Advances in Precision Medicine, 2026, Volume 11, Issue 7
https://bbwpublisher.com/journal/APM
Online ISSN: 2424-9106
Print ISSN: 2424-8592

Study on the Stratified Characteristics of the Detection Rate of Specific Multidrug-resistant Bacteria and the Incidence of Hospital Infections Based on Regional Surveillance Data

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Abstract: *Objective:* To analyze the detection spectrum of specific multidrug-resistant bacteria, the incidence of hospital infections, and the characteristics of institutional stratification in monitored medical institutions in a certain city, so as to provide a basis for regional differentiated prevention and control. *Methods:* The regional platform data of 13 surveillance medical institutions in a certain city in 2025 were retrospectively collected, and indicators such as methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), carbapenem-resistant *Enterobacteriaceae* (CRE), carbapenem-resistant *Acinetobacter baumannii* (CRAB), and carbapenem-resistant *Pseudomonas aeruginosa* (CRPA) were included. Stratified according to hospital grade and bed size, detection rate, absolute difference, range, Z-score standardization, and Ward hierarchical clustering analysis were used. Results: The overall detection rate of multidrug-resistant bacteria in the city was 6.25%; CRAB, MRSA, and CRPA were 29.87%, 18.91%, and 14.69%, respectively, and the remaining bacterial species were all less than 5%. The overall detection rates of tertiary and secondary hospitals are similar, but the CRAB of secondary hospitals is higher, and the CRPA of tertiary hospitals is higher. Institutions with 501 to 1,000 beds have the highest overall detection rate, while institutions with ≤ 300 beds have the lowest rates, forming a relatively independent low detection spectrum. The city's hospital infection incidence rate and case incidence rate of multidrug-resistant bacteria are both 0.02%. Conclusion: Regionally specific multidrug-resistant bacteria are heterogeneous in species and institutional levels. CRAB, MRSA, and CRPA are key risk bacteria. Stratified early warning and precise prevention and control should be implemented based on bacterial species spectrum, institutional level, and change amplitude.

Keywords: Multidrug-resistant bacteria; Detection rate; Nosocomial infection; Regional surveillance; Stratified analysis

Online publication: July 26, 2026

1. Introduction

Multidrug-resistant bacteria (MDRO) are characterized by limited treatment options, complex nosocomial transmission, and high outbreak control costs. The risk depends not only on the resistance level of a single bacterial species, but also on the hospital grade, patient composition, and medical service capacity. CHINET monitoring in 2023 shows that carbapenem-resistant Gram-negative bacteria are still the focus of drug resistance monitoring in my country [1]; data in 2024 further indicate that the carbapenem resistance level of *Acinetobacter* remains at a high level [2]. As regional hospital infection surveillance shifts from data aggregation to risk identification and hierarchical feedback, there is significant heterogeneity in infection management indicators among different levels of medical institutions, and data consistency and standardization quality directly affect the reliability of cross-institutional comparisons [3,4]. City-level monitoring also shows that the detection spectrum of MDRO in second- and third-level hospitals does not increase unidirectionally with the hospital level [5]. Therefore, this study included the summary data of 13 monitored medical institutions in a certain city in 2025, and analyzed the detection spectrum, differences, and standardized clustering characteristics according to hospital grade and bed size to identify regional key risk bacteria and priority intervention levels.

2. Materials and methods

2.1. Data sources and research objects

The specific MDRO and nosocomial infection indicators reported by 13 surveillance medical institutions in a certain prefecture and city from January to December 2025 were retrospectively collected. Among the 13 institutions, there are 8 tertiary hospitals and 5 secondary hospitals; according to the actual open bed size, they are divided into 1 hospital with ≥ 2001 beds, 1 hospital with 100–1500 beds, 6 hospitals with 501–1000 beds, 4 hospitals with 301–500 beds, and 1 hospital with ≤ 300 beds. The research object is the institution-level summary indicators formed by the regional monitoring platform, which does not involve patient identity information.

2.2. Inclusion and exclusion criteria

Include medical institutions that have completed continuous monitoring throughout the year, have clear hospital grade and bed size information, complete target bacteria monitoring fields, and verifiable statistical calibers; exclude institutions that are missing key monitoring fields, have incomplete annual reporting cycles, or have statistical calibers that cannot be unified with the regional platform. MDRO monitoring objects, duplicate strain elimination principles and detection rates, hospital infection incidence and other indicators are defined with reference to WS/T 312-2023 “Hospital Infection Surveillance Standards”, and strains repeatedly isolated from the same part of the same patient are handled according to specifications [6].

2.3. Monitoring indicators and stratification

Mainly observe the overall detection rate of multidrug-resistant bacteria and the detection rate of MRSA, VRE, CRE, carbapenem-resistant Escherichia coli (CREC), carbapenem-resistant Klebsiella pneumoniae (CRKP), other carbapenem-resistant Enterobacteriaceae, CRAB, and CRPA; also observe the incidence and case incidence of MDRO hospital infections. CRE is the general name for carbapenem-resistant Enterobacteriaceae, and CREC, CRKP, and other CRE are their species/flora sub-items; each detection

rate is calculated independently with the number of isolates of the corresponding species (bacteria) as the denominator, and the sub-item detection rates cannot be added directly. Stratification variables were hospital grade and bed size.

2.4. Statistical analysis

Python 3.11 was used for data collection and exploratory analysis. The counting index is expressed as a rate (%); the absolute difference between hospital levels is calculated by subtracting the detection rate of level 2 hospitals from the detection rate of level 3 hospitals, and the bed size is described by the maximum value, minimum value, and range. The 8 bacterial strain indicators at the 5 bed levels were Z-score standardized by strain and hierarchically clustered using Euclidean distance and the Ward method. Because the platform does not provide the numerator, denominator, and institution-by-institution frequency of strains at each level, the χ^2 test or individual-level regression analysis is not performed.

3. Results

3.1. Overall detection of specific multidrug-resistant bacteria and hospital infections

The overall detection rate of MDRO in 13 monitored medical institutions in 2025 is 6.25%. The detection rate of CRAB was the highest at 29.87%; MRSA and CRPA were 18.91% and 14.69%, respectively, and the other bacterial species were all less than 5%. The incidence rate and case incidence rate of hospital infection in MDRO are both 0.02%; see **Table 1**.

Table 1. Overall detection of specific multidrug-resistant bacteria and hospital infections in a certain city in 2025

Monitoring objects	Detection rate (%)	Incidence of nosocomial infections (%)	Incidence rate of hospital-acquired infections (%)
Multidrug-resistant bacteria overall	6.25	0.02	0.02
MRSA	18.91	0.00	0.01
VRE	0.43	0.00	0.00
CRE	2.31	0.00	0.00
CREC	1.03	0.00	0.00
CRKP	3.26	0.00	0.00
Other CRE	4.49	0.00	0.00
CRAB	29.87	0.01	0.01
CRPA	14.69	0.00	0.00

3.2. Analysis of detection rates and differences of specific multidrug-resistant bacteria in hospitals of different levels

The overall MDRO detection rates in tertiary and secondary hospitals were 6.37% and 6.04%, respectively, with a difference of only 0.33 percentage points. See **Table 2** and **Figure 1**.

Table 2. Detection rates and differences of specific multidrug-resistant bacteria in hospitals of different levels

Monitoring objects	Tertiary hospital (%)	Secondary hospital (%)	Difference (percentage points)
Multidrug-resistant bacteria overall	6.37	6.04	+0.33
MRSA	19.21	18.12	+1.09
VRE	0.25	0.90	-0.65
CRE	2.24	2.41	-0.17
CREC	0.93	1.20	-0.27
CRKP	2.92	3.78	-0.86
Other CRE	4.97	3.77	+1.20
CRAB	26.29	34.06	-7.77
CRPA	15.72	13.00	+2.72

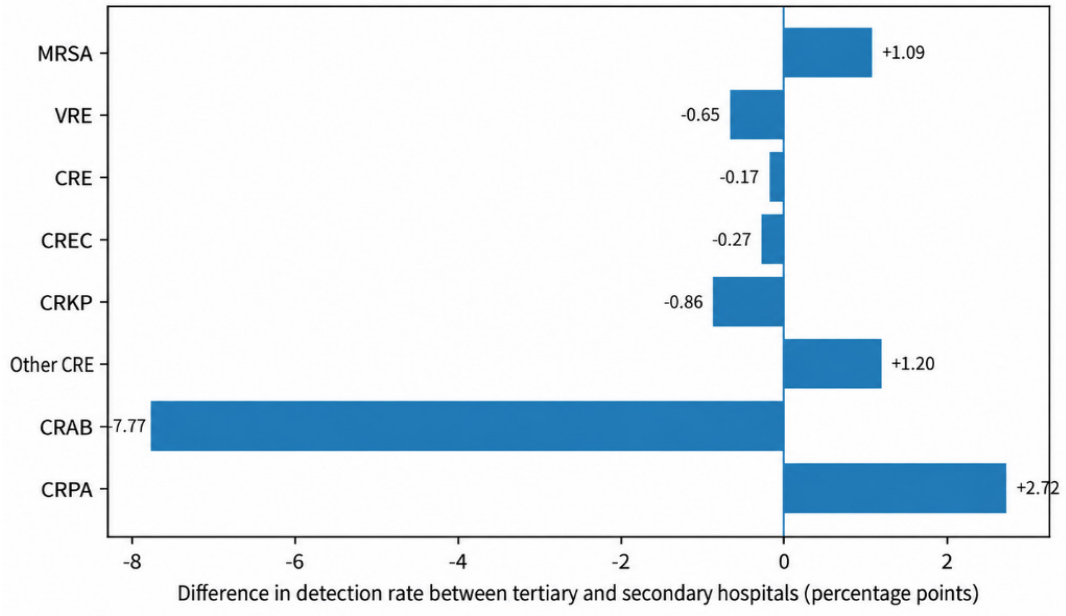

Figure 1. Difference spectrum of detection rates of specific multidrug-resistant bacteria in hospitals of different levels.

3.3. Stratification characteristics of drug-resistant bacteria detection in medical institutions with different bed sizes

Institutions with 501 to 1,000 beds had the highest overall detection rate (7.61%), and institutions with ≤ 300 beds had the lowest rate (2.28%). The ranges of CRAB and CRPA are 26.56 and 18.55 percentage points, respectively, and the detection rates of both institutions with ≥ 2001 beds are relatively high; see **Table 3**.

Table 3. Detection rate (%) of major multidrug-resistant bacteria in medical institutions with different bed sizes

Bed size (beds)	Number of hospitals	Overall	MRSA	CRE/CRKP	CRAB/CRPA
≥ 2001	1	6.92	18.38	2.59/4.36	35.53/19.86
1001–1500	1	4.92	15.23	2.09/1.28	19.86/8.20
501–1000	6	7.61	21.78	2.50/2.80	34.28/18.92
301–500	4	5.13	21.80	2.19/4.70	33.68/8.31
≤ 300	1	2.28	11.34	1.30/3.58	8.97/1.31

3.4. Standardized heat map and hierarchical clustering

Clustering showed that institutions with ≥ 2001 beds and 301–500 beds were first aggregated, and then institutions with 501-1000 beds were merged; institutions with ≤ 300 beds were the farthest from other levels, forming a relatively independent low detection spectrum. The standardized distribution shown in the heat map is basically consistent with the clustering results; see **Figure 2**.

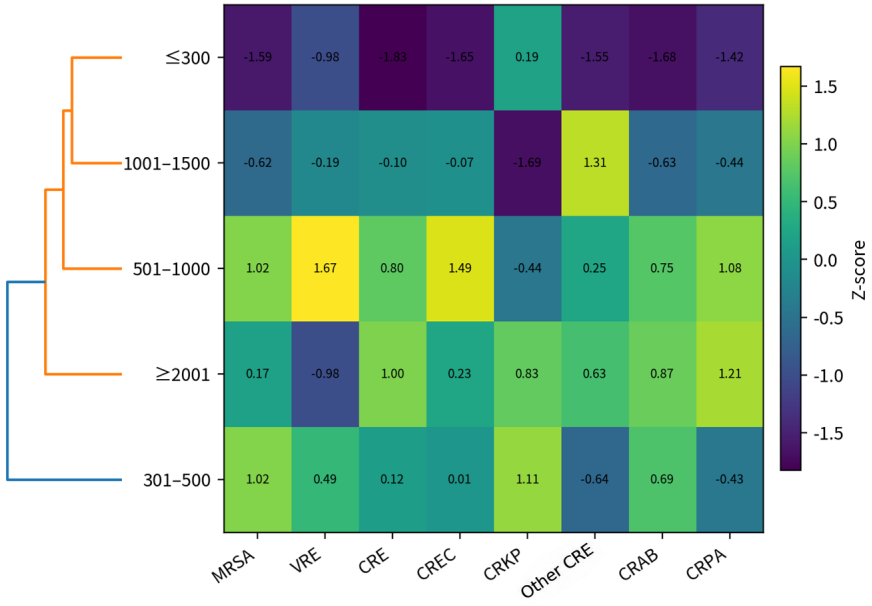

Figure 2. Z-score standardized heat map and hierarchical clustering of drug-resistant bacteria detection profiles in medical institutions with different bed sizes.

4. Discussion

This study shows that the detection rate of CRAB is 29.87%, which is significantly higher than that of other target bacteria. MRSA and CRPA are also at high levels, suggesting that the three are the focus of regional prevention and control. Acinetobacter baumannii can continue to survive on dry surfaces and in medical environments, and maintains its drug resistance advantage through mechanisms such as biofilms, efflux pumps, and carbapenemases. When critically ill patients, invasive operations, and broad-spectrum antibacterial drug exposure are superimposed, colonization and transmission are more likely to occur. Studies by Zhou Ping and others suggest that continuous informatized monitoring and strengthening MDRO prevention and control can reduce the risk of the spread of key drug-resistant bacteria [7]. Therefore, the regional platform should further shift from report summary to abnormal bacterial species identification, feedback, and closed-loop processing.

The overall detection rate difference between tertiary and secondary hospitals is only 0.33 percentage points, but the CRAB of secondary hospitals is 7.77 percentage points higher, and the CRPA of tertiary hospitals is 2.72 percentage points higher, indicating that hospital grade cannot simply replace drug resistance risk judgment. The differences may be related to the referral structure, allocation of critical care resources, exposure to invasive devices, use of antimicrobial drugs, density of testing, and infection control capabilities. Studies by Shen Xiaoyue and others have shown that locating MDRO based on real-time

monitoring and implementing precise hand hygiene intervention can simultaneously reduce MDRO infection and the detection rate of key drug-resistant bacteria [8]. Therefore, a two-dimensional early warning of strains and institutions should be established to strengthen the environmental transmission chain of CRAB and the management of CRPA-related wet environments and respiratory equipment, respectively.

Bed size analysis shows that the risk of resistance does not increase linearly with facility capacity. Institutions with 501 to 1,000 beds have the highest overall detection rate, while institutions with ≥ 2,001 beds have higher CRAB and CRPA levels, suggesting that medium and large institutions may be under pressure from rapid patient turnover, complex cases, exposure to antimicrobial drugs, and clustering of high-risk departments. CRPA can easily form a continuous source of pollution in waterways and wet equipment, while CRAB can rely on environmental persistence and contact to spread. Fan Pengchao and others confirmed in the CRAB hospital infection outbreak investigation that molecular epidemiology combined with environmental tracking can help identify hidden transmission chains [9]. Although the heat map and clustering in this study cannot replace molecular typing, they can be used for regional preliminary screening to determine priorities for on-site verification and environmental sampling. In addition, the overall detection rate of MDRO in this region is 6.25%, but the detection rate of some target bacteria is higher, while the incidence and case incidence of hospital infections are both 0.02%. Regional quality control should jointly observe the detection rate of key bacteria, indicators of hospital infection occurrence, institutional size, and changes in bacterial species spectrum, to avoid evaluating institutional risks based on a single overall rate.

5. Conclusion

Specific MDRO monitoring in a certain city showed dual heterogeneity at the bacterial species and medical institution levels. CRAB, MRSA, and CRPA should be regarded as regional key risk bacteria. It is recommended to unify the monitoring caliber, establish a hierarchical early warning mechanism linking hospital grade, bed size, and key bacterial species, and promptly transform abnormal detection spectra into key department verification, environmental cleaning, hand hygiene, and antimicrobial drug management measures. This study has certain limitations. Since the regional monitoring platform only provides summary data and lacks the original frequencies of bacterial species at each level, only descriptive comparisons between different hospital levels and bed sizes were made, and χ^2 tests and multi-factor analysis were not carried out. In addition, the number of included institutions is limited, and the samples at some bed levels are small, which may affect the stability of the results. In the follow-up, the monitoring scope should be expanded and more complete original data should be obtained to verify the research results further.

Disclosure statement

The authors declare no conflict of interest.

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