Infection and Drug Resistance Dovepress

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Improving Antimicrobial Utilization and Infection Control in Ophthalmology: An Information-Assisted Transparent Supervision and Multidisciplinary Team Model

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Background: Using antimicrobials wisely is crucial for effective treatment and reducing antimicrobial resistance (AMR). As ocular infections can lead to serious consequences and ophthalmic surgery has a great impact on patients, the application of antimicrobials in ophthalmology needs to be managed in a standardized manner.

Methods: A multidisciplinary team (MDT) on antimicrobial stewardship was set up by adopting comprehensive management measures and a continuous improvement model with all-staff training and empowerment, information-assisted medical prescription control, and transparent supervision.

Results: After intervention, the antibiotics use density, antibiotics utilization rate and antibiotics prophylactic utilization rate for type I incision operation among inpatients decreased from 30.02%, 49.64% and 58.04% in 2018 to 8.78% (decrease by 70.77%), 18.31% ($p < 0.001$) and 8.93% ($p < 0.001$) in 2022, respectively; the microbiological submission rate related to antibiotics utilization, etiological submission rate before antibiotic therapy and before combined use of key antibiotics rose from 13.44%, 17.39% and 50.00% to 27.33% ($p < 0.001$), 51.3% ($p < 0.001$) and 100.00% (increase by 100%), respectively; the incidence of nosocomial infection and surgical site infection for type I incision operation both reduced to zero, while the use of hand hygiene products markedly increased. For pathogen detection, a total of 489 pathogens were isolated from 2018 to 2022, of which 69.30% were Gram-positive bacteria, 26.02% were Gram-negative bacteria, and 4.68% were fungi. Ocular secretion was the main detection site (89.31%). Antibiotic resistance analysis results indicated that *Staphylococci* maintained complete sensitivity to linezolid, vancomycin, and teicoplanin. *Streptococcus pneumoniae* maintained complete sensitivity to vancomycin, benzathine, levofloxacin, and moxifloxacin, with resistance to penicillin G and ceftriaxone down to zero.

Conclusion: Multidisciplinary team and information-assisted transparent supervision have displayed obvious effects in promoting the standardized application of antimicrobials in ophthalmology, via distinctly improving indicators relevant to antimicrobial application and nosocomial infection. Our work may provide guidance for improving the medical quality and curbing the AMR.

Keywords: antimicrobial stewardship, nosocomial infection, transparent supervision, multidisciplinary team, ophthalmology

Introduction

Rational application of antimicrobials is crucial for improving drug efficacy, reducing the adverse drug reactions, alleviating the AMR, and ensuring medical quality.[1] It is an urgent issue of social concern and a long-term task for medical institutions to strengthen the management of the clinical application of antimicrobials.[2,3]

Received: 27 August 2024
Accepted: 25 October 2024
Published: 13 November 2024

The rationality of antimicrobial application is mainly based on the appropriateness of indications for application, type, and dosing regimen. The problems such as the overuse of broad-spectrum antimicrobials and the application without indication for surgery has caused increasing AMR, rising medical costs, drug toxicity, and adverse drug reactions and attracted growing attention.[4–6] To standardize the clinical application of antimicrobials, the national health administrative departments of China have issued a series of guiding documents, such as the "Guiding Principles for Clinical Application of Antimicrobial Drugs" in 2015;[7] the "Notice on Further Strengthening the Management of Clinical Application of Antimicrobial Drugs, so as to Curb Bacterial Resistance" in 2017;[8] and the "Notice on Continuously Succeeding at Work of Management of Clinical Application of Antibacterial Drugs" in 2018.[9]

Eyes have complex and fragile structures, which are exposed to the air outwardly and connected to the cranium inwardly. Although ophthalmic surgery is smaller in scale compared with other surgical operations, it has problems such as a high rate of comorbidity occurrence, frequent use of examination instruments and poor air mobility, close contact with the surgical site, and the great number of operations, which lead to the emergence of cross-infections easily.[10] On the other hand, ophthalmic surgical site infections (SSI) are vital causes of poor incision healing and a common surgical complication.[11] Although the incidence of hospital-acquired infection (HAI) in ophthalmology is relatively low, it can lead to endophthalmitis, blindness, or even secondary intracranial infections, removal of the eyeball, and other serious consequences.[12]

Currently, the clinical management of ocular infections is primarily empiric. Improper use of antibiotics in ocular infections, combined with polypharmacy and inappropriate dosing regimens, collectively exacerbate the development of AMR.[13] To promote the standardized application of antimicrobials and curbing AMR, this study adopted multidisciplinary team and information-assisted transparent supervision strategies in ophthalmology and assessed the impacts on indicators relevant to antimicrobial application and nosocomial infection.

Material and Methods

Study Setting and Subjects

This study was conducted at Tongji Hospital, Tongji Medical College, Huazhong University of Science & Technology, a comprehensive tertiary hospital located in Wuhan, China. The department of ophthalmology has 146 beds, with nearly 10,000 patient admissions and more than 9,000 surgeries performed annually. The patients in this study were hospitalized in ophthalmology between 1 January 2018 and 31 December 2022. The study was conducted by the Declaration of Helsinki, and the study design was reviewed and approved by the Ethics Committee of Wuhan Tongji Hospital, Huazhong University of Science & Technology.

Study Design and Intervention

The study was conducted in two phases: baseline phase (from 1 January 2018 to 31 December 2018) and intervention phase (from 1 January 2019 to 31 December 2022). Continuous monitoring of indicators related to antimicrobial application and HAI was conducted throughout the study.

At the end of 2018, a MDT on antimicrobial stewardship of the hospital was established, consisting of the leaders of medical, nursing, pharmacy, microbiology, operating department, information technology, nosocomial infection management, and ophthalmology. Team members participated in monthly meetings as stipulated to jointly formulate systems and procedures, ensuring effective communications and reinforcement of the interventions.

The following intervention strategies were adopted:

All-Staff Training and Empowerment

The medical department, pharmacy department, microbiology department and nosocomial infection management department regularly conduct all-staff training on the knowledge of clinical application of antimicrobials, submission of etiological tests, standardized collection and delivery of microbiological specimens. Physicians can obtain the hierarchical prescription authority only after attending the training and passing the examination.

Formulate Antimicrobial Prescription Sets and Guidelines

The supply catalogue of antimicrobials, prescription sets, and guidelines for diagnosing and treating infectious diseases in ophthalmology were collaboratively developed by medical service office, department of pharmacy, department of microbiology, department of nosocomial infection management and department of ophthalmology, and regularly updated based on documentation requirements, local pathogen composition, and bacterial resistance surveillance data.

Information-Assisted Prescription Management

The "Antimicrobial Application Stewardship System" was developed by computer science center, medical service office, department of pharmacy, department of microbiology and department of nosocomial infection management to strengthen the informatization management of medical prescriptions. Once inappropriate antibiotic prescriptions are filtered out, warnings will be triggered and a request for antibiotic consultation will be initiated. Prescriptions can only be issued after consultation by physicians with senior technical qualifications. This system enables all-round intelligent monitoring of hierarchical management of antimicrobials, consultation decision support for infection diagnosis and treatment, and timely release of information on antimicrobial stewardship. Additionally, real-time statistics, analysis, evaluation, and feedback on relevant indicators are also facilitated.

Prescription Review

Prescription review was regularly carried out by medical service office, department of pharmacy, department of microbiology, department of nosocomial infection management and department of infectious diseases to assess whether the indications for medication, timing of administration, variety and duration were reasonable. Physicians with problems were trained and tracked for improvement, and physicians with frequent problems were restricted in the prescription authority.

Nosocomial Infection Management

Emphasis on the implementation of prevention and control measures was laid, such as aseptic operation, hand hygiene, disinfection and sterilization, shortening of preoperative hospitalization, control of basic diseases, correction of malnutrition and hypoproteinemia, control of intraoperative blood glucose levels, intraoperative thermal insulation measures, and enhancement of postoperative nursing care.

Transparent Supervision

Taking the monitoring data as the entry point, monthly meetings discussed the problems in the practice of antimicrobial stewardship, analyzed the possible causes and put forward the solving measures. After the meeting, the monitoring indicators were ranked and internally publicized, which were used as the basis for physician's medical quality and performance assessment.

Continuous Improvement

Based on the baseline data and unique features of ophthalmology, a scientifically determined improvement target was established. The progress of improvement was consistently monitored and assessed for feedback. Staff members who showed slower progression received timely, targeted guidance. By following the monitoring-feedback-intervention-tracking model, continuous improvement was ensured.

Definition of Terms

Hospital-acquired infections (HAI) are diagnosed by the Department of Nosocomial Infection Management based on the diagnostic criteria issued by the National Health Commission in 2001.

Type I incision surgical site infections are surgical site infections that occur in type I (clean) incisions, ie, where the surgery has not entered the inflammatory area, the respiratory, gastrointestinal, or genitourinary tracts, and where closed trauma surgeries meet the above conditions, including surgical site infections occurring within 30 days of surgery without implantation, and within 1 year of surgery with implantation.

Type I incision surgical site infection rate (%) = number of cases with type I incision surgical site infection/number of patients receiving type I incision surgery during the same period*100%.

Antibiotics use density (AUD) of inpatients = cumulative number of defined daily doses of antibiotics of inpatients/(number of patients discharged during the same period*average number of days of hospitalization during the same period) *100.

Antibiotics utilization rate of inpatients (%) = number of inpatients using antibiotics/number of inpatients during the same period*100%.

Antibiotics therapeutic utilization rate of inpatients (%) = number of inpatients using antibiotics therapeutically/number of inpatients during the same period *100%.

Antibiotics prophylactic utilization rate for type I incision surgery of inpatients (%) = number of cases of type I incision surgery in which antibiotics were applied prophylactically/number of type I incision surgeries performed during the same period *100%.

Microbiological submission rate related to antibiotics utilization of inpatients (%) = number of microbiological submissions related to antibiotics utilization of inpatients/number of antibiotics utilization of inpatients during the same period *100%.

Etiological submission rate before antibiotics therapy of inpatients (%) = number of inpatients with etiological submission before antibiotic therapy/number of inpatients with therapeutic application of antibiotics during the same period *100%.

Etiological submission rate before combined use of key antibiotics = the number of cases of etiological submission before use of two or more key antibiotics/the number of cases received combined use of two or more key antibiotics during the same period *100% (Note: key antibiotics refer to carbapenems, glycopeptides, tigecycline, linezolid, polymyxin, cefoperazone sodium and sulbactam sodium, antifungal).

Utilization of hand hygiene products = cumulative number of hand hygiene products used/total number of hospitalization days of patients discharged during the same period.

Microbial Identification

Bacteria were cultured and isolated according to the standard microbiological procedures, the strain identification was carried out using the VITEK2-Compact microbial identification system (bioMérieux, France), and the quality control strains were provided by the Clinical Laboratory Center of the Ministry of Health. The antibiotic sensitivity testing was performed using the Kirby-Bauer disk diffusion technique or E-test. The interpretation criteria and quality control followed the 2017 recommendations of the Clinical and Laboratory Standards Institute (CLSI).[14]

Data Collection and Analysis

Relevant data were collected via the *Xingling* Real-Time Nosocomial Infection Surveillance System and Antimicrobial Application Stewardship System. All data were analyzed using SPSS (version 26; SPSS, Inc, Chicago, IL). Categorical variables were expressed as counts and percentages. The chi-square test or Fisher exact test was used for categorical data that met the analytic assumptions. P values <0.05 were considered significant.

Results

Utilization of Antimicrobials

The annual number of cases of inpatients in ophthalmology from 2018 to 2022 was 4273, 5877, 5142, 9903, and 9973, respectively, and the annual number of type I incision surgical cases was 1039, 3524, 3427, 6196, and 6711, respectively.

The AUD of inpatients showed a decreasing trend over the years, dropping from 30.02 in 2018 to 8.78 in 2022, marking a decrease of 70.77%. Specifically, the restricted-grade AUD decreased from 18.59 in 2018 to 4.79 in 2022, showing a decrease of 74.26%, while the special-grade AUD decreased from 0.98 in 2018 to 0.62 in 2022, indicating a decrease of 36.62% (Figure 1A).

The antibiotics utilization rate among inpatients presented a consistent decrease over the years, with a drop from 49.64% in 2018 to 18.31% in 2022 ($\chi^2 = 1465.716$, $p < 0.001$). Specifically, the utilization rates for restricted-grade

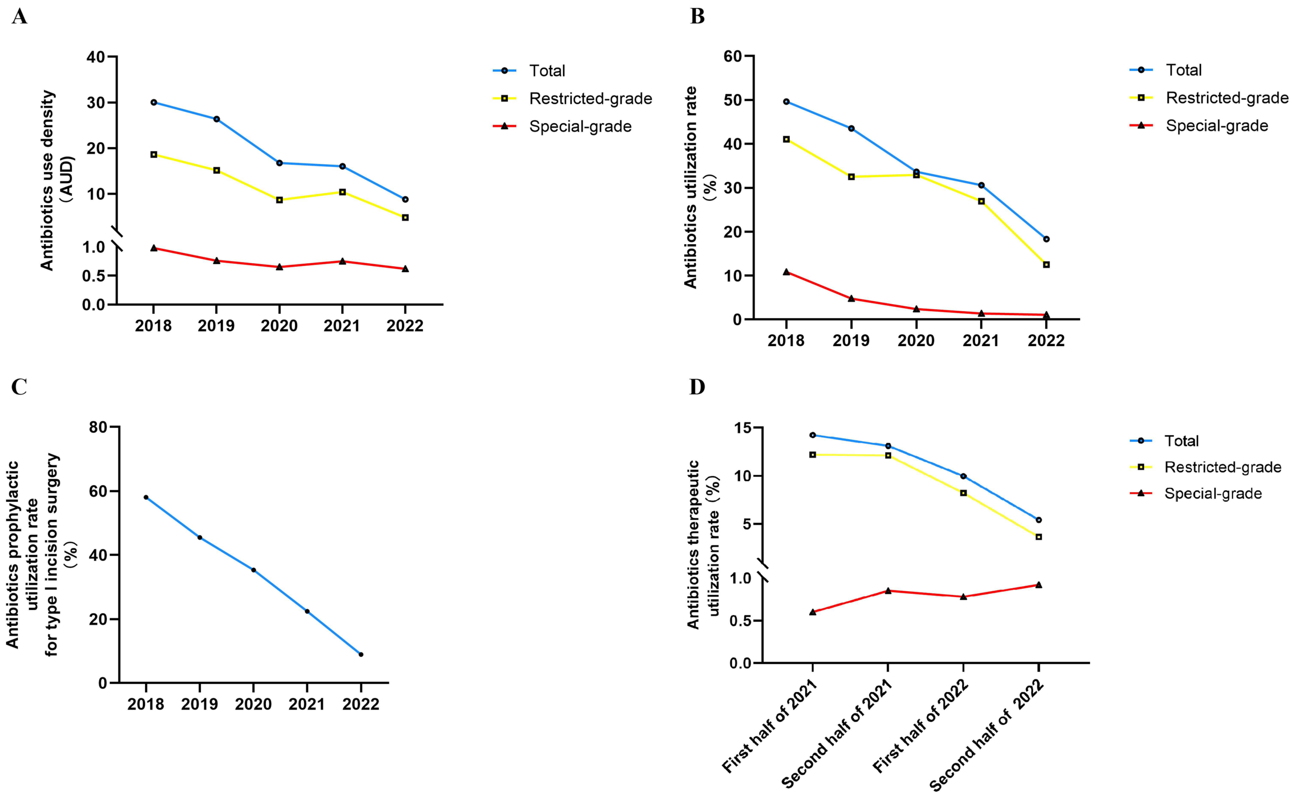

Figure 1 Indicators related to the utilization of antimicrobials. (**A**). The antibiotics use density (AUD) of inpatients from 2018 to 2022. (**B**). The antibiotics utilization rate of inpatients from 2018 to 2022. (**C**). The antibiotics prophylactic utilization rate for type I incision surgery of inpatients from 2018 to 2022. (**D**). Antibiotics therapeutic utilization rate of inpatients from 2021 to 2022.

antibiotics decreased from 41.07% in 2018 to 12.50% in 2022 (χ^2 = 1467.853, p < 0.001), while the rates for special-grade antibiotics saw a decline from 10.84% in 2018 to 1.05% in 2022 (χ^2 = 747.812, p < 0.001) (Figure 1B).

The antibiotics prophylactic utilization rate for type I incision surgery decreased yearly from 58.04% in 2018 to 8.93% in 2022 (χ^2 = 1655.952, p < 0.001) (Figure 1C).

Antibiotics therapeutic utilization rate among inpatients decreased gradually from 14.24% in the first half of 2021 to 5.42% in the second half of 2022 (χ^2 = 258.815, p < 0.001). To note, the restricted-grade antibiotics therapeutic utilization rate decreased from 12.20% in the first half of 2021 to 3.64% in the second half of 2022 (χ^2 = 362.393, p < 0.001). However, the change of special-grade antibiotics therapeutic utilization rate was not obvious (Figure 1D).

Antibiotics-Related Etiological Submission

The microbiological submission rate related to antibiotics utilization of inpatients increased from 13.44% in 2018 to 27.33% in 2022 (χ^2 = 118.939, p < 0.001). Specifically, the restricted-grade antibiotics related rate increased from 14.25% in 2018 to 33.52% in 2022 (χ^2 = 156.562, p < 0.001), while the special-grade antibiotics related rate increased from 15.77% in 2018 to 71.43% in 2022 (χ^2 = 137.633, p < 0.001) (Figure 2A).

The etiological submission rate before antibiotics therapy of inpatients increased from 17.39% in the first half of 2021 to 51.42% in the second half of 2022 (χ^2 = 103.622, p < 0.001). Specifically, the restricted-grade antibiotics related rate increased from 18.80% in the first half of 2021 to 60.24% in the second half of 2022 (χ^2 = 106.301, p < 0.001), while the special-grade antibiotics related rate increased from 61.54% in the first half of 2021 to 69.05% in the second half of 2022 (Figure 2B).

The etiological submission rate before combined use of key antibiotics increased from 50.00% in the first half of 2021 to 100.00% in the second half of 2022 (Figure 2C).

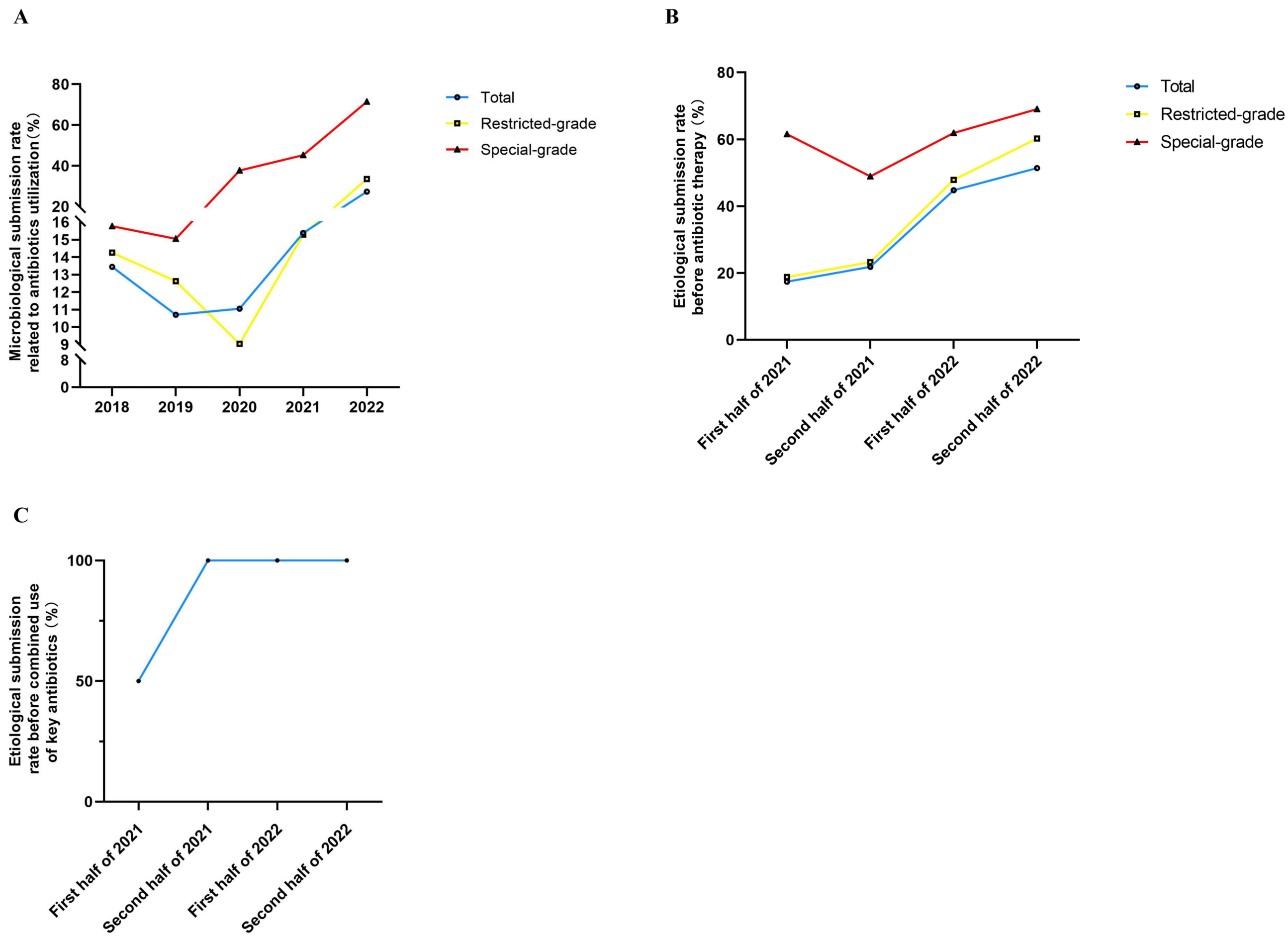

Figure 2 Indicators related to antibiotics-related etiological submission. (**A**). The microbiological submission rate related to antibiotics utilization of inpatients from 2018 to 2022. (**B**). The etiological submission rate before antibiotic therapy of inpatients from 2021 to 2022. (**C**). The etiological submission rate before combined use of key antibiotics from 2021 to 2022.

Pathogen Detection and Antibiotic Resistance

Table 1 shows the top ten pathogens detected in ophthalmology from 2018 to 2022, with Gram-positive bacteria (predominantly *Staphylococcus* and *Streptococcus*) accounting for 69.30%, Gram-negative bacteria accounting for 26.02%, and fungi (predominantly *Candida*) accounting for 4.68%. *Staphylococcus aureus* was the most common almost every year, except for 2019 when *Streptococcus pneumoniae* showed a detection peak. *Staphylococcus epidermidis* showed an increasing trend yearly. Multidrug-resistant organisms were dominated by methicillin-resistant *Staphylococcus aureus* (MRSA) (17/20, 85.00%). Ocular secretion was the main detection site (89.31%), followed by pus (5.85%) and tissue (2.42%), as shown in Table 2.

According to antibiotic resistance analysis results, *Staphylococcus aureus* maintained completely sensitive to linezolid, vancomycin and teicoplanin, with resistance to rifampicin, cotrimoxazole and fosfomycin decreasing; *Coagulase-negative staphylococci* (CoNS) remained completely sensitive to linezolid, vancomycin and teicoplanin, and highly sensitive to rifampicin, ampicillin/sulbactam, cefazolin, and cefuroxime, with resistance to cotrimoxazole declining but to levofloxacin increasing; *Streptococcus pneumoniae* maintained completely sensitive to vancomycin, benzathine, levofloxacin and moxifloxacin, with resistance to penicillin G and ceftriaxone down to 0; *Pseudomonas aeruginosa* maintained completely sensitive to piperacillin, cefoperazone/sulbactam, piperacillin/tazobactam and imipenem, and highly sensitive to meropenem, amikacin and tobramycin; *Haemophilus influenzae* maintained fully sensitive to ampicillin/sulbactam, cefotaxime, ciprofloxacin, levofloxacin and chloramphenicol, with resistance to cotrimoxazole and azithromycin increasing; *Enterobacteriaceae* remained fully sensitive to tigecycline, highly sensitive to minocycline,

Table 1 Top ten Pathogens Detected in Ophthalmology from 2018 to 2022

Isolates	2018	2019	2020	2021	2022	Total (%)
Sta. aureus	9	22	8	29	9	77 (15.75)
Str. pneumoniae	9	45	5	15	3	77 (15.75)
Staph. epidermidis	0	2	9	9	18	38 (7.77)
Ps. aeruginosa	4	8	4	8	5	29 (5.93)
H. influenzae	4	8	0	6	4	22 (4.50)
K. pneumoniae ss. *pneumoniae*	2	6	6	2	4	20 (4.09)
Es. coli	2	6	1	5	4	18 (3.68)
S. oralis	2	10	0	5	1	18 (3.68)
S. mitis	4	7	0	3	3	17 (3.48)
C. parapsilosis	2	8	4	2	0	16 (3.27)

Table 2 Pathogen Detection Sites in Ophthalmology from 2018 to 2022

	Ocular Discharge	Pus	Tissue	Sputum	Urine	Blood
2018	51	7	0	0	0	0
2019	156	5	0	1	0	0
2020	40	8	0	3	0	4
2021	113	7	5	0	1	0
2022	83	2	7	0	3	0
Total (%)	443 (89.31)	29 (5.85)	12 (2.42)	4 (0.81)	4 (0.81)	4 (0.81)

Abbreviations: AUC, area under the curve; AMR, antimicrobial resistance; MDT, multidisciplinary team; SSI, surgical site infections; HAI; hospital-acquired infection; AUD, Antibiotics use density; MRSA, methicillin-resistant *Staphylococcus aureus*; CoNS, *Coagulase-negative staphylococci.*

imipenem, meropenem and piperacillin/tazobactam, with resistance to aztreonam, cefoperazone/sulbactam, ampicillin/sulbactam and cefepime reducing. Specific data on changes in antibiotic resistance are shown in Table S1 and Table S2.

Nosocomial Infection and Hand Hygiene

The incidence of HAI decreased from 0.09% in 2018 to 0.00% in 2022 (p = 0.008) (Figure 3A), while the incidence of type I incision surgical site infections decreased from 0.10% in 2018 to 0.00% in 2022, and there were no type I incision surgical site infections for 3 consecutive years (Figure 3B). Hand sanitizer utilization increased from 7.51 mL/(day, bed) in 2018 to 12.60 mL/(day, bed) in 2022 (an increase of 67.72%), hand wash utilization increased from 4.95 mL/(day, bed) in 2018 to 5.37 mL/(day, bed) in 2022 (an increase of 8.44%), and hand towel utilization increased from 9.16 sheets/(day, bed) in 2018 to 12.13 sheets/(day, bed) in 2022 (an increase of 32.38%) (Figure 3C).

Discussion

Antimicrobial resistance (AMR) is a global public health problem of increasing severity.[15,16] Once the support of effective antimicrobials is lost, it would result in dramatically increasing rates of morbidity and mortality relevant to

https://doi.org/10.2147/IDR.S481050

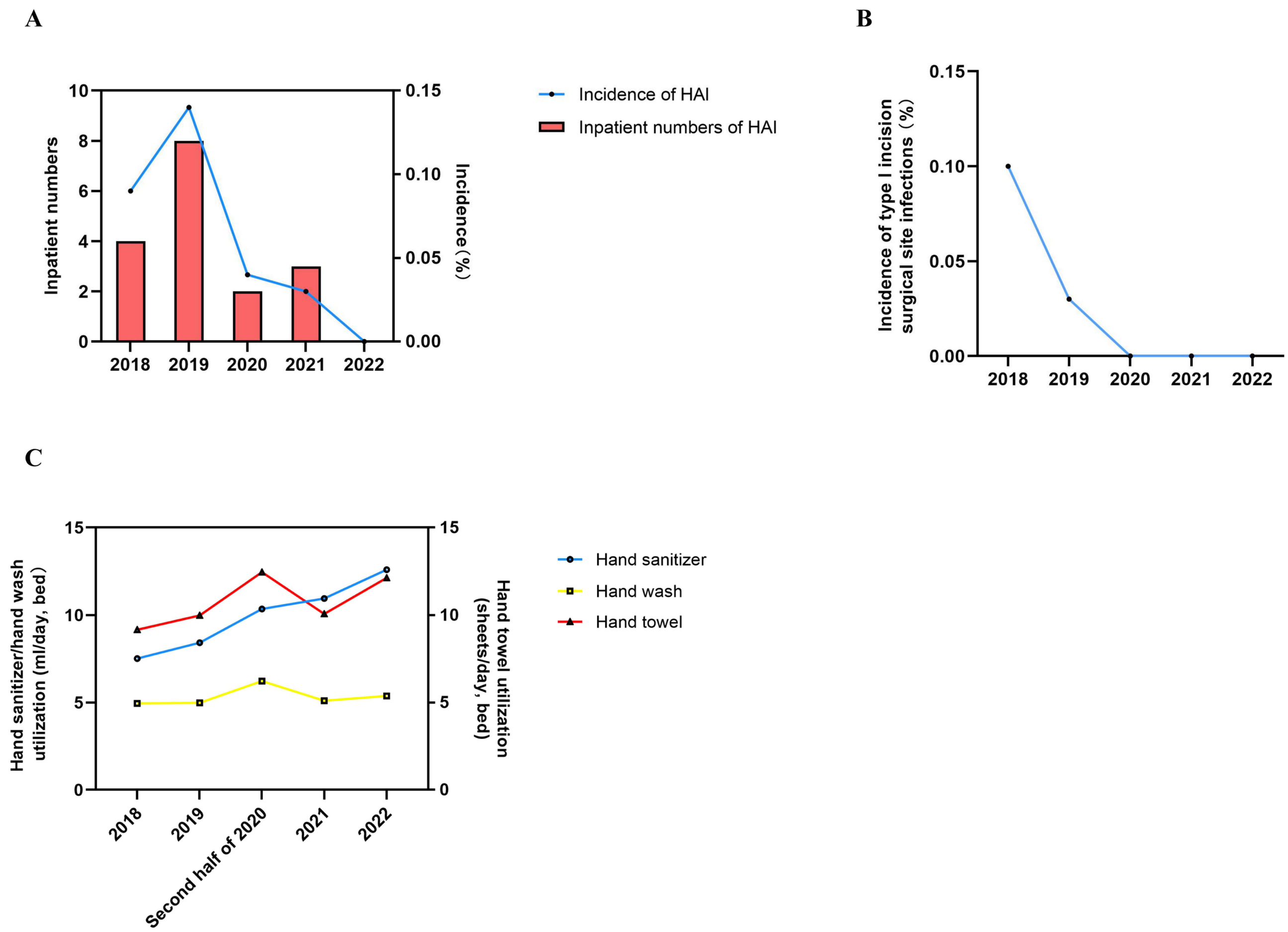

Figure 3 Indicators related to HAI and hand hygiene products. (**A**). The incidence of HAI and numbers of HAI inpatients from 2018 to 2022. (**B**). The incidence of type I incision surgical site infections from 2018 to 2022. (**C**). The utilization of hand towel, hand wash and hand sanitizer from 2018 to 2022 (due to the influence of epidemic COVID-19, the data for 2020 is only for the second half of the year).

infectious diseases, thus seriously jeopardizing human health. The AMR burden estimates indicate that 1.27 million people died in 2019 due to drug-resistant bacterial infections.[17]

Inadequate dosage, incomplete treatment, overdose, and misuse of antimicrobials can compromise their effectiveness, leading to bacterial proliferation and the activation of resistance genes.[18] Antibiotic abuse not only fuels the spread of resistance but also accounts for more than half of adverse medical reactions.[19] Unfortunately, many physicians lack sufficient awareness of the dangers of AMR and often rely on empirical drug use without consulting diagnostic test results. The low rate of specimen collection before initial antimicrobial therapy hinders the identification of the exact bacteria causing the infection, while drug-resistant strains in healthcare settings are readily detected, resulting in a low rate of positive microbiological tests and poor reliability of clinical isolates.[20] Additionally, the lengthy time required for drug sensitivity testing often leads to the empirical use of antibiotics to meet treatment needs.

On the other hand, the use of perioperative antimicrobials in surgical departments presents various problems, including prophylactic use without clear indication, inappropriate timing of prophylactic administration, prolonged postoperative use, and overuse of antibiotics. Prolonged antibiotic use can disrupt the normal flora balance and diversity in the human body, leading to alterations in colonization resistance, flora function, and inter-flora interactions. This disruption can impact immune regulation and physiological functions, increasing susceptibility to infections.[21] Standardized antimicrobial application not only ensures treatment safety and effectiveness but also helps control SSI, ultimately improving therapy outcomes and easing economic burden.[22]

Prior to this intervention, there were systemic obstacles hindering the management of antimicrobial application. The traditional methods of pharmacist prescription review presented clear limitations: manual oversight was both time-consuming and labor-intensive, sampling methods were random and biased, analysis results could be skewed, and retrospective management led to delayed outcomes.[23] Furthermore, the reliability of supervision could not be consistently ensured, and there was a lack of effective communication and coordination among relevant departments.

The informatization management system has been increasingly utilized in antimicrobial stewardship, yielding positive results.[24] Transparent supervision has been widely applied and played an increasingly critical role as a cutting-edge management innovation.[25] MDT is widely acknowledged for enhancing communication, coordination, and decision-making through multisectoral collaboration and leveraging diverse expertise.[26,27] Antimicrobial stewardship has effectively adopted these strategies to guide a gradual shift in the knowledge and attitudes of medical staff, ultimately leading to clinical behaviors that prioritize the rational use of antimicrobials. Following interventions, there has been a significant decrease in antibiotic utilization among inpatients over the past 5 years. This indicates an improved awareness of rational drug application and stricter control over the use of restricted-grade and special-grade antimicrobials among medical staff.

The National Health Commission has identified increasing the etiological submission rate before antibiotic therapy among inpatients as one of the top ten healthcare quality and safety improvement goals for 2021. The specified etiological submission items include microbiological samples, immunological and molecular rapid diagnostic tests, and biomarkers such as procalcitonin, interleukin-6, and fungal G-test.[28] To facilitate this, an automatic pop-up window has been added to prompt physicians to submit etiological specimens when prescribing antibiotics, and a requirement for mandatory etiological submission before prescribing restricted-grade/special-grade antibiotics has been put in place. While informatization interventions have been successful in promoting etiological submission, the rates of microbiological submission before antibiotic therapy have not yet fully met the national target for improvement. There is a need to enhance the timeliness and quality of submission, with a focus on utilizing more rapid diagnostic techniques. Domestic hospitals tend to collect specimens from easily contaminated areas like the respiratory tract and skin wounds, whereas foreign hospitals prefer urine and blood samples.[29] Therefore, it is important to prioritize sterile specimens like blood, choose optimal collection times, and submit them promptly to shift from empirical to evidence-based practices.

Monitoring local pathogens and drug sensitivities is of great importance for guiding antibiotic therapy. In ophthalmology, Gram-positive bacteria are identified as the primary pathogens, while Gram-negative bacteria, although less common, display a greater diversity.[30,31] *Staphylococcus aureus* has posed an increasing threat in ocular infections,[32] with hospital-acquired MRSA being linked to ocular infections, healthcare exposures, and ophthalmic surgery.[33] *Streptococcus pneumoniae*, commonly found in conjunctivitis patients, is highly pathogenic and the most prevalent streptococcus.[34] *Staphylococcus epidermidis* has emerged as a significant causative agent of nosocomial infections, contributing to septic infections and sepsis.[35] Accurate isolation, characterization of pathogens, and determination of drug sensitivity are imperative for tailored antimicrobial therapy. Bacterial pathogenesis and resistance patterns may vary according to environmental and demographic characteristics. In the absence of drug sensitivities, antibiotic resistance data from microbiologic surveillance can guide the choice of initial or empiric therapy. Physicians should timely adjust medications based on the results of drug sensitivity to inhibit the development of AMR.

Assessing the rational application of antimicrobials based solely on the decline in antibiotics utilization among inpatients is incomplete. It is essential to optimize HAI-related indicators simultaneously to ensure healthcare quality and curb AMR. HAIs not only present a serious challenge to patient health and increase medical burden but also elevate the workload of medical staff and lead to costly antibiotic applications that contribute to AMR.[36] SSI has significantly contributed to the rise in HAI.[37] Following interventions, the incidence of HAI in ophthalmology decreased, with no occurrence of type I incision surgical site infection for three consecutive years. This suggests that strengthening nosocomial infection management influences a shift away from over-reliance on antibiotics for infection prevention, ultimately leading to a reduction in HAI risk through the rational use of antibiotics.

The hands of medical personnel play a crucial role in the transmission of pathogens between healthcare settings and patients.[38] Hand hygiene compliance is closely linked to the occurrence of HAI.[39] However, the Hawthorne effect may come into play when observing hand hygiene compliance, as medical personnel might alter their behavior upon realizing they are being monitored.[40] The consumption of hand hygiene products, calculated from receipt records and hospitalization days, serves as an objective measure of hand hygiene performance. Following the intervention, there was a notable increase in the consumption of hand hygiene products in ophthalmology, indicating that improved awareness of hand hygiene practices provided strong safeguards for the prevention and control of HAI.

The limitations of this study are reckoned as follows: (1) Due to the impact of the epidemic COVID-19, data collection and statistics during the intervention phase were incomplete. Tongji Hospital became a COVID-19 designated hospital for critically ill patients in 2020. Most clinical departments, including ophthalmology, did not have regular admissions during this period, resulting in our inability to collect data of ophthalmology inpatient. Besides, a large number of hand hygiene products were donated during the epidemic, it was unable to calculate the consumption of hand hygiene products. During this period, the primary mission of the hospital was to treat patients with COVID-19, thus no alternative methods were adopted to collect data related to the study. These changes may potentially lead to an inaccurate reflection of the true intervention effect. (2) As a quality improvement study, we are unable to definitively determine the effectiveness of specific interventions. However, we believe that a distinct set of measures focusing on ophthalmology antimicrobial drug stewardship and utilization resulted in improved clinical outcomes. (3) As a single-center study carried out in a tertiary care hospital, the findings and conclusions should be cautiously interpreted. Considering real-world challenges, such as uneven distribution of medical resources, technical barriers to informatization, disparities in the professional quality of medical staff, and practical needs for higher-level regulation, this study does not apply to all medical settings. However, we will provide technical and material support to medical institutions in need of ophthalmic antimicrobial information-assisted transparent regulation and MDT model through cooperation or assistance.

Conclusion

In summary, the implementation of MDT approach continuously promoted the overall antimicrobial management intervention strategies. It facilitated collaborative training, reinforced hierarchical prescribing authorization, and improved consultative decision-making support and etiological diagnosis through real-time regulation of antimicrobial prescriptions via an informatization system. Emphasis was also placed on transparent supervision and nosocomial infection management to address the issue of over-reliance on antibiotics for infection prevention. This model effectively boosted rational antimicrobial application through targeted treatments, contributing to the mitigation of AMR.

After the intervention, antimicrobial application in ophthalmology showed sustained improvement in a rational and precise manner, alongside optimization of nosocomial infection control. In order to maintain the synergy of the current information-assisted transparent supervision and MDT model in the future, we will continue to conduct regular all-staff training, optimize the supervision system, dynamically adjust the MDT staffing and monitor the trend of the existing indicators in ophthalmology, based on the latest national policies and documents for clinical application of antimicrobials. We believe that all these findings and measures will offer valuable insights for enhancing medical quality and combating AMR.

Data Sharing Statement

All data collected and analyzed in this study are included in this article. Further inquiries can be directed to the corresponding author if needed.

Ethics Statement

The study was conducted by the Declaration of Helsinki, and the study design was reviewed and approved by the Ethics Committee of Wuhan Tongji Hospital, Huazhong University of Science & Technology. The waiver of informed consent has also been obtained from the Ethics Committee of Wuhan Tongji Hospital, Huazhong University of Science & Technology. We waived access to patients' original medical records because this study did not directly obtain basic information about the participants but rather collected and analyzed indirect statistical data that had been processed and extracted by the information-assisted system. We assure the privacy and confidentiality or anonymity of the participants at any stage of this study. The anonymous indirect data of participants will be collected, analyzed, and presented in this study.

Acknowledgments

We would like to thank Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology, for approving and supporting us in conducting this big-scale study, and gratefully acknowledge all the medical staff who participated in this project. We would also like to express our sincere appreciation to Prof. Hong Zhang for suggesting corrections and language assistance to the content of this manuscript.

Funding

This work was supported by the National Natural Science Foundation of China (grant number 82204871) and Scientific Research Fund of Tongji hospital (grant number 2024B01).

Disclosure

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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