpreted the findings; MPK prepared the final manuscript;

all authors read and approved the final manuscript.

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Availability of Data and Materials

All data and materials used during this study can be made available from the corresponding author on request.

Ethical Approval and Consent to Participate

Approval to conduct the study was obtained from KCMUCo Research and Ethics Committee with CRERC No PG 39/2023. Permission to conduct the study was also obtained from the Executive Director of KCMC Hospital and the Head of Department of Otorhinolaryngology, District Medical Officer and the Medical Officer in charge of St. Josph Hospital, Pasua and Majengo Health Centres respectively. Formal consent both verbal and written was obtained from the parents of the study participants.

Conflicts of Interest

The authors declare they have no competing interests.

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Abbreviations

AOM	Acute Otitis Media
KCMC	Kilimanjaro Christian Medical Centre
OM	Otitis Media
OME	Otitis Media with Effusion
PCV	Pneumococcal Conjugate Vaccine
SPSS	Statistical Package for Social Sciences