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# Bacterial, fungal pathogens, and antimicrobial resistance patterns in ocular infections: Insights from a tertiary care hospital, North Karnataka

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ABSTRACT

**Background:** Ocular infections, including conjunctivitis, keratitis, and endophthalmitis, significantly impact eye health, leading to morbidity, visual impairment, and blindness if not treated. **Aims and Objectives:** This study focuses on reviewing and analyzing the prevalence of bacterial and fungal pathogens in ocular infections and assessing their antimicrobial susceptibility patterns at Vijayanagar Institute of Medical Sciences, Ballari. **Materials and Methods:** A cross-sectional study was conducted by collecting ocular infection samples from January 01, 2022, to December 31, 2022. Samples, including corneal scrapings and conjunctival swabs, underwent initial procedures such as Gram staining and were inoculated on various agars. Antimicrobial susceptibility testing was performed using the Kirby–Bauer disk diffusion method. **Results:** Out of 404 evaluated samples, corneal scrapings were predominant, with a significant incidence of fungal and bacterial growth. *Aspergillus* spp. and *Pseudomonas* spp. were the most common fungal and bacterial isolates, respectively. Antimicrobial susceptibility testing revealed that Gram-negative bacilli showed more susceptibility to gentamycin, ceftriaxone, and ciprofloxacin, whereas Gram-positive cocci were more susceptible to tetracycline and doxycycline. **Conclusion:** The study highlights the cornea as the most common source of ocular infections, with *Aspergillus* and *Pseudomonas* spp. being the predominant fungal and bacterial pathogens, respectively. Identifying the prevalent species in this geographical area aids in early diagnosis and treatment, thereby preventing morbidity and improving patient outcomes. The antimicrobial susceptibility pattern observed suggests effective options for treatment, emphasizing the need for ongoing surveillance to adapt to resistance patterns.

**Key words:** Ocular infections; Bacterial isolates; Antibiotics

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## INTRODUCTION

Ocular infections encompass a broad spectrum of conditions that can range from minor, self-limiting irritations to severe, sight-threatening diseases. These infections can impact various structures of the eye, leading to a diverse array of symptoms and requiring different treatment approaches.[1] The global burden of visual impairment is significant, with an estimated 2.2 billion people affected worldwide.[2] Specifically, in India, the year 2022 has seen an estimated 4.95 million individuals living with blindness and an additional 70 million suffering from vision impairment, including 0.24 million blind children.[3,4] The eye's natural defense mechanisms, including the blink reflex, the bioactive components of the tear film such as lysozyme, immunoglobulin A, and immunoglobulins G, and the corneal epithelium, play crucial roles in protecting against infections.[5]

Despite these defenses, the eye remains vulnerable to infections due to factors such as its avascular lens and

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vitreous body, which provide ideal conditions for bacterial and fungal growth. External ocular infections can be caused by a variety of agents including bacteria, fungi, viruses, and parasites, with bacteria being the predominant cause worldwide. These infections can result from monomicrobial or polymicrobial invasions and are influenced by several factors, including the use of contact lenses, trauma, surgery, a dry eye state, chronic nasolacrimal duct obstruction, and previous ocular infections.[6]

The route of infection can be external or through the bloodstream, leading to localized or more widespread disease affecting the conjunctiva, cornea, inner eye, orbit, and even the brain. The eyelid and conjunctiva's normal microbial flora, which is regulated by host mechanisms, can be altered, leading to conditions such as blepharitis, conjunctivitis, hordeolum (internal and external), keratitis, dacryocystitis, microbial scleritis, canaliculitis, orbital cellulitis, endophthalmitis, and panophthalmitis.[7]

Untreated ocular infections can cause significant damage to eye structures, potentially resulting in visual impairments or blindness. Ocular permanent damage occurs due to inflammation, and scarring despite antibacterial components, which is needed for effective and prompt treatment. The management of bacterial eye infections often begins with empirical therapy using topical broad-spectrum antibiotics, a practice common among ophthalmologists and general practitioners. Antibiotic-resistance strains are mainly due to inappropriate prescription of antibiotics.[8,9]

This review aims to examine the prevalence of bacterial and fungal pathogens in ocular infections and to evaluate the antimicrobial susceptibility patterns of these infections in a tertiary care hospital setting in Ballari, highlighting the critical need for judicious antibiotic use and the development of targeted treatment strategies to combat the growing issue of antibiotic resistance.

### Aims and objectives

The main aim of this work is to review and analyse the prevalence of Bacterial and Fungal pathogen of eye and to assess the Antimicrobial Susceptibility pattern of Bacterial Ocular Infections at Vijayanagar Institute of Medical Sciences, Ballari.

## MATERIALS AND METHODS

A cross-sectional study was designed to analyze ocular infection samples collected over 1 year, from January 01, 2022, to December 31, 2022. This study aims to examine the prevalence and antimicrobial susceptibility of bacterial and fungal pathogens in ocular infections at a tertiary care hospital in Vijayanagar Institute of Medical Sciences, Ballari. Ocular specimens received from the Department of Ophthalmology, including corneal scrapings, conjunctival swabs, corneal buttons, vitreous taps, eviscerated eyes, and iris tissues, were meticulously collected under sterile conditions. These samples were then transported to the laboratory for further analysis, ensuring the integrity and contamination-free status of each specimen.

### Inclusion criteria

Patients attending the Ophthalmology Outpatient department and who were clinically suspected or diagnosed to have ocular infections.

### Exclusion criteria

Patients who had received antibiotic treatment before sample collection were excluded to prevent skewing antimicrobial susceptibility results to concentrate specifically on bacterial infections.

Upon receipt, samples underwent a series of standardized procedures:

1. Gram staining: All samples were first subjected to Gram staining to differentiate between Gram-positive and Gram-negative organisms
2. Culture media inoculation: Following staining, specimens were inoculated onto blood agar and MacConkey agar plates to promote the growth of aerobic bacteria
3. Identification and antimicrobial susceptibility testing: The colonies that developed on the agar plates were further analyzed through Gram staining and biochemical reactions for organism identification. Antimicrobial susceptibility testing was then performed using the Kirby–Bauer disk diffusion method on Mueller–Hinton agar plates. This test determined the susceptibility patterns of the bacterial isolates to various antimicrobial agents, guiding effective treatment strategies
4. Identification of fungal pathogens was done by KOH and Gram staining. Growth on sabouraud dextrose agar (SDA) was seen every day for 1st week, twice weekly from 2$^{nd}$ week till 4$^{th}$ week. If growth was noticed, further confirmation was done by slide culture and LPCB mount. If there was no growth on SDA, it was given negative after 4 weeks of incubation.

Through this comprehensive methodology, the study aimed to accurately identify the bacterial and fungal pathogens responsible for ocular infections and assess their antimicrobial resistance profiles, thereby contributing valuable information for clinical management and treatment protocols.

## RESULTS

Overall, 404 ocular samples were received over the period of 1 year from January 1st, 2022 to December 31st, 2022. Of these, growth was observed in both bacterial and fungal n=114. The overall prevalence of bacterial and fungal isolates was 28.22% and no growth was observed in 290 samples (71.78%). 71.78% of the samples did not show any growth. Our study showed that high incidence was among males (62.87%) compared to females (37.13%). The most affected age group was 60–69 years, with 162 cases (40.09%), as detailed in Table 1.

95.79% of the samples were collected from the cornea, among which 93.81% were corneal scrapings and 1.98% corneal buttons. This was followed by 10 conjunctival swabs (2.48%), 4 vitreous taps (0.99%), 2 iris tissues (0.49%), and 1 evisceration (0.25%).

Table 2 reveals that 4.95% were bacterial isolates and 23.27% fungal isolates. These data underscore the higher prevalence of fungal infections in ocular samples, particularly in corneal scrapings.

The variability in the presence of bacterial and fungal pathogens across different types of specimens highlights the importance of targeted diagnostic and treatment strategies for ocular infections. Corneal scrapings, despite being the most collected specimen, showed a low bacterial infection rate (1.32%).

**Table 1: Comprehensive overview of ocular infection prevalence by age group and specimen type**

| Category | Subgroup | Number | Percentage |
|---|---|---|---|
| Age group (years) | | | |
| | 1–19 | 1 | 0.24 |
| | 20–39 | 19 | 4.70 |
| | 40–59 | 167 | 41.33 |
| | 60–79 | 207 | 51.23 |
| | 80–99 | 10 | 2.47 |
| Specimen type | | | |
| | Corneal scrapings | 379 | 93.81 |
| | Conjunctival swab | 10 | 2.48 |
| | Corneal button | 8 | 1.98 |
| | Vitreous tap | 4 | 0.99 |
| | Iris tissue | 2 | 0.49 |
| | Evisceration | 1 | 0.25 |

Table 3 showed that predominant species was *pseudomonas* (40%) isolates, indicating its significant role in ocular infections. *Klebsiella* species also play a considerable role, making up 20% of the isolates. Other notable bacteria include coagulase-negative *Staphylococcus*, *Streptococcus* species, and *Escherichia coli*, each accounting for 10%, suggesting their presence in ocular infections albeit to a lesser extent. *Staphylococcus aureus* and *Proteus* species, each representing 5%, were the least prevalent, indicating their occasional role in such infections. *Aspergillus* spp. emerge as the most common fungal pathogens, with a prevalence of nearly 66%, highlighting their significant contribution to fungal ocular infections. *Fusarium* spp., with a 19.15% prevalence, are also a common cause but less so than *Aspergillus*. Other fungi, including *Candida* spp., *Penicillium* spp., *Rhizopus* spp., and *Curvularia* spp., demonstrate the variety of fungal pathogens involved in ocular infections, with *Candida* spp. being somewhat more prevalent among these. *Pseudomonas* species (40%) was predominantly isolated from bacterial isolates, followed by Klebsella (20%), *Staphylococcus* (10%), *Streptococcus species* (10%), *E. coli* (10%), *S. aureus* (5%) and *Proteus* species (5%).

Table 4 showed that higher rates of bacterial involvement was observed in conjunctival swabs, corneal buttons, and vitreous taps which highlights susceptibility to bacterial infections. This underscores the necessity for accurate diagnosis and targeted treatment strategies, especially for infections in these specific ocular tissues.

Table 5 revealed that gram negative isolates were susceptible to gentamycin (GEN), third-generation cephalosporins ceftriaxone (CTR), amikacin (AK), ciprofloxacin (CIP), and Gram-positive isolates were susceptible to tetracycline (TE), doxycycline (DOX), and CTR. Antibiotics used for susceptibility testing include AK, CIP, CTR, cefotaxime, GEN, TE, and DOX.

## DISCUSSION

Our study identified a predominant collection of corneal specimens from males aged between 50 and 70 years, residing in subtropical regions. This demographic prevalence correlates with findings by Suja et al., (2019) and Brown et al., (2019), where corneal ulcers were

**Table 2: Overall prevalence of specimens showing bacterial isolates**

| Type of specimen | Total number of specimens | Bacterial isolate (%) | Fungal isolate (%) | Total growth seen (%) |
|---|---|---|---|---|
| Corneal scraping | 379 | 5 (1.32) | 93 (94.9) | 98 (25.86) |
| Conjunctival swab | 10 | 6 (60.00) | 0 (0) | 6 (60.00) |
| Corneal button | 8 | 4 (50.00) | 1 (20) | 5 (62.50) |
| Vitreous tap | 4 | 3 (75.00) | 0 (0) | 3 (75.00) |
| Iris tissue | 2 | 1 (50.00) | 0 (0) | 1 (50.00) |
| Evisceration | 1 | 1 (100.00) | 0 (0) | 1 (100.00) |
| Total | 404 | 20 (4.95) | 94 (23.2) | 114 (28.22) |

mainly attributed to infections from foreign bodies such as sand, thorn, and paddy husk, common among individuals engaged in agricultural activities in tropical and subtropical areas.[1,10] The consistency between these observations emphasizes the significance of occupational hazards in the prevalence of ocular infections within these demographics.

The prevalence and diversity of bacterial and fungal isolates in clinical settings have been the subject of extensive research globally, underscoring the importance of understanding regional microbiological landscapes to enhance infection control and antimicrobial stewardship. This discussion synthesizes findings from various studies conducted in India, Ethiopia, and China, highlighting the variability in bacterial and fungal prevalence and the spectrum of bacterial and fungal isolates identified.

The present study conducted in Ballari, Karnataka, India, in 2022, revealed a distinctive pattern of ocular infections, with fungal pathogens (23.2%) being more prevalent than bacterial ones (4.95%), a finding that contrasts with several studies across various regions. For instance, studies such as Amsalu et al., (2015) in Southern Ethiopia and Bharathi et al., (2010) in South India reported a higher bacterial prevalence, with figures such as 48.8% and 58.8%, respectively, indicating a significant variation in the microbial landscape of ocular infections.[7,11] Conversely, our findings align more closely with studies such as Priya(2018) in Kerala, India, and Pei et al., (2022) in China, where fungal infections were also found to be more prevalent than bacterial ones, suggesting a possible regional influence on the type of pathogens predominant in ocular infections.[4,12] Notably, the prevalence and distribution of specific pathogens also varied, with our study identifying *Pseudomonas* and *Klebsiella* as the leading bacterial isolates, similar to the trend in bacterial isolates observed in other regions. However, the overall higher prevalence of fungal over bacterial infections in our study underscores the unique epidemiological profile of ocular infections in Ballari, contrasting with the majority of other studies where bacterial infections were more common, highlighting the importance of geographical and environmental factors in the epidemiology of ocular infections.

**Table 3: Distribution of bacterial and fungal isolates and its prevalence**

| Isolate | Prevalence | Percentage |
|---|---|---|
| Bacterial Isolates | | |
| *Pseudomonas* species | 8 | 40 |
| *Klebsiella* species | 4 | 20 |
| Coagulase-negative *Staphylococcus* | 2 | 10 |
| *Streptococcus* species | 2 | 10 |
| *Escherichia coli* | 2 | 10 |
| *Staphylococcus aureus* | 1 | 5 |
| *Proteus* species | 1 | 5 |
| Fungal isolates | | |
| *Aspergillus* species | 62 | 65.96 |
| *Fusarium* species | 18 | 19.15 |
| *Candida* species | 8 | 8.51 |
| *Penicillium* species | 3 | 3.19 |
| *Rhizopus* species | 2 | 2.13 |
| *Curvularia* species | 1 | 1.06 |

**Table 4: Distribution of bacterial isolates among the specimens received**

| Bacteria | Corneal scraping | Conjunctival swab | Corneal button | Vitreous tap | Iris tissue | Evisceration |
|---|---|---|---|---|---|---|
| *Pseudomonas* species | 5 | 0 | 0 | 1 | 1 | 1 |
| *Klebsiella* species | 0 | 1 | 3 | 0 | 0 | 0 |
| Coagulase-negative *Staphylococcus* | 0 | 2 | 0 | 0 | 0 | 0 |
| *Streptococcus* species | 0 | 2 | 0 | 0 | 0 | 0 |
| *Escherichia coli* | 0 | 0 | 1 | 1 | 0 | 0 |
| *Staphylococcus aureus* | 0 | 1 | 0 | 0 | 0 | 0 |
| *Proteus* species | 0 | 0 | 0 | 1 | 0 | 0 |

**Table 5: Distribution of antibiotic susceptibility pattern among bacterial isolates**

| Bacteria | AK | CIP | CTR | CTX | GEN | TE | DOX |
|---|---|---|---|---|---|---|---|
| *Pseudomonas* species (n=5) | 5 | 3 | 2 | 2 | 2 | 0 | 0 |
| *Klebsiella* species (n=4) | 3 | 3 | 4 | 3 | 4 | 0 | 0 |
| Coagulase-negative *Staphylococcus* (n=2) | 0 | 0 | 1 | 1 | 0 | 2 | 2 |
| *Streptococcus* species (n=2) | 0 | 0 | 1 | 1 | 1 | 2 | 2 |
| *Escherichia coli* (n=2) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Staphylococcus aureus* (n=1) | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| *Proteus* species (n=1) | 1 | 1 | 1 | 1 | 1 | 0 | 0 |

AK: Amikacin, CIP: Ciprofloxacin, CTR: Ceftriaxone, CTX: Cefotaxime, GEN: Gentamicin, TE: Tetracycline, DOX: Doxycycline

Similar studies conducted in Kerala (Priya et al, 2018), Chennai (Suja et al., 2019), Punjab (Oberoi et al., 2021), and Bangalore (Sarmah and Shenoy, 2014), reveal a wide range of bacterial isolates, including *S. aureus*, *Acinetobacter* spp., *E. coli*, streptococci and cons.[1,12-14] other studies done by Bharathi et al., (2010) in South India reported the highest prevalence of 58.8% with *Staphylococcus* spp. being the most common isolate, suggesting a significant burden of staphylococcal infections in that region.[15]

The socioeconomic status of present study was primarily low, a factor Vaughan et al. (1996) highlighted as a crucial determinant of eye diseases due to pathogenic microorganisms, influenced by personal hygiene, living standards, nutrition, and other socioeconomic factors.[16] This report underlines the broader implications of socioeconomic status on ocular health, suggested that interventions aimed at improving living conditions could substantially mitigate infection risks.

Present study showed that increased sample collections were done between April and July suggests seasonal climatic variations. Plays very important role in the incidence of ocular infections. These seasonal variations may indicate specific times of the year when individuals are more susceptible to infections, and mostly due to climatic conditions which can be very conducive to the proliferation of pathogens.

With an overall prevalence of bacterial isolates at 17.54%, our study showed that there is a variation in pathogen prevalence when compared to Hemavathi et al (2014) where *S. aureus* was more commonly reported.[14] This discrepancy might be attributed to geographical, climatic, or methodological differences, highlighting the dynamic and region-specific nature of ocular pathogen prevalence.

These results were supported by other studies studies, including Pei et al., (2022), Amsalu et al., (2015), and others illuminates the geographical and climatic influences on the prevalence and types of ocular infections and pathogens. These variations underscore the necessity of localized research to effectively understand and combat ocular infections within specific populations.[4,11]

Our analysis of antibiotic susceptibility patterns is essential for guiding empirical treatment strategies amid rising antibiotic resistance concerns. The need for antibiotic susceptibility testing, as discussed in our study and supported by Bharathi et al. (2002), is critical for ensuring effective treatment and mitigating the risk of drug resistance.[15]

In summary, our study not only contributes to the body of knowledge on the prevalence and causative agents of ocular infections in subtropical regions but also stresses the importance of considering geographical, environmental, and socioeconomic factors in the epidemiology and management of these infections. The findings advocate for the necessity of ongoing surveillance, region-specific preventive measures, and empirically guided therapeutic strategies to enhance patient care and quality of life in affected populations.

## CONCLUSION

In this present study, predominant specimens were obtained from Cornea. Fungal pathogens show highest prevalence than bacterial pathogens. The most common Fungal isolates were Aspergillus followed by Fusarium sps, candida sps. The most common Bacterial isolates were Pseudomonas sps followed by Klebsiella sps, E. coli. Identifying the prevalent species in a particular geographical area aids in early diagnosis and treatment, thereby preventing the morbidity and improves the patient's outcome.

## ETHICAL CLEARANCE

Ethical clearance was obtained from the Institution Ethics Committee. (Ethical approval letter dated January 07, 2023).

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**Authors' Contributions:**
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