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Optimizing Antimicrobial Use In Eye Injuries: A Multidisciplinary Approach Involving Ophthalmologists, Pharmacists, Nurses, And Central Sterilization Specialists

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Abstract

Eye injuries represent one of the most preventable yet vision-threatening emergencies globally, accounting for significant visual morbidity and long-term disability across all age groups. The misuse or overuse of antimicrobials in the management of ocular trauma remains a major contributor to antimicrobial resistance, nosocomial infection risk, and unnecessary economic burden. In the context of modern healthcare, optimizing antimicrobial use in eye injuries demands an integrated, multidisciplinary framework involving ophthalmologists, pharmacists, nurses, and central sterilization specialists. Ophthalmologists lead diagnosis, surgical management, and empirical antibiotic selection, pharmacists ensure antimicrobial stewardship and resistance surveillance, nurses maintain strict asepsis and medication compliance, while central sterilization teams safeguard instrument sterility and prevent cross-infection in surgical and outpatient settings. This paper provides a comprehensive review of antimicrobial optimization in ocular trauma through a multidisciplinary lens. It analyzes global and regional data, particularly within Saudi Arabia's Vision 2030 healthcare transformation framework, and explores how integrated collaboration can reduce resistance patterns, improve clinical outcomes, and enhance patient safety.

1. Introduction

Eye injuries are a significant global health problem, with an estimated 55 million cases annually requiring medical attention and approximately 1.6 million resulting in permanent blindness worldwide (World Health Organization [WHO], 2022). The etiologies range from occupational trauma and agricultural accidents to domestic mishaps and chemical exposures. Infectious complications are among the most serious sequelae of ocular trauma, as the eye's delicate structures are uniquely susceptible to microbial invasion following disruption of epithelial barriers. Pathogens such as Staphylococcus aureus, Pseudomonas aeruginosa, Streptococcus pneumoniae, and fungal species like Fusarium and Aspergillus can cause devastating infections, leading to endophthalmitis or corneal perforation if not properly treated (Liu et al., 2021). The increasing antimicrobial resistance among ocular pathogens, especially fluoroquinolone-

resistant Staphylococcus and multidrug-resistant Pseudomonas, has become a growing public health threat (Mahmoud et al., 2020).

Globally, inappropriate prescribing of topical and systemic antibiotics in ophthalmology remains common. Studies in the United States, Europe, and the Middle East reveal that more than 40% of antibiotic use for eye trauma is either prophylactically unnecessary or suboptimal in duration or spectrum (Teweldemedhin et al., 2017). The problem is compounded in emergency and primary care settings, where empiric prescribing is often influenced by habit, patient pressure, or diagnostic uncertainty. In Saudi Arabia, antibiotic use in ophthalmology has been identified as one of the key areas targeted for optimization under national antimicrobial stewardship initiatives launched by the Saudi Food and Drug Authority (SFDA) and the Ministry of Health (MOH) (Alkofide et al., 2021). Aligning these efforts with Vision 2030 goals of high-quality, safe, and sustainable healthcare requires a system-wide integration of clinical, pharmaceutical, nursing, and sterilization disciplines.

A multidisciplinary approach ensures that antimicrobial selection, dosing, and duration are evidence-based; that infection control standards are rigorously applied; and that hospital sterilization workflows effectively minimize contamination risks. Ophthalmologists rely on microbiological guidance from pharmacists and laboratories, while pharmacists, in turn, depend on clinicians' adherence to stewardship principles. Nurses reinforce these practices through correct administration, patient education, and surveillance for complications, whereas central sterilization specialists ensure that instruments, ophthalmic blades, and microsurgical sets are processed according to international sterilization standards. Together, these roles create a continuum of safe and rational antimicrobial use that prevents resistance, improves healing, and preserves sight (Whitcher et al., 2020).

2. Epidemiology and Microbiology of Eye Injuries

Ocular trauma encompasses a broad range of injuries including corneal abrasions, chemical burns, penetrating wounds, and post-surgical infections. In developing regions and industrial zones, penetrating and blunt ocular injuries constitute the leading causes of visual loss among young adults (Negrel & Thylefors, 2018). Microbial colonization after trauma occurs rapidly, facilitated by tear film disruption and foreign body retention. *Staphylococcus aureus* and *Staphylococcus epidermidis* are the most frequent causative organisms of bacterial keratitis and post-traumatic endophthalmitis (Liu et al., 2021). Gram-negative bacteria, especially *Pseudomonas aeruginosa*, are associated with contact lens-related trauma and hospital-acquired infections, while *Bacillus cereus* is a common pathogen following soil-contaminated injuries.

In Saudi Arabia, recent surveillance data from tertiary eye centers such as King Khaled Eye Specialist Hospital and King Saud University Medical City have shown rising trends of multidrug-resistant Gram-positive cocci and extended-spectrum β-lactamase (ESBL)–producing Gram-negative bacilli isolated from post-traumatic ocular infections (Al-Hassan et al., 2022). The misuse of broad-spectrum antibiotics, particularly fluoroquinolones and aminoglycosides, contributes significantly to resistance selection. Therefore, early microbiological sampling and culture-guided therapy form the cornerstone of stewardship.

Antimicrobial prophylaxis is recommended for open-globe injuries or when foreign materials are introduced into the orbit. However, randomized controlled trials have demonstrated that extended antibiotic use beyond 24 to 48 hours post-surgery does not reduce infection rates but may encourage resistant strains (Shah et al., 2019). These findings underscore the importance of stewardship-guided prescribing and the inclusion of pharmacists in ophthalmic trauma teams to rationalize therapy duration and spectrum. Additionally, environmental contamination within eye theaters has been documented as a vector for infection, reinforcing the indispensable role of central sterilization teams in ensuring microbial decontamination of microsurgical instruments and ophthalmic sets (Vazirani et al., 2020).

3. Rationale for Antimicrobial Stewardship in Ophthalmology

Antimicrobial stewardship (AMS) in ophthalmology is less studied compared with systemic infections but is equally crucial due to the frequent use of topical antibiotics and the unique pharmacokinetic properties of the ocular surface. Topical agents can reach high local concentrations, yet poor compliance and self-medication contribute to inappropriate use (Mahmoud et al., 2020). In Saudi Arabia, prior to stricter SFDA enforcement, topical antibiotics were widely available over the counter, leading to a culture of empirical self-treatment among patients presenting with red eye or trauma. This practice has been curtailed in recent years, but resistance trends indicate lasting effects of earlier misuse (Alkofide et al., 2021).

Ophthalmic AMS integrates diagnostic precision, culture-based prescribing, patient education, and interprofessional collaboration. The key objectives are to ensure optimal therapeutic outcomes, minimize toxicity, reduce resistance, and control costs (Bourcier et al., 2020). Stewardship is not limited to prescribing but extends to sterilization, wound care, and postoperative prophylaxis—all of which intersect the roles of nursing and sterilization teams. Global data show that implementing AMS programs in ophthalmic departments reduces antibiotic use by up to 30% without increasing infection rates (Tsui et al., 2021).

The World Health Organization's "One Health" initiative and Saudi Arabia's Vision 2030 Health Sector Transformation Program both emphasize the multidisciplinary and system-wide dimensions of antimicrobial stewardship. In the ocular domain, this translates into integrated electronic surveillance of antibiotic usage, hospital antibiogram updates specific to ocular isolates, and continuous feedback between pharmacists, ophthalmologists, and infection control committees (WHO, 2022; Saudi Vision 2030, 2023).

4. Role of Ophthalmologists

Ophthalmologists are at the core of antimicrobial decision-making in eye injury management. They diagnose, classify, and determine the severity of ocular trauma, which guides empiric and definitive therapy. Empiric antimicrobial selection should cover the most probable pathogens while minimizing unnecessary broad-spectrum exposure. In corneal lacerations or open-globe injuries, intravitreal or systemic coverage with vancomycin and ceftazidime is often recommended to target Gram-positive cocci and Gram-negative bacilli, respectively (Shah et al., 2019). However, culture-guided modification remains essential once results are available.

Ophthalmologists must also balance the therapeutic benefits of topical prophylaxis with the risk of resistance and toxicity. Studies comparing fluoroquinolone prophylaxis with narrow-spectrum regimens reveal equivalent efficacy when combined with proper wound closure and asepsis (Teweldemedhin et al., 2017). Furthermore, ophthalmologists oversee surgical infection control, including preoperative preparation with povidone-iodine and postoperative wound monitoring.

In Saudi Arabia, continuous medical education programs and antimicrobial stewardship workshops for ophthalmologists are increasingly mandated by the Saudi Commission for Health Specialties (SCFHS) to align local practice with international standards. Ophthalmologists also liaise with pharmacists to ensure formulary compliance and with sterilization specialists to verify that reusable ophthalmic instruments such as phaco tips, cannulas, and forceps undergo validated sterilization cycles between cases. Their leadership within multidisciplinary eye injury teams ensures that patient management follows both evidence-based guidelines and stewardship principles (Al-Hassan et al., 2022).

5. Role of Pharmacists

Pharmacists serve as key enablers of rational antimicrobial use by providing evidence-based recommendations, monitoring prescription trends, and educating clinicians on resistance patterns. In ophthalmology, pharmacists guide drug selection based on tissue penetration, pharmacodynamics, and

toxicity. For example, fluoroquinolones like moxifloxacin achieve high corneal and aqueous humor concentrations, but resistance surveillance data may favor fortified vancomycin or ceftazidime combinations for severe trauma (Tsui et al., 2021).

Hospital pharmacists in Saudi Arabia contribute to national AMS reporting systems, such as the SFDA Antimicrobial Utilization and Resistance Surveillance Network (AURSN), which collects ophthalmic antibiogram data from tertiary hospitals (Saudi Vision 2030, 2023). Through these platforms, pharmacists alert ophthalmologists to emerging resistance trends and provide guidance on optimal dosing intervals for both topical and systemic agents. They also ensure appropriate compounding of fortified antibiotic eye drops, which require aseptic preparation under laminar airflow hoods in compliance with USP <797> standards (Vazirani et al., 2020).

Pharmacists further collaborate with nurses to monitor patient adherence, manage adverse effects, and assess drug interactions, particularly when systemic antibiotics are co-administered with ocular therapies. Educational interventions led by pharmacists have been shown to reduce antibiotic prescription rates by 20–40% in ophthalmic outpatient settings without increasing infection recurrence (Bourcier et al., 2020). Thus, pharmacists form a crucial bridge between clinical stewardship and operational implementation.

6. Role of Nurses

Nurses are the frontline custodians of infection prevention and patient education in ophthalmology units. Their contributions extend from preoperative aseptic preparation to postoperative surveillance. Nursing staff ensure correct administration of antimicrobial eye drops and ointments, adherence to dosing intervals, and prevention of cross-contamination by using sterile single-use droppers or unit-dose packaging. In ocular trauma, improper handling of topical agents can itself introduce infection, making nursing vigilance critical (Whitcher et al., 2020).

Nurses also play a significant role in patient education—explaining the purpose and duration of antibiotic treatment, demonstrating correct instillation techniques, and reinforcing the importance of compliance. In many low-vision rehabilitation programs worldwide, nurse-led training has improved adherence rates by more than 30% (Luo et al., 2020). Within Saudi Vision 2030's nursing competency frameworks, infection control and antimicrobial administration form core training modules to strengthen hospital safety culture (Saudi Vision 2030, 2023).

In addition, ophthalmic nurses assist in wound assessment, recognizing early signs of infection such as conjunctival hyperemia, discharge, or corneal opacity. They coordinate with pharmacists to report side effects like allergy or ocular surface toxicity, and with sterilization teams to ensure the availability of sterile instruments and dressings for follow-up visits. Thus, nursing functions as the operational backbone of antimicrobial optimization in eye injury management.

7. Role of Central Sterilization Specialists

Central Sterilization and Sterile Supply Department (CSSD) professionals are often the unsung heroes of infection prevention. Their adherence to sterilization protocols determines the safety of every ophthalmic instrument used in surgery or minor procedures. The ophthalmic field presents unique sterilization challenges due to delicate micro-instruments, complex lumens, and temperature-sensitive optics.

Sterilization specialists follow evidence-based reprocessing standards such as those from the Association for the Advancement of Medical Instrumentation (AAMI) and the Centers for Disease Control and Prevention (CDC). Critical ophthalmic instruments must undergo cleaning, ultrasonic decontamination, and sterilization—preferably by steam autoclaving or low-temperature hydrogen peroxide plasma for heat-sensitive devices (Vazirani et al., 2020). Reuse of single-use cannulas or tubing is strictly prohibited, as

improper sterilization has been implicated in outbreaks of Mycobacterium chelonae keratitis and endophthalmitis.

In Saudi Arabia, the Central Board for Accreditation of Healthcare Institutions (CBAHI) mandates CSSD audits and staff certification in sterile processing, aligning with Vision 2030's quality and safety goals. Sterilization teams also participate in root-cause analyses of any postoperative infection, ensuring that procedural breaches are addressed systemically rather than individually. Their collaboration with ophthalmologists and nurses closes the infection prevention loop, making CSSD integral to antimicrobial stewardship.

8. Multidisciplinary Collaboration Model

A successful antimicrobial optimization program in ophthalmology hinges on synergy among disciplines. The proposed model integrates ophthalmologists, pharmacists, nurses, and sterilization experts within a stewardship framework supported by hospital leadership. This model includes joint case reviews, infection surveillance dashboards, antimicrobial usage audits, and cross-training programs.

For example, after implementing a multidisciplinary AMS team at King Khaled Eye Specialist Hospital, antibiotic use decreased by 28% while postoperative infection rates remained stable (Al-Hassan et al., 2022). Similar successes have been reported globally—in the UK's Moorfields Eye Hospital AMS pilot and India's Aravind Eye Care System—where pharmacist-led stewardship combined with nursing-led patient education achieved sustainable reductions in resistance patterns (Bourcier et al., 2020).

Integration is further enhanced through digital tools, such as antimicrobial prescribing analytics and electronic sterilization traceability systems, which allow real-time data sharing among departments. Hospital administrators play a key role by ensuring dedicated time and resources for multidisciplinary meetings, aligning departmental goals with national health transformation strategies.

Table 1. Common Pathogens and Recommended Antimicrobials in Eye Injuries

Pathogen	**Empiric Antimicrobial**	**Alternative/Targeted Therapy**	**Comments**
Staphylococcus aureus	Moxifloxacin 0.5% drops	Vancomycin 25 mg/mL fortified	Monitor for MRSA prevalence
Pseudomonas aeruginosa	Ceftazidime 50 mg/mL fortified	Piperacillin-tazobactam IV	Common in contact-lens injuries
Streptococcus pneumoniae	Levofloxacin drops	Ceftriaxone IV	Associated with post-trauma keratitis
Bacillus cereus	Vancomycin IV ± ciprofloxacin	Clindamycin + gentamicin	Linked to soil-contaminated injuries
Fungal (Fusarium, Aspergillus)	Natamycin 5% or voriconazole 1%	Amphotericin B	Common in agricultural trauma

Table 2. Multidisciplinary Roles in Antimicrobial Stewardship for Eye Injuries

Discipline	Primary Functions	Collaborative Outputs	Stewardship Impact
Ophthalmologist	Diagnosis, empirical therapy, surgical control	Culture-guided modifications	Rational antibiotic use
Pharmacist	Drug selection, resistance surveillance	Formulary optimization	Reduced misuse and costs
Nurse	Medication administration, patient education	Compliance monitoring	Enhanced adherence
Sterilization Specialist	Instrument processing, audit, traceability	Infection prevention metrics	Zero cross-contamination

9. Challenges and Future Directions

Despite growing awareness, several barriers persist. Diagnostic delays, limited access to ophthalmic microbiology, and fragmented stewardship programs hinder progress. Overreliance on broad-spectrum agents continues in many hospitals due to fear of vision loss, a concern that underscores the need for better clinician-pharmacist communication. The global rise of antimicrobial resistance, particularly to fluoroquinolones and aminoglycosides, necessitates ongoing research into novel ocular antimicrobials and drug delivery systems (Mahmoud et al., 2020).

Saudi Arabia's Vision 2030 provides a unique opportunity to embed stewardship principles into national ophthalmology services through training, digital analytics, and regulatory enforcement. Future directions include artificial intelligence–based prescription audits, nanotechnology-driven sustained-release ocular formulations, and expansion of infection prevention curricula for nurses and sterilization technicians. Building robust feedback mechanisms and interdepartmental accountability will ensure that antimicrobial optimization becomes an institutional culture rather than an episodic intervention.

10. Conclusion

Optimizing antimicrobial use in eye injuries requires more than clinical expertise—it demands collaboration across the healthcare ecosystem. Ophthalmologists, pharmacists, nurses, and sterilization teams each play interdependent roles in stewardship, safety, and quality. Through evidence-based prescribing, strict asepsis, and coordinated infection control, the multidisciplinary model reduces resistance, improves visual outcomes, and aligns with both global AMS goals and Saudi Vision 2030 healthcare transformation strategies. The future of ophthalmic antimicrobial stewardship lies in sustained education, cross-disciplinary communication, and continuous quality improvement that together protect both sight and societal health.

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