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Integrated assessment of antimicrobial stewardship in carbapenem resistant *Klebsiella pneumoniae* prevalent hospitals in China: a multidisciplinary surveillance network-based survey

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Abstract

Background China has established an extensive multidisciplinary surveillance network encompassing antimicrobial utilisation, antimicrobial resistance, and nosocomial infections. We aimed to identify challenges and barriers in antimicrobial stewardship (AMS) development based on this national multidisciplinary surveillance network.

Methods This cross-sectional study was conducted in 15 hospitals across China from July 2021 to April 2023. Purposeful sampling was employed to select the hospitals based on the rising prevalence of carbapenem-resistant *Klebsiella pneumoniae*. The survey consisted of three parts: a testing questionnaire was used to assess the awareness of clinical physicians regarding AMS; a scoring table was developed through the Delphi method to assess the hospitals' multidisciplinary management covering antibacterial usage surveillance, resistance surveillance, fungal surveillance, infectious disease management, and infection prevention and control; an on-site investigation based on case review and field inspection. Pearson correlation tests were used to examine the relationship between resistance levels and scores for various items. Theme analysis was applied to highlight key areas of focus in hospital multidisciplinary AMS from the on-site investigation.

Results Findings revealed that physicians of respiratory, infectious disease, and critical care were the top 3 specialists in AMS awareness scores, with an average of 70 points, 65 points and 62.5 points, respectively (a full mark of 100 points). Performance in infectious disease management, antibacterial surveillance, and infection prevention and control showed a scoring rate over 70%, with relatively low scores in resistance surveillance (49.1%) and fungal surveillance (36.0%). No significant correlation was found between any single scoring item and the resistance levels of

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focused drug-resistance pathogens. Five key areas were identified for improving multidisciplinary AMS: organizational structure, staffing and training, drug formulary and prescription management, laboratory testing and quality control, and clinical sampling and data reporting.

Conclusions The prevalence of focused drug-resistance pathogens could not attribute to any single factor. The following AMS activities should emphasise the establishment of sophisticated communication and collaboration mechanisms within multidisciplinary teams.

Trial registration Approval for this study was granted by the Ethics Committee of Peking University (reference number IRB00001052-22100).

Keywords Antimicrobial stewardship, Antimicrobial resistance, Surveillance network, Multidisciplinary evaluation, China

Background

Antimicrobial resistance (AMR) poses a global health crisis, with an estimated 1.14 million attributing deaths in 2021, with an expected increase to 1.91 million deaths in 2050, particularly concentrated in low- and middle-income countries (LMICs) [1, 2]. The escalation of AMR in healthcare settings primarily stems from the inappropriate and excessive use of antimicrobials, compounded by challenges in infection prevention, control, and the management of infectious diseases. Recognizing this, the World Health Organization (WHO) in 2021, launched integrated antimicrobial stewardship (AMS) activities targeting healthcare facilities in LMICs [2]. This initiative emphasizes the critical role of infection prevention and control (IPC), water, sanitation, hygiene (WASH), and vaccination optimization, aiming for a holistic approach that surpasses the traditional focus on antimicrobial usage optimization and fosters broad sectoral integration and coordination [3, 4].

LMICs grapple with not only a disproportionately high burden of AMR but also the challenging slow progress in containing AMR. WHO has adopted a global action plan on antimicrobial resistance in 2015, advocating for a multi-sectoral and interdisciplinary strategy [5]. As of now, 93% of countries have developed national action plans, with 68% implementing various plan components. However, only 27% of these plans are costed and budgeted, including a monitoring and evaluation framework, more importantly, predominantly in high-income countries [6]. LMICs, in contrast, encounter distinct challenges in combating AMR, such as limited diagnostic capabilities, suboptimal management practices, inadequate regulatory frameworks, and fragile healthcare infrastructures, which makes it a great challenge to develop a multidisciplinary surveillance network and evaluation framework [7].

China, as one of the first patches of LMIC countries echoing the WHO's endeavors, has established a national, budgeted operational plan with monitoring networks to address AMR [8, 9]. Despite a nearly 40% decrease in antibiotic use was achieved in hospital setting from 2013 to 2021 [10], China still faces significant AMR challenges. Approximately 70% of isolated strains in China were Gram-negative bacteria, with a notable prevalence and resistance in species such as *Escherichia coli*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, and *Pseudomonas aeruginosa*, particularly carbapenem-resistant *Klebsiella pneumoniae* (CRKP), which has shown a persistent increasing prevalence since 2005 [11–13]. Therefore, China launched an integrative program (4C1B Program) in 2021 to develop a multidisciplinary evaluation system for AMS development in hospital settings based on preliminary multidisciplinary surveillance network covering the China Antimicrobial Resistance Surveillance System (CARSS), the Center of Antibacterial Surveillance (CAS), the China Fungal Diseases Surveillance System (CFDSS), the National Medical Institution Infection Surveillance System of China (CMIISS), and the Bacterial Infection Society of China (BISC) [9, 14]. To provide evidence for a comprehensive evaluation framework of AMS development, as a pilot survey of the 4C1B Program, we aimed to identify challenges and barriers in AMS development based on multidisciplinary surveillance network in China's hospitals.

Method

Study design

The study was a nationwide cross-sectional on-site survey conducted in 15 hospitals across mainland China from July 2021 to April 2023.

Study setting

We employed purposive sampling to select hospitals nationwide. Given the significant challenge posed by CRKP in clinical settings, we first screened 100 hospitals with CRKP detection rates increasing continuously for seven years nationwide. Then we chose 15 hospitals from 100 hospitals in different provinces, which participated both in CARSS and CAS with complete data connectivity (Fig. 1).

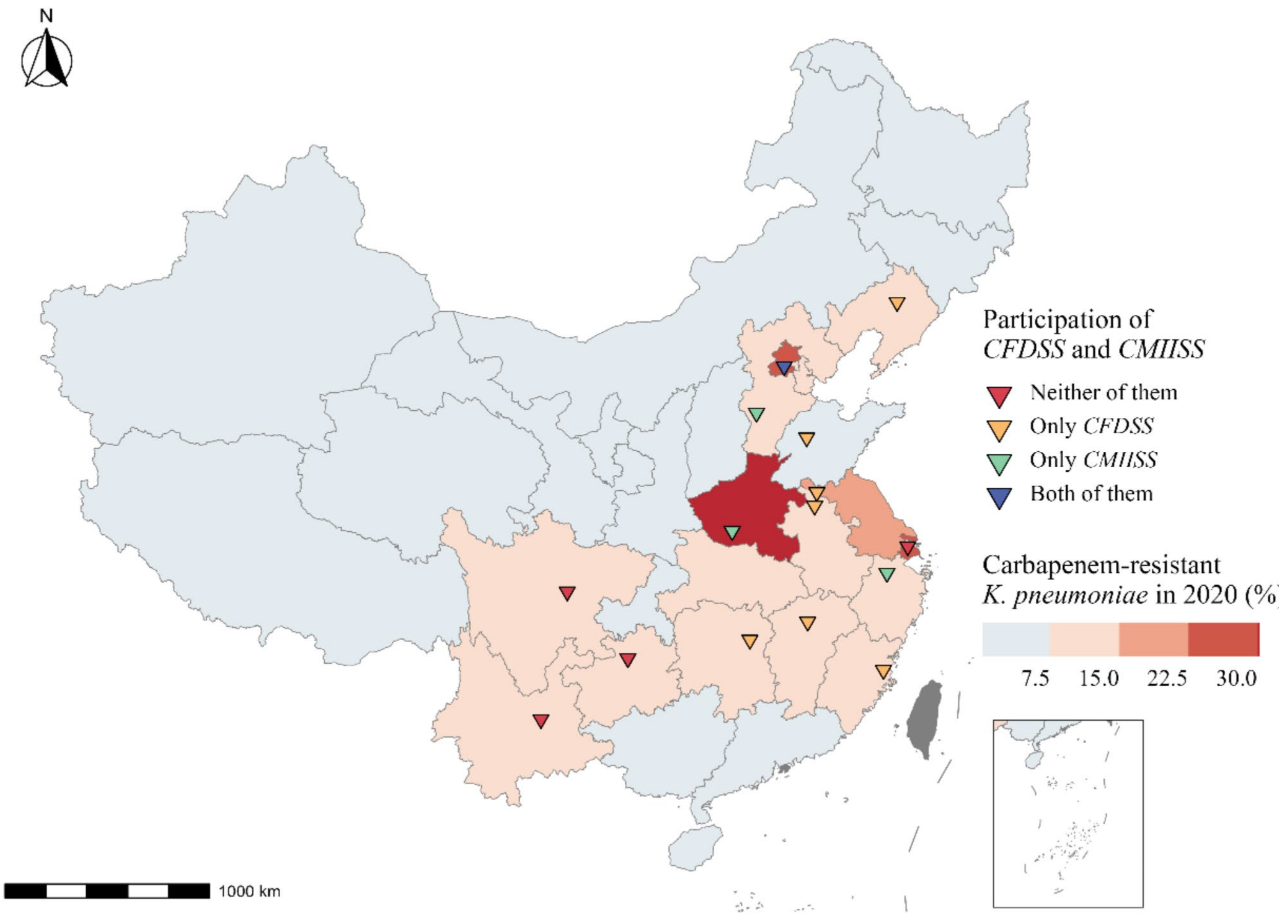

Fig. 1 Selection of sample hospitals. All hospitals participated in the China Antimicrobial Resistance Surveillance System (CARSS) and the Centre of Antibacterial Surveillance (CAS) but not fully in the China Fungal Diseases Surveillance System (CFDSS) and the National Medical Institution Infection Surveillance System of China (CMIISS)

On-site survey

The on-site survey comprised three parts: (1) A testing questionnaire was used to assessed the clinical physicians about their awareness regarding AMS; (2) A multidisciplinary assessment scoring table was applied to assess the hospitals' multidisciplinary management antibacterial surveillance, resistance surveillance, fungal surveillance, infectious disease management, and infection prevention and control. (3) An on-site investigation by committee members involving multidisciplinary to each hospital based on field inspection to assess the potential challenge regarding AMS.

The questionnaire survey was conducted in specialties with high antimicrobial consumption, including the departments of respiratory medicine, infectious diseases, critical care medicine, urology, paediatrics, and general medicine. Clinical leaders from these departments were strategically selected for their representative clinical practices and valuable insights into organizational-level implementation barriers. The testing questionnaire was adapted by multidisciplinary committee members from annual National inspection conducted by the National Health Commission targeting at hospital quality improvement, consisting of 20 choice questions, which involved fundamental knowledge on the rational use of antimicrobial agents, the diagnosis and treatment of infectious diseases, and epidemiological data on antimicrobial resistance. The details of the questionnaire were provided in the supplementary materials (Table S1). The questionnaire was designed with a maximum score of 100 points, and we calculated the scores for each participating physician.

The multidisciplinary investigation was conducted at the institutional level, with experts scoring based on various objective indicators outlined in a scoring table developed using the Delphi method. The table consisted of five domains: antibacterial surveillance, resistance surveillance, fungal surveillance, infectious disease management, and infection prevention and control (Fig. 2). Fifty-six experts participated in three rounds of discussions: (1) The first round involved qualitative discussions to determine the framework of 16 sub-items and 62

Fig. 2 Multidisciplinary measure structure. The size of sectors represent the weight of items (MRSA = methicillin resistant *S. aureus*, VREFM = vancomycin resistant *E. faecium*, CRKP = carbapenem resistant *K. pneumoniae*, CRPA = carbapenem resistant *P. aeruginosa*, CRAB = carbapenem resistant *A. baumannii*, 3GCREC = third-generation cephalosporin resistant *E. coil*), VAP = ventilator-associated pneumonia, CRUTI = catheter-related urinary tract infections, CLABSI = central line-associated bloodstream infections

scoring items across five domains. (2) The second round involved quantitative discussions, using the Likert scale to rate the importance of each indicator, selecting the key indicators for continuous monitoring in terms of infection disease treatment, the intensity of key antimicrobial medicines, hospital infection monitoring, and antimicrobial resistance levels. (3) The third round involved further quantitative discussions, utilizing the previous round's scale ratings to allocate weights to each item and discussing the specific scoring methods for each indicator. The final evaluation instrument (presented in Table 1, with operational details in Table S2- S6) features positively oriented metrics where higher composite scores reflect superior performance in antimicrobial stewardship and institutional infection control capabilities. Individual indicator achievement rates were calculated as obtained score divided by its total score.

Table 1 Content of multidisciplinary quantitative evaluation forms

Sector	Items	Content
1. Infectious disease management	1.1 Multidisciplinary team construction	Staffing and training of infectious disease specialists, clinical pharmacists in infection, clinical microbiology professionals, hospital infection prevention professionals; organizational structure and interdisciplinary collaboration mechanisms.
	1.2 Procurement	Supply catalogues for targeted antibiotics (e.g., penicillin, benzylpenicillin, furazolidone, compound sulfamethoxazole, fluorouracil, cefazolin, cefuroxime [injection]).
	1.3 β-lactam skin test	Implementation of standardized Cephalosporin allergy testing protocols and clinical practices.
2. Antibacterial usage surveillance	2.1 Data reporting	Timeliness and completeness of antibacterial usage data submission (e.g., outpatient, inpatient, emergency).
	2.2 Management practices	Regulatory compliance in antibacterial formulary development, temporary procurement procedures, and documentation of antibacterial prescription reviews.
	2.3 Antibacterial usage indicators	Prescription rate and usage intensity of antibacterial use in outpatient, emergency, and inpatient settings.
	2.4 Focused antibiotics usage intensity	Usage intensity of tigecycline, carbapenems, 3rd-generation cephalosporins, cephalosporin/enzyme inhibitors, and quinolones compared to national averages.
3. Antibacte-rial resistance surveillance	3.1 Specimen quality & quantity	Proportion of outpatient specimens, blood cultures, and cerebrospinal fluid samples meeting quality standards; annual bacterial strain counts.
	3.2 Antibacterial susceptibility testing	Completeness of antimicrobial susceptibility panels for *Enterobacteriaceae*, *P. aeruginosa*, *A. baumannii*, *S. aureus*, *Enterococcus*, *S. pneumoniae*, *Salmonella*, *Shigella*, *Haemophilus influenzae*, and *Campylobacter*.
	3.3 Focused drug-resistance pathogens	Detection rates of MRSA, VREFM, CRKP, CRPA, CRAB, and 3GCREC compared to national averages.
4. Fungal diseases surveillance	4.1 Participation & data quality	Retrospective mycological studies, active surveillance of fungal bloodstream infections, and data accuracy in reporting.
	4.2 Training	Participation of clinicians and laboratory staff in online training programs.
	4.3 Diagnostic capability	Proficiency in microscopy (e.g., Gram staining, KOH mounts), fungal culture/identification, antifungal susceptibility testing, and quality control (e.g., internal/external assessments).
5. Hospital infection surveillance	5.1 Informatization	Organizational structure of infection control departments, functionality of surveillance information systems, and completeness of prevalence data reporting.
	5.2 Hospital infection indicators	Incidence of VAP, CRUTI, and CLABSI; perioperative antimicrobial prophylaxis compliance; hand hygiene compliance; sample submission; prevalence of hospital infection.
	5.3 Infection prevention & control	Isolation protocols, identification accuracy, and single-use equipment management for multidrug-resistant infections.

* MRSA = methicillin resistant *S. aureus*, VREFM = vancomycin resistant *E. faecium*, CRKP = carbapenem resistant *K. pneumoniae*, CRPA = carbapenem resistant *P. aeruginosa*, CRAB = carbapenem resistant *A. baumannii*, 3GCREC = third-generation cephalosporin resistant *E. coil*, VAP = ventilator-associated pneumonia, CRUTI = catheter-related urinary tract infections, CLABSI = central line-associated bloodstream infections

Based on the results from the testing questionnaire and multidisciplinary assessment scoring table, an on-site investigation based on field inspection was conducted by discussing with hospital medical staff to identify potential barriers and challenges in the clinical, pharmaceutical, microbiological, and infection control sectors regarding AMS. The thematic analysis framework for the investigation report was developed based on management requirements outlined in the Notice on Continuous Improvement of Antimicrobial Clinical Use Management (National Health Commission Office Medical Development [2020] No. 8) [15]. Detailed descriptions of challenges identified in on-site reports have been added to Supplementary Table S7.

Statistical analysis

The scores of testing questionnaires and scoring tables were analysed using stratified analysis to calculate average scores and standard errors. Pearson correlation tests were used to analyse the correlation between antimicrobial resistance levels and scores of various items. Thematic analysis was employed to code and summarize the identified issues from on-site investigation, categorizing typical problems according to different themes. Analysis was conducted using R version 4.3.0 and Excel 2021.

Results

Awareness of AMS among clinicians across different departments

Figure 3 illustrates the scores of the testing questionnaire of AMS awareness among clinicians from various departments. A total of 30 clinicians from various departments were interviewed, with a 100% response rate (30/30 completed questionnaires). Clinicians from the respiratory medicine department scored the highest (an average of 70 points out of 100), followed by clinicians from departments of infectious diseases and critical care medicine (an average of 65 and 62.5 points, respectively), while other departments, including urology, paediatrics, and general medicine, scored an average of 55 points.

Scoring rate of multidisciplinary assessment

Table 2 displays the scores of the multidisciplinary assessment scoring table across 15 hospitals across. Scoring rate in infectious disease management, antibacterial surveillance, and infection prevention and control were above 70% across the items. Averaged scoring rates of key indicators of the multidisciplinary professional team construction in infectious disease management, focused antibiotics use density in antibacterial surveillance, and hospitals infection indicators in infection prevention and control were 81.9%, 77.7%, and 70.4% respectively. In contrast, the scoring rate of antimicrobial resistance and fungal diseases were relatively lower, with most items scoring below 60%. The lowest two items were participation of CFDSS in fungal surveillance (36.0%), and detection of focused drug-resistance pathogens in resistance surveillance (49.1%).

Correlation between antimicrobial resistance levels and scores of various items

Table 3 shows the correlation between the scores of focused drug-resistance pathogens and various items. There was a potential correlation between scores of focused drug-resistance pathogens and multidisciplinary team construction ($r = 0.46$, $p < 0.1$) as well as antibacterial susceptibility testing ($r = 0.49$, $p < 0.1$). However, no significant statistical correlation was found between scores of focused drug-resistance pathogens and antibacterial surveillance, infection prevention and control, fungal disease surveillance, or awareness of AMS among clinicians, suggesting that the prevalence of focused drug-resistant pathogens may not be attributable to a single factor.

Thematic analysis of on-site research evaluation reports

Table 4 outlined challenges encountered in AMS implementation across sampled hospitals, encompassing five key areas: organizational structure and infrastructure, personnel allocation and training, drug formulary and prescription management, laboratory testing and

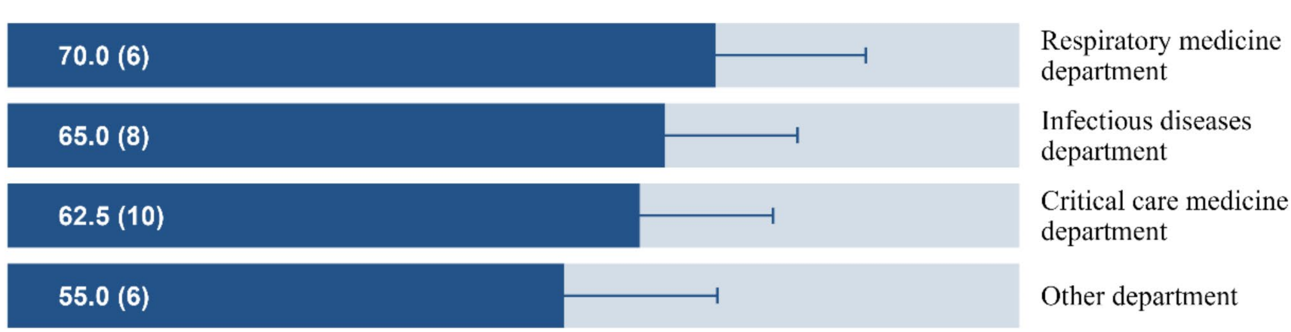

Fig. 3 Scores of testing questionnaire of physicians' antimicrobial stewardship awareness among clinicians from various departments. The questionnaire was scored out of a total of 100 points. The length of the bars reflects the average score of the questionnaire. The figures denote the average score of participating departments, with the numbers in parentheses denoting the number of clinicians. The length of error bars denotes the standard errors

Table 2 Scores of multidisciplinary quantitative evaluation forms

Items	Total	Score range	Mean rating
1. Infectious disease management			
1.1 Multidisciplinary team construction	45	36.8 ± 5.5	81.9%
1.2 Procurement	20	17.5 ± 2.8	87.3%
1.3 β-lactam skin test	10	8.4 ± 1.8	84.0%
2. Antibacterial usage surveillance			
2.1 Data report	12	11.3 ± 1.7	93.9%
2.2 Management practices	18	16.3 ± 2.6	90.7%
2.3 Antibacterial usage indicators	20	16.9 ± 3.6	84.5%
2.4 Focused antibiotics usage intensity	50	38.8 ± 8.0	77.7%
3. Antibacterial resistance surveillance			
3.1 Specimen quality & quantity	20	10.9 ± 4.0	54.7%
3.2 Antibacterial susceptibility testing	30	18.4 ± 6.2	61.4%
3.3 Focused drug-resistance pathogens	50	24.6 ± 9.9	49.1%
4. Fungal diseases surveillance			
4.1 Participation & data quality	33	11.9 ± 12.2	36.0%
4.2 Training	6	3.0 ± 2.8	50.0%
4.3 Diagnostic capability	36	22.8 ± 6.6	63.3%
5. Hospital infection surveillance			
5.1 Informatization	30	26.4 ± 4.6	88.1%
5.2 Hospital infection indicators	62	43.6 ± 9.1	70.4%
5.3 Infection prevention & control	8	7.1 ± 0.8	88.3%

Table 3 Correlation between scores of focused drug-resistance pathogens and other items

Items	Cor*	*p*	90% CI
Antimicrobial stewardship awareness	0.27	0.322	(-0.28, 0.69)
1. Infectious disease management			
1.1 Multidisciplinary team construction	0.46	0.087	(-0.07, 0.79)
1.2 Procurement	0.34	0.217	(-0.21, 0.73)
1.3 β-lactam skin test	0.10	0.711	(-0.43, 0.59)
2. Antibacterial usage surveillance			
2.1 Data report	-0.02	0.934	(-0.53, 0.49)
2.2 Management practices	0.16	0.560	(-0.38, 0.62)
2.3 Antibacterial usage indicators	-0.18	0.526	(-0.63, 0.37)
2.4 Focused antibiotics usage intensity	-0.04	0.887	(-0.54, 0.48)
3. Antibacterial resistance surveillance			
3.1 Specimen quality & quantity	0.05	0.870	(-0.48, 0.55)
3.2 Antibacterial susceptibility testing	0.49	0.061	(-0.02, 0.80)
4. Fungal diseases surveillance			
4.1 Participation & data quality	-0.33	0.232	(-0.72, 0.22)
4.2 Training	-0.40	0.143	(-0.76, 0.15)
4.3 Diagnostic capability	-0.22	0.426	(-0.66, 0.33)
5. Hospital infection surveillance			
5.1 Informatization	0.06	0.826	(-0.46, 0.56)
5.2 Hospital infection indicators	0.28	0.321	(-0.28, 0.69)
5.3 Infection prevention & control	0.03	0.927	(-0.49, 0.53)

* Correlation coefficient

quality control, and clinical sampling and data reporting. The result showed that the lack of adequate information system support and hardware infrastructure makes it difficult to coordinate multidisciplinary collaboration effectively. Moreover, limited human resources and knowledge bases within relevant departments severely restrict the execution of AMR-related activities. The absence of ongoing education and training further exacerbates these issues, impeding staff proficiency in managing antimicrobial resistance effectively. In terms of drug formulary and prescription management, an irrational supply structure of antimicrobial drugs, superficial

Table 4 Summary of typical challenges from the on-investigation

Main theme	Subtheme	Key points
Organizational structure and hardware facilities	Multidisciplinary team (MDT) collaboration	Widespread issues in hospitals include infrequent MDT meetings, limited participation from the Infectious Diseases Department and clinical pharmacists, and minimal collaboration beyond case reviews.
	Information systems	Some hospitals have underdeveloped information systems, insufficient for supporting prescription audits and reviews.
	Hardware equipment	Issues in some hospitals include insufficient laboratory space and a lack of computers for medical record access.
Staffing and training	Staff numbers	A general shortage of staff, inconsistent task allocation and lack of professional knowledge in microbiology laboratory staff at some hospitals.
	Staff training	Limited external training opportunities for microbiology laboratory staff and inadequate training in antimicrobial stewardship in some hospitals' infectious disease departments.
Drug formulary and prescription management	Drug procurement	Most hospitals face issues with irrational antimicrobial supply catalogues and insufficient variety in antimicrobial procurement.
	Prescription review	Some hospitals suffer from low-quality prescription reviews, particularly lacking in special-class antimicrobials.
	Skin test management	Incomplete implementation of β-lactam skin testing guidelines in some hospitals.
Laboratory testing and quality control	Specimen submission	Common reluctance among clinical doctors to submit high-quality specimens such as blood and sterile body fluids.
	Quality control	Issues include non-standard specimen types and insufficient proactive screening and enzymatic testing for resistant bacteria.
Clinical sampling and data reporting	Sampling standards	Rigid sampling standards in some hospitals do not accurately reflect clinical situations.
	Reporting standards	Most hospitals have low reporting rates of fungal bloodstream infections and incomplete reporting data.

prescription reviews, and ineffective management of allergy testing contributes significantly to the difficulty of AMS implementation. For laboratory testing and quality control, non-standard specimen submission and quality control issues greatly diminishes the quality of surveillance data. These deficiencies obstruct the establishment of effective early warning systems and the implementation and assessment of AMR interventions. The rigidity of clinical sampling processes and non-standardized data reporting practices were likely to obscure and exacerbate existing clinical AMR issues. Table S7 presents the detailed practical issues identified during the on-site investigation.

Discussion

The study is the first attempt to evaluate the hospital level AMS development in China, integrating multidisciplinary surveillance network with comprehensive on-site assessments. Our findings indicate commendable performance in antibacterial surveillance, infectious disease management, and infection prevention and control in Chinese hospitals. Nonetheless, it underscores the urgent need for enhancing the surveillance of key drug-resistant pathogens and fungal diseases. Moreover, we identified five aspects of potential barriers in implementing effective clinical multidisciplinary antimicrobial resistance strategies.

Due to our sample hospital selection was based on the continuous increase in CRKP prevalence, the scores in terms of antimicrobial resistance of each hospital were generally low. Given these hospitals demonstrated fair performance in other aspects of multidisciplinary professional team construction, antibiotic use density, and hospitals infection indicators, the high antimicrobial resistance levels highlighted the underlying issues beyond these quantitative metrics. Analysis of the correlation between antimicrobial resistance levels and various scoring items indicated that the construction of professional teams for infectious disease treatment may play a pivotal role in AMS, which encompasses staffing, training, organizational structure, and interdisciplinary collaboration mechanisms. As demonstrated in a review incorporating 53 studies, optimising multidisciplinary team communication and collaboration in IPC and AMC practices positively impacts patient outcomes associated with infections [16]. Specifically, further on-site investigation revealed that immature multidisciplinary teams and communication mechanisms in most hospitals, issues such as infrequent communication meetings and low involvement of infectious disease departments and clinical pharmacists.

The widely existing insignificant association also suggests that the prevalence of drug-resistant bacteria is unlikely to be a single factor cause. We summarised five main barriers, revealing imbalances and inadequacies in the progress of clinical multidisciplinary AMS in China, a situation similar to that faced by most LMICs. Unlike developed countries where comprehensive multidisciplinary AMS is widely implemented in hospitals, hospitals in LMICs generally lack the conditions for such activities [17]. A review of studies from 34 LMICs identified human resource shortages, a lack of microbiological laboratory support, insufficient leadership, and limited government support as major obstacles to antimicrobial management in hospitals [18]. Although China has introduced many supportive policies, as a vast developing country, it faces regional disparities in AMR prevalence and management, which makes it difficult to address the key issues leading to rising clinical resistance rates by national policy interventions alone. A cross-sectional survey of 116 hospitals in China in 2018 showed that while over 90% of hospitals had antimicrobial management programs, a quarter lacked a formal Department of Infectious Diseases (DID), significantly undermining the reliability of their multidisciplinary resistance management efforts [19]. Despite increased attention in the field of infection prevention and control after the COVID-19 outbreak, with a mandate for secondary and higher-level general hospitals to establish DID [15], China's hospital antimicrobial-resistant infection prevention and control still faces significant challenges in transitioning from conventional infectious disease treatment to antimicrobial resistance and nosocomial infection management [20].

This survey on the basis of multidisciplinary collaborative assessment for AMS serves as an important supplement to current administrative interventions for tacking AMR, yet it also has its limitations. First, restricted by limited resources, we employed purposive sampling to select a subset of hospitals for the survey, which may not fully reflect the overall situation of multidisciplinary AMS in Chinese hospitals. Second, the small sample of hospitals and cross-sectional data limit our ability to analyse the causes behind high AMR prevalence. Third, while the highly customized scoring table provides a valuable template for similar evaluations in resource-limited settings, its specificity may limit its broader applicability in other contexts. Additionally, the questionnaire survey focused exclusively on clinical doctors, potentially overlooking the perspectives of other MDT members, who should be included in future assessments to provide a more comprehensive understanding. Despite these limitations, the preliminary findings confirm the feasibility and effectiveness of integrating interconnected information with multidisciplinary assessments. Given the preliminary confirmation of the feasibility and effectiveness of interconnected information with multidisciplinary assessments. Moving forward, broader evaluations are planned, incorporating pre- and post-expert survey data comparisons to assess improvements and identify significant factors contributing to the rise in AMR prevalence.

Conclusions

The construction of the "4C1B" system in China provides substantial support for the further development of AMS based on multidisciplinary surveillance network, but it faces challenges due to underdeveloped communication and collaboration mechanisms within multidisciplinary teams. Additionally, the national multidisciplinary AMR surveillance network needs to expedite the establishment and dissemination of multidisciplinary cooperative surveillance frameworks and management paradigms. It should also broaden its scope to include hospitals where multidisciplinary AMS presents notable challenges.

Abbreviations

AMR	Antimicrobial resistance
AMS	Antimicrobial stewardship
LMICs	Low- and middle-income countries
WHO	World health organization
IPC	Infection prevention and control
WASH	Water, sanitation, hygiene
CARSS	The China antimicrobial resistance surveillance system
CAS	The center of antibacterial surveillance
CFDSS	Tthe China fungal diseases surveillance system
CMIISS	The national medical institution infection surveillance system of China
BISC	The bacterial infection society of China
CRKP	Carbapenem-resistant Klebsiella pneumoniae
MRSA	Methicillin resistant S. aureus
VREFM	Vancomycin resistant E. faecium
CRPA	Carbapenem resistant P. aeruginosa
CRAB	Carbapenem resistant A. baumannii
VAP	Ventilator-associated pneumonia
CRUTI	Catheter-related urinary tract infections
CLABSI	Central line-associated bloodstream infections
3GCREC	Third-generation cephalosporin resistant E. coil
MDT	Multidisciplinary team
DID	Department of infectious diseases

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13756-025-01545-2.

Supplementary Material 1

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Author contributions

H.W., X.G., X.L., A.W., X.Y., M.W., Y.X., Y.L., X.H. and L.S. conceptualized and designed the project. X.L., A.W., X.Y., M.W., Y.X., Y.L., X.H. collected the data and performed data quality assurance. H.W., W.L., J.Y., L.H. analysed and interpreted the data. H.W. and W.L. drafted the manuscript. X.G., X.L., A.W., X.Y., M.W., Y.X., Y.L., X.H. and L.S provided critical review of the manuscript. All authors contributed to final approval of the paper.

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Data availability
The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Declarations

Ethics approval and consent to participate
Approval for this study was granted by the Ethics Committee of Peking University (reference number IRB00001052-22100). Prior to administering the questionnaire, verbal consent was obtained from all participants. The consent procedure followed the information-sharing phase, and interviews began only after participants affirmed their consent. Participants were guaranteed confidentiality and anonymity of their responses. They were informed that their personal data would be handled confidentially and used exclusively for research. The entire verbal consent process was documented as part of the interview procedure.

Consent for publication
All authors have given consent for submission and potential publication of this manuscript.

Competing interests
The authors declare no competing interests.

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