Infection and Drug Resistance

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ORIGINAL RESEARCH

Impact of Multidisciplinary Collaboration on Microbiological Specimen Submission and Appropriate Use of Carbapenems: A Pre-Post Cohort Study

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Purpose: This study assessed the impact of multidisciplinary collaborative management on microbiological specimen submission rates and the rational use of carbapenem antibiotics.

Patients and Methods: A pre- and post-intervention cohort design was employed. From February to November 2024, a multidisciplinary antimicrobial stewardship intervention was implemented for hospitalized patients receiving carbapenem antibiotics. Patients treated in January 2024 served as the control group, and those in November 2024 formed the intervention group.

Results: Following the intervention, the pathogen testing rate among patients receiving carbapenem treatment increased significantly from 64.76% to 74.27% ($p = 0.042$), with the most notable improvement in the surgical ward (36.84% to 66.07%, $p < 0.001$). The blood culture qualification rate increased from 34.29% to 60.47% ($p = 0.009$), and the blood culture submission rate also increased from 2.86% to 16.02%, ($p < 0.001$). Additionally, there were improvements in the targeted therapy, rational antibiotics use, and treatment adjustments based on sensitivity results. However, no significant change was observed in the detection rate of hospital-acquired carbapenem-resistant pathogens (0.46% vs 0.35%, $p = 0.341$).

Conclusion: A multidisciplinary, information-based intervention significantly improved pathogen testing and promoted more rational carbapenem use, highlighting the value of collaborative antimicrobial stewardship.

Keywords: carbapenem, antimicrobial stewardship, pathogen testing, multidisciplinary team, intervention

Introduction

Antimicrobial resistance poses a growing threat to global public health. According to the World Health Organization, over 1.27 million deaths annually are attributed to infections caused by resistant bacteria, and this number could surpass 10 million by 2050 without effective intervention.[1] Central to rational antibiotic use is accurate diagnosis, with microbiological testing playing a critical role in guiding targeted therapy and reducing empirical broad-spectrum antibiotic use. However, several studies report low rates of microbiological testing before antibiotic treatment, especially among patients with severe infections. Moreover, failure to adjust treatment plans based on microbiological results remains common, contributing to the spread of resistant organisms and the misuse of antibiotics.[2,3]

Received: 12 May 2025
Accepted: 18 August 2025
Published: 25 August 2025

In China, the National Action Plan to Combat Bacterial Resistance (2016–2020) highlighted the need to strengthen pathogen diagnostic capacity. However, challenges in implementation persist. A cross-sectional survey of tertiary hospitals showed that the microbiological submission rate before carbapenem use was only 63.04%.[4] Contributing factors include limited clinician awareness, cumbersome microbiological testing processes, and lengthy turnaround times for results. Furthermore, test submission rates have been managed through administrative measures in China. This singular management model often lacks long-term effectiveness, is difficult to sustain, and can increase healthcare costs due to frequent audits and excessive interventions, thereby raising the economic burden on patients.[5]

The multidisciplinary team (MDT) approach has demonstrated the potential to improve microbiological testing rates and promote rational antibiotic use. However, MDTs in China are typically employed in the context of individualized patient care. There remains a pressing need to explore how institution-wide, multidisciplinary collaborative management can improve infectious disease diagnostics. By emphasizing the integrative capacity of MDT's, healthcare institutions can streamline diagnostic workflows and establish a sustainable mechanism for antimicrobial stewardship.

Materials and Methods

Study Design and Participants

This pre- and post-intervention controlled study included inpatients treated with carbapenems in January 2024 (before the intervention) and November 2024 (after the intervention) at a tertiary teaching hospital in Beijing. Hospitalized patients who received carbapenems (meropenem, imipenem-cilastatin, and ertapenem) were included in this study. Patients admitted to specialized wards, such as neonatology and emergency rescue units, were excluded to ensure participant homogeneity and minimize confounding factors related to the unique characteristics of these wards. The study protocol was approved by the Beijing hospital's Ethics Committee on December 16, 2023 (Approval No. 2023BJYYEC-445-01).

Intervention Measures

From February 2024 to October 2024, a series of hospital-wide, multidisciplinary interventions were implemented, as detailed below:

Establishment of a Multidisciplinary Management Mechanism: A dedicated management team was formed, led by the Infection Control Department and consisting of representatives from the Medical Affairs Department, Pharmacy Department, Microbiology Laboratory, Infectious Disease Department, Information Center, and Nursing Department. The team meets monthly to review data on microbiological specimen submission rates, blood culture specimen qualification and contamination rates, and the incidence of resistant pathogens. Intervention strategies are dynamically adjusted based on these analyses, including targeted training and guidance for departments with low submission rates or poor specimen quality.

Optimization of Management Processes and Quality Control Indicators: Improving blood culture specimen quality was identified as a priority. Process quality control indicators—such as the blood culture qualification rate and contamination rate—were established to ensure specimen integrity and diagnostic accuracy.

Revision of Guidelines for Pathogen Submission and Antimicrobial Use: The hospital's Guidelines for the Collection of Bacterial Pathogen Testing Specimens (3rd Edition) were revised. Additionally, evidence-based antimicrobial use recommendations for common surgical infections were developed and disseminated.

Tiered Training and Behavioral Standardization: A structured training program was implemented. Physicians received education on rational antibiotic prescription, including adherence to clinical guidelines and prescription protocols. Moreover, nurses were trained in the proper collection of microbiological specimens. MDT case discussions reinforced physicians' awareness of the importance of adjusting treatments based on pathogen test results, thereby fostering appropriate prescribing habits.

Information System Optimization: Clinical decision support tools—such as smart reminders and real-time monitoring functions—were embedded within the Hospital Information System (HIS). When physicians prescribe carbapenem antibiotics, the system automatically checks for specimen submission status. If no test has been submitted, a pop-up

reminder prompts the prescribing physician. During pharmacy review, the system flags untested carbapenem orders and requires justification for exceptions.

Data Collection

Patient data was collected from multiple sources, including the hospital infection surveillance system, electronic medical records, clinical microbiology testing system, and hospital information management system. The collected information included the patient's inpatient department, infection diagnosis, details of antibiotic use, microbiological testing data (such as microbial culture, smear, molecular biology assays, procalcitonin, and interleukin-6), and microbial culture results.

The hospital infection surveillance system was used to determine the pre- and post-intervention microbiological testing rates before carbapenem therapy, as well as the incidence of hospital-acquired infections caused by carbapenem-resistant pathogens in patients receiving carbapenems. Microbiological testing rates is the proportion of collecting specimens from patients for etiololgical teats (such as microbial culture, smear, molecular biology assays, and procalcitonin) before starting the use of carbapenem antibiotics, regardless of whether there is a positive result or not. Blood culture specimen qualification and contamination rates were calculated by laboratory technicians in accordance with the operational standards of the clinical microbiology laboratory. Qualified specimen rate refers to the proportion of two sets of blood cultures collected simultaneously from two different sites among all the blood culture specimens submitted each time. One set of blood culture means the blood specimens collected from the same puncture site are injected into aerobic and anaerobic culture bottles respectively. Contamination rate is he proportion of contaminated blood culture specimens to the total number of blood culture specimens in the same period. The doctors in the clinical laboratory determine whether a specimen is contaminated according to the operating procedures of blood culture for clinical microbiology laboratory.

Infectious disease physicians and clinical pharmacists independently assessed the rationality of carbapenem use, treatment intent, and whether antibiotic regimens were adjusted based on drug sensitivity results, using the Evaluation Criteria for the Clinical Application of Carbapenem Antibiotics[6] through case reviews. The rational use of carbapenems includes compliance with indications, appropriate dosage/duration, and adjustment based on antimicrobial susceptibility results. In cases of inconsistent judgments, discussions were held and the patients' attending physicians were consulted to reach a consensus.

Statistical Analysis

Data analysis was performed using SPSSAU software. Categorical data were expressed as percentages (%), and inter group comparisons were conducted using the χ^2-test or Fisher's exact test, as appropriate. A p-value of less than 0.05 was considered statistically significant.

Results

Pre-Treatment Pathogen Testing Rate for Antibacterial Agents

The implementation of comprehensive, multidisciplinary intervention measures significantly improved the pre-treatment pathogen testing rate for antibacterial agents hospital-wide through multidisciplinary collaboration. Before the intervention, 210 patients received carbapenems, with a pre-treatment pathogen detection rate of 64.76%. After the intervention, 206 patients were administered carbapenems, and the detection rate increased significantly to 74.27% ($\chi2 = 4.204$, $p = 0.042$). Among all departments, the surgical wards showed the greatest improvement, with the detection rate rising from 36.84% to 66.07% ($\chi2 = 17.616$, $p < 0.001$) (Table 1).

Quality of the Blood Culture Specimen

After the intervention, the blood culture test rate increased significantly from 2.86% to 16.02% ($\chi^2 = 21.205$, $p < 0.000$). Additionally, the qualification rate of blood culture specimens improved significantly, rising from 35.29% to 60.47% ($\chi^2 = 7.061$, $p < 0.009$). However, no statistically significant change was observed in the contamination rate of blood culture specimens (Table 2).

Table 1 Pre- and Post-Intervention Pathogen Test Rate Before Antibiotic Treatment in Different Wards

Ward	Pre-Intervention			Post-Intervention			χ^2	*p*-value
	Number of Patients Receiving Medications (n)	Number of Patients with Testing (n)	Pathogen Test Rate (%)	Number of Patients Receiving Medications (n)	Number of Patients with Testing (n)	Pathogen Test Rate (%)		
Surgical ward	95	35	36.84	112	74	66.07	17.616	0.000*
Medical ward	39	35	89.74	30	21	70.00	3.437	0.106
Respiratory Medical Ward	15	14	93.33	17	16	94.12	0.008	1.000
Transplant Medical Ward	9	4	44.44	11	9	81.82	3.039	0.160
Hematology–oncology ward	22	20	90.91	23	20	86.96	2.804	0.236
Intensive Care Unit	30	28	93.33	13	13	100.00	0.909	1.000
Total	210	136	64.76	206	153	74.27	4.204	0.042*

Note: *p-value <0.05.

Table 2 Quality of Blood Culture Specimens Before and After the Intervention Across Different Wards

Blood Culture Situation	Before Intervention	After Intervention	χ^2	*p*-value
Qualified specimen rate (%)	35.29	60.47	7.061	0.009*
Contamination rate (%)	4.08	2.78	0.206	0.645
Test rate (%)	2.86	16.02	21.205	0.000*

Note: *p-value <0.05.

Rational Use of Carbapenem Antibiotics

The proportion of targeted therapy using carbapenem antibiotics significantly increased from 4.29% to 10.68% (χ^2 = 6.164, p = 0.015). The most notable improvement was seen in the intensive care unit, where the proportion increased from 10.0% to 38.46% (χ^2 = 4.852, p = 0.042). Other wards also showed varying degrees of increase, but these changes did not reach statistical significance (Figure 1).

The overall rate of rational use of carbapenem in the hospital-wide significantly improved (X^2 = 5.389, p = 0.024). The surgical ward exhibited the most notable improvement, with the rational use rate increasing from 22.1% (21/95) to 55.4% (62/112) (χ^2 = 23.662, p < 0.001). Although the medical ward (p = 0.067) and respiratory medical ward (p = 0.088) demonstrated a trend toward improvement, the changes were not statistically significant. Similarly, no significant changes were observed in the intensive care unit, transplant medical ward, or hematology–oncology ward (p > 0.05) (Figure 2).

Detection of Hospital-Acquired Carbapenem-Resistant Pathogens and Adjustment of Antibiotic Use Based on Drug Sensitivity Results

Following the intervention, the detection rate of hospital-acquired carbapenem-resistant pathogens was 0.46%, showing no significant difference compared to the pre-intervention rate of 0.35% (χ^2 = 1.035, p = 0.341). However, the proportion of patients whose antimicrobial therapy was adjusted based on drug sensitivity results increased from 15.71% to 22.33%. The most significant improvement was observed in the surgical ward, where the adjustment rate rose from 20.00% to 52.94% (χ^2 = 5.241, p = 0.032) (Table 3).

Discussion

The MDT management model proved to be an effective strategy for enhancing microbiological testing rates before antimicrobial treatment. In this study, the pathogen testing rate among patients receiving carbapenem antibiotics increased from 65.94% to 82.08% following the intervention. This improvement is consistent with results from a European multicenter study, which reported an increase in testing rates from 55% to 82%,[7] as well as findings from studies in China, where testing rates rose from 63% to 85%.[8,9]

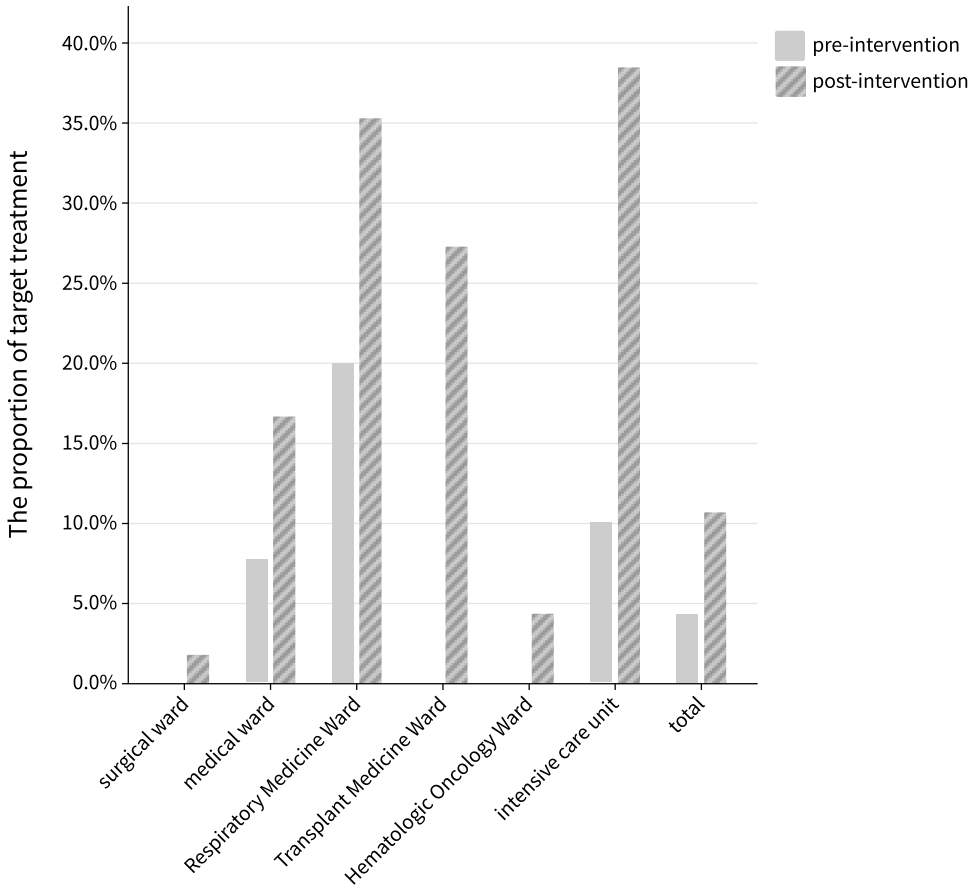

Figure 1 Changes of targeted treatment rate of carbapenems in different wards.

Unlike policy-driven management approaches, the multidisciplinary model seeks to identify and address the key factors influencing antimicrobial stewardship. By collaboratively utilizing resources from the infectious disease, microbiology, and pharmacy departments,[5] this approach optimizes the hospital's antimicrobial management system and testing processes. Moreover, it actively engages healthcare personnel with antimicrobial stewardship through mechanisms such as information system integrations, including HIS pop-up reminders. These tools help minimize human error and reinforce adherence to protocols.[8] The shift from passive compliance to active optimization marks a significant advancement in antimicrobial stewardship practices.

The effectiveness of the interventions varied across different departments. The surgical ward demonstrated the most significant Improvement in microbiological specimen submission rates. This improvement can be partly attributed to the initially low baseline levels of microbiological testing and the rational antibiotics use in the surgical ward. Previous studies have reported similarly low compliance among surgeons with antimicrobial stewardship recommendations.[10] For instance, Huang et al found that the rational use rate of carbapenem antibiotics in surgical wards, such as neurosurgery and hepatobiliary surgery, ranged from only 36.5% to 55.2%.[11]

A key factor contributing to the low specimen submission rate is a lack of knowledge among surgeons regarding the rational use of antimicrobial agents. Surgeons often prioritize maintaining a normal clinical presentation in patients and may adopt a "just-in-case" approach, prescribing broad-spectrum antibiotics post-operatively to prevent infection symptoms until discharge, without considering the risk of antimicrobial resistance. Consequently, surgeons have shown lower acceptance of administrative antimicrobial stewardship program (ASP) interventions compared to other healthcare professionals.

However, acceptance improves when surgeons engage directly with infectious disease (ID) physicians in treatment planning.[12,13] This is particularly evident when ID physicians perform bedside assessments, which tend to increase

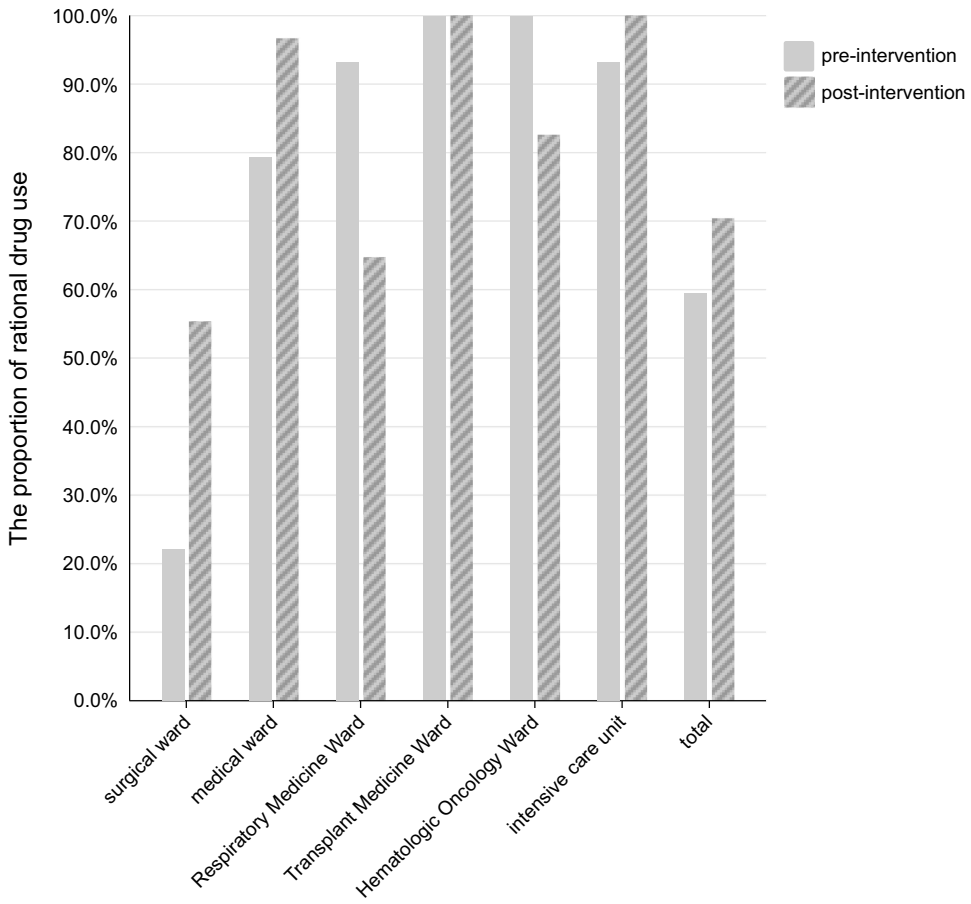

Figure 2 Changes of the rational application of carbapenems in different wards.

surgeons' trust in recommended adjustments to antimicrobial regimens. Furthermore, the hierarchical nature of surgical teams can hinder adherence to ASP recommendations, as junior doctors often defer to senior surgeon decisions rather than those proposed by ID physicians.[14]

In this study, the surgical ward exhibited the most significant improvement in microbiological specimen submission rates following the intervention. This improvement is likely attributable to the development of antibiotic prescribing guidelines tailored specifically to common surgical infections and pathogens, as well as the active involvement of department heads in training and managing key personnel responsible for antibiotic prescriptions. Additionally, the introduction of a multidisciplinary consultation system, including ID physicians, clinical pharmacists, and laboratory technicians, strengthened surgeons' understanding of rational medication use and promoted standardized practices. These

Table 3 Proportion of Patients with Antibiotic Adjustments Based on Drug Sensitivity Results Before and After the Intervention

Ward	Before Intervention (%)	After Intervention (%)	χ^2	*p-value*
Surgical ward	0	5.36	1.332	0.281
Medical ward	7.69	16.67	3.689	0.076
Respiratory Medical Ward	20.00	52.94	5.241	0.032*
Transplant Medical Ward	33.33	54.55	3.785	0.070
Hematology–oncology ward	22.73	34.78	0.900	0.406
Intensive Care Unit	63.33	92.31	0.795	0.514
Total	15.71	22.33	2.959	0.104

Note: *p-value <0.05.

efforts collectively improved adherence to the intervention measures, resulting in the most notable increase in microbiological specimen submission rates within the surgical ward.

Conversely, a decline in microbiological test rates was observed in the internal medicine and hematology–oncology wards after the intervention. This decline may be linked to the hospital's emphasis on geriatric care, where a significant proportion of hospitalized patients are elderly. Elderly patients and those with hematologic malignancies are more vulnerable to a wide range of pathogens, often exhibit atypical inflammatory responses, and frequently require prolonged antibiotic prophylaxis. As a result, when infections occur, there is an urgent need for effective empirical antimicrobial agents.[15,16] This situation leads attending physicians to adopt a more proactive approach toward the empirical use of carbapenem antibiotics. Research by Stewart et al indicates that physicians view antibiotic use as essential for both patient safety and their own protection. Some clinicians reported prescribing antibiotics regardless of test results. Additionally, physicians have concerns about the consequences of antibiotic over-treatment following the detection of colonizers and are mindful of patient compliance with specimen collection; hence, some physicians only submit microbiological specimens when empirical treatment fails.[17]

In this study, we focused on blood specimens as a key target for enhancing specimen quality. Within China's microbial culture testing landscape, non-sterile specimens (eg, sputum) account for the largest proportion, whereas blood culture rates remain relatively low and specimen quality is often suboptimal. This substandard quality may erode clinicians' trust in test results, thereby reducing their adherence to microbial specimen submission. Against the backdrop of rising multidrug-resistant organism (MDRO) infection rates, blood culture stands as one of the most sensitive modalities for diagnosing infections. Thus, we reasoned that prioritizing blood culture specimen quality management would help holistically improve the timeliness and accuracy of clinicians' infection diagnoses. Previous studies report that the quality of blood culture specimens directly affects culture results; the sensitivity of monitoring positive patients with 1, 2, or 3 sets of blood culture bottles is 73.2%, 93.9%, and 96.9%, respectively. This indicates that increasing the number of blood culture bottles can improve positivity rates.[18]

Recent studies have also highlighted that enhancing specimen quality through a multidisciplinary management approach can help standardize antibiotic use.[19] Contaminated blood culture samples can result in prolonged hospital stays and delayed or unnecessary antimicrobial treatment. Some studies report that the blood culture contamination rate ranges from 0.9% to 41%, with up to 59% of patients receiving unnecessary intravenous vancomycin due to contamination, leading to increased medication costs and extended hospitalizations of 1–22 days. Therefore, interventions aimed at reducing contamination not only ensure appropriate treatment but also reduce downstream economic costs and shorten hospital stays.[20] To improve the quality of blood culture specimens, we have implemented a policy requiring that each blood culture submission include 2 sets (4 bottles) of blood cultures. We also established Standard Operating Procedures for collecting blood culture specimens via peripheral venous and central catheters (with or without catheter retention). Comprehensive training and supervision were conducted hospital-wide to standardize specimen collection practices and reduce contamination rates.

The overall improvement in microbiological specimen submission rates across the hospital has contributed to an increase in the proportion of targeted therapy and adjustments to antibiotic use based on sensitivity results. This trend is most pronounced in the intensive care unit, where targeted treatments have reduced the reliance on broad-spectrum antibiotics, notably decreasing the number of patients receiving these medications. Several factors likely contributed to this improvement: First, clinical pharmacists have played a vital role in the multidisciplinary management approach by utilizing biomarkers and pharmacokinetic/pharmacodynamic parameters to minimize unnecessary antibiotic use. This has resulted in an increased proportion of targeted treatments, reducing the risk of antimicrobial misapplications and the potential for antibiotic resistance.[21] Second, as specimen submission rates increased, clinical physicians were able to adjust treatment regimens more effectively based on the latest microbiological data, further enhancing the use of targeted therapy.[22] Furthermore, the use of newly developed antibiotics, guided by sensitivity results, has helped mitigate the risk of inappropriate antibiotic use and the emergence of new resistant strains.[23]

In this study, no significant change was observed in the incidence of hospital-acquired carbapenem-resistant pathogens. This finding contrasts with existing research,[24] and several factors may explain this result. First, long-term monitoring of resistance rates is necessary, as this study only observed changes over one year. Pollack et al

suggested a 3–5 year follow-up period,[25] indicating that one year of observation may be insufficient. Additionally, a study by Zhang Jing et al found no notable decrease in the detection rate of carbapenem-resistant pathogens during the first year of multidisciplinary management.[26] Moreover, the absence of a reduction in the absolute number of carbapenem antibiotic prescriptions in the hospital may have prevented a significant decrease in antimicrobial selection pressure, thus explaining the unchanged incidence of carbapenem-resistant organisms within the hospital.

This study demonstrated the positive effects of multidisciplinary collaboration on improving microbiological specimen submission rates and optimizing antibiotic use through a single-center, short-term interventional study design. However, several limitations exist: First, the data were sourced from a tertiary hospital in Beijing, and its management model and resource allocation may differ from those in primary care or healthcare institutions in other regions. Therefore, further validation is needed to assess the generalizability of these results. Second, the relatively short observation period did not allow for tracking the long-term impact of the interventions on trends in resistant bacteria. Additionally, the small sample sizes for some specialties may limit their representativeness. Future research should focus on sustainable management strategies through multicenter, prospective studies to provide evidence-based recommendations for healthcare institutions at various levels.

Conclusion

This study confirms that a multidisciplinary collaborative management model can significantly increase the rate of microbiological specimen submission before carbapenem antibiotic treatment, improve the quality of submitted blood culture specimens, and promote behaviors such as increasing targeted therapy and encouraging physicians to adjust treatments based on sensitivity results, thereby enhancing the rational use of carbapenem antibiotics.

Statement of Ethics

This study was conducted in accordance with the Declaration of Helsinki. The protocol was reviewed and approved by the Ethics Committee of Beijing Hospital on December 16, 2023 (Approval No. 2023BJYYEC-445-01). Since the data used were retrospective and anonymized, and the Ethics Committee waived the requirement for informed consent, the study was conducted in accordance with ethical guidelines. The waiver was granted based on the retrospective and anonymous nature of the data, and the study posed minimal risk to participants.

Acknowledgments

The authors thank all participants who participated in this study.

Funding

This research was funded by the National High Level Hospital Clinical Research Funding (Grant Number BJ-2023-134). The funders had no role in considering the study design or in the collection, analysis, interpretation of data, writing of the report, or decision to submit the article for publication.

Disclosure

The authors declare no conflict of interest.

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