Open Journal of Medical Microbiology, 2025, 15(2), 110-124
https://www.scirp.org/journal/ojmm
ISSN Online: 2165-3380
ISSN Print: 2165-3372

Antimicrobial Susceptibility Patterns of Bacterial Isolates from Children with Chronic Suppurative Otitis Media in Northern Uganda

Alex Olia[1*], Felix Bongomin[1], Robert Ocakacon[2], Michael Dfendu[2], Simon Peter Alarakol[3], Emmanuel Igwaro Odongo Aginya[1], Stephen Ochaya[1,4]

[1]Department of Medical Microbiology and Immunology, Faculty of Medicine, Gulu University, Gulu, Uganda
[2]Department of Clinical Microbiology, St. Mary's Hospital Lacor Gulu, Gulu, Uganda
[3]Department of Biochemistry, Faculty of Medicine, Gulu University, Gulu, Uganda
[4]Department of Clinical Pathology, Uppsala Academic University Hospital, Uppsala, Sweden
Email: *alex.olia@gu.ac.ug, *oliaalexander@gmail.com

How to cite this paper: Olia, A., Bongomin, F., Ocakacon, R., Dfendu, M., Alarakol, S.P., Aginya, E.I.O. and Ochaya, S. (2025) Antimicrobial Susceptibility Patterns of Bacterial Isolates from Children with Chronic Suppurative Otitis Media in Northern Uganda. *Open Journal of Medical Microbiology*, **15**, 110-124.
https://doi.org/10.4236/ojmm.2025.152009

Received: March 7, 2025
Accepted: June 20, 2025
Published: June 23, 2025

Abstract

Chronic suppurative otitis media (CSOM) is a common childhood infection and can lead to hearing impairment. We characterized bacterial isolates from children with CSOM and determined their antimicrobial susceptibility patterns among children attending outpatient department of a large teaching hospital in northern Uganda. A cross-sectional study was conducted among children attending outpatients and Nutrition wards at St. Mary's Hospital Lacor, Gulu. Using culture techniques, ear pus swabs were cultured on blood agar, MacConkey and chocolate agar. Organisms were identified by standard microbiological tests. The antimicrobial susceptibility test was done using Kirby-Buer disk diffusion method. Out of 108 children enrolled with CSOM, we identified 11 bacterial species, predominantly *Proteus mirabillis* (42.6%, n = 46), *Staphylococcus aureus* (19.4%, n = 21), *Acinetobacter spp.* (9.3%, n = 10), *Klebsiella pneumoniae* (7.4%, n = 8), *Pseudomonas aeruginosa* (5.6%, n = 6), *Escherichia coli* (4.6%, n = 5), *Enterococcus faecalis* (2.8%, n = 3), *Haemophilus influenzae* (1.9%, n = 2), *Enterobacter spp.* (1.9%, n = 2), *Proteus vulgaris* (0.9%, n = 1), *Streptococcus pneumoniae* (0.9%, n = 1) and unidentified coliform bacteria (0.9%, n = 1). Resistance was mostly frequent with Tetracycline (77.8%, 84/108), Chloramphenicol (73.1%, 79/108), Cotrimoxazole (64.5%, 69/108), and Ampicillin (64.5%, 69/108), Most isolates were sensitive to Ciprofloxacin (88.9%, 96/108), Gentamicin (85.2%, 92/108), and Methicillin (100%, 21/21). CSOM remains a public health problem with high prevalence among children ≤ 60 months of age dwelling in poor communities in Northern Uganda, continuous surveillance of the causative agents and their antibiogram is necessary.

Keywords

Chronic Suppurative Otitis Media, Antimicrobial Susceptibility Patterns, Lacor Hospital Gulu

1. Introduction

Otitis (Ear) infections are categorized according to the part of the ear affected. This includes Otitis Interna (inner part), Otitis Media (middle part) and Otitis Externa (outer part). Otitis (Ear) infection has been found to mostly affect children globally, and is the major cause of hospital visits, especially in low-income countries. In the United Kingdom, 90% of children with ear infections are between the ages of 0 - 6 years. In Nigeria (Zaria), the infection is prevalent in children between 6 month - 6 years [1]. Otitis media (acute and chronic) are frequent, and the complications and sequelae represent significant health hazards in children [2]. Otitis media has probably been recognized for hundreds of years, where it has caused significant childhood morbidity and increasingly impacted upon general public health [3]. Chronic suppurative otitis media (CSOM) is a persistent, insidious ear condition characterized by discharge into the external ear canal continuing for over two weeks and associated with perforation of the tympanic membrane [4]. COSM has multiple etiologies, a destructive and a persistent disease with irreversible sequelae and can proceed to serious intra and extra cranial complication. The disease is common in children and infants of low socio-economic background [5].

CSOM is the most common cause of childhood hearing impairment in the developing countries, and hearing loss during the first five years of life can have serious effects on the child's language development, retarding school progress later [6]. The disease affects 65 - 330 million people worldwide mainly in the developing countries [7], supporting the arguments that, it is a disease of poverty. Of these, 60% have significant hearing loss, mainly as a result of long-term suppuration, persisting perforation of the tympanic membrane and disruption of the middle ear structures due to complications. Fatalities attributable to CSOM are estimated at 28,000 per year [4].

In Nigeria, a survey conducted among Nigerian school children aged between 6 - 15 years, revealed that CSOM was common among rural than urban children in the ratio of 4:1. The overall prevalence of CSOM in sub-Saharan African countries ranges from 0.4% to 4.2% [8] [9]. In another study, the most frequently isolated microorganisms from CSOM were *Pseudomonas aeruginosa*, *Klebsiella spp.*, *Staphylococcus aureus*, *Proteus spp.*, *Escherichia coli*, *Staphylococcus albus* and hemolytic *Streptococci*. Furthermore, the study investigated the antimicrobial susceptibility profiles and found out that, Amikacin was the most effective antibiotic against many isolates, followed by Ciprofloxacin, Ceftriaxone, Gentamicin, Cefotaxime and Amoxicillin respectively [4]. In Uganda, a study done on Otitis media with effusion in children aged 2 - 12 years attending the paediatric clinic at Mulago National Referral Hospital, a Ugandan tertiary hospital revealed a prevalence of 11% [10]. In another study done on CSOM in Mulago, Uganda, by Rubena Justin *et al.*, 2018, the commonest isolates identified were *Pseudomonas aeruginosa* (17.32%), *Klebsiella pneumoniae* (17.32%), *Proteus mirabilis* (13.39%), *Escherichia coli* (9.5%) and *Staphylococcus aureus* (9.5%). *P. aeruginosa* was found to be 64.7% sensitive to ciprofloxacin, 57.1% to chloramphenicol, and 41.2% to gentamicin. More than 60% of patients had a hearing impairment; 78% had a central perforation [11]. In northern Uganda, the burden, explicit prevalence, bacterial causative agents and antimicrobial susceptibility profiles of CSOM has not been reported. Therefore, our study aimed at determining the prevalence of bacteria associated with COSM infection in children and their susceptibility patterns to commonly used antibiotics.

2. Methods

2.1. Study Design

This was a hospital based cross-sectional study carried among children who presented with chronic suppurative otitis media. The study subjects were children ≤60 months of age.

2.2. Study Settings

This study was conducted in Outpatient Department, Nutrition ward and Clinical microbiology Laboratory at St. Mary's Hospital Lacor Gulu, Northern Uganda. The hospital is located approximately 6 Km along Gulu Nimule Road. Gulu City is located approximately 335 Km north of Kampala City, Uganda. Gulu City is centrally located and the biggest City in Northern Uganda. The coordinates of Lacor Hospital are 02˚46'03"N 32˚15'11"E (Latitude: 2.767500; Longitude: 32.253056). St Mary's Hospital Lacor serves a large population of Northern Uganda and South Sudan. It therefore receives a large number of patients and it is the sentinel center for WHO in the region.

2.3. Exclusion Criteria

Children above 60 months of age presenting with CSOM and those who received prior antibiotics for the previous two weeks, or were on antibiotic chemotherapy during the visit were excluded from the study.

2.4. Inclusion Criteria

Children who were 60 months of age and below, and presented with CSOM, with no history of antibiotic therapy for the last two weeks, and/or not on treatment during the visit to the hospital were recruited in the study. The study participants who satisfied the inclusion criteria were recruited after a written informed consent was obtained from their parents/guardians.

2.5. Sampling Procedure

Non-randomized purposive sampling was used to recruit study participants. We collected samples from 108 children who were confirmed to be having CSOM. We relied on only those who were sent to us in the laboratory. The total number screened in the clinic is unknown to us.

2.6. Bacteriological Techniques

Ear pus discharge was taken from external auditory canal using sterile cotton swab after cleaning the outer ear canal using cotton wool moistened with sterile physiological saline or 70% ethanol. Two swabs were taken. The first swab was used for direct Gram staining for presumptive diagnosis, and the second swab was cultured immediately on blood agar (Mast diagnostic UK), Chocolate agar (heated blood agar) and MacConkey agar (Mast diagnostic UK). The inoculated plates were incubated at 37˚C for 24 hours. Chocolate plates were incubated at 37˚C in 5% CO_2 atmosphere for a period of 48 hours. After incubation, colonial/phenotypic characteristics such as morphology, shape of colony, swarming of colony, sugar fermentation, hemolysis of Red Blood Cells, pigment production on solid culture medium, were used for preliminary identification of bacteria. After colonial identifications, Gram stain was done to differentiate Gram positive from Gram negative bacteria. Biochemical identification test such as catalase test was used to differentiate *Staphylococcus spp.* from *Streptococcus spp*. Coagulase test was done to differentiate *S. aureus* from other species of *Staphylococcus*, Oxidase test was used to differentiate *P. aeruginosa* from other Gram-negative organisms. Other tests such as citrate utilization test, phenylalanine deaminase test, triple iron sugars (TSI), lysine iron agar, motility test were used to identify Gram-negative rods/bacilli.

Antimicrobial susceptibility test was performed using Kirby-Bauer disc diffusion method according to NCCLS. The following antibiotics were tested. Methicillin (10 μg), Ampicillin (10 μg), Gentamicin (100 μg), Erythromycin (5 μg), Ciprofloxacin (1 μg), Cotrimoxazole (25 μg), Chloramphenicol (10 μg) and tetracycline (10 μg). Reference strains, *E. coli* (ATCC 25922) for Gram negative oxidase negative organisms, *P. aeruginosa* (ATCC 27853) for Gram negative oxidase positive organisms and *S. aureus* (ATCC 25923) for Gram positive cocci were used as quality control during susceptibility testing. Each batch of culture media used in the isolation of microorganism and antibiotics sensitivity testing was first incubated overnight and those plates found with growth/contamination were discarded. All materials used were checked for dates of manufacture and expiry.

2.7. Data Analysis

The data was entered in Microsoft excel, cleaned and analyzed using STATA version 18.0. Quantitative variables were summarized as either mean with standard deviation or median with extreme values. Chi-square and Pearson correlation tests were used to test for the relationship between variables. A $p < 0.005$ was taken as statistically significant, and the results were presented as figures and tables.

3. Result

3.1. Demographic and Clinical Characteristics of Study Participants with CSOM

A total of 108 study participants who presented with CSOM were enrolled. The age ranged from 5 - 60 months, with mean age of 29.9 months, and SD of ±17.1. In all those age groups, 57.41% were male (62/108) and 42.59% were females (46/108) with a ratio of ~2:1. One hundred and seven (99.1%) of study participants visited OPD, while only 1 (0.9%) participant visited nutrition ward. All the study participants, 108 (100.0%) who presented with CSOM were ear swabbed (**Table 1**).

Table 1. Demographic, clinical characteristics and bacteria isolated from patients with CSOM, who attended St. Mary's Hospital Lacor Gulu, IPD and OPD from March to September 2004.

Demographics & Clinical characteristics	Frequency (%)
Age (months)	
0 - 12	18 (16.7%)
13 - 24	37 (34.3%)
25 - 36	19 (17.6%)
37 - 48	18 (16.7%)
49 - 60	16 (14.8%)
Sex	
Female	46 (42.6%)
Male	62 (57.4%)
Ward	
Nutrition	1 (0.9%)
OPD	107 (99.1%)
Type of swab	
Ear Pus Swab	108 (100.0%)
Gram Stain	
Gram Negative Pleomorphic Rod	1 (0.9%)
Gram Negative Rod	74 (68.5%)
Gram Negative coccobacilli	3 (2.8%)
Gram Positive cocci	30 (27.8%)
Organisms Isolated	
Acinetobacter spp.	10 (9.3%)

Continued

Coliform	1 (0.9%)
Enterobacter spp.	3 (2.8%)
Enterococcus faecalis	3 (2.8%)
Escherichia coli	5 (4.6%)
Haemophilous influenzae	2 (1.9%)
Klebsiella pneumoniae	8 (7.4%)
No bacterial growth	1 (0.9%)
Proteus mirabilis	46 (42.6%)
Proteus vulgaris	1 (0.9%)
Pseudomonas aeruginosa	6 (5.6%)
Staphylococcus aureus	21 (19.4%)
Streptococcus pneumoniae	1 (0.9%)

OPD: Out Patient Department, IPD: Inpatient Department.

3.2. Pattern of CSOM among Children by Age Groups

The disease was more prevalent in children aged between 13 - 24 months compared to other age groups (Table 1).

3.3. Bacteriology of CSOM

Majority of the organisms isolated were Gram-negative, 78 (72.2%) and only 30 (27.8%) were Gram-positive, implying that there was a significant association between organisms isolated and their gram reaction ($p < 0.001$) (Table 1). Eleven species of bacteria and one unidentified coliform were isolated from 108 children who presented with CSOM (Table 1, Figure 1). The most prevalent bacteria isolated were *P. mirabillis* (42.6%, n = 46) followed by *S. aureus* (19.4%, n = 21), *Acinetobacter spp.* (9.3%, n = 10), *K. pneumoniae* (7.4%, n = 8), *P. aeruginosa* (5.6%, n = 6), *E. coli* (4.6%, n = 5), *Enterococcus faecalis* (2.8%, n = 3), *Enterobacter spp.* (2.8%, n = 3), *Haemophilus influenzae* (1.9%, n = 2), *P. vulgaris* (0.9%, n = 1), *S. pneumoniae* (0.9%, n = 1) and unidentified coliform (0.9%, n = 1).

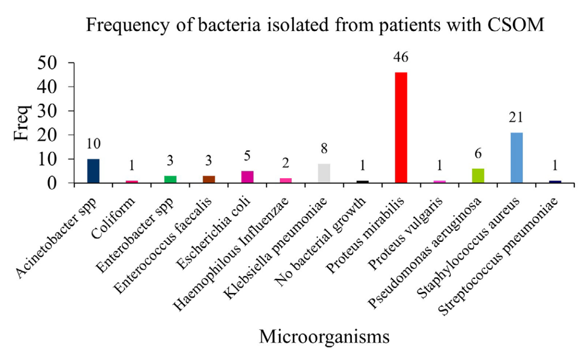

Figure 1. A bar graph showing the frequency of bacterial isolates from patients who presented with Chronic Suppurative Otitis Media in St. Mary's Hospital Lacor Gulu.

3.4. Antibiotic Susceptibility Patterns of the Bacterial Isolates

Methicillin was set for *S. aureus* only and it showed 100% (21/21) average susceptibility. There was a low level of average bacterial resistance to Optochin, 1.9% (2/108), Ciprofloxacin, 8.3% (9/108), Gentamicin, 12% (13/108) and Erythromycin, 18.5% (20/108). However, very high level of resistance was observed in Tetracycilin, 77.8% (84/108), Chloramphenicol, 73.1% (79/108), Cotrimoxazole, 64.5% (69/108) and Ampicillin, 64.5% (69/108) respectively (Table 2, Table 3).

Table 2. Antibiotics, number of bacterial isolates and average percentage resistance in patients with CSOM.

Summary of antibiotic resistance of Bacteria			
S/N	**Antibiotics**	**Number of microorganisms**	**% Resistance**
1	Ciprofloxacin	9/108	8.3%
2	Gentamicin	13/108	12.0%
3	Erythromycin	20/108	18.5%
4	Optochin	2/108	1.9%
5	Chloramphenicol	79/108	73.1%
6	Co-trimoxazole	69/108	64.5%
7	Ampicillin	69/108	64.5%
8	Tetracycline	84/108	77.8%
9	Methicillin	21/21	100%

3.5. Susceptibility of Bacteria to Specific Antibiotics

A detailed analysis of the susceptibility profiles of Bacteria to antibiotics showed that, all the isolates of *Proteus mirabilis* were susceptible to ciprofloxacin (100%, n = 46), (8.7%, n = 4) of the isolates were resistant to Gentamicin and only (2.2%, n = 1) isolate was resistant to Erythromycin. However, a very high level of resistance, was observed in Chloramphenicol (82.6%, n = 38), Ampicillin (73.3%, n = 33) and Cotrimoxazole (68.9%, n = 31). Interestingly all the isolates tested with Tetracycline showed resistance (91.3%, n = 42). All the isolates of *Staphylococcus aureus* were susceptible to Methicillin and Ciprofloxacin (100%, n = 21), while high level resistance was noted with Tetracycline (57.1%, n = 12) and Ampicillin (47.6%, n = 10). We also noted moderate resistance to Cotrimoxazole (42.9%, n = 9), Chloramphenicol (33.3%, n = 7) and Erythromycin (42.9%, n = 9). However, only (4.8%, n = 1) bacterium resisted Gentamicin. *Acinetobacter spp.* Showed high level of resistance to Cotrimoxazole (90%, n = 9), Chloramphenicol and Tetracycline (80%, n = 8), respectively. Moderate resistance was seen in Ampicillin (60%, n = 6), while (40%, n = 4) of the microorganisms were resistant to Ciprofloxacin and Erythromycin respectively, and only (20%, n = 2) were resistant to Gentamicin.

In *Klebsiella pneumoniae*, high level of resistance was noted in Chloramphenicol and Ampicillin (87.5%, n = 7), Tetracycline and Cotrimoxazole (75.0%, n = 6), while we noted low level of resistance (25.0%, n = 2) to Ciprofloxacin and finally, all the organisms did not resist Gentamicin. There was very low level of resistance of *Klebsiella pneumoniae* to Ciprofloxacin (16.7%, n = 1) and (33.3%, n = 2) for Gentamicin. One hundred percent of *E. coli* were resistant to Tetracycline, Ampicillin and Chloramphenicol, while only one isolate resisted Ciprofloxacin and all the isolates were sensitive to Gentamicin.

Other bacteria with low prevalence also had varying susceptibility patterns. *Enterococcus faecalis* showed 100% (n = 3) susceptibility to Ciprofloxacin and Ampicillin respectively, However, it showed 100% (n = 3) resistance to Chloramphenicol and Co-trimoxazole. *Hemophilus influenza* was 100% (n = 2) susceptible to Ciprofloxacin and Gentamicin respectively, but showed 100% (n = 2) resistance to the rest of the antibiotics tested. *Enterobacter species* showed 100% (n = 3) susceptibility to Ciprofloxacin, while one isolate was resistant to Gentamicin. However, isolates were 100% (n = 3) resistance to the rest of the antibiotics tested. It was interesting to find that *Proteus vulgaris* was 100% (n = 1) resistant to Tetracycline, Chloramphenicol and Cotrimoxazole and 100% susceptible to the rest of the antibiotics tested. *Streptococcus pneumoniae* was susceptible to Chloramphenicol, Ampicillin, Tetracycline and Erythromycin (100%, n = 1). An identified coliform was susceptible to a majority of the antibiotics tested (**Table 3**).

4. Discussion

CSOM is a disease with worldwide prevalence and having potentially serious long-term consequences. This disease remains an important global public health problem which can lead to hearing impairment, hence potentially posing serious long-term effects on language, auditory, cognitive development and educational progress [10]. Children from low socio-economic status may be more susceptible than their counterparts with better living conditions [11] [12]. Factors such as poor living conditions, overcrowding, poor hygiene and poor nutrition have been suggested as a basis for the widespread prevalence of CSOM in developing countries [13]. The correct choice of antibiotics is essential for the treatment of bacterial diseases, but misuse and overuse of antibiotics has induced changes in predominant bacterial species and their susceptibility profiles to commonly used antibiotics, thus making it more difficult to manage CSOM [5] [14]. It is very common for an otologist to see discharging ears, whose bacterial flora have been modified by prior antibiotic therapy, leading often to sterile culture and hence treatment becomes a problem. This may be because of microbial resistance to these antibiotics, suggesting their failure and leading to continuation of purulent discharge in the ear. Therefore, it is very important to know what type of bacteria takes part in suppuration, and to determine their susceptibility patterns so that appropriate antibiotics may be instituted early and effectively to prevent complications [5].

In this study, children ≤60 months of age presenting with CSOM were investigated for the presence of bacterial causative agents and their susceptibility patterns

Table 3. Bacterial isolates from patients with CSOM and their detailed susceptibility profiles to commonly used antibiotics.

	Microorganisms Isolated and their susceptibility patterns to antibiotics														
	Acin spp	*Coliform*	*Enterob. spp.*	*E. faecalis*	*E. coli*	*H. Influenzae*	*K. pneum.*	*Nbg.*	*P. mirabilis*	*P. vulgaris*	*P. aerug.*	*S. aureus*	*S. pneumoniae*	*Total*	*Test*
N	10(9%)	1 (0.9%)	3 (2.8%)	3 (2.8%)	5 (4.6%)	2 (1.9%)	8 (7.4%)	1 (0.9%)	46 (42.6%)	1 (0.9%)	6 (5.6%)	21 (19.4%)	1 (0.9%)	108 (100.0%)	
Cip															
I	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (25.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (1.9%)	
NT	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	<0.001
R	4 (40.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (20.0%)	0 (0.0%)	2 (25.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (16.7%)	0 (0.0%)	1 (100.0%)	9 (8.3%)	
S	6 (60.0%)	1 (100.0%)	3 (100.0%)	3 (100.0%)	4 (80.0%)	2 (100.0%)	4 (50.0%)	0 (0.0%)	46 (100.0%)	1 (100.0%)	5 (83.3%)	21 (100.0%)	0 (0.0%)	96 (88.9%)	
Gen															
I	2 (20.0%)	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 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (1.9%)	
NT	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	<0.001
R	2 (20.0%)	0 (0.0%)	1 (33.3%)	2 (66.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	4 (8.7%)	0 (0.0%)	2 (33.3%)	1 (4.8%)	1 (100.0%)	13 (12.0%)	
S	6 (60.0%)	1 (100.0%)	2 (66.7%)	1 (33.3%)	5 (100.0%)	2 (100.0%)	8 (100.0%)	0 (0.0%)	42 (91.3%)	1 (100.0%)	4 (66.7%)	20 (95.2%)	0 (0.0%)	92 (85.2%)	
Ery															
I	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (2.2%)	0 (0.0%)	0 (0.0%)	2 (9.5%)	0 (0.0%)	3 (2.8%)	
NT	5 (50.0%)	1 (100.0%)	3 (100.0%)	0 (0.0%)	5 (100.0%)	2 (100.0%)	6 (75.0%)	1 (100.0%)	43 (93.5%)	1 (100.0%)	2 (33.3%)	1 (4.8%)	0 (0.0%)	70 (64.8%)	<0.001
R	4 (40.0%)	0 (0.0%)	0 (0.0%)	1 (33.3%)	0 (0.0%)	0 (0.0%)	1 (12.5%)	0 (0.0%)	1 (2.2%)	0 (0.0%)	4 (66.7%)	9 (42.9%)	0 (0.0%)	20 (18.5%)	
S	1 (10.0%)	0 (0.0%)	0 (0.0%)	2 (66.7%)	0 (0.0%)	0 (0.0%)	1 (12.5%)	0 (0.0%)	1 (2.2%)	0 (0.0%)	0 (0.0%)	9 (42.9%)	1 (100.0%)	15 (13.9%)	
Opt															
NT	6 (60.0%)	1 (100.0%)	1 (33.3%)	3 (100.0%)	2 (40.0%)	2 (100.0%)	8 (100.0%)	1 (100.0%)	40 (87.0%)	1 (100.0%)	5 (83.3%)	18 (85.7%)	0 (0.0%)	88 (81.5%)	
NT	4 (40.0%)	0 (0.0%)	2 (66.7%)	0 (0.0%)	3 (60.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	6 (13.0%)	0 (0.0%)	1 (16.7%)	1 (4.8%)	0 (0.0%)	17 (15.7%)	<0.001
R	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%)	0 (0.0%)	0 (0.0%)	2 (9.5%)	0 (0.0%)	2 (1.9%)	
S	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%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	1 (0.9%)	
Tet															
I	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%)	0 (0.0%)	0 (0.0%)	3 (14.3%)	0 (0.0%)	3 (2.8%)	<0.001
NT	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (12.5%)	1 (100.0%)	2 (4.3%)	0 (0.0%)	1 (16.7%)	1 (4.8%)	0 (0.0%)	7 (6.5%)	

Continued

NT	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%)	0 (0.0%)	1 (16.7%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	
R	8 (80.0%)	0 (0.0%)	3 (100.0%)	1 (33.3%)	5 (100.0%)	2 (100.0%)	6 (75.0%)	0 (0.0%)	42 (91.3%)	1 (100.0%)	4 (66.7%)	12 (57.1%)	0 (0.0%)	84 (77.8%)	
S	2 (20.0%)	0 (0.0%)	0 (0.0%)	2 (66.7%)	0 (0.0%)	0 (0.0%)	1 (12.5%)	0 (0.0%)	2 (4.3%)	0 (0.0%)	0 (0.0%)	5 (23.8%)	1 (100.0%)	13 (12.0%)	
Chlo															
I	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (4.3%)	0 (0.0%)	0 (0.0%)	2 (9.5%)	0 (0.0%)	4 (3.7%)	
NT	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	3 (6.5%)	0 (0.0%)	1 (16.7%)	3 (14.3%)	0 (0.0%)	8 (7.4%)	
NT	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%)	0 (0.0%)	1 (16.7%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	0.038
R	8 (80.0%)	1 (100.0%)	3 (100.0%)	3 (100.0%)	5 (100.0%)	2 (100.0%)	7 (87.5%)	0 (0.0%)	38 (82.6%)	1 (100.0%)	4 (66.7%)	7 (33.3%)	0 (0.0%)	79 (73.1%)	
S	2 (20.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (12.5%)	0 (0.0%)	3 (6.5%)	0 (0.0%)	0 (0.0%)	9 (42.9%)	1 (100.0%)	16 (14.8%)	
Am															
NT	2 (20.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (12.5%)	1 (100.0%)	0 (0.0%)	1 (100.0%)	3 (50.0%)	1 (4.8%)	0 (0.0%)	9 (8.4%)	
NT	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%)	0 (0.0%)	1 (16.7%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	<0.001
R	6 (60.0%)	1 (100.0%)	3 (100.0%)	0 (0.0%)	5 (100.0%)	2 (100.0%)	7 (87.5%)	0 (0.0%)	33 (73.3%)	0 (0.0%)	2 (33.3%)	10 (47.6%)	0 (0.0%)	69 (64.5%)	
S	2 (20.0%)	0 (0.0%)	0 (0.0%)	3 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	12 (26.7%)	0 (0.0%)	0 (0.0%)	10 (47.6%)	1 (100.0%)	28 (26.2%)	
Cotr															
I	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (2.2%)	0 (0.0%)	0 (0.0%)	1 (4.8%)	0 (0.0%)	2 (1.9%)	
NT	1 (10.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	3 (50.0%)	1 (4.8%)	1 (100.0%)	7 (6.5%)	
NT	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%)	0 (0.0%)	1 (16.7%)	0 (0.0%)	0 (0.0%)	1 (0.9%)	<0.001
R	9 (90.0%)	1 (100.0%)	3 (100.0%)	3 (100.0%)	2 (40.0%)	2 (100.0%)	6 (75.0%)	0 (0.0%)	31 (68.9%)	1 (100.0%)	2 (33.3%)	9 (42.9%)	0 (0.0%)	69 (64.5%)	
S	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (60.0%)	0 (0.0%)	2 (25.0%)	0 (0.0%)	13 (28.9%)	0 (0.0%)	0 (0.0%)	10 (47.6%)	0 (0.0%)	28 (26.2%)	
Met															
NT	4 (40.0%)	1 (100.0%)	0 (0.0%)	1 (33.3%)	2 (40.0%)	1 (50.0%)	6 (75.0%)	1 (100.0%)	25 (55.6%)	0 (0.0%)	5 (83.3%)	2 (9.5%)	1 (100.0%)	49 (45.8%)	
NT	6 (60.0%)	0 (0.0%)	3 (100.0%)	2 (66.7%)	3 (60.0%)	1 (50.0%)	1 (12.5%)	0 (0.0%)	18 (40.0%)	1 (100.0%)	1 (16.7%)	1 (4.8%)	0 (0.0%)	37 (34.6%)	<0.001
S	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (12.5%)	0 (0.0%)	2 (4.4%)	0 (0.0%)	0 (0.0%)	18 (85.7%)	0 (0.0%)	21 (19.6%)	

Acin. Spp-Acinetobacter species, *Enterob. spp-Enterobacter species*, *K. pneum-Klebsiella pneumoniae*, *Nbg-No bacterial growth*, *P. aerug-Pseudomonas aeruginosa*. N, Total number of isolates, Cip-Ciprofloxacin, Gen-Gentamycin, Ery-Erythromycin, Opt-Optochin, Tet-Tetracycline, Chlo-Chloramphenicol, Am-Ampicillin, Cotr-Cotrimoxazole, S-Susceptible, R-Resistant, I-Intermediate & NT-Antibiotic not tested.

to commonly prescribed antibiotics. We limited ourselves to this age group because of the high incidence and prevalence of Otitis media. However, other studies from elsewhere indicate that children in other age brackets and adults also presents with CSOM [13]. Our results show that, children between 13 - 24 months of age had the highest prevalence of CSOM than other age brackets (**Table 1**). A study done elsewhere reveals that, the prevalence of the disease is inversely proportional to age (the prevalence decreases with an increasing age). This is because in children, the Eustachian tube is much shorter and less slanted than in adults, thus allowing bacteria to find their way in to the middle ear more easily, and causing acute Otitis media (AOM) with a buildup of pus within the middle ear, as a result, the pressure and inflammation within the middle ear leads to impairment and inability of the eardrum to vibrate. This leads to the perforation of the tympanic membrane if it persists for a period of more than 2 weeks. Following this sequence of events, secondary microbial invaders gain access through perforated hole to the middle ear and cause infection. However, as the children aged, the Eustachian tube elongates and becomes more slanted. This therefore prevents the microorganism from gaining access to the middle ear thus reducing the risk of acute and chronic otitis media [8]. In addition, other environmental factors such as overcrowding, poor hygiene, poor nutrition, exposure to large group of children such as in childcare centers, low immunity and inability to mention the problem early have been suggested for the high prevalence of the disease in these age groups. We also found that, more males 62 (57.4%) had CSOM than females, 46 (42.6%) with a ratio of 1.5:1. Although this M:F ratio is not statistically significant ($p = 0.1$), a study done elsewhere indicates that CSOM is more prevalent in males than females with a ratio of 4:1 [4]. However, the cause for these differences remains elusive.

Next, we investigated the bacteriology of CSOM. First, we analyzed the gram reaction of the bacterial isolates. We found that, there were more gram-negative bacilli (rod) 78 (72.2%) than gram positive cocci 30 (27.8%). We then identified the individual gram negative and gram-positive bacteria causing CSOM using biochemical tests. It was found that, the most frequent bacterial isolates, were, *P. mirabilis*, *S. aureus*, *Acinetobacter spp.*, *K. pneumoniae*, *P. aeruginosa*, *E. coli*, *Enterococcus faecalis*, *H. influenzae*, *Enterobacter spp.*, *Proteus vulgaris*, *Streptococcus pneumoniae* and unidentified coli form respectively (**Table 1**, **Figure 1**). Although PCR or MALDI-TOF tests were necessary to confirm the isolates, it was not performed due to the high cost involved. In addition, St Mary's hospital Lacor lacks the facility to perform these molecular tests.

In other studies done elsewhere, the findings were slightly different from ours, for example a study on the bacteriology of CSOM by Madana *et al.*, reported *Pseudomonas aeruginosa* as the most frequently isolated bacteria (32%), followed by *Proteus mirabilis* (20%) and *Staphylococcus aureus* (19%) [5]. Afolabi *et al.*, reported similar findings, however *Klebsiella species* was second to *Pseudomonas aeruginosa* in prevalence followed by *Staphylococcus aureus* [13]. Further, Poorely *et al.*, also reported similar prevalence, *Pseudomonas aeruginosa* 36 (35.2%), *Klebsiella spp.* 26 (25.4%), *Staphylococcus aureus* 15 (14.7%), *Bacillus proteus* 10 (9.8%), *Escherichia coli* 6 (5.88%). *Staphylococcus albus* 5 (4.9%), *Haemolytic streptococci* in 4 (3.92%) cases [4] and Chirwa M *et al.*, reported the slightly different findings with *Proteus mirabilis* as the most predominant bacterial isolate, followed by *Pseudomonas aeruginosa* and *Staphylococcus aureus* [15].

Our result is similar to those of Chirwa M. *et al.*, who found that, *Proteus mirabilis* leads in prevalence. Although different studies above implicate *Pseudomonas aeruginosa* as the leading bacterial causative agent of CSOM, the general findings agree with our results in terms of the composition and similarity of the bacterial isolates but differs in the prevalence of each bacterium isolated. Taken together, all these variations in similarities and differences in the results from these different studies could be due to differences in experimental designs and protocols, laboratory expertise, geographical locations among others. *Proteus mirabilis* predominates probably because it's widely distributed in the environment (water, soil,) and animal intestines including humans. Therefore, susceptible children get in to contact with the organisms as a result of poor water and sanitation practices, playing in contaminated soil or touching contaminated manures and plants material [9] and misuse of antibiotics. Furthermore, their minimal nutritional growth requirements, ability to swarm and cover the fastidious organism, as shown by the appearance of the fastidious organism in association with the non-swarming organisms like Staphylococcus (Personal observation from Lacor hospital microbiology laboratory, unpublished), is also suggested as a possible cause for the high prevalence. *Staphylococcus aureus* is a member of the skin commensals, mucosal surfaces and nasopharynx in humans. It can gain access in the tympanic membrane after perforation and express many virulent factors such as enzymes (catalase, coagulase, staphylokinases, hyaluronidases, collagenases, etc.) and toxins such as hemolysins which collectively helps them to colonize, invade and cause suppurations in the in the middle ear. Together with *Pseudomonas aeruginosa*, *Staphylococcus aureus* frequently form biofilm. Bacteria present in biofilms have a defensive advantage than their planktonic counterparts. A particular portion of the bacteria within biofilms maintains a lower metabolic rate than planktonic forms, which helps in the bacteria's defense against antibiotics. Bacteria in biofilms have protection from phagocytosis and host immune response. It is thought that biofilms periodically release planktonic bacteria into the host that cause local and systemic illness [5]. Fecal bacteria, like *Escherichia coli*, could indicate that the individuals acquired infection due to poor hygiene and sanitary conditions. *Klebsiella species* possess capsular materials that aid in overcoming the harsh environmental conditions, protects from phagocytosis. It is an important cause of nosocomial and community acquired infections [9].

Finally, there was, high level of *in-vitro* average bacterial resistance noted with Tetracycline 77.8% (84/108), Chloramphenicol 73.1% (79/108), Cotrimoxazole 64.5% (69/108), and Ampicillin, 64.5% (69/108). Bacterial resistance can be inherent (intrinsic) or acquired. We did not analyze the gene mediating this high-level resistance to these antibiotics to clarify whether they were natural or acquired. Factors such as antibiotic abuse, inadequate dose or acquisition of resistant bacterial strains from the environment, among others could explain this bacterial resistance. Conversely, majority of the microorganisms expressed low level of average resistance to Ciprofloxacin 8.3% (9/108), Gentamicin 12% (13/108), Methicillin, 0% (0/22) and Erythromycin 18.5% (20/36) (Table 2, Table 3). This finding agrees with several reports indicating high efficacy of Ciprofloxacin, Gentamicin towards most bacterial isolates.

5. Study Limitations

This was a hospital-based cross-sectional study which only provided a snapshot of the bacterial prevalence and antimicrobial susceptibility patterns at a single point in time. Furthermore, the study did not address the actual prevalence of CSOM in Northern Uganda. A longitudinal study designed to address both the prevalence of CSOM, its antibiogram and susceptibility patterns could have provided complete data on this subject.

Although St Mary's Hospital Lacor serves as a referral hospital in Northern Uganda, it would have been good if the study collected samples from participants from various health centers within the region for appropriate representation.

Another limiting factor in this study was the small sample size, which may not represent the entire population in Northern Uganda. Geographical location of Northern Uganda could have influenced the type, prevalence and antimicrobial susceptibility patterns of bacteria in CSOM compared to other regions in Uganda and the rest of the world. Age bias is another limitation in this study. Although it is frequently reported that children ≤5 of age are the most affected with CSOM, other age groups are also affected. This may introduce a bias in the type of bacteria present. We used a traditional bacterial identification method which is less accurate, therefore, Modern methods such as Nucleic acid amplification test such as PCR should have been applied, however, St Mary's Hospital Lacor lacks this test. Finally, lack of funds made us restrict ourselves within only one hospital setting.

6. Conclusion and Recommendation

CSOM remains a public health problem with high prevalence among children ≤5 years of age dwelling in poor communities in Northern Uganda. The most common bacterial pathogens associated with CSOM include *Proteus mirabilis*, *Staphylococcus aureus*, *Acinetobacter species*, *Klebsiella pneumonia*, *Pseudomonas aeruginosa* and *Escherichia coli*. Ciprofloxacin and Gentamicin were found to be the most effective antibiotics against most isolates. Although Ciprofloxacin was the most efficacious antibiotics, its use in children is controversial due to potential cartilage toxicity risks. Alternative nontoxic or less toxic efficacious drugs should be considered in treating CSOM in children. Methicillin resistant *Staphylococcus aureus* was not detected. High level resistance to Chloramphenicol, Cotrimoxazole, Ampicillin, and Tetracycline were detected in most isolates, therefore for effective management of CSOM, continuous surveillance of the causative agents and their antibiogram is recommended. Furthermore, this study was done many years ago. It's important to conduct a similar study currently to understand the antibiogram of CSOM, analyze if there is a change in the susceptibility patterns to the commonly used antibiotics and analyze the genes mediating these resistances.

Acknowledgements

We acknowledge Lacor Hospital directors, Laboratory staff in general and patients who participated in this study for giving us the opportunity to conduct and complete this study successfully. Secondly, we would like to thank the Government of the republic of Uganda and Makerere University for allocating students research grant that enabled us to complete this study successfully.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Agbawu, A.M., Ikrama, H., Zakou, A.T., Lamini, N.J., Osanga, C., Dogara, A.N., *et al.* (2023) Assessment of Ear Infection in Children Attending Dalhatu Araf Specialist Hospital, Lafia. *Global Pediatrics*, **5**, Article 100063. https://doi.org/10.1016/j.gpeds.2023.100063

[2] Moffet, H.L. (1981) Paediatric Infectious Diseases, A Problem-Oriented Approach.

[3] Fleisher, G. and Ludwig, S. (1998) Textbook of Peadiatrics Emergency Medicine.

[4] Aduda, D.S.O., Macharia, I.M., Mugwe, P., Oburra, H., Farragher, B., Brabin, B., *et al.* (2013) Bacteriology of Chronic Suppurative Otitis Media (CSOM) in Children in Garissa District, Kenya: A Point Prevalence Study. *International Journal of Pediatric Otorhinolaryngology*, **77**, 1107-1111. https://doi.org/10.1016/j.ijporl.2013.04.011

[5] Poorey, V.K. and lyer, A. (2002) Study of Bacterial Flora in Csom and Its Clinical Significance. *Indian Journal of Otolaryngology and Head and Neck Surgery*, **54**, 91-95. https://doi.org/10.1007/bf02968724

[6] Madana, J., Yolmo, D., Kalaiarasi, R., Gopalakrishnan, S. and Sujatha, S. (2011) Microbiological Profile with Antibiotic Sensitivity Pattern of Cholesteatomatous Chronic Suppurative Otitis Media among Children. *International Journal of Pediatric Otorhinolaryngology*, **75**, 1104-1108. https://doi.org/10.1016/j.ijporl.2011.05.025

[7] Jensen, R.G., Koch, A. and Homøe, P. (2013) The Risk of Hearing Loss in a Population with a High Prevalence of Chronic Suppurative Otitis Media. *International Journal of Pediatric Otorhinolaryngology*, **77**, 1530-1535. https://doi.org/10.1016/j.ijporl.2013.06.025

[8] Ologe, F.E. and Nwawolo, C.C. (2004) Chronic Suppurative Ototis Media in School Pupils in Nigeria. *East African Medical Journal*, **80**, 130-133. https://doi.org/10.4314/eamj.v80i3.8681

[9] Nshimirimana, J.P.D. and Mukara, K.B. (2018) Causes of Delayed Care Seeking for Chronic Suppurative Otitis Media at a Rwandan Tertiary Hospital. *International Journal of Otolaryngology*, **2018**, Article 5386217. https://doi.org/10.1155/2018/5386217

[10] Bamaraki, K., Namwagala, J., Hidour, R. and Bambi, E.N. (2022) Otitis Media with Effusion in Children Aged 2 - 12 Years Attending the Paediatric Clinic at Mulago National Referral Hospital, a Ugandan Tertiary Hospital: A Cross-Sectional Study. *BMC Pediatrics*, **22**, Article No. 357. https://doi.org/10.1186/s12887-022-03408-w

[11] Justin, R., Tumweheire, G., Kajumbula, H. and Ndoleriire, C. (2018) Chronic Suppurative Otitis Media: Bacteriology, Susceptibility and Clinical Presentation among ENT Patients at Mulago, Uganda. *South Sudan Medical Journal*, **11**, 31-35.

[12] Ruthraford, K. (2001) New Approaches for Analysis, Treatment and Prevention of Otitis Media.

[13] Sharma, K., Aggarwal, A. and Khurana, P.M.S. (2010) Comparison of Bacteriology in Bilaterally Discharging Ears in Chronic Suppurative Otitis Media. *Indian Journal of Otolaryngology and Head & Neck Surgery*, **62**, 153-157. https://doi.org/10.1007/s12070-010-0021-9

[14] Afolabi, O., Salaudeen, A., Ologe, F., Nwabuisi, C. and Nwawolo, C. (2013) Pattern of Bacterial Isolates in the Middle Ear Discharge of Patients with Chronic Suppurative Otitis Media in a Tertiary Hospital in North Central Nigeria. *African Health Sciences*, **12**, 362-368. https://doi.org/10.4314/ahs.v12i3.18

[15] Chirwa, M., Mulwafu, W., Aswani, J., Masinde, P., Mkakosya, R. and Soko, D. (1970) Microbiology of Chronic Suppurative Otitis Media at Queen Elizabeth Central Hospital, Blantyre, Malawi: A Cross-Sectional Descriptive Study. *Malawi Medical Journal*, **27**, 120-124. https://doi.org/10.4314/mmj.v27i4.1