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Open Access Journal of Ophthalmology
ISSN: 2578-465X

Prevalence and Antimicrobial Susceptibility Pattern of Micro-Organisms Associated with Ocular Infections

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Research Article
Volume 7 Issue 2
Received Date: August 24, 2022
Published Date: September 14, 2022
DOI: 10.23880/oajo-16000247

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Abstract

Background and Objective: Ocular infections in man are the contamination and invasion of ocular tissues by micro-organisms leading to the breakdown of the natural defense mechanisms of the eyes. This study was undertaken to determine the prevalence and antimicrobial susceptibility pattern of microorganisms associated with ocular infections.

Methods: A hospital based cross-sectional study was conducted at four (4) tertiary hospitals in Abia State. Ocular specimens were collected from 500 patients. Subsequent identification was done based on morphology and biochemical tests. Susceptibility pattern of the isolates were done using the disk diffusion method.

Results: The prevalence of ocular infection was 264(52.8%). Conjunctivitis was the most prevalent ocular infection of 105(39.8%) followed by Blepharitis 76(28.8%). *S. aureus* was the most prevalent pathogen 63(23.9%) followed by CoNS 36(13.6%). *S. aureus* was 100% sensitive to vancomycin and chloramphenicol. CoNS were also 100% sensitive to ciprofloxacin, vancomycin and chloramphenicol. *K pneumoniae* was 100% sensitive to gentamicin and Amoxicillin-clavulanic acid while N. gonorrhoeae was 100% sensitive to gentamicin, ciprofloxacin, ceftriaxone, Amoxicillin-clavulanic acid and cefotaxime. The overall MAR bacteria were 38(16.2%).

Conclusion: The prevalence of ocular infection was high with Conjunctivitis being the dominant. The dominant bacteria species were *S. aureus* and *CoNS*. The overall MAR bacteria proportion was relatively high. The findings in this study calls for *CoNS*tant bacterial surveillance before starting empirical treatment.

Keywords: Bacteria; Keratitis; Conjunctivitis; Blepharitis; Antibiotics

Abbreviations: GEN: Gentamicin; CIP: Ciprofloxacin; VA: Vancomycin; CHL: Chloramphenicol; TET: Tetracycline; CTR: Ceftriaxone; AMP: Ampicillin; AMC: Amoxicillin Clavulanic Acid; MAR: Multi-Antimicrobial Resistance; NIMR: Nigerian Institute of Medical Research; ASTHA: Abia State Teaching Hospital Aba; GHU: General Hospital Ugwunagbo; ASDHU: Abia State Diagnostic Hospital Umuahia; FMCU: Federal Medical Centre Umuahia; WHO: World Health Organization.

Introduction

Ocular infections in man are the contamination and invasion of ocular tissues by micro-organisms leading to the breakdown of the natural defense mechanisms of the eyes (i.e. the bony orbits, eyelids, eyelashes and tears). This situation results in various ocular disorders including conjunctivitis, keratitis, blepharitis, lid abscess, external hordeolum, dacryocystitis and blepharo-conjuctivitis [1]. The effects of these ocular infections are enormous as they cause both physical, emotional stress including psychological trauma if it leads to blindness or severe ocular distortions [2].

Ocular infections are common and their morbidity can vary from self-limiting, trivial infection to sight- threatening. The areas in the eye that are frequently infected are the conjunctiva, lid and cornea [3]. These infections have been known to affect both male and female of various age groups. In addition, individuals of various occupations have had cause to suffer ocular microbial infections [3]. However, some occupations have been reported to predispose people to ocular microbial infections. In addition, some habits especially those that involve cleaning or rubbing the eyes with contaminated hands/fingers transfer these pathogens to the eyes hence the infections. World Health Organization (WHO), reported that industries were dusts and particles are sent into the air have higher ocular microbial infections [4].

Several other factors have also been known to influence the spread of the microbial ocular invasion. Such factors may include the type of residence, social and attitudinal. Some of these infections carry poor prognosis as patients are at risk of losing either their sights or life, or both [2]. This has necessitated the prompt detection of the etiologic agent and the timely institution of appropriate antibiotic treatment for patients with ocular infections.

In Nigeria, conjunctivitis is one of the most common eye problems which causes "red eye" that affect all age groups. Infective keratitis is a major cause of vision loss and blindness second to cataract [5]. Blepharitis is an inflammation of the eyelid margins which can result in patient discomfort and decline in visual function while lid abscess may cause vision-threatening ocular complications [6]. Dacryocystitis is an inflammation of the lacrimal sac and duct. Lastly, eyelid infection causes redness of the eyelids and the skin around the eyes [7].

In Ethiopia the prevalence of blindness from ocular infections was reported about 1.6 % and it was estimated that 87.4 % of the cases were due to avoidable causes [8]. Studies by investigators from Ethiopia, India and Pakistan indicated that Gram-positive and Gram-negative bacteria are the most commonly isolated pathogens in patients with blepharitis, dacryocystitis and conjunctivitis, but variations exist in etiologies, drug susceptibilities of pathogens, and antibiotic resistance mechanisms [8-10]. Gram positive bacteria such as *Staphylococcus aureus*, non-coagulase- positive Staphylococci, *Bacillus* sp, *Corynebacterium* sp, *Streptococcus pneumoniae*, *Streptococcus pyogenes*, and *Streptococcus viridans* have been implicated as etiologies of most ocular infections in patients [8,6]. In Gram negative- mediated ocular infections, pathogens such as *Pseudomonas aeruginosa, Escherichia coli*, *Proteus* sp, *Moraxella* sp and *Neisseria gonorrhoeae* have been isolated as etiologic agents [8,6].

The management of bacterial eye infections may involve treatment with broad spectrum antibiotics. The indiscriminate use of antibiotics led to the development of resistance to many commonly used antimicrobial medications. The emergence of bacterial resistance towards topical antimicrobial agents may increases the risk of treatment failure with potentially serious consequences [9]. Therefore, up to date information is essential for appropriate antimicrobial therapy and management of ocular infections [6].

The number of people attending various health institutions for eye related problems in Nigeria is currently in the increase. This has resulted in the establishment of optometry clinics in various hospitals across the country. But there have not been adequate data regarding etiologic agents of ocular infections, lens, frames and care system; coupled with lack of updates on trends in antibiotic resistance patterns of ocular pathogens to inform treatment guidelines in the care of eye-infected patients. Thus, this study was conducted to isolate the dominant bacteria associated with ocular infections; and to assess the drug susceptibility patterns of the bacterial isolates to commonly prescribed antibiotics in Abia State, Nigeria.

Materials and Methods

Study Area

Eye-patients attending the Optometry clinic at Abia State University Teaching Hospital Aba, Federal Medical Centre Umuahia, Abia State Diagnostic Hospital Umuahia and General Hospital Ugwunagbo were the target population.

Study Design

This is a cross-sectional study that included patients with clinically diagnosed bacterial Conjunctivitis, keratoconjunctivitis, Keratitis, Blepharo-conjunctivitis, Blepharitis, Dacryo-cystitis and Lid abscess between July 2020 to June 2021. All patients were diagnosed by a number of ophthalmologists using standard protocols.

Sample Size/Study Techniques

A total of 500 ocular specimens, conisting of 125 ocular specimens (swabs), each from the four hospitals were used for this study. All individuals examined and diagnosed using the silt-lamp bio-microscope by ophthalmologists as ocular infection patients were included in this study.

Ethical Clearance

Ethical permission was obtained from the hospital authorities and the consent of the patients was also obtained before specimen collection.

Eligibility Criteria

Inclusion Criteria

- Clinically diagnosed patients suspected with ocular infections.
- Patients who gave their informed consent.

Exclusion Criteria

- Patients on topical antibiotics treatment
- Patients with trachoma, peripheral ulcerative keratitis, viral keratitis, allergic and viral conjunctivitis, severe ocular trauma, and patients who had recent ocular surgery

Data and Specimen Collection

Demography data was collected from patients using structured and predesigned questionnaire. Specimens from the eyes (eye, conjunctiva, lacrimal sac and cornea) was collected using sterile swab sticks following routine clinical management of the patients [11].

Culture, Isolation and Identification of Bacteria

The obtained swabs were examined in the laboratory within 20 mins to 1hr of collection using two methods, direct wet mount and culture technique. The swabs were cultured on the appropriate media (chocolate agar, Macconkey agar and blood agar) for microbial growth.

Specimens were cultured by the streak plate methods using wire loop on Chocolate agar, Macconkey agar and two blood agar plates (Oxoid Basingstoke, UK). Macconkey agar and one blood agar plates were incubated at 37˚C aerobically and the other blood agar and chocolate agar plates were incubated at 37˚C within a candle jar to enhance the growth of bacterial species that needs 5-10 % CO_2 (microaerophilic organisms).

After 24 hours incubation, plates were examined for microbial growth. Specimens taken from the eyelid, conjunctiva or lacrimal sac were considered as culture positive according to Ramesh S, et al. [12]. In the case of microbial keratitis, a culture was considered positive when there was growth of the same organism on two or more media or confluent growth of a known ocular pathogen at the site of inoculation on one solid medium [13]. Plates which did not show any growth were further incubated for additional 24 hours. All observed colonies were identified by their characteristic appearance on their respective media. Furthermore, it was confirmed by the pattern of biochemical reactions using the standard method according to Clinical Laboratory Standard Institute [14].

Chromogenic Agar Test

A loopful of the isolates was aseptically inoculated onto the surface of plates containing chromogenic agar medium. The inocula were spread all over the agar medium by streaking for bacteria isolates. The plates were incubated for 48 hours. Color change was observed after incubation [14].

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was performed for all bacterial isolates (307 isolates) using disk diffusion method on Mueller-Hinton agar (Oxoid Basingstoke, UK) according to the direction of the Clinical and Laboratory Standards Institute [15]. Briefly, 3-5 colonies of the test organism were emulsified in 5 ml of nutrient broth and mixed gently. The suspension was incubated at 37°C and the turbidity of the suspension becomes adjusted to 0.5 McFarland standards. The suspension was uniformly rapped onto Mueller-Hinton agar. The antimicrobial impregnated disks were placed using sterile forceps on the agar surface and the plates were incubated at 37°C for 24 hours and the zone of inhibition was determined. The antimicrobials agents on the disks and their concentrations are as follows: ofloxacin (5µg), gentamicin (GEN, 10µg), ciprofloxacin (CIP, 5µg), vancomycin (VA, 30µg), chloramphenicol (CHL, 10µg), tetracycline (TET, 10µg), ceftriaxone (CTR, 30µg) and ampicillin (AMP, 10µg). The rest are amoxicillin-clavulanic acid (AMC, 30 µg) and cefotaxime (CEF, 30µg). The zones of inhibition were measured to the nearest millimeter using a transparent foot ruler. The results obtained were interpreted as sensitive or resistant according to the direction of the Clinical and Laboratory Standards Institute (Resistance 0 -16mm and sensitive >16mm) [13].

Identification of Multi-Antimicrobial Resistance (MAR) Bacteria

The multi-antimicrobial Resistance bacteria in this study were identified by observing the resistance pattern of the isolates to at least one antimicrobial drug in three or more antimicrobial categories used in this study [14].

Reference Strains

Escherichia coli (ATCC 25922), *Staphylococcus aureus* (ATCC 25923) and *Pseudomonas aeruginosa* (ATTC 27853) were used as reference strains for culture and sensitivity testing.

Controls

Prior to actual data collection, comprehensiveness, reliability and validity of questionnaires were pre-tested on ten patients each from the four aforementioned hospitals. All specimens were collected following standard operating procedure for ophthalmic specimen collection. The sterility of culture media was ensured by incubating 5 % of each batch of the prepared media at 37°C for 24 hours. Performances of all prepared media were also checked by inoculating standard-strains such as *Escherichia coli* (ATCC 25922), *Staphylococcus aureus* (ATCC 25923) and *Pseudomonas aeruginosa* (ATCC 27853) obtained from Nigerian Institute of Medical Research (NIMR) Yaba, Lagos State. The qualities of biochemical testing procedures were checked by these reference strains.

Statistical Analysis

Statistical analysis was carried out using the SPSS 21.0 window-based program. The proportion of isolated bacteria with patient demographic information, and susceptibility to commonly used antibiotics was compared using the chi-square test. A value of P<0.05 was considered to be statistically significant.

Results

Table 1 shows the Association between Socio-demographic characteristics of study population and Ocular infection. The prevalence of ocular infection was 264(52.8%). There was no statistical significance between ocular infection in relation to gender (p=0.183) and educational status (p 0.067). Age and Occupation were significantly associated with ocular infection (p=0.031) and (p=0.014) respectively.

Characteristics	Total Tested (%)	Number Positive (%)	η2	df	P- Value
GENDER					
Male	262(52.4)	145(55.3)	4.612	1	0.183
Female	238(47.6)	119(50.0)			
Total	**500(100)**	**264(52.8)**			
AGE IN YEARS					
0- 15	71(14.2)	25(35.2)	15.142	6	0.031
15 – 30	99(19.8)	36(36.4)			
30 – 45	122(24.4)	94(77.0)			
45 – 60	118(23.6)	65(55.1)			
> 60	90(18.0)	44(48.9)			
Total	**500**	**264(52.8)**			
OCCUPATION					
Schooling	68(13.6)	35(51.5)	11.732	5	0.014
Farming	90(18.0)	56(62.2)			
Civil Servants	80(16.0)	24(30.0)			
Trading	76(15.2)	31(40.8)			
Artisans	59(11.8)	26(44.1)			
Metal mining	62(12.4)	44(71.0)			
Stone Quarrying	65(13.0)	48(73.8)			
Total	**500(100)**	**264(52.8)**			
EDUCATIONAL STATUS					
Tertiary education	121(24.2)	61(50.4)	6.101	2	0.067
Secondary education	128(25.6)	77(60.2)			
Primary education	117(23.4)	44(37.6)			
None/Illiterate	134(26.8)	82(61.2)			
Total	**500(100)**	**264(52.8)**			

ASTHA: Abia State Teaching Hospital Aba, GHU: General Hospital Ugwunagbo, ASDHU: Abia State Diagnostic Hospital Umuahia, FMCU: Federal Medical Centre Umuahia

Table 1: Ocular Infections and Sociodemographic Characteristics.

Table 2 shows the Clinical Presentations of Ocular Infections from ASTHA, GHU, and FMCU AND ASDHU. Conjunctivitis was the most prevalent ocular infection of 105(39.8%) followed by Blepharitis 76(28.8%) and Keratitis 36(13.6%). The least was Dacryocytitis 5(1.9 %). More so, ASTHA had the highest prevalence of ocular infection of 133(50.4%) followed by FMC 71(26.9%). The least was seen in GHU 22(8.3%).

CASES	ASTHA			FMC			GHU			ASDHU			Total
	M	F	Sub Total	M	F	Sub Total	M	F	Sub Total	M	F	Sub Total	No (%)
1) Conjunctivitis	30(11.4)	21(8.0)	51(19.3)	19(7.2)	10(3.8)	29(11.0)	6(2.3)	4(1.5)	10(3.8)	10(3.8)	5(1.9)	5(5.7)	105(39.8)
2) Dacryocytitis	2(0.8)	1(0.4)	3(1.1)	1(0.4)	0	1(0.4)	1(0.4)	0	1(0.4)	0	0	0	5(1.9)
3) Blephartitis	20(7.6)	9(7.2)	39(14.8)	12(4.5)	8(3.0)	20(7.9)	4(1.5)	2(0.8)	6(2.3)	6(2.3)	5(1.9)	11(4.2)	76(28.8)
4) Keratitis	10(3.8)	8(3.0)	18(6.8)	5(1.9)	4(1.5)	9(3.4)	2(0.8)	2(0.8)	4(1.5)	4(1.5)	1(0.4)	5(1.9)	36(13.6)
5) Blepharo-conj	6(2.3)	5(1.9)	11(4.2)	3(1.1)	2(0.8)	5(1.9)	1(0.4)	0	1(0.4)	1(0.4)	1(0.4)	2(0.8)	19(7.2)
6) Lid Abscess	5(1.9)	4(1.5)	9(3.4)	5(1.9)	1(0.4)	6(2.3)	1(0.4)	0	1(0.4)	3(1.1)	1(0.4)	4(1.5)	20(7.6)
7)Others**	1(0.4)	1(0.4)	2(0.8)	1(0.4)	0	1(0.4)	0	0	0	0	0	0	3(1.1)
TOTAL	**74 (28.0)**	**59 (22.3)**	**33 (50.4)**	**46 (17.2)**	**25 (9.5)**	**71 (26.9)**	**15 (5.7)**	**7 (2.7)**	**22 (8.3)**	**24 (9.0)**	**13 (4.9)**	**37 (14.0)**	**264 (100)**

Others** Post traumatic Suppurative scleritits,
ASTHA: Abia State Teaching Hospital Aba; Hepatic Keratitis; GHU: General Hospital Ugwunagbo; Ext Hordeolum: External Hordeolum; FMCU: Federal Medical Centre Umuahia; Blepharo-conjuctivitis; ASDHU: Abia State Diagnostic Hospital Umuahia

Table 2: Clinical Presentations of Ocular Infections from ASTHA, GHU, FMCU AND ASDHU.

Table 3 shows the Prevalence of Bacteria pathogens across the different Clinical features of Ocular infections. *S. aureus* was the most prevalent pathogen 63(23.9%) followed by *CoNS* 36(13.6%) and *S. pneumoniae* 35(13.3%). The least pathogen was *Neisseria gonorrheae* 4(1.3%). Pathogens isolated from conjunctivitis includes *S. aureus* 25(23.8%), *CoNS* 16(15.2%), *E. coli* 14(13.3%), *P. aeruginosa* 6(5.7%), *S. pneumoniae* 24(22.9%), *Moraxella catarrhalis* 3(2.9%) and *Neisseria gonorrhoeae* 3(2.9%). Pathogens isolated from keratitis includes *S. aureus* 11(30.6%), *P. aeruginosa* 8(22.2%) and *S. pneumoniae* 10(27.8%). Other pathogens isolated from clinical features are found in Table 4.

S.No		CONJUCTIVITIS 105(39.8%)	DACRYO 5(1.9%)	BLEPHARITIS 76(28.8%)	KERATITIS 36(13.6%)	BLEPH-CON 19(7.2%)	LID ABSCESS 20(7.6%)	OTHERS 3(1.1%)	TOTAL 264(%)
1	*S. aureus*	25(23.8)	2(40.0)	19(25.0)	11(30.6)	2(10.5)	3(15.0)	1(33.3)	63(23.9)
2	*CoNS*	16(15.2)	0	14(18.4)	0	6(31.6)	0	0	36(13.6)
3	*S. pneumoniae*	24(22.9)	1(20.0)	0	10(27.8)	0	0		35(13.3)
4	E.coil	14(13.3)	0	0	0	5(26.3)	0	0	19(7.2)
5	*P. aeruginosa*	6(5.7)	1(20.0)	5(6.6)	8(22.2)	0	6(30.0)	0	26(9.8)
6	*K. pneumoniae*	0	1(20)	20(26.3)	0	2(10.5)	0	0	23(8.7)
7	*Moraxella catarrhalis*	3(2.9)	0	0	0	0	2(10.0)	0	5(1.9)
8	*Neisseria gonorrhoeae*	3(2.9)	0	0	0	0	0	0	3(1.1)
	TOTAL	**91(86.7)**	**5(100)**	**58(76.3)**	**29(80.6)**	**15(78.9)**	**11(55.0)**	**1(33.3)**	**210(79.5)**

Others: Post traumatic Suppurativescleritis and Hepatic keratitis, *CoNS*: Coagulase negative staphylococcus, Bleph-con: Blepharoconjuctivitis, Dacryo: Dacryocystitis

Table 3: Prevalence of Bacteria pathogens across the different Clinical features of Ocular infections at ASTHA, GHU, and FMCU AND ASDHU.

Table 4 shows the antimicrobial Susceptibility Pattern of Bacteria Isolated from the Hospitals. *S. aureus* was 100% sensitive to vancomycin and chloramphenicol. *CoNS* were also 100% sensitive to ciprofloxacin, vancomycin and chloramphenicol. *K pneumoniae* was 100% sensitive to gentamicin and Amoxicillin-clavulanic acid while *N. gonorrhoeae* was 100% sensitive to gentamicin, ciprofloxacin, ceftriaxone, Amoxicillin-clavulanic acid and cefotaxime.

Isolates	No. of Isolates	S/R	OFL	CN	CIP	VA	CHL	TET	CTR	AMP	AMC	CEF
S. aureus	*63(23.9)*	S	53(84.1)	56(88.9)	60(95.2)	63(100)	63(100)	6(9.5)	59(93.7)	9(14.3)	60(95.2)	61(96.8)
		R	10(15.9)	7(11.1)	3(4.8)	0	0	57(90.4)	4(6.3)	54(85.7)	3(4.8)	2(3.2)
CoNS	36(13.6)	S	4(11.1)	1(2.8)	36(10	0) 36(100)	36(100)	6(16.7)	10(27.8)	1(2.8)	8(22.2)	11(30.6)
		R	32(88.9)	35(97.2)	0	0	0	30(83.3	26(72.2)	35(97.2)	28(77.8)	25(96.2)
S. pneumoniae	*35(13.3)*	S	28(80.0)	9(25.7)	33(94.3)	35(100)	35(100)	15(42.9) 35	35(100)	7(20.0)	4(11.4)	33(94.3)
		R	7(20.0)	26(72.3)	2(5.7)	0	0	20(57.1)	0	28(80.0)	31(88.6)	2(5.7)
E. coli	*19(7.2)*	S	16(84.2)	10(52.6)	10(52.6)	14(73.7)	0	9(47.4)	19(100)	0	19(100)	18(94.7)
		R	3(15.8)	9(47.4)	9(47.4)	5(26.3)	19(100)	10(52.6)	0	19(100)	0	1(5.3)
P. aeruginosa	*26(9.8)*	S	22(84.6)	26(100)	22(84.6)	20(76.9)	1(3.8)	3(11.5)	16(61.5)	0	26(100)	2(7.7)
		R	4(15.4)	0	4(15.4)	6(23.1)	25(96.2)	23(88.5)	10(38.5)	26(100)	0	24(92.3)
K. pneumoniae	*23(8.7)*	S	0	23(100)	12(52.2)	19(82.6)	2(8.7)	0	20(87.0)	0	23(100)	19(82.6)
		R	23(100)	0	11(47.8)	4(17.4)	21(91.3)	23(100)	3(8.7)	23(100)	0	4(17.4)
M. catarrhalis	*5(1.9)*	S	4(80.0)	4(80.0)	5(100)	2(40.0)	5(100)	3(60.0)	5(100)	0	5(100)	5(100)
		R	1(20.0)	1(20.0)	0	3(60.0)	0	2(40.0)	0	5(100)	0	0
N. gonorrhoeae	*3(1.1)*	S	2(66.7)	3(100)	3(100)	2(66.7)	1(33.3)	1(33.3)	3(100)	1(33.3)	3(100)	3(100)
		R	1(33.3)	0	0	1(33.3)	2(66.7)	2(66.7)	0	2(66.7)	0	0

CONS: Coagulase Negative staphylococci, OFL: Ofloxacin, CN: Gentamicin, VA: Vancomicin, CHL: Chloramphenicol, AMC: Amoxicillin-clavulanic acid, CEF: Cefotaxime, TET: Tetracycline, CTR: Ceftriaxone, AMP: Ampicillin, CIP: Ciprofloxacin.

Table 4: Antimicrobial Susceptibility Pattern of Bacteria Isolated from the Selected Hospital.

Table 5 shows the Multiple Antimicrobial Resistance (MAR) Bacteria. The overall MAR bacteria were 38(16.2%). They include *S. aureus* 11(28.9%), *E. coli* 2(31.6%), *P. aeruginosa* 8(21.1%) and *K. pneumoniae* 7(18.4%).

Isolates	No of MAR Isolates	Percentage of Organism Resistant to Isolates (%)	No of Antibiotics Resistant to Isolate
S. aureus	11	28.9	2-4
E. coli	12	31.6	2-4
P. aeruginosa	8	21.1	2-3
K. pneumoniae	7	18.4	1-3
	38(16.2%)	100%	

Table 5: Multiple Antimicrobial Resistance (MAR) Bacteria.

Discussion

The prevalence of ocular infection in this study was 52.8% which was similar to other studies conducted in Ethiopia whose prevalence were (61%), (59.4%) and (60.8%) [6, 15,16]. The varying rate of isolation of bacteria pathogens from country to country and from different regions within a country might be due to study periods, variations in study populations, variations in climate periods, variations in geographical distributions of bacterial etiology and infection prevention practice in different countries and regions [17, 6]. The absence of bacterial growth in some clinically diagnosed cases of ocular infection may be due to nonbacterial causes like fungi, viruses, eye allergies, post traumatic suppurative scleritits or Hepatic keratitis [18].

The ocular infections were predominantly seen in male (55.3%) who were within the age group 30-45 years (77%). This may be attributed to their outdoor activities as people within this age range make up majority of the labor force. Similar result was seen in the study conducted in India [19]. More so, patients of low socio-economic group like farmers, stone quarries, metal miners had a prevalence of (62.2%), (73.8%) and (71%%) respectively. This may be due to the fact that their occupations exposed them to eye pollution. This was in agreement with the study conducted in India and also, at Southern Ethiopia by Anteneh A, et al [6] who observed patients of low socio-economic group were most affected by ocular infections as a result of exposure to eye infection [19, 6].

The illiterates were mostly affected in this study (61.2%) and similar findings (73.3%) have been reported in Northwest Ethiopia [20]. The reason could be due to their limited knowledge about personal hygiene and the mode of spread of some commensal organisms due to their alteration in the normal flora.

Conjunctivitis was the most common eye infection seen in this study (39.8%) as was found in previous studies [18, 20]. This was followed by Blepharitis (28.8%), Keratitis (13.6%), Lid abscess (7.6%), Blepharo-Conjuctivitis (7.2%) and Dacryocystitis (1.9%). This was in agreement to other similar studies [19, 21]. The causes of bacterial conjunctivitis were due to the alteration in the normal flora which can occur by external contamination, by infection spread from adjacent sites or via blood-born path way and disruption of epithelial layer covering the conjunctiva [21].

The highest cases of ocular infections were observed in Abia State Teaching Hospital Aba (50.4%) and Federal Medical Centre Umuahia (26.9%). This may be due to the fact that both hospitals are located in urban areas. More so, these are hospitals with very high level of equipment and qualified staff, so many patients prefer these two. Accessibility is also high and cost is low. The other two hospitals are not much equipped with optometry equipment. Similar findings were reported by Ergibnesh G, et al. [22].

The predominant bacterial isolates were *Staphylococcus aureus* (23.9%) followed by Coagulase-Negative Staphylococci (13.6%), which was the normal conjuctival flora [22]. This finding is in agreement with previous studies by Anagaw B, et al. [1] and Olatunji FO, et al. [23] who reported 37.4% and 12.3% as the isolation rates for *S. aureus* and coagulase-negative Staphylococci respectively in the same environment [1,23]. In southeast Nigeria, Ubani also recovered *S. aureus* (23.7%) and Staphylococcus albus (19.3%) as the predominant Gram-positive pathogens of ocular infections in patients [24]. In India, isolation rates of 25% and 18.3% have been reported in *S. aureus* and non-coagulase Staphylococci as ocular pathogens respectively [12]. Generally, the predominance of *Staphylococcus aureus*, *CoNS* and *S. pneumoniae* as major ocular pathogens might be due to the fact that these organisms represent the major flora of the eye lid and the conjunctiva and under normal conditions, their clinical manifestations are averted by eye innate immune defense system constituted by tear flow, secretory immunoglobulin, and the presence of cidal agents such as lysozyme and lactoferrin [25,26]. In other study the predominant isolates were *Coagulase negative Staphylococcus* (22%) followed by *Streptococcus pneumoniae* (19.3%) [9]. The little difference may be due to the difference in climate and geographical location between Nigeria and India reconfirming previous reports that ocular pathogens vary in etiology in different countries and different locations within a country [12,24].

With regards to Gram-negative pathogens in ocular infections in this study, *Pseudomonas aeruginosa* was found to be the predominating species with an isolation rate of (9.8%), whereas in a previous study in the same environment, *Klebsiella pneumoniae* was the most commonly isolated pathogen (10.3%) followed by *P. aeruginosa* (8.7%) [24]. Findings in this study therefore indicate a changing trend in the Gram-negative etiology of ocular infections in Abia State. In other parts of the country, *K. pneumoniae* was also most commonly isolated, followed by *E. coli* coupled with the involvement of other Gram-negative pathogens such as *N. gonorrhoeae* and Neisseria meningitides [3]. This again corroborates the influence of locations on the etiology of ocular infections.

The high prevalence of Gram-negative enteric bacteria in this study could be due to ineffective personal hygiene, as the most important mode of transmission for enteric pathogens is faeco-ocular contamination [27]. During data collection, we noticed that the surrounding communities near the hospitals lack proper waste and sewage disposal system.

Among the clinical features, significant association of culture-positivity was observed among study subjects with Blepharitis (28.8%) with *S. aureus* (25%), *CoNS* (18.4%), *P. aeruginosa* (6.6%) and *K. pneumoniae* (26.3%) being the major etiological agent. This is in agreement with the study done in Ethiopia [6].

Streptococcus pneumoniae (27.8%), *Staphylococcus aureus* (30.6%) and *Pseudomonas aeruginosa* (22.2%) were found to be the predominant isolates in the cases of microbial keratitis (13.6 %). This was also in agreement with previous works in Ethiopia [28]. In contrast, other studies reported *P. aeruginosa* as the major isolate [9, 29]. This may be due to inter-population variations and environmental dissimilarities in different countries [30]. Microbial keratitis is often related to contact lens wear especially improper contact lens use or storage; and wearing of contact lens overnight (i.e. extended wear). Bacterial keratitis cannot be spread from person to person [31].

More so, *Staphylococcus aureus* (23.8%), *CoNS* (15.2%), S*. pneumoniae* (22.9%), E*. coli* (13.3%), P*. aeruginosa* (5.7%), *Moraxella catarrhalis* (2.9%) and *Neisseria gonorrhoeae* (2.9%) were also found to be predominant in the cases of conjunctivitis. This was also in agreement with the study done by Anteneh A, et al. [6]. Bacterial conjunctivitis is highly contagious; most bacteria that cause conjunctivitis are spread through direct hand-to-eye contact from contaminated hands or improper lens hygiene [32,33].

Staphylococcus aureus (10.5%), *Coagulase negative Staphylococcus* (31.6%), *E. coli* (26.3%) and *K. pneumoniae* (10.5%) were the predominant bacterial isolates observed in Blepharo-conjuctivitis cases. This was in agreement with the study conducted in Nigeria [3]. The reason for the high rate of *S. aureus* and *CoNS* among Blepharitis and Blepharo-conjuctivitis may be virulence factor such as exo-enzymes and a surface slime that may play a role in the pathogenesis [34].

Moraxella catarrhalis was implicated in conjunctivitis (2.9%) and Lid abscess (10.0%) in this study. This contrasted with previous study in Ethiopia which implicated it in Dacryocystitis and keratitis [6]. *Moraxella catarrhalis* being an opportunistic pulmonary invader and which causes harm especially in immune-compromised individuals have been reported to be an emerging bacterial pathogen of ocular infection [35].

The *Neisseria gonorrheae* seen in conjunctivitis cases were likely from the age group 0-15 years. Susceptibility to infection is increased in babies due to low immunity at such ages [35]. In addition to this, the air facilitates the transfer of bacteria to hospital delivery rooms especially when opening the doors and windows [36].

In this study, different bacterial species showed high level of resistance pattern to different anti-microbial agents. For example, most of the bacterial isolates have shown high resistance to tetracycline and ampicillin. This is in agreement with the studies done by Muluye D, et al. [36] and Obiazi HAK, et al. [37]. Reduced efficacy to the above-mentioned antibiotics could possibly be due to frequent usage of these drugs by patients with or without prescription as they are readily available and easy to purchase in any chemist store around.

S. aureus was 100% sensitive to vancomycin and chloramphenicol. *CoNS* were also 100% sensitive to ciprofloxacin, vancomycin and chloramphenicol. *K pneumoniae* was 100% sensitive to gentamicin and Amoxicillin-clavulanic acid while *N. gonorrhoeae* was 100% sensitive to gentamicin, ciprofloxacin, ceftriaxone, Amoxicillin-clavulanic acid and cefotaxime. This observation is consistent with those studies conducted in Libya and India [36,9]. Yet, it is contradictive to the findings obtained from a recent study in Ethiopia which reported high resistance to ciprofloxacin and ceftriaxone [1]. The high susceptibility shown by vancomycin, ciprofloxacin and chloramphenicol to all Gram-positive isolates in this study implies that such drugs can be used to treat ocular infections caused by gram positive bacteria in such environment. Furthermore, the high susceptibility shown by gentamicin, amoxicillin-clavulanic acid and ceftriaxone to Gram-negative bacteria also implies that such drugs can be used to treat ocular infections caused by gram negative bacteria in the study environment.

The prevalence of multi-antimicrobial resistant bacteria to at least one antimicrobial drug in three or more antimicrobial categories used in this study was 16.2% and his is similar to results from previous studies [39,40]. In Nigeria, antimicrobial drugs can be purchased at any pharmaceutical store without prescription, which may contribute to the emergence and spread of antimicrobial resistance [29]. Other factors may include improper dosage regimen and substandard antimicrobial drugs which is sold all over Nigeria [40].

Conclusions

The prevalence of ocular infection in this study was very high. Conjunctivitis was the dominant ocular infection followed by blepharitis and keratitis. *S. aureus* was the predominant isolated bacteria followed by *CoNS* and *S. pneumoniae*. Gram positive isolates were highly susceptible to ciprofloxacin, vancomycin and chloramphenicol while Gram negative isolates were highly susceptible to ceftriaxone, amoxicillin clavulanic acid and gentamicin. The overall MAR bacteria were relatively high. Therefore, the identification of potential pathogenic bacteria implicated in these infections through culture and biochemical tests methods as well as conducting drug susceptibility test should be practiced as a routine diagnostic procedure to prevent the increasing rate of antimicrobial resistance bacteria seen in this study.

Funding

No fund was received.

Conflict of Interest

The authors declare that they have no conflicts of interests.

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