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ORIGINAL RESEARCH

Bacteriology and Antimicrobial sensitivity in Otorhinolaryngology infections in a Tertiary hospital in South-West Nigeria

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Abstract

Background: Otorhinolaryngology (ORL) infections constitute a significant clinical burden, with evolving antimicrobial resistance necessitating local surveillance to guide empirical therapy.

Objective: To determine the bacterial profile, antimicrobial susceptibility patterns, demographic and anatomical associations of ORL infections in a Nigerian private tertiary hospital.

Methods: A retrospective cross-sectional study analysed 166 ORL specimens (swabs and aspirates) processed from the year 2018 to 2024, representing 77.2% of 215 initially identified samples. Forty-nine were excluded due to sterile cultures (n=31) or incomplete demographic data (n=18). Data on demographics, anatomical site, microbial isolates, and susceptibility were extracted. Associations were assessed using Chi-square tests ($p<0.05$).

Results: Thirteen microorganisms were isolated. *Pseudomonas aeruginosa*. predominated (87, 52.4%), followed by *Klebsiella* spp. (29, 17.5%) and *Proteus* spp. (11, 6.6%). Bacteria accounted for 91.0% of infections and fungi for 9.0%. Ear infections were most common (154, 92.8%), particularly among females (59.6%) and patients aged 11–20 years (34.3%). Significant associations were observed between organism type and anatomical site (p = 0.003), organism type and age (p = 0.001), and infection site and age (p = 0.049). *Pseudomonas aeruginosa* showed high susceptibility to piperacillin–tazobactam (89%) and levofloxacin (75%), whereas *Klebsiella* spp. showed marked resistance to ceftriaxone, ceftazidime, and gentamicin (≤5% susceptibility).

Conclusion: *Pseudomonas aeruginosa* was the predominant ORL pathogen. Piperacillin–tazobactam and fluoroquinolones may be useful empirical options, while culture-guided therapy and antimicrobial stewardship are

essential for addressing emerging resistance. The presence of fungal infections also highlights the importance of considering non-bacterial aetiologies in chronic or antibiotic-resistant ORL infections.

Keywords: Antimicrobial resistance, Antimicrobial stewardship, Nigeria, Otorhinolaryngology infections, Private Tertiary hospital

Introduction

Otorhinolaryngology (ORL) infections constitute a substantial proportion of clinical presentations in both primary and tertiary healthcare settings worldwide. [1] These infections encompass a diverse spectrum of conditions affecting the ear, nose, and throat, with marked implications for patient morbidity, quality of life, and healthcare resource utilisation. [1,2] The global burden of otitis media alone increased from 322.1 million cases in 1992 to 391.3 million cases in 2021, illustrating the persistent and growing public health significance of ORL infections. [1,3,4] In paediatric populations, approximately 80% of children experience acute otitis media (AOM) by school age, with recurrent infections affecting 10 - 15% of children annually. [5]

The microbiology of ORL infections varies considerably by geography, influenced by environmental conditions, antimicrobial prescribing patterns, and healthcare infrastructure.[6,7] In high-income settings, *Pseudomonas aeruginosa* and *Staphylococcus aureus* are recognised as the primary bacterial pathogens in otitis externa, [6] while *Streptococcus pneumoniae, Haemophilus influenzae, and Moraxella catarrhalis* predominate in acute otitis media.[2,6,8] The warm, humid climate characteristic of tropical regions, including Nigeria, creates favourable conditions for bacterial proliferation, especially *Pseudomonas aeruginosa*, which thrives in moisture-rich environments.[8,9]

Antimicrobial resistance (AMR) is a critical global threat, particularly in sub-Saharan Africa where limited diagnostics, weak surveillance, and poor access to second-line drugs compound the burden.[7,10] Data from 14 African countries (in the year 2016–2019) revealed alarming resistance rates, with third-generation cephalosporin-resistant Enterobacterales most prevalent and carbapenem resistance varying geographically from 1.0% to 49.6%.[10] In Nigeria, prevalence rates of 5.0-7.9% have been reported, while one ORL clinic study found 25.3% of patients had chronic suppurative otitis media (CSOM).[11-13]

Clinically, identifying fungal ear infections (Otomycosis) is crucial, as it mimics bacterial CSOM but requires antifungals rather than antibiotics; misdiagnosis fuels inappropriate antimicrobial use and exacerbates AMR.[14] Moreover, rising carbapenem resistance, driven by inappropriate antimicrobial utilisation, carries grave implications: carbapenems are last-resort drugs for multidrug-resistant infections, and their diminishing efficacy in settings with limited intensive care and alternative agents directly increases mortality, prolongs hospitalisations, and threatens surgical and oncological outcomes.[15,16]

Despite this recognised burden, there is a notable paucity of recent, institution-specific data characterising the bacteriological profile and antimicrobial resistance patterns in private tertiary hospital settings within Nigeria. Most published studies originate from public institutions or focus narrowly on specific infection subtypes. Private tertiary hospitals serve a distinct patient demographic, often with different healthcare-seeking behaviours, antibiotic exposure histories, and access to advanced diagnostic services. The dynamic nature of antimicrobial resistance also necessitates regular institutional surveillance to inform evidence-based treatment guidelines. The objectives were to determine the bacterial spectrum of ORL infections in a private tertiary hospital, assess the susceptibility patterns of isolated organisms to commonly prescribed antibiotics, and evaluate associations between patient age, sex, anatomical infection site, and the microorganisms isolated from clinical specimens in the study population. By addressing these objectives, this study sought to provide contemporary microbiological data to guide empirical antimicrobial therapy, inform antimicrobial stewardship policies, and contribute to the broader understanding of ORL infection epidemiology in the Nigerian private healthcare sector. Such institution-specific data are critical for developing locally relevant treatment protocols that account for the unique resistance patterns and patient demographics encountered in these settings.

Methods

Study Design, Setting, and Period: This retrospective cross-sectional, analytical study was conducted at Babcock University Teaching Hospital (BUTH), Ilishan-Remo, Ogun State, Southwest Nigeria. BUTH is the tertiary healthcare facility (Teaching hospital) of Babcock University and serves as a referral centre for surrounding communities. The

hospital has a dedicated Otorhinolaryngology unit and a functional Medical Microbiology department. The study spanned seven years from January 2018 to December 2024.

Ethical Considerations: Ethical approval was obtained from the Babcock University Health Research Ethics Committee (BUHREC 0729/26R/2252). As this was a retrospective study utilising de-identified data from existing laboratory records, there was no direct patient contact or clinical intervention. Patient confidentiality was maintained; all data were anonymous and stored in password-protected electronic files.

Study Population and Eligibility: The population comprised all patients presenting with ORL infections whose specimens were processed during the study period. A total of 215 ORL samples were initially identified among which 49 were excluded. The exclusion criteria were sterile cultures (in 31 samples), and incomplete records (in 18 patients). The final analytical sample consisted of 166 clinical specimens (77.2% of all processed samples), representing complete enumeration of all eligible records with comprehensive microbiological data. Information recorded included complete demographic profiles of patients, culture, and susceptibility results of the samples.

Data Collection and Variables: Data were systematically extracted from laboratory registers and clinical case notes using a structured proforma. Extracted variables included patient demographics (sex and age of the patients; anatomical site of infection (ear, nose, or throat); microbial isolates; and antimicrobial susceptibility profiles.

Microbiological Methods: Specimens (swabs and aspirates) were collected aseptically and transported immediately to the medical microbiology laboratory. Samples were inoculated onto Blood Agar, MacConkey Agar, Chocolate Agar (incubated at 35–37°C in 5–10% CO_2), and Sabouraud Dextrose Agar (incubated at 25°C and 37°C for up to 7 days for fungi). Bacterial identification utilized Gram staining, colony morphology, and biochemical tests (catalase, coagulase, oxidase, indole, urease, citrate, TSI). Fungi were identified via germ tube tests and lactophenol cotton blue mounts. Antimicrobial susceptibility testing was performed using the Kirby-Bauer disc diffusion method on Mueller-Hinton Agar per CLSI guidelines. A 0.5 McFarland inoculum was used, and discs for Gram-positives (Penicillin, Cefoxitin, Erythromycin, Clindamycin, Vancomycin, Tetracycline) and Gram-negatives (Ampicillin, Amoxicillin-Clavulanate, Ceftriaxone,

Ciprofloxacin, Gentamicin, Meropenem) were applied. Plates were incubated at 35–37°C for 16–18 hours, and zone diameters were interpreted as Susceptible, Intermediate, or Resistant per CLSI M100 standards. Cefoxitin disc diffusion was used for MRSA detection.

Statistical Analysis: Data were analysed using IBM SPSS Statistics for Windows, Version 26.0. Descriptive variables were summarised as frequencies and percentages. Associations between categorical variables (organism type vs. site, age, and sex; infection site vs. age and sex) were assessed using the Chi-square test. Where >20% of cells had expected frequencies <5, Fisher's Exact Test was reported. All tests were two-tailed, with statistical significance set at $p < 0.05$. The results were presented in Tabular and graphical formats.

Results

Demographic Characteristics: A total of 166 clinical samples from patients with ORL infections were analysed. The age distribution showed marked variation across groups. The highest proportion of participants were aged 11 - 20 years (57, 34.3%), followed by 0 - 10 years (34, 20.5%), 31 - 40 years (24, 14.5%), and 21 - 30 years (18, 10.8%). Older age categories had progressively lower frequencies: 61 - 80 years (12, 7.2%), 51 - 60 years (11, 6.6%), and 41 - 50 years (10, 6.0%). Gender distribution showed a female predominance, with 99 females (59.6%) compared to 67 males (40.4%), yielding a male-to-female ratio of approximately 1:1.5 (Table I).

Microbiological Profile: Thirteen distinct microorganisms were isolated from the 166 clinical samples, encompassing both bacterial and fungal pathogens. *Pseudomonas aeruginosa*. was the most frequently isolated pathogen, accounting for 87 isolates (52.4%). *Klebsiella spp*. was the second most common organism with 29 isolates (17.5%), followed by Proteus spp and *Candida spp*., each representing 11 isolates (6.6%). Staphylococcus aureus was identified in 10 isolates (6.0%), and *Escherichia coli* in 8 isolates (4.8%). Less frequently isolated organisms included *Haemophilus spp*. (3, 1.8%), *Aspergillus spp*. (3, 1.8%), and single isolates (0.6% each) of *Acinetobacter spp*., *Moraxella catarrhalis*., *Staphylococcus epidermidis*., and *Trichophyton mentagrophyte* (Table I).

Table I: Characteristics and micro-organism distribution among ORL infection cases

	Characteristics	Frequency	Percent
Age	0 - 10years	34	20.5
	11 - 20years	57	34.3
	21 - 30 years	18	10.8
	31 - 40 years	24	14.5
	41 - 50 years	10	6.0
	51 -60years	11	6.6
	61 -80years	12	7.2
Gender	Male	67	40.4
	Female	99	59.6
Micro-organisms	*Acinetobacter spp*	1	.6
	Escherichia coli	8	4.8
	Hemophilus spp	3	1.8
	Klebsiella spp	29	17.5
	Moraxella catarrhalis	1	.6
	Proteus spp	11	6.6
	Pseudomonas spp	87	52.4
	Staph aureus	10	6.0
	Staph epidermidis	1	.6
	Aspergillus spp	3	1.8
	Candida spp	11	6.6
	Trichophyton mentagrophytes	1	.6
Type of micro-organism isolated	Bacteria	151	91.0
	Fungi	15	9.0
Site of infection	Nose infection	6	3.6
	Ear infection	154	92.8
	Throat infection	6	3.6
	Total	166	100.0

When categorised by microbial type, bacterial isolates constituted the overwhelming majority at 151 (91.0%), while fungal isolates accounted for 15 (9.0%). The fungal component comprised *Candida spp*. (11 isolates), *Aspergillus spp*. (3 isolates), and *Trichophyton mentagrophytes* (1 isolate) (Figure 1).

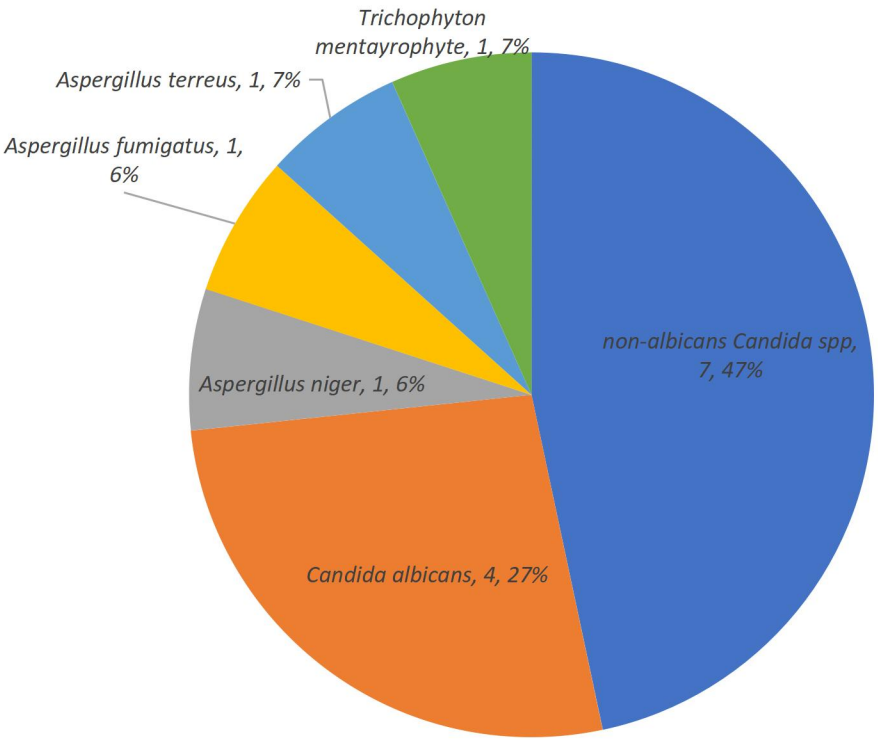


Figure 1. Pattern of fungi isolated from ORL infection

Anatomical Distribution and Statistical Associations: The anatomical distribution showed a marked predominance of ear infections, accounting for 154 cases (92.8%). Nose infections and throat infections each represented 6 cases (3.6%). Statistical analysis indicated a significant association between the anatomical region of infection and the type of microorganism isolated ($\chi^2 = 44.400$, df = 22, p = 0.003). The majority of *Pseudomonas aeruginosa* isolates originated from ear infections, consistent with the overall predominance of otologic specimens (Table II).

Age showed a statistically significant association with the type of organism isolated ($\chi^2 = 109.408$, df = 66, p = 0.001). In the 0 - 10 years age group, *Pseudomonas aeruginosa*. accounted for 38.2% of isolates, followed by *Klebsiella spp.* (17.6%) and *Proteus spp*. (11.8%). The 11 - 20 years group had a markedly higher proportion of *Pseudomonas aeruginosa* at 71.9%. *Pseudomonas aeruginosa* continued to predominate across older age groups: 55.6% in the 21–30 years group, 63.6% in the 51 - 60 years group, and 50.0% in the 61 - 80 years group. The 51 - 60 and 61 - 80 years age groups had 100%

prevalence of ear infections, with no nose or throat infections documented (Table II).

Age and infection site were also significantly associated ($\chi^2 = 21.111$, df = 12, p = 0.049). Nose infections were most commonly recorded in the 21–30 years (5.6%) and 41–50 years (20.0%) groups, while throat infections were most frequent in the 0–10 years (5.9%) and 31–40 years (12.5%) groups. Gender did not show statistically significant associations with either organism type ($\chi^2 = 14.488$, df = 11, p = 0.207) or infection site ($\chi^2 = 1.884$, df = 2, p = 0.390), indicating that sex was not a determining factor in pathogen or site distribution (Table III).

Antimicrobial Sensitivity Patterns: Escherichia coli (n=8) demonstrated excellent susceptibility to Amikacin (AK), Cefepime (FEP), and Meropenem (MEM), with 100% susceptibility in Table IV (S=8) and confirmed by Table V 5 (95% CI: 63.1–100). Piperacillin-Tazobactam (TZP) showed good activity at 75% (Table V, 95% CI: 40.9–92.9), while Levofloxacin (LEV) was moderately effective at 50% (Table V, 95% CI: 21.5–78.5). However, Table IV reveals alarmingly high resistance rates, with 6 out of 8 isolates resistant to Amoxicillin-Clavulanate (AMC), Ceftazidime (CAZ), Ciprofloxacin (CIP), Gentamicin (CN), Ceftriaxone (CRO), and Cefoxitin (CXM), corresponding to only 12.5–25% susceptibility in Table V.

For *Klebsiella spp*. (n=29) the most effective antibiotics were TZP (48.3% susceptible, 95% CI: 30.9–66.1) and MEM (41.4%, 95% CI: 25.3–59.5) in Table V. Table IV provides additional context, showing that 21 isolates were resistant to AK, 27 to AMC/CAZ/CRO/CXM, and 24 to LEV. Intermediate susceptibility was notably high for SAM (15 isolates intermediate) and FEP (6 intermediate), suggesting these agents may have limited clinical utility. Penicillins and cephalosporins were largely ineffective, with only 3.4% susceptibility to AMC, CAZ, CRO, and CXM (Table V).

Table III: Age and sex of Patients against region of infection

Variable		Region of infection			Total	X^2	df	P-value
		Nose infection	Ear infection	Throat infection				
Age	0 - 10years	0 (0.0%)	32 (94.1%)	2 (5.9%)	34 (100.0%)	21.111	12	0.049****
	11 - 20years	2 (3.5%)	55 (96.5%)	0 (0.0%)	57 (100.0%)			
	21 - 30 years	1 (5.6%)	17 (94.4%)	0 (0.0%)	18 (100.0%)			
	31 - 40 years	1 (4.2%)	20 (83.3%)	3 (12.5%)	24 (100.0%)			
	41 - 50 years	2 (20.0%)	7 (70.0%)	1 (10.0%)	10 (100.0%)			
	51 -60years	0 (0.0%)	11 (100.0%)	0 (0.0%)	11 (100.0%)			
	61 -80years	0 (0.0%)	12 (100.0%)	0 (0.0%)	12 (100.0%)			
Sex	Male	2 (3.0%)	61 (91.0%)	4 (6.0%)	67 (100.0%)	1.884	2	0.390
	Female	4 (4.0%)	93 (93.9%)	2 (2.0%)	99 (100.0%)			
	Total	6 (3.6%)	154 (92.8%)	6 (3.6%)	166 (100.0%)			

In Proteus spp. (n=11) infection, amikacin remained highly active at 81.8% susceptibility (Table V, 95% CI: 52.3–95.1), followed by TZP at 63.6% (95% CI: 35.3–85.0) and LEV at 45.5% (95% CI: 21.1–72.4). However, Table 4 shows that 7–8 isolates were resistant to CAZ, CIP, CRO, and CXM, correlating with the low susceptibility percentages (9.1–18.2%) reported in Table V. Interestingly, Table IV reveals that 5 isolates showed intermediate susceptibility to AMC and CN, and 8 to SAM, indicating potential for alternative dosing strategies. *Pseudomonas aeruginosa* (n=87) (Table V) showed the highest susceptibility to TZP (78.2%, 95% CI: 68.3–85.7), MEM (63.2%, 95% CI: 52.5–72.8), and CN (55.2%, 95% CI: 44.5–65.5). Table IV provides critical additional data, revealing that while no isolates were resistant to AK, 55 showed intermediate susceptibility.

Table IV: Susceptibility pattern of bacteria isolated

		ANTIBIOTICS														
Micro-organisms isolated		AK	AMC	AZM	CAZ	CIP	CN	CRO	CXM	E	FEP	FOX	LEV	MEM	SAM	TZP
Acinetobacter spp (1)	S	1	1	-	0	1	1	1	1	-	0	-	1	1	0	1
	I	0	0	-	1	0	0	0	0	-	1	-	0	0	0	0
	R	0	0	-	0	0	0	0	0	-	0	-	0	0	1	0
Escherichia coli (8)	S	8	1	-	1	2	2	1	1	-	8	-	4	8	4	6
	I	0	1	-	1	1	0	1	1	-	0	-	0	0	0	2
	R	0	6	-	6	5	6	6	6	-	0	-	4	0	4	0
Hemophilus spp (3)	S	3	2	-	1	2	3	2	2	-	1	-	2	3	0	3
	I	0	1	-	0	1	0	1	1	-	1	-	0	0	1	0
	R	0	0	-	2	0	0	0	0	-	1	-	1	0	2	0
Klebsiella spp (29)	S	7	1	-	1	3	9	1	1	-	2	-	4	12	2	14
	I	1	1	-	1	5	2	1	1	-	6	-	1	5	15	1
	R	21	27	-	27	21	18	27	27	-	18	-	24	12	12	14
Moraxella catarrhalis (1)	S	1	1	1	0	1	1	1	1	-	0	-	1	1	1	1
	I	0	0	0	1	0	0	0	0	-	1	-	0	0	0	0
	R	0	0	0	0	0	0	0	0	-	0	-	0	0	0	0
Proteus spp (11)	S	9	1	-	1	2	2	2	2	-	2		5	2	2	7
	I	2	5	-	2	1	5	1	1	-	3		1	5	8	4
	R	0	5	-	7	8	4	8	8	-	6		5	4	1	0
Pseudomonas aeruginosa (87)	S	32	-	-	15	35	48	20	-	-	5	-	38	55	-	68
	I	55	-	-	31	9	29	30	-	-	3	-	1	14	-	11
	R	0	-	-	41	43	10	37	-	-	79	-	48	18	-	8
Staph aureus (10)	S	9	-	8	-	6	4	-	-	4	-	5	3	-	6	-
	I	1	-	2	-	1	0	-	-	2	-	0	1	-	4	-
	R	0	-	0	-	3	6	-	-	4	-	5	6	-	0	-

Similarly, 31 isolates were intermediate to CAZ, and 29 to CN. Notably, Table IV showed 79 isolates resistant to FEP, explaining its poor 5.7% susceptibility in Table V, while

AMC and SAM were completely inactive (0% susceptible

Table V: Antibiogram pattern of bacteria isolated

	Antibiotic	**AK**	**AMC**	**CAZ**	**CIP**	**CN**	**CRO**	**CXM**	**FEP**	**LEV**	**MEM**	**SAM**	**TZP**
Escherichia coli (n=8)	Susceptible (S)	8	1	1	2	2	1	1	8	4	8	4	6
	%S	100	12.5	12.5	25.0	25.0	12.5	12.5	100%	50.0	100	50.0	75.0
	95% CI	63.1–100	2.2 – 44.5	2.2 – 44.5	7.1–59.1	7.1 – 59.1	2.2 – 44.5	2.2–44.5	63.1 – 100	21.5 – 78.5	63.1 – 100	21.5–78.5	40.9 – 92.9
Klebsiella spp (n=29)	S	7	1	1	3	9	1	1	2	4	12	2	14
	%S	24.1	3.40	3.40	10.3	31.0	3.40	3.40	6.90	13.8	41.4	6.90	48.3
	95% CI	12.2 – 42.1	0.6 – 17.8	0.6 – 17.8	3.6 – 26.3	17.0 – 49.5	0.6 – 17.8	0.6 – 17.8	1.9 – 22.0	5.5 – 30.8	25.3 – 59.5	1.9 – 22.0	30.9 – 66.1
Proteus spp (n=11)	S	9	1	1	2	2	2	2	2	5	2	2	7
	%S	81.80	9.10	9.10	18.20	18.20	18.20	18.20	18.20	45.50	18.20	18.20	63.60
	95% CI	52.3 – 95.1	1.6 – 37.7	1.6 – 37.7	5.1 – 47.7	5.1 – 47.7	5.1 – 47.7	5.1 – 47.7	5.1 – 47.7	21.1 – 72.4	5.1 – 47.7	5.1 – 47.7	35.3 – 85.0
Pseudomonas aeruginosa (n=87)	S	32	0	15	35	48	20	0	5	38	55	0	68
	%S	36.80		17.20	40.20	55.20	23.00		5.70	43.70	63.20		78.20
	95% CI	27.3 – 47.3		10.6 – 27.0	30.4 – 50.8	44.5 – 65.5	15.4 – 32.7		2.5 – 12.8	33.6–54.3	52.5 – 72.8		68.3 – 85.7
Staph aureus (n=10)	Antibiotic	AK	AZM	CIP	CN	E	FOX	LEV	SAM				
	S	9	8	6	4	4	5	3	6				
	%S	90.0	80.0	60.0	40.0	40.0	50.0	30.0	60.00				
	95% CI	55.5 – 98.3	49.0 – 94.3	31.3 – 83.2	16.8 – 68.7	16.8 – 68.7	21.5 – 78.5	10.8 – 60.3	31.3 – 83.2				

Antibiogram formulae: $\frac{\text{Sensitvity X 100}}{\text{Sensitivty + Intermediate + Resistant}}$

AK: Amikacin, AMC: Amoxicillin-clavulanate, AZM: Azithromycin, CAZ: Ceftazidime, CIP: Ciprofloxacin, CN: Gentamicin, CRO: Ceftriaxone, CXM: Cefuroxime, E: Erythromycin, FEP: Cefipime, FOX: Cefoxitin, LEV: Levofloxacin, MEM: Meropenem, SAM: Trimethoprim-Sulphamethoxazole, TZP: Piperacillin-Tazobactam

Other Gram-Negative Organisms: Table IV includes data on less frequent isolates. *Acinetobacter spp.* (n=1) showed susceptibility to most agents except CAZ, FEP, and SAM. *Hemophilus spp*. (n=3) demonstrated good susceptibility to AK (3/3), CN (3/3), and TZP (3/3), though 2 isolates were resistant to CAZ. Moraxella catarrhalis (n=1) was susceptible to all tested antibiotics except CAZ and FEP.

Table V showed that Amikacin was most effective against *Staphylococcus aureus* (n=10) (90% susceptible, 95% CI: 55.5–98.3), followed by Azithromycin (AZM) at 80% (95% CI: 49.0–94.3). CIP and SAM both showed 60% susceptibility (95% CI: 31.3–83.2). Critically, only 50% of isolates were susceptible to Cefoxitin (FOX) in Table V (95% CI: 21.5–78.5), indicating a 50% methicillin-resistant *S. aureus* (MRSA) prevalence. Table IV corroborates this, as 5 isolates resistant to FOX and 5 resistant to LEV, while 6 were resistant to CN and E. Notably, Table IV reveals that 4 isolates were intermediate to SAM, suggesting possible therapeutic options despite the high resistance to other agents. The variability in sensitivity across different antimicrobial classes and organisms highlights the importance of culture-guided therapy in ORL infections. Resistance patterns are implicitly reflected in the complement of these sensitivity percentages, with several organisms showing multidrug resistance to commonly prescribed first-line agents.

Discussion

This retrospective study of 166 ORL infection samples from a Nigerian private tertiary hospital produced several important findings regarding pathogen distribution, demographic associations, and antimicrobial resistance patterns. The results carry direct implications for empirical therapy selection and antimicrobial stewardship in similar clinical settings.

The dominance of *Pseudomonas aeruginosa*, accounting for 52.4% of all isolates, is consistent with both regional and international literature documenting this organism as a primary pathogen in ORL infections, especially otitis externa and chronic suppurative otitis media. In a Ghanaian paediatric study, *Pseudomonas aeruginosa* accounted for 38.5% of otitis media isolates,[17]

while a Nigerian retrospective study identified *Pseudomonas aeruginosa* as the most prevalent ear pathogen at 45.10%.[18] A Tanzanian cross-sectional study similarly reported *Pseudomonas aeruginosa* as the leading ear pathogen in a tertiary setting.[19] The higher prevalence in our study likely reflects the private tertiary setting, where patients with chronic and treatment-resistant infections, conditions where Pseudomonas excels, are disproportionately represented through referral patterns. The ecological basis for Pseudomonas predominance in ear infections is well established: the external auditory canal provides warmth, moisture, and pH conditions that favour bacterial proliferation, with documented seasonal peaks during warmer and wetter months.[8,9] Nigeria's tropical climate, characterized by high ambient temperature and humidity, creates year-round favourable conditions for Pseudomonas colonization and infection. In addition, the well-documented capacity of Pseudomonas for biofilm formation contributes to chronic infection persistence, as biofilm-embedded bacteria exhibit up to 1000-fold increased antibiotic resistance compared to planktonic forms.[20,21] Research has shown that neutrophils, rather than eliminating Pseudomonas, may paradoxically enhance biofilm development, further explaining the chronicity and recalcitrance of Pseudomonas-associated ear infections.[22]

The highest infection prevalence in the 11 - 20 years age group (34.3%) and substantial representation in the 0 - 10 years group (20.5%) align with established epidemiological patterns of paediatric and adolescent susceptibility to ORL infections. Although Pearson's Chi-Square tests yielded $\chi^2 = 44.400$ (df=22, p=0.003) for anatomical region and $\chi^2 = 109.408$ (df=66, p=0.001) for age, these results are statistically invalid-The high degrees of freedom relative to sample size, combined with extremely sparse contingency tables, violated the expected-frequency assumption (<5 in most cells). Consequently, these P-values are unreliable and cannot be interpreted as evidence of significant associations. Findings should be viewed as descriptive trends requiring validation with larger, adequately powered studies.

Multiple anatomical, physiological, and immunological factors underlie this age distribution. In young children, the eustachian tube is shorter, more horizontal, and narrower compared to the mature adult configuration, resulting in impaired drainage and increased susceptibility to middle ear infections. Proportionally larger adenoids can obstruct eustachian tube openings, further

compromising middle ear ventilation.[23] The paediatric immune system undergoes progressive maturation throughout childhood, with innate and adaptive responses gradually strengthening. Young children exhibit reduced production of antimicrobial peptides, suboptimal neutrophil function, and less developed antibody responses, rendering them more vulnerable to bacterial infections. [5,24] Approximately 90% of children experience at least one episode of acute otitis media before school age, consistent with the high prevalence in our younger age groups.[5] By adolescence, while eustachian tube anatomy has matured, behavioural factors such as increased water exposure during swimming and sports activities may sustain elevated infection rates, especially for otitis externa. The lower infection rates in older adults (41–80 years) may reflect reduced exposure risk factors and maturation of immune defences. However, the finding that adults above 50 years had exclusively ear infections (100%) suggests that age-related changes in tissue integrity and local immune function may predispose to specific otologic pathology, consistent with documented immunosenescence phenomena. [24,25]

The overwhelming predominance of ear infections (92.8%) requires careful interpretation. While consistent with the high burden of otologic pathology documented in Nigerian populations, CSOM prevalence placing Nigeria in the WHO's highest burden category, [12,13] this degree of predominance likely also reflects referral and sampling biases. Chronic or treatment-resistant ear infections are more commonly referred to tertiary centres, and ear infections are more likely to undergo bacterial culture compared to acute pharyngitis or rhinosinusitis, which are often managed empirically without microbiological investigation. Nevertheless, the statistically significant associations between infection site and both organism type ($p = 0.003$) and age ($p = 0.049$) support genuine epidemiological patterns beyond purely artefactual findings.

The antimicrobial sensitivity findings carry direct clinical implications. The high sensitivity of *Pseudomonas aeruginosa* to piperacillin-tazobactam (89%) is clinically important and supported by pharmacokinetic-pharmacodynamic evidence. Studies have shown that extended-infusion dosing strategies for piperacillin-tazobactam optimize the time-above-MIC parameter, achieving target attainment rates exceeding 90% against susceptible Pseudomonas isolates and improving clinical outcomes compared to traditional intermittent dosing.[26] This makes piperacillin-tazobactam a strong empirical choice for severe ORL infections in this setting.

The 75% sensitivity to levofloxacin provides an important oral step-down option for ambulatory patients, which is especially valuable in resource-limited settings where intravenous access may be limited. However, judicious use of fluoroquinolones is needed given documented associations between fluoroquinolone exposure and resistance development. A case-control study identified fluoroquinolone exposure as an independent risk factor (odds ratio 4.6) for fluoroquinolone-resistant *Pseudomonas* infection, with resistance in turn associated with a 3.5-day median delay in receiving effective therapy.[27,28] The markedly low sensitivity to ceftriaxone (6%) reflects *Pseudomonas's* constitutive AmpC beta-lactamase activity, which confers intrinsic resistance to third-generation cephalosporins such as ceftriaxone and cefotaxime. Ceftazidime, a third-generation cephalosporin with anti-pseudomonal activity, had moderate sensitivity (27%), lower than piperacillin-tazobactam and levofloxacin but still representing a viable option in selected cases.

The *Klebsiella spp*. resistance profile is alarming and demands close attention. Sensitivity of ≤5% to amoxicillin-clavulanate, ceftriaxone, ceftazidime, and gentamicin strongly suggest widespread extended-spectrum beta-lactamase (ESBL) production among these isolates.[10,29] ESBLs are plasmid-mediated enzymes capable of hydrolysing penicillins, third-generation cephalosporins, and aztreonam, but typically remain susceptible to carbapenems. However, the 17% sensitivity to meropenem in this study raises serious concern about carbapenem resistance, as carbapenems represent the last-line treatment for ESBL-producing *Enterobacterales*. This finding is consistent with carbapenem resistance rates of 0–35.7% reported across African countries in a recent multicontinental analysis, with West African nations showing high rates.[10] The moderate sensitivity to levofloxacin (50%) and trimethoprim-sulfamethoxazole (50%) provides some therapeutic options, though these cannot be relied upon for empirical coverage. The convergence of multidrug resistance with hypervirulence traits in *Klebsiella pneumoniae*, including capsular polysaccharide conferring resistance to phagocytosis and siderophores for iron acquisition, represents a dangerous clinical evolution.[30] These findings collectively indicate that commonly prescribed first-line antibiotics are largely ineffective against *Klebsiella* in this setting, requiring culture-guided therapy as standard practice.

From a clinical practice standpoint, several evidence-based recommendations follow from

these data. First, empirical therapy for suspected Pseudomonas ORL infections should prioritize piperacillin-tazobactam, with fluoroquinolones as oral alternatives when clinically appropriate. For suspected ESBL-producing Enterobacterales, carbapenem selection must be guided by local sensitivity data, with carbapenems reserved for documented multidrug-resistant organisms or critically ill patients. Second, the practice of obtaining cultures before initiating antimicrobial therapy, especially for chronic, recurrent, or severe infections, is essential to guide definitive therapy and minimize inappropriate antibiotic exposure. Third, antimicrobial de-escalation based on culture results represents a core stewardship principle that reduces selective pressure while maintaining therapeutic efficacy. [31,32] Furthermore, culture-based therapy is recommended, but in resource-constrained circumstances where culture is not available, piperacillin-tazobactam is preferred for severe Pseudomonas, oral options fluoroquinolones. Milder infections may be treated with conservative topical treatment.

The 9.0% fungal isolation rate, comprising predominantly Candida spp (11 isolates) and *Aspergillus spp* (3 isolates), deserves attention. Otomycosis has been associated with repeated use of topical antibacterial agents, immunocompromise, humid climates, and ear canal instrumentation. [33] Some studies in Nigeria have found a significant burden of otomycosis in the country. Yabo *et al.* (2024a) [34] documented a 6.9% prevalence in Sokoto, with *Aspergillus niger* (40.0%) and Candida spp (33.3%) as the commonest isolates. [35] A Kano-based study similarly identified *Aspergillus spp* (77.0%) and *Candida spp* (23.0%) as the predominant pathogens. [36]

The predisposing factors identified in some studies include. repeated topical antibacterial use, immunocompromise, humid climates, and ear canal instrumentation.[35,37] Recognition of fungal aetiology is clinically critical, as continued antibacterial therapy in the absence of bacterial infection exacerbates fungal overgrowth. Management requires discontinuation of unnecessary antibacterials, thorough aural toilet, and topical antifungal therapy, which typically results in rapid symptom resolution.[34] These findings underscore the need for heightened diagnostic suspicion and appropriate therapeutic protocols in Nigerian otolaryngology practice.

These resistance patterns reinforce the critical importance of antimicrobial stewardship programs (ASPs) in healthcare facilities. Core stewardship strategies, including prospective audit and feedback (shown to achieve 23%

reductions in antibiotic utilisation), formulary restrictions, syndrome-specific prescribing guidelines, and regular antibiogram updates, should be implemented systematically.[31,32] ORL-focused stewardship should emphasise that uncomplicated otitis externa may be managed with topical therapy and aural toilet without systemic antibiotics, narrow-spectrum agents should be prioritized initially, and treatment duration should be evidence-based and minimized.

This study has several limitations that should be acknowledged. The retrospective design constrains data completeness and limits confounding control. The single-centre, private-sector setting may limit generalizability to public or primary care facilities. The predominance of ear infections may partially reflect culture submission practices. Clinical outcome data were not available, preventing correlation of sensitivity patterns with treatment success rates. Molecular characterization of resistance mechanisms (e.g., ESBL genes, carbapenemase genes) was not performed, and the study did not differentiate between community-acquired and healthcare-associated infections. Future prospective, multicentre studies incorporating molecular resistance profiling, clinical outcome data, and systematic sampling across all ORL infection types are recommended to provide broader epidemiological insights.

Conclusion

This study identified *Pseudomonas aeruginosa* as the predominant bacterial pathogen (52.4%) in ORL infections, with ear infections accounting for 92.8% of cases and the highest disease burden occurring among individuals aged 11–20 years. Piperacillin-tazobactam (89% sensitivity) and levofloxacin (75% sensitivity) demonstrated the highest activity against *Pseudomonas* spp., supporting their consideration for empirical therapy guided by local susceptibility data. *Klebsiella* spp. exhibited substantial multidrug resistance, including markedly reduced susceptibility to commonly prescribed antibiotics and only 17% sensitivity to meropenem.

Recommendations: Culture-guided therapy should be prioritised for chronic and severe ORL infections, with treatment tailored to antimicrobial susceptibility results and de-escalated when appropriate. Empirical therapy should consider infection severity and local resistance patterns, while uncomplicated localised infections should emphasise appropriate topical and non-antimicrobial measures. Antimicrobial stewardship programmes should incorporate regular antibiograms, prescription audits, restricted

use of reserve antibiotics, and continuous prescriber education. Strengthened institutional and national AMR surveillance, including molecular resistance characterisation and multicentre collaboration, is essential to monitor resistance trends and inform evidence-based treatment guidelines and public health policies.

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Table II: Region of infection, Age and Gender against micro-organisms isolated

Variables		Micro-organisms isolated												Total	X^2	df	P-value
		A. spp	*E. coli*	*H. spp*	*K. spp*	*Moraxella catarrhalis*	*Proteus spp*	*P. spp*	*S. aureus*	*Staph epidermidis*	*Aspergillus spp*	*Candida spp*	*T. mentagrophytes*				
Region of infection	Neck infection	0 (0.0%)	1 (16.7%)	1 (16.7%)	2 (33.3%)	0 (0.0%)	0 (0.0%)	2 (33.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	6 (100.0%)	44.400	22	0.003***
	Ear infection	1 (0.6%)	7 (4.5%)	2 (1.3%)	25 (16.2%)	0 (0.0%)	11 (7.1%)	84 (54.5%)	9 (5.8%)	1 (0.6%)	3 (1.9%)	10 (6.5%)	1 (0.6%)	154 (100.0%)			
	Throat infection	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (33.3%)	1 (16.7%)	0 (0.0%)	1 (16.7%)	1 (16.7%)	0 (0.0%)	0 (0.0%)	1 (16.7%)	0 (0.0%)	6 (100.0%)			
Age	0 – 10 years	0 (0.0%)	1 (2.9%)	2 (5.9%)	6 (17.6%)	0 (0.0%)	4 (11.8%)	13 (38.2%)	3 (8.8%)	1 (2.9%)	1 (2.9%)	3 (8.8%)	0 (0.0%)	34 (100.0%)	109.408	66	0.001***
	11 – 20 years	1 (1.8%)	0 (0.0%)	0 (0.0%)	9 (15.8%)	0 (0.0%)	3 (5.3%)	41 (71.9%)	2 (3.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (1.8%)	57 (100.0%)			
	21 - 30 years	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (22.2%)	0 (0.0%)	1 (5.6%)	10 (55.6%)	1 (5.6%)	0 (0.0%)	1 (5.6%)	1 (5.6%)	0 (0.0%)	18 (100.0%)			
	31 - 40 years	0 (0.0%)	6 (25.0%)	0 (0.0%)	4 (16.7%)	0 (0.0%)	0 (0.0%)	5 (20.8%)	4 (16.7%)	0 (0.0%)	0 (0.0%)	5 (20.8%)	0 (0.0%)	24 (100.0%)			
	41 - 50	0	0	1	3	1	0	5	0	0 (0.0%)	0 (0.0%)	0	0 (0.0%)	10			

	years	(0.0 %)	(0.0 %)	(10.0 %)	(30.0 %)	(10.0%)	(0.0 %)	(50.0 %)	(0.0 %)			(0.0 %)		(100. 0%)			
	51 - 60 years	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)	0 (0.0%)	3 (27.3 %)	7 (63.6 %)	0 (0.0 %)	0 (0.0%)	0 (0.0%)	1 (9.1 %)	0 (0.0%)	11 (100. 0%)			
	61 - 80 years	0 (0.0 %)	1 (8.3 %)	0 (0.0 %)	3 (25.0 %)	0 (0.0%)	0 (0.0 %)	6 (50.0 %)	0 (0.0 %)	0 (0.0%)	1 (8.3%)	1 (8.3 %)	0 (0.0%)	12 (100. 0%)			
Gen der	Male	0 (0.0 %)	6 (9.0 %)	3 (4.5 %)	11 (16.4 %)	0 (0.0%)	2 (3.0 %)	34 (50.7 %)	4 (6.0 %)	0 (0.0%)	2 (3.0%)	5 (7.5 %)	0 (0.0%)	67 (100. 0%)	14.4 88	1 1	0.207
	Fema le	1 (1.0 %)	2 (2.0%)	0 (0.0%)	18 (18.2 %)	1 (1.0%)	9 (9.1 %)	53 (53.5 %)	6 (6.1 %)	1 (1.0%)	1 (1.0%)	6 (6.1 %)	1 (1.0%)	99 (100. 0%)			
	Total	1 (0.6 %)	8 (4.8 %)	3 (1.8 %)	29 (17.5 %)	1 (0.6%)	11 (6.6 %)	87 (52.4 %)	10 (6.0 %)	1 (0.6%)	3 (1.8%)	11 (6.6 %)	1 (0.6%)	166 (100. 0%)			

A. spp: Acinetobacter spp, E. coli: Escherichia coli, H. spp: Haemophilus spp, K. spp: Klebsiella spp, P. spp: Pseudomonas aeruginosa, S. aureus: Staphylococcus aureus, S. epidermidis: Staphylococcus epidermidis, Aspergillus spp, Candida spp, Trichophyton mentagrophytes

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