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Bacterial aetiologies of otitis media and their antimicrobial susceptibility in ear swab culture

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Abstract
An acute otitis media infection occurs in the middle ear. Otitis media has three types: acute, chronic suppurative, and effusion. After upper respiratory infections, acute otitis media is the second-most common pediatric emergency department diagnosis. Otitis media is most common in children aged 6–24 months.
Aims of the study: Knowing the most common types of bacteria that cause otitis media infections and their sensitivity to a group of antibiotics.
Methodology: The retrospective study collected 1,000 ear swabs from January 10 to November 10, 2023. Without medical consultation, 500 male and female ear swabs were collected to record age, nutritional status, and antibiotic use. The samples were tested for bacteria using oxidase, catalase, Voges-Proskauer, Simmon's citrate, Indole, and methyl red after culture on blood and MacConkey agar. The Mueller-Hinton agar drug sensitivity test at Al-Habbobi Teaching Hospital used several antibiotics in sterile conditions.
Results: The study found no significant difference in age among participants. The frequency of *Klebsiella* spp. was highest in all samples, while *Staphylococcus* spp. was less frequent. Females had a higher frequency of *Klebsiella* spp. than males. *Proteus* spp. was identical in both genders, while *Pseudomonas* was lower in females. Antibiotic usage was highest for AK, AMC, and IMP, with ATM having the lowest efficacy against otitis media infections. AZM was the most common antibiotic, followed by CAZ and AFB. The CIP and FOX repeats were significant in combating specific bacteria.
Conclusion: No significant age difference was found among the participants. In all samples, *Klebsiella* was the most common, and *Staphylococcus* was less common. *Klebsiella* spp. was more common in women. Females had lower *Pseudomonas* and identical *Proteus* spp. Amikacin, ciprofloxacin, and cefoxitin were the most common antibiotics, indicating their effectiveness in preventing and killing bacteria. Thus, healthcare workers ought to focus on these antibiotics to treat middle ear infections and prevent complications.

Keywords: Antibiotics, otitis media, acute inflammation, ear swab, culture

Introduction
An acute otitis media infection occurs in the middle ear. Otitis media includes acute, chronic, and effusion-related diseases. Acute otitis media is the second-most common emergency department diagnosis for children after upper respiratory infections. Otitis media can occur at any age, but it is most common in children aged 6–24 months [1].
Globally, otitis media affects more men than women. Due to poor reporting and regional variations, estimating the annual number of cases is difficult. Otitis media is most common between six and twelve months and decreases after five. At least 80% of children will develop otitis media, and 80% to 90% will develop an effusion before school. Adults have a lower likelihood of experiencing otitis media compared to children. However, individuals who had a history of recurrent otitis media during childhood, a cleft palate, immunodeficiency, immune compromised status, or other related conditions are more likely to develop it [2-3].
Several risk factors can increase the likelihood of a child developing acute otitis media. A prior upper respiratory tract infection is the most prevalent risk factor. Risk factors for adenoid hypertrophy-causing obstruction include male gender, allergies, attendance at daycare, exposure to environmental smoke, use of pacifiers, immunodeficiency, gastro

esophageal reflux, a parental history of recurrent childhood OM, and other genetic predispositions [4].

It is possible to develop suppurative acute otitis media (AOM). The term AOM stands for middle ear fluid. This middle-ear infection is associated with acute inflammation. The most common AOM symptoms and the main reasons children visit the clinic are ear pain (otalgia) and fever [5].

Streptococcus pneumoniae, *Haemophilus influenzae*, *Moraxella catarrhalis*, *Streptococcus pyogenes*, *Staphylococcus aureus*, viridans streptococci, *Klebsiella* spp., and *Pseudomonas aeruginosa* were isolated from AOM effusion. *Streptococcus pneumoniae*, a spherical, pair-forming gram-positive bacterium, causes acute otitis media (AOM) in all ages. AOM treatment failure and recurrence are caused by penicillin-resistant *S. pneumoniae* in over 50% of cases [25].

The main symptom of AOE is severe pain. The doctor manipulates the patient's pinna or tragus to distinguish Acute Otitis Externa (AOE) from AOM, causing AOE patients to experience more pain. Pain lasts up to 48 hours. A small amount of lactescent discharge causes auditory canal swelling and inflammation. AOM affects infants and children who cannot express their complaints, making it difficult to diagnose their symptoms. Acute otitis media (AOM) causes irritability, sleeplessness, decreased appetite, and ear pain, which causes children to pull on their ears. Upper respiratory tract infections cause much of the AOM, which can cause rhinorrhea. Fluid retention in the middle ear canal can cause balance issues and dizziness, as well as hearing loss [7-8].

Gram-negative *Klebsiella pneumoniae* belongs to the Enterobacteriaceae family. Captured and immobile. Bacterial virulence and antibiotic resistance are caused by a variety of factors. The polysaccharide capsule protects the bacteria from host opsonophagocytosis and serum killing, making them virulent. According to research, 77 *Klebsiella* species without capsules are less virulent. Gram-negative bacteria are protected by lipopolysaccharides, but they become pathogenic. Host inflammation and sepsis/septic shock are caused by lipopolysaccharides. Virulence factors such as fimbriae aid the organism's attachment to host cells. Siderophores aid the organism in infecting hosts. Siderophores steal host iron to promote infection [9-10].

Gram-negative bacteria, such as *S. aeruginosa*, do not stain in laboratory tests. To survive, the rod-shaped aerobic organism requires oxygen. It does not produce spores. This bacterium has the ability to infect both healthy and weakened immune systems. The organism's adaptability, antibiotic resistance, and diverse defense mechanisms make it difficult to treat in modern medicine. This activity's specifics Infections caused by *Pseudomonas aeruginosa* and their treatment [11].

Proteus mirabilis, a member of the Enterobacteriaceae rod-shaped bacteria family, is a type of gram-negative bacterium that can survive with or without oxygen and can break down maltose but not lactose. *P. mirabilis* has swarming motility and the ability to elongate itself and secrete a polysaccharide when it comes into contact with solid surfaces. This allows the bacterium to easily attach to and move along surfaces such as medical equipment. *P. mirabilis*' motility is aided by its flagella, which not only aids in colonisation but also in the formation of biofilms and is thought to contribute to resistance against host defences and specific antibiotics [12].

In humans, *Staphylococcus aureus* acts as both a symbiotic bacterium and a pathogen. Around 30% of the human population is colonised by *S. aureus*. It is also a primary cause of bacteremia and infective endocarditis (IE), as well as infections of the bones and joints, skin and soft tissues, lungs and pleural cavity, and medical devices. The goal of this review is to provide a concise overview of the most recent advances in the investigation of the occurrence, underlying mechanisms, symptoms, and treatment of these important clinical infection syndromes caused by *S. aureus*. We don't go into great detail about colonization or drug resistance mechanisms. Instead, we recommend that readers refer to recent reviews for more in-depth information on these topics [13].

Methodology

A retrospective study was carried out between January 10, 2023, and November 10, 2023, with a sample size of 1,000 ear swabs. The samples were evenly distributed, with 500 ear swab samples collected for males and 500 for females. Age, nutritional status, and antibiotic use were recorded without a medical consultation. The aforementioned samples were grown on blood and MacConkey agar. Several chemical tests, such as the Voges-Proskauer, oxidase, catalase, Simmon's citrate, Indole, and methyl red tests, were used to identify and isolate bacteria. Following culturing on Mueller-Hinton agar, a drug sensitivity test was performed under sterile conditions in the microbiology laboratory at Al-Habbobi Teaching Hospital. The sensitivity test used a diverse range of antibiotics.

Results

The demographic characteristics of the patient group

The findings indicated that there is no statistically significant difference in age among all participants in the study (P = 0.69).

Table 1: Demographic characteristics of the patient group

Characteristic	Male group (n=500)	Female group (n=500)	P. value
Age (year) Mean ± SD	27.53±6.19	27.68±6.21	0.69 NS

Both the frequency and the percentage of *Klebsiella* species, *Proteus* species, *Pseudomonas* species, and *Staphylococcus* species were determined.

The findings pertaining to every participant in the study are presented in Table 2. The frequency and percentage of *Klebsiella* spp. were (376, 37.6), whereas *Proteus* spp. were (156, 15.6). *Pseudomonas* spp. had (331, 33.1), and *Staphylococcus* spp. had (137, 13.7). Among the samples collected, *Klebsiella* spp. were the most prevalent (56.1%) and occurred least frequently (13.7).

Table 2: The frequency and percentage of *Klebsiella* species, *Proteus* species, *Pseudomonas* species, and *Staphylococcus* species.

Spp.	Frequency	Percent
Klebsiella spp	376	37.6%
Proteus spp	156	15.6%
Pseudomonas spp	331	33.1%
Staphylococcus spp	137	13.7%
Total	1000	100.0%

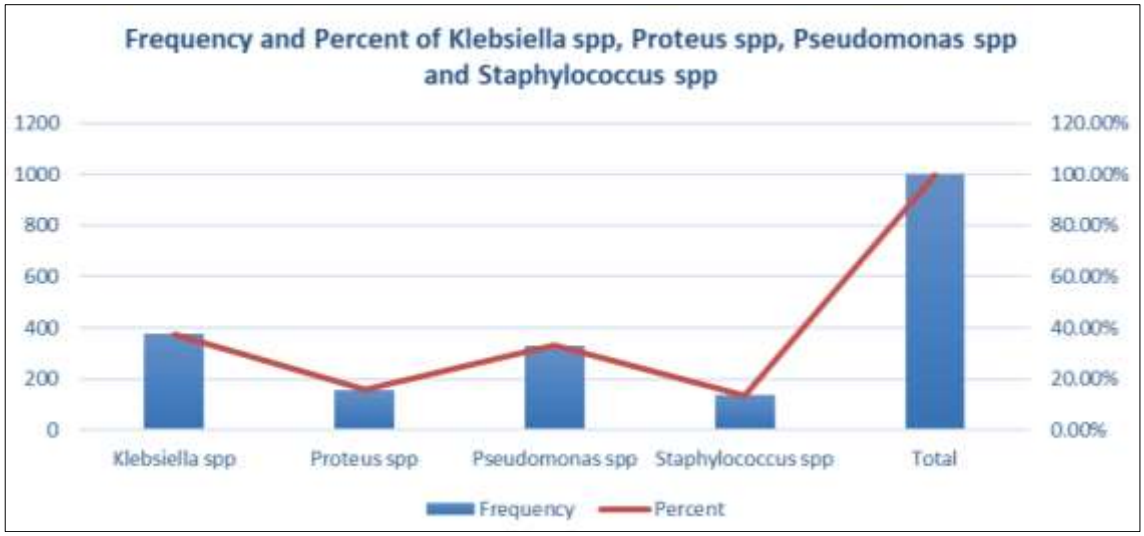

Fig 1: Frequency and percent of bacteria that cause otitis media

***Klebsiella* species, *Proteus* species, *Pseudomonas* species, and *Staphylococcus* species were analyzed in terms of their frequency and percentage in male and female samples**

The results revealed that the incidence rate of *Klebsiella* spp. in females was 195, while in males it was 181. The data also revealed that the occurrence of *Proteus* spp. was the same in both females and males, with a frequency of 78. The prevalence of *Pseudomonas* in females was 161, which was comparatively lower than the incidence in males, which was 170. The incidence of *Staphylococcus* in females was 66, but in males it was 71.

Table 3: Otitis media in males and females, with regard to the frequency and percentage of bacteria that cause it.

	Female		Male	
Spp.	**Frequency**	**Percent**	**Frequency**	**Percent**
Klebsiella spp.	195	39.0%	181	36.2%
Proteus spp.	78	15.6%	78	15.6%
Pseudomonas spp.	161	32.2%	170	34.0%
Staphylococcus spp.	66	13.2%	71	14.2%
Total	500	100%	500	100%

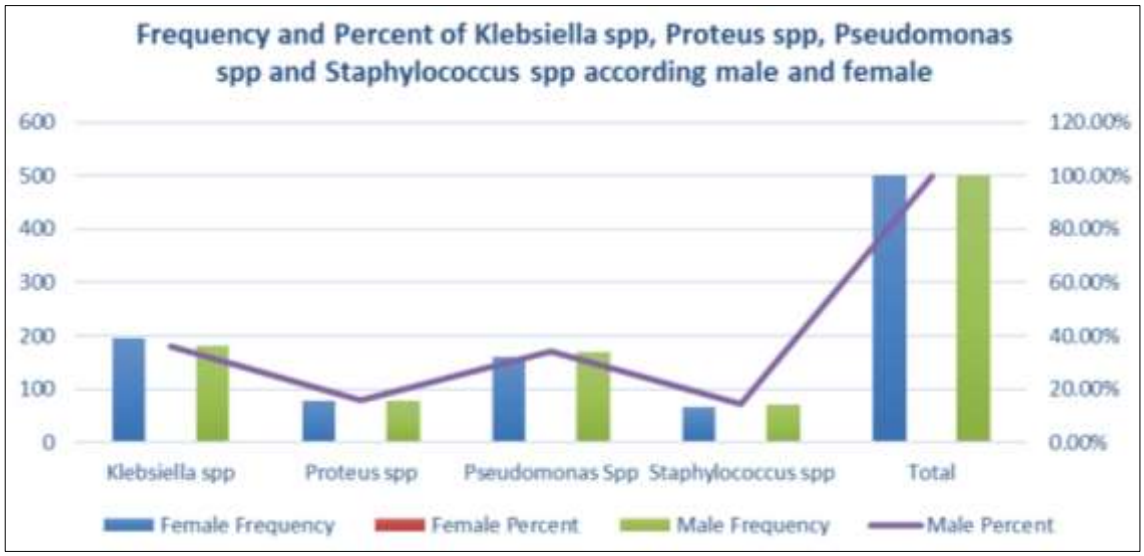

Fig 2: In both males and females, the frequency and percentage of bacteria that cause otitis media

The table's findings demonstrated a higher frequency of AK, suggesting its crucial efficacy in combating various bacteria responsible for otitis media infections. The occurrence rate of AMC and IMP was 33. The findings also revealed that the frequency of ATM was 12, indicating its limited efficacy against this particular strain of bacteria, as it had the lowest frequency compared to all other antibiotics tested. The results also indicated that the frequency of AZM was 34. The occurrence rate of CAZ and AFB was 40. The CIP repeat had a value of 91, while the FOX repeat had a value of 92, indicating their significant contribution in combating the specific bacteria present in the sample. The results also indicated a frequency of CN 42. The frequencies of CRO, CTX, DO, E, F, LEV, MEM, and PRL were 39, 31, 59, 29, 53, 51, 36, and 55, respectively.

Table 4: The frequency of antibiotic use and the percentage of people who were included in the study

Antibiotic	Frequency	Percent
AK	248	24.8%
AMC	33	3.3%
ATM	12	1.2%
AZM	34	3.4%
CAZ	40	4.0%
CIP	91	9.1%
CN	42	4.2%
CRO	39	3.9%
CTX	31	3.1%
DO	59	5.9%
E	29	2.9%
F	35	3.5%
FEP	40	4.0%
FOX	92	9.2%
IMP	33	3.3%
LEV	51	5.1%
MEM	36	3.6%
PRL	55	5.5%
Total	1000	100.0%

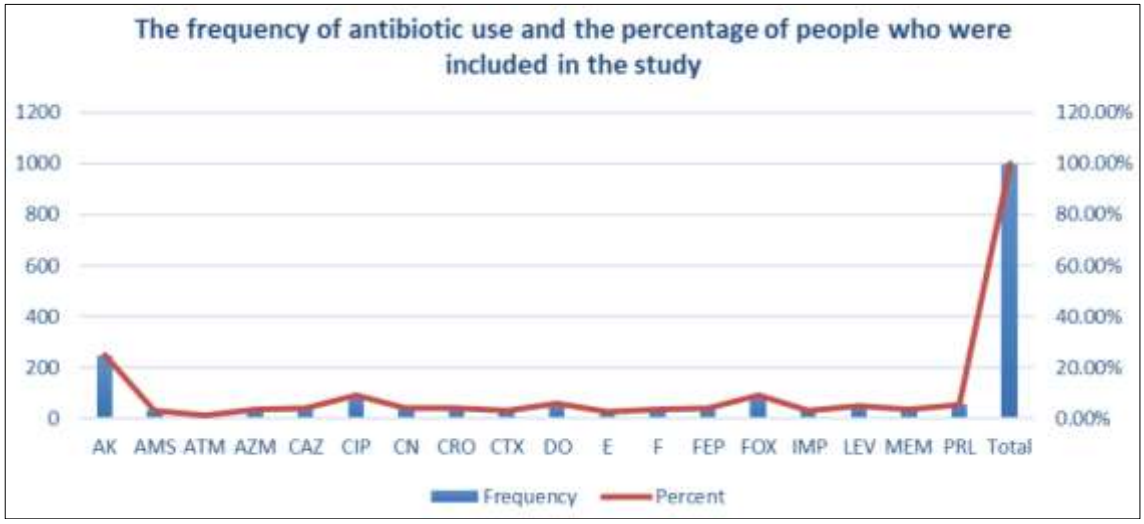

Fig 3: The Frequency and Percent of Antibiotics

Discussion

Otitis media is a major global healthcare issue because it not only causes distress to patients and their families, but it also places a significant financial burden on the healthcare system. Previous research has shown that both racial and socioeconomic factors influence the occurrence of this phenomenon [14].

Klebsiella was found more frequently than other types of bacteria, with *Pseudomonas* coming in second, according to the first table's results. *Staphylococcus* and *Proteus* were less common. This points to the fact that middle ear infections are most commonly caused by *Klebsiella* and *Pseudomonas*. This result is agree with [15].

Otitis media in poorer countries is commonly caused by factors such as poor living circumstances, overpopulation, hunger, and inadequate cleanliness. The study also identified a significant prevalence of the condition, particularly among children, who comprise over 50% of the subjects. According to empirical research, this condition has a higher prevalence among males compared to females. This observation was made in two separate investigations, one conducted in a hospital setting and the other in a community-based study [14-15].

Gram-negative bacteria are the predominant type of bacteria responsible for middle ear infections, occurring three times more frequently than Gram-positive bacteria. Several studies have indicated a higher incidence of otitis media in women compared to men. The investigation revealed *Pseudomonas aeruginosa* and *Klebsiella* as the Gram-negative bacteria accountable for 31.3% and 23.9% of the cases, respectively. *Staphylococci* might be regarded as a contamination of the external auditory canal [16].

This result is agree with [17]. *Pseudomonas aeruginosa* is the predominant Gram-negative bacteria responsible for middle ear infections, as indicated by the bacterial isolates. *Klebsiella* spp. It is the second most abundant organism, while *Staphylococcus aureus* has been identified as the second most common organism in other centres such as Ibadan and Jos, Nigeria. According to the results of middle-ear cultures, the incidence of *Proteus* spp. was relatively lower at 14.9% compared to previous studies conducted in Egypt, where it was identified as the most common, and studies conducted in Ibadan, where it was identified as the second most common [18-19].

Table 2 revealed a disparity in infection rates between genders. Specifically, the prevalence of *Klebsiella* infection was greater among women, but the incidence of *Pseudomonas* infection was higher among men. The

incidence of *Proteus* was equivalent in males and females. Men had a greater occurrence of *Staphylococcus* infection. This finding suggests that there may be sex differences in the frequency and regularity of *Klebsiella* and *Pseudomonas*. Women may show a greater tendency to receive multiple nominations than men, although this disparity may be considered undemocratic. This disparity can be attributed to physiological differences between males and females, such as differences in the immune system or proteins that can affect the likelihood of infection. Regarding the frequency of infection with *Pseudomonas*, research has shown that men show a higher incidence of infection than women. Another potential difference in increased gatherings of men may lie in their unique presence and level of participation.

This result is agree with [14, 20]

There are several possible reasons for the higher frequency of *Pseudomonas* in men compared to women. Some of these reasons may include; Hormone differences, Differences in hormone levels between the sexes may play a role in increasing the prevalence of *Pseudomonas* in men. Certain hormones may affect the immune system and make men more susceptible to *Pseudomonas* infection. Exposure factors, There may be exposure factors specific to men that make them more susceptible to *Pseudomonas* infection. For example, there may be differences in work patterns, such as working on farms or in industries that provide greater exposure to the agents causing *Pseudomonas*. Biological composition differences the unique biological composition of men's urinary systems may have an impact on their increased prevalence of *Pseudomonas*. There can be factors in the urine system that make it more favorable for *Pseudomonas* growth. The findings demonstrated that the prevalence of amikacin, ciprofloxacin, and cefoxitin above that of other antibiotics, suggesting their efficacy in inhibiting bacterial growth and promoting bacterial eradication.

Amikacin binds to the 30S subunit of the bacterial ribosome, preventing protein synthesis and genetic code reading. This causes protein production to stop early and include incorrect amino acids. Amikacin and other aminoglycosides are bacteriocidal and may have another mode of action. Aminoglycosides have post-antibiotic effects and bactericidal activity proportional to concentration. On some microorganisms, amikacin and penicillins work together. Gram-positive organisms can be synergistically treated with amikacin and carbapenems. Amikacin may be effective against tobramycin and gentamicin-resistant strains because bacterial acetylase, adenylase, and phosphorylase enzymes inactivate it less. Thus, its clinical use should be limited to severe nosocomial infections [21-22].

The fluoroquinolone antibiotic ciprofloxacin kills bacteria. By inhibiting bacterial DNA topoisomerase and DNA gyrase, it stops DNA replication. Ciprofloxacin is the most potent fluoroquinolone against gram-negative bacilli bacteria, especially Enterobacteriaceae like Escherichia coli, Salmonella, Shigella, and Neisseria. Ciprofloxacin kills some gram-positive bacteria. The most effective quinolone against *Pseudomonas aeruginosa* is ciprofloxacin. In Europe, North America, and South America, *P. aeruginosa* susceptibility has decreased, mostly in hospitals and nursing homes with risk factors. Few oral antibiotics treat *P. aeruginosa* infections, like ciprofloxacin [23].

Cefoxitin is a bactericidal agent that works by inhibiting bacterial cell wall synthesis. Cefoxitin is active in the presence of beta-lactamases, penicillinases, and cephalosporinases from Gram-negative and Gram-positive bacteria [24].

Due to their potent bactericidal properties and efficacy in inhibiting bacterial growth, these antibiotics were employed more frequently compared to other alternatives. Several other antibiotics were infrequently used in laboratory settings, either due to their limited efficacy or their absence of activity. Additionally, genetic mutations can alter the bacterial composition, rendering them more resistant to multiple classes of antibiotics.

Conclusion

The study found no significant age difference among participants. The frequency of *Klebsiella* spp. was highest in all samples, while *Staphylococcus* spp. was less frequent. Females had a higher frequency of *Klebsiella* spp. than males. *Proteus* spp. was identical in both genders, while *Pseudomonas* was lower in females. The frequency of amikacin, ciprofloxacin, and cefoxitin was higher than all other antibiotics, and this indicates the effectiveness of these types of antibiotics to prevent the growth and killing of bacteria. Therefore, we advise workers in the health sector and health care to have a focus on choosing these antibiotics for the purpose of getting rid of middle ear infection and preventing the occurrence of complications.

Ethical approval

Before the samples were taken, all of the patients who were going to be part of this study were properly informed and gave their verbal permission. The Committee on Publication Ethics at the Thi-Qar Health Directorate, Al Habbobi Teaching Hospital, gave its approval to the study.

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