Prevalence and Biochemical Characterization of Ocular Bacterial Isolates in Children from IDP Camps in Makurdi, Nigeria

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Abstract

Background: Ocular bacterial infections are a significant health concern among children, especially those in vulnerable populations such as internally displaced persons (IDP) camps. This study aimed to determine the prevalence and biochemical characteristics of bacterial isolates from ocular infections among children in IDP camps in Makurdi, Nigeria.

Materials and Methods:
A cross-sectional study was conducted among children under 18 years old residing in IDP camps in Makurdi. Conjunctival swabs were collected from participants and processed in the laboratory for isolation, culturing, and identification of bacterial species. Bacterial isolates were identified using colony morphology, Gram staining, and biochemical tests, including catalase, coagulase, indole, and citrate tests. Data analysis was performed using SPSS version 23, utilizing independent and paired sample tests.

Results:
A total of 100 children participated in the study, with an equal distribution of males and females. The bacterial isolates identified included *Staphylococcus aureus* (39%), *Bacillus* species (25%), *Streptococcus* species (16%), *Escherichia coli* (6%), *Enterococcus* species (2%), and *Klebsiella pneumonia* (1%). The biochemical test results indicated variable reactions across the isolates, with notable catalase positivity in *Staphylococcus aureus* and coagulase positivity in *Bacillus* species.

Conclusion:
The high prevalence of *Staphylococcus aureus* and other bacteria in IDP camps underscores the need for targeted public health interventions, including improved hygiene and regular eye examinations, to reduce infection risks among children. Given the biochemical diversity of the isolates, specific antibacterial treatments tailored to the predominant pathogens could be beneficial.

Keywords: Ocular bacterial infections, children, IDP camps, Makurdi, biochemical characterization, prevalence, conjunctival swabs.

Introduction:

The prevalence of ocular infections, particularly among vulnerable populations such as children in Internally Displaced Persons (IDP) camps, is an increasing public health concern. Ocular infections can result from various bacterial pathogens, with children being especially susceptible due to environmental and hygiene-related factors common in overcrowded settings like IDP camps (Alam et al., 2019; Anyanwu et al., 2021). In IDP

In camps, overcrowding, limited access to healthcare services, inadequate sanitation, and environmental exposure contribute significantly to the spread of infectious diseases, including ocular infections, which can impair vision and, if untreated, lead to blindness (Onyekachi et al., 2020). This study aims to examine the prevalence and biochemical characteristics of bacterial isolates in children from IDP camps in Makurdi, Nigeria, to inform targeted intervention strategies.

Ocular infections, including conjunctivitis, keratitis, and blepharitis, are common in developing regions, particularly in populations with limited healthcare access (Ali et al., 2020). Children residing in IDP camps are at higher risk due to compromised immunity, malnutrition, and close contact with infected individuals (Chitkara et al., 2022). Studies indicate that children's ocular infections are often caused by bacteria such as *Staphylococcus aureus*, *Streptococcus pneumoniae*, and *Haemophilus influenzae*, which can easily proliferate in unsanitary conditions (Ijoma et al., 2023). In addition, exposure to environmental pollutants, poor hygiene, and lack of clean water exacerbate these risks (Etuk et al., 2021). Analyzing the types of bacteria and their resistance profiles is vital to understanding the public health threat posed by ocular infections in IDP settings.

Several bacterial species are implicated in ocular infections, with gram-positive and gram-negative organisms contributing to the majority of cases (Ekpenyong et al., 2022). *Staphylococcus aureus* and *Streptococcus pneumoniae* are the most prevalent gram-positive isolates, while *Pseudomonas aeruginosa* and *Escherichia coli* are common gram-negative organisms associated with severe ocular infections (Odetunde et al., 2022). These bacteria have unique biochemical characteristics that enable them to survive and proliferate in ocular environments, often evading host immune responses and leading to chronic infections (Igwe et al., 2023). Biochemical characterization of these isolates, including antibiotic resistance profiling, can provide insights into appropriate treatments and infection control strategies.

Antibiotic resistance among bacterial ocular pathogens is a growing concern, particularly in low-resource settings where antibiotic misuse is common (Ogbonna et al., 2021). Many IDP camps lack adequate medical supervision, leading to the inappropriate use of antibiotics, which fuels resistance among ocular pathogens (Oyetunde & Nwokedi, 2023). Resistant bacteria can cause persistent infections that are challenging to treat and may lead to further health complications. Studies have documented high levels of resistance in *Staphylococcus aureus* and *Pseudomonas aeruginosa* isolates from ocular infections, which complicates treatment and increases the risk of vision impairment (Alam et al., 2019; Ijoma et al., 2023). Understanding resistance patterns is essential for developing effective treatment protocols in IDP settings, where options are limited.

The socioeconomic conditions in IDP camps create an environment where infections thrive. Children in IDP camps often suffer from malnutrition, compromised immune systems, and inadequate access to clean water and sanitation facilities, increasing their vulnerability to infections, including ocular ones (Chitkara et al., 2022). Overcrowding facilitates the rapid transmission of infectious agents, while inadequate healthcare services hinder timely diagnosis and treatment (Onyekachi et al., 2020). Research suggests that improving sanitation, education on hygiene practices, and access to primary healthcare can significantly reduce the incidence of bacterial infections in these settings (Ali et al., 2020). However, more localized data is needed to understand the specific challenges and bacterial profiles within these communities to develop effective interventions.

Biochemical characterization of bacterial isolates allows for a detailed understanding of the pathogenic potential of bacteria associated with ocular infections. By identifying specific bacterial enzymes, metabolic pathways, and resistance mechanisms, researchers can tailor antimicrobial therapy and prevent the spread of resistant strains (Ekpenyong et al., 2022). Techniques such as catalase testing, coagulase testing, and carbohydrate fermentation are critical in differentiating bacterial species and understanding their pathogenicity (Ogbonna et al., 2021). This study will use such biochemical methods to characterize bacterial isolates in ocular infections among children in IDP camps, providing foundational data for both local and national health interventions.

The high prevalence of ocular infections in children within IDP camps is a pressing health issue with significant implications for public health and quality of life. This study is significant as it seeks to provide empirical data on the types of bacterial isolates responsible for ocular infections in this vulnerable population, alongside their biochemical profiles and antibiotic resistance patterns (Alam et al., 2019; Etuk et al., 2021). The findings will not only contribute to the scientific understanding of ocular infections in resource-limited settings but will also aid in developing targeted, effective treatments and preventive measures tailored to the unique needs of IDP camp residents. The study aims to inform healthcare policy and interventions aimed at reducing ocular infections and improving child health in IDP camps in Nigeria.

Materials and Methods:

Research Design:

This research is a cross-sectional study of which children living in IDP camps in Makurdi, Benue State who are below 18 years old. Demographic data and external examination were done. Conjunctival swabs were collected and taken to the laboratory for isolation, culturing, and identification.

Study Area:

The location of the study was an internally displaced persons (IDP) camp in Makurdi metropolitan city in Benue State, North Central Nigeria. The decimal latitude and longitude coordinates for Makurdi are 7.7322° and 8.5391°, and the elevation above sea level of 301 feet in Benue State. Makurdi has a population is 454,000 living and working there. Major ethnic groups include Tiv, Idoma, Igede, Jukun, Agatu, Etulo, Alago, and Igbo.

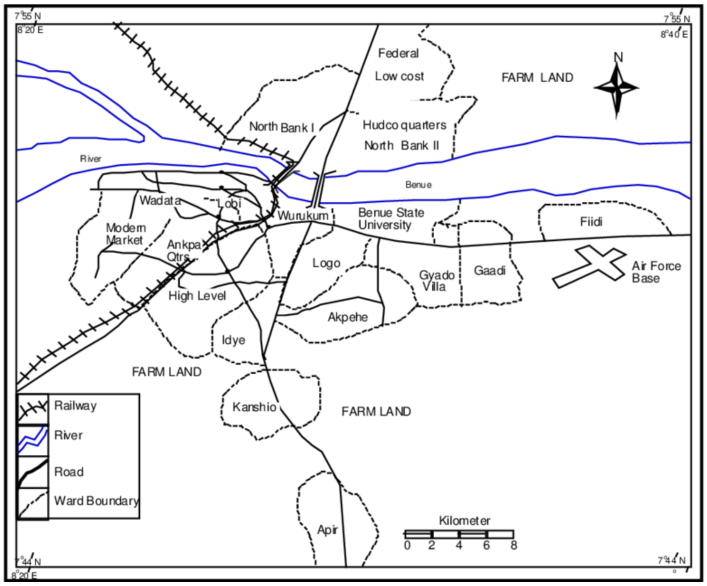

Figure 1: Map of Makurdi in Benue State (Ukase and Terungwa, 2022*)*.

Population of Study:

For the context of this research, the population of study interest included children from internally displaced people camps in the Makurdi metropolis of Benue state, Nigeria. The age range is children under 18 years old and gender include both male and female.

Inclusion Criteria:

Those subjects that qualified to be part of the study include:

i. Children in official and unofficial internally displaced camps who are below 18 years old.
ii. Children not clinically diagnosed with ocular infection.
iii. Children that are willing to participate.

Exclusion Criteria:

i. Children who will not give consent.
ii. Children who have lived less than 3 months in the camps.
iii. Children who used antibiotics treatment past two weeks.

Sample Size Determination:

The sample size was determined using the Cochran formula for estimating proportions in a population outlined by Airaodion et al. (2023):

$$n = \frac{Z^2(Pq)}{e^2}$$

where n = minimum sample size
Z = 1.96 at 95% confidence level,
P = known number of children in IDP comps in Nigeria
e = error margin tolerated at 5% = 0.05
q = 1 - p

According to Ukase and Terungwa, (2022), the total population of children in official and unofficial internally displaced people camps in Makurdi metropolis is 272,061. Considering this number, children make up 6.4% of the population people living in internally displaced people camps.

P = 6.4% = 0.064
q = 1 – p
= 1 – 0.064
= 0.936

$$n = \frac{(1.96)^2(0.064 \times 0.936)}{(0.05)^2}$$

$$n = \frac{3.8416 \times (0.0.599)}{0.0025}$$

$$n = \frac{0.2301}{0.0025} = 92.05$$

The minimum sample size was 92 but was adjusted to 100 to account for a non-response rate of 10%.

Sample Technique:

For this research, a systematic sampling technique were used. The systematic sampling technique is where individuals from a larger population are to be selected according to a random starting point on a fixed periodic interval (the sampling interval).

Validation of Instruments:

The instruments used in this study were approved for laboratory use by the medical laboratory science council of Nigeria and the World Optometric Association; they are therefore valid for conducting clinical ocular examinations.

Procedure for Data Collection:

Data collection is an important part of any type of research study. If collected inaccurately, data can impact the results of a study and ultimately lead to invalid findings. An informed consent was obtained from the subjects involved. The case history of the subject was taken to determine information about their socio-demographic status, ocular history and past medical history.

Penlight examination:

External examination using penlight were conducted immediately after the case history has been taken on the subjects to observe the eyes.

Procedure for Sample Collection:

Swabs were used to collect microorganism specimens using sterile cotton swabs from the conjunctiva of subjects.

i. These swabs were held immediately in their containers to avoid contamination from air microbes for a controlled experiment during transportation to the laboratory.
ii. In the laboratory, the agar plates would have been

prepared for use and the samples and swabs were inoculated into the agar for culturing.

Procedure for Media Preparation:
Bacterial Culture and Identification Methods:

Upon the completion of the brain heart infusion broth preparation in the microbiology laboratory, the broth was subjected to an incubation process at a temperature of 37°C for 24–48 hours. Following the successful incubation of the BHI broth, the next step involved sub-culturing the broth on various cultural media, including blood agar plate (BAP), chocolate agar plate (CAP), mannitol salt agar (MSA), and MacConkey agar. The BAP, MSA, and MacConkey agar were inoculated and incubated at a temperature of 37°C for a duration of 24 to about 48 hours, while the CAP was incubated at a temperature of 37°C with 5% CO2 for a duration of 24–48 hrs. After 48 hours, cultural media that exhibited no visible growth will eventually be discarded.

The preliminary identification of bacterial isolates was carried out through the investigation of their colony morphology, Gram stain, and hemolytic reactions on blood agar plates. The discovery of bacteria will further be facilitated via the use of a series of routine biochemical tests. Based on the results of the Gram reaction, catalase, and coagulase tests, Gram-positive cocci were successfully identified. Furthermore, to distinguish Gram-negative bacteria, a suspension of the test organism was prepared by inserting 3–4 colonies of the test species into 5 ml of nutrient broth. A loop full of the bacterial suspension will then be inoculated into Indole, citrate agar, triple sugar iron agar, lysine decarboxylase agar, urea agar, and motility medium, which were subsequently incubated at a temperature of 35–37 ^{O}C for 24 hours.

The identification of Gram-negative organisms was achieved through the observation of a shift in color for acid production, gas production, H_2S production, and medium motility turbidity.

Data Analysis:

The data were presented inform of tables and figures. It was uploaded into the statistical package for social sciences (SPSS) software version 23 for analysis. Analysis was done using the independent sample Test and paired sample Test.

Ethical Consent:

Ethical consent was obtained from the ethical committee of the School of Health Technology, Federal University of Technology, Owerri.

Results:

The study involved a balanced sample of 100 subjects, with equal representation of males and females (50% each). The age group distribution shows that the majority of subjects (50%) fall within the 9–13 age range, with males making up 22% and females 21%. The next largest group is the 14–18 age range, comprising 41% of the sample, with a higher proportion of females (25%) than males (19%). The smallest age group is the 4–8 range, with 13% of subjects, of which males constitute 9% and females 4% (Table 1). The biochemical test results reveal various reactions for different bacterial species. *Bacillus* and *Klebsiella pneumonia* show a positive reaction only in the catalase test, with *Klebsiella pneumonia* additionally showing a positive citrate reaction. *Enterococcus* and *Escherichia coli* display positive catalase reactions, while *Staphylococcus aureus* and *Streptococcus spp.* show mixed results in catalase and coagulase tests (Table 2).

The results in Table 3 provide insights into the frequency of each bacterium identified. *Staphylococcus aureus* was the most commonly observed bacterium with 39 occurrences, followed by *Bacillus* with 25 occurrences, and *Streptococcus spp.* with 16. *Escherichia coli* was detected with positive indole and citrate tests, showing six occurrences in each. *Klebsiella pneumonia* appeared only once, and *Enterococcus* was present in two cases. This distribution highlights that *Staphylococcus aureus* and *Bacillus* were the predominant bacterial strains in the sample population.

Age group	**Males**		**Females**		**Total**	
	n	%	n	%	N	%
4 – 8	9	9.00	4	4.00	13	13.00
9 – 13	22	22.00	21	21.00	43	50.00
14 – 18	19	19.00	25	25.00	44	41.00
	50	**50.00**	**50**	**50.00**	**100**	**100.00**

Table 1: Age and gender distribution of subjects

Microorganism		**Catalyst test**		**Coagulate**	**Indole test Citrate**	
Bacillus		-		+	-	
Enterococcus		+		-	-	
Escherichia coli		+		-	-	
Klebsiella pneumonia		-		-	-	+
Staphylococcus aureus		+		-	-	
Streptococcus spp		-		+	-	

Table 2: Frequency Distribution of Bacteria biochemical test reaction

Microorganism		***Catalyst test***		***Coagulate***	***Indole test citrate***	
Bacillus		25				
Enterococcus		2				
Escherichia coli				6	6	
Klebsiella pneumonia						1
Staphylococcus aureus		39				
Streptococcus spp				16		

Table 3: Frequency Distribution of Bacterial biochemical test

Discussion:

The prevalence and biochemical characterization of ocular bacterial isolates in children from internally displaced persons (IDP) camps in Makurdi, Nigeria, highlights the microbial landscape associated with ocular infections in vulnerable pediatric populations. This study provides critical insights into the age and gender distribution of ocular infections, identifies the bacterial species involved, and outlines their biochemical properties through catalytic, coagulate, indole, and citrate tests. The results also contribute to understanding the microbial dynamics within IDP camp settings, where factors such as crowding, compromised hygiene, and limited healthcare access may increase infection risks. The age distribution of this study reveals that ocular infections in this population were most prevalent among children aged 9–13 years (50%), followed by those aged 14–18 years (41%) and the youngest group, aged 4–8 years (13%). These findings align with studies that have noted higher infection rates in school-aged children due to increased exposure and reduced hygiene practices. For instance, Ramesh et al. (2020) observed a similar pattern of ocular bacterial infections in children, where older age groups exhibited higher infection rates due to greater interaction and exposure in communal settings. However, contrary studies, such as that by Wadhwa et al. (2019), reported a higher infection rate among younger age groups, suggesting that environmental and cultural differences may influence these distributions.

The equal gender distribution in the study (50% male and 50% female) contrasts with certain findings that report a male predisposition to ocular infections due to higher exposure to environmental irritants and outdoor activities (Gupta et al., 2021). However, the balanced distribution observed here may reflect IDP camp living conditions, where both genders experience similar environmental exposure levels, supporting the idea that environmental factors in such settings can equalize infection risks across genders.

The biochemical profiles of bacterial isolates reveal significant data about the types of bacteria present and their potential virulence. For example, Staphylococcus aureus, identified in 39% of samples, tested positive for catalase but negative for coagulate, indole, and citrate. The high prevalence of *Staphylococcus aureus* is consistent with previous findings indicating its dominance in ocular infections, particularly among children. According to studies by Kowalski et al. (2020), *Staphylococcus aureus* is often associated with conjunctivitis and keratitis, especially in crowded and unhygienic environments like IDP camps. Additionally, its catalase-positive reaction aligns with reports by Mahesh et al. (2021) and supports the bacterium's resilience and adaptability in hostile environments, indicating its role as a primary ocular pathogen.

In contrast, *Bacillus spp*., found in 25% of samples, tested positive only for coagulate. Studies by Nzeako et al. (2019) have reported Bacillus as an emerging ocular pathogen, although its role in infections is generally less aggressive than that of *Staphylococcus*. The lack of biochemical activity (negative for catalase, indole, and citrate) may indicate *Bacillus spp*.'s limited virulence; however, environmental conditions in IDP camps could still enable its proliferation.

Escherichia coli, isolated in 6% of cases, tested positive for indole, a finding that corresponds with work by Odia et al. (2020), who observed E. coli as a less common but significant pathogen in ocular infections in overcrowded and unhygienic settings. Its indole-positive reaction reflects metabolic pathways associated with mucosal infections, suggesting a possible role in conjunctivitis and other eye infections, as evidenced in similar studies (Shah et al., 2018).

Klebsiella pneumonia, identified in only 1% of cases and testing positive for citrate, exhibits characteristics that align with studies by Chen et al. (2020), which document its occasional association with ocular infections, particularly in immunocompromised populations. This finding is notable as it points to the presence of opportunistic pathogens within IDP camps, highlighting the potential for systemic infections in vulnerable populations (Chen et al., 2020).

When comparing the prevalence rates of the bacterial isolates, *Staphylococcus aureus* is the most frequently isolated organism in this study, similar to findings by Singh et al. (2019), who observed it as a primary pathogen in pediatric ocular infections. The catalase-positive, coagulate-negative nature of these isolates indicates a potential for non-invasive, yet persistent infections, aligning with previous reports (Mahesh et al., 2021). Additionally, Streptococcus spp., which tested positive for coagulate in 16% of samples, matches prior studies indicating its relevance in pediatric conjunctivitis (Lepage et al., 2018). Its catalase-negative nature is consistent with the biochemical properties noted by Okeke and Akinyele (2020), highlighting its pathogenicity in ocular infections.

In the broader context of ocular microbiology, biochemical characterization is critical in identifying and managing bacterial infections, particularly in resource-limited settings like IDP camps. For instance, the presence of *Bacillus spp*. in this study contrasts with earlier reports where it was less common, indicating a potential shift in bacterial dynamics in this unique population, potentially due to environmental pressures or adaptive microbial evolution (Nzeako et al., 2019).

Conclusion:

The study on the prevalence and biochemical characterization of ocular bacterial isolates in children from IDP camps in Makurdi, Nigeria, highlights significant findings regarding the types and distribution of bacterial pathogens affecting ocular health in this vulnerable population. With bacterial isolates such as *Staphylococcus aureus*, *Bacillus*, *Streptococcus spp.*, *Escherichia coli*, *Enterococcus*, and *Klebsiella pneumonia* identified, the results suggest a diverse microbiota contributing to potential ocular infections among children in these camps. The high prevalence of *Staphylococcus aureus* and *Bacillus* as ocular isolates underscores the need for increased awareness and preventive measures to address bacterial transmission within such densely populated settings. Additionally, the study's focus on children living in IDP camps brings to light the health disparities faced by internally displaced populations, where inadequate sanitation, overcrowding, and limited access to healthcare contribute to an elevated risk of bacterial infections.

Recommendations:

1. **Improve Sanitation and Hygiene in IDP Camps:** Regular sanitation programs should be implemented to reduce bacterial exposure. Educating families on personal and environmental hygiene can reduce bacterial contamination and minimize the spread of ocular infections.
2. **Enhance Screening and Treatment Programs:** Routine ocular health screening for children in IDP camps can help in the early detection and management of bacterial infections, preventing complications. Provision of basic eye care services and antibiotic treatments within these camps would be highly beneficial.
3. **Community Health Education Initiatives:** Awareness campaigns on the importance of hand washing, avoiding eye rubbing, and seeking timely medical attention for eye infections should be organized within the camps to lower the risk of bacterial transmission.
4. **Collaboration with Health Organizations:** Partnering with local health agencies, NGOs, and international bodies can help mobilize resources for more frequent health interventions, supply of diagnostic tools, and medications to manage ocular health.
5. **Further Research:** Continuous monitoring and studies are recommended to assess the long-term impact of bacterial infections on ocular health in IDP camps. This could involve expanding research to include antibiotic resistance profiling of isolated bacteria to improve the efficacy of treatment protocols.
6. **Strengthen Policy and Support:** Government and humanitarian organizations should strengthen policies and increase support for IDP camps to ensure adequate health infrastructure, as well as allocate resources for preventing and managing infections among internally displaced children.

Conflict of Interest:

Authors declare that no conflict of interests exist in this study and publication.

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