

# Analysis of Multi-Drug Resistant Organism Surveillance and Antimicrobial Resistance Early Warning in a Hospital in 2022

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**Abstract:** *Objective:* To determine the clinical distribution of multi-drug resistant organism (MDRO) in Jiangyan Hospital and the monitoring and warning of drug-resistance bacteria to provide an important basis for guiding the application of broad-spectrum antibiotics in clinical treatment and reducing the occurrence of nosocomial infection. *Methods:* Retrospective screening and analysis were conducted on the pathogenic strains of hospitalized patients in our hospital in 2022. *Results:* A total of 2,769 strains of pathogenic bacteria and 390 strains of MDRO were detected and isolated in our hospital in 2022; the detection rate of MDRO was 14.08%. A total of 516 strains (18.64%) *Klebsiella pneumoniae* (KP) and 62 strains (12.02%) of carbapenem-resistant *Klebsiella pneumoniae* (CR-KP) were detected; 436 strains (15.75%) of *Escherichia coli* (ECO) were detected, including 8 strains (1.83%) of CR-ECO; 342 strains (12.35%) of *Pseudomonas aeruginosa* (PA) and 116 strains (33.92%) of CR-PA were detected; there were 194 strains (7.01%) of *Acinetobacter baumannii* (AB), among which 125 strains (64.43%) were CR-AB; there were 291 strains (10.51%) of *Staphylococcus aureus*, among which 79 strains (27.15%) of methicillin-resistant *Staphylococcus aureus* (MRSA) were detected; 78 strains (2.82%) of *Enterococcus faecalis* were detected, and vancomycin-resistant enterococcus (VRE) was not detected. The first five MDROs were CR-AB, CR-PA, MRSA, CR-KP, and CR-ECO. The top five departments with the highest MDRO detection rate in 2022 were the ICU (37.44%), the Pulmonology Department (ward 13; 31.03%), the Department of Rehabilitation (ward 5; 6.67%), the Department of Neurosurgery (ward 11; 4.62%), and the Department of General Surgery (ward 10; 3.59). The resistance rate of antibacterial drugs is divided into four levels for early warning: 30% to 40%, 41% to 50%, 51% to 75%, and 75% or more. *Conclusion:* Our hospital should strengthen the monitoring of antimicrobial resistance warning related to MDRO and the abuse of antimicrobial drugs. Based on the results of drug sensitivity and antimicrobial resistance warning, the use of antibiotics should be standardized in clinical practice to reduce nosocomial infection.

**Keywords:** Antimicrobial resistance; Antibiotics; Early warning; Multi-drug resistant organism

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## 1. Introduction

With the widespread use of broad-spectrum antimicrobial drugs in patients, the issue of antimicrobial resistance is worsening, and the detection rate of multi-drug resistant organism (MDRO) has risen sharply. The worsening antimicrobial resistance increases the hospitalization time of drug-resistant patients, the economic burden on patients [1], and the fatality rate [2]. The aim of this study was to evaluate and analyze the MDRO monitoring situation in Jiangyan Hospital of Traditional Chinese Medicine throughout 2022 and the early warning index of antimicrobial resistance in the same year to provide a basis for promoting

the active, effective, and rational use of various conventional broad-spectrum antimicrobial drugs by clinicians in our hospital, so as to reduce antimicrobial resistance in patients and the occurrence of nosocomial infections.

## 2. Materials and methods

### 2.1. Strain source

According to the requirements of the National Inspection Technology Operation Guidelines <sup>[3]</sup>, all pathogenic bacteria isolated from clinical specimens submitted for inspection (repeated strains from the same patient and the same site were excluded) were collected for disinfection inoculation and *in vitro* isolation and purification. The hospital's information system was used to collect target data, and WPS Office was used for statistical analysis. In this study, we selected a few common drug-resistant bacteria for analysis, including carbapenem-resistant *Pseudomonas aeruginosa* (CR-PA), carbapenem-resistant *Escherichia coli* (CR-ECO), carbapenem-resistant *Acinetobacter baumannii* (CR-AB), methicillin-resistant *Staphylococcus aureus* (MRSA), and carbapenem-resistant *Klebsiella pneumoniae* (CR-KP) <sup>[4]</sup>. Ward 4 and Ward 9 belong to the Department of Orthopedics and Traumatology, Ward 5 belongs to the Department of Rehabilitation, Ward 6 belongs to the Department of Orthopedics 1, Ward 7 belongs to the Department of Orthopedics 2, Ward 8 belongs to the Department of Orthopedics 3, Ward 10 belongs to the Department of General Surgery, Ward 11 belongs to the Department of Neurosurgery, Ward 12 belongs to the Department of Thoracic Surgery, Ward 13 belongs to the Pulmonology Department, Ward 14 belongs to the Department of Cardiovascular Disease, Ward 15 belongs to the Oncology Department, Ward 16 belongs to the Department of Encephalopathy, Ward 17 belongs to the Department of Pediatrics, and Ward 18 belongs to the Department of Geriatrics.

### 2.2. Pathogen identification and drug susceptibility test

For bacteria identification and drug susceptibility test, VITEK 2 COMPACT (bioMerieux, France) bacterial identification card and supporting drug sensitivity card was used. The quality-control strains were *Pseudomonas aeruginosa* ATCC27853, *Escherichia coli* ATCC25922, and *Staphylococcus aureus* ATCC29213, which were purchased from Symerfeld, USA. Drug susceptibility test was performed according to the American Clinical and Laboratory Standards Institute (CLSI) M100-S29 <sup>[5]</sup> standard operation and result judgment, supplemented by Kirby-Bauer (KB) Paper method. The medium used for blood plate and drug susceptibility test was MH agar plate purchased from Antu Company, and the drug susceptibility reagent disc of KB method agar was imported from the United Kingdom.

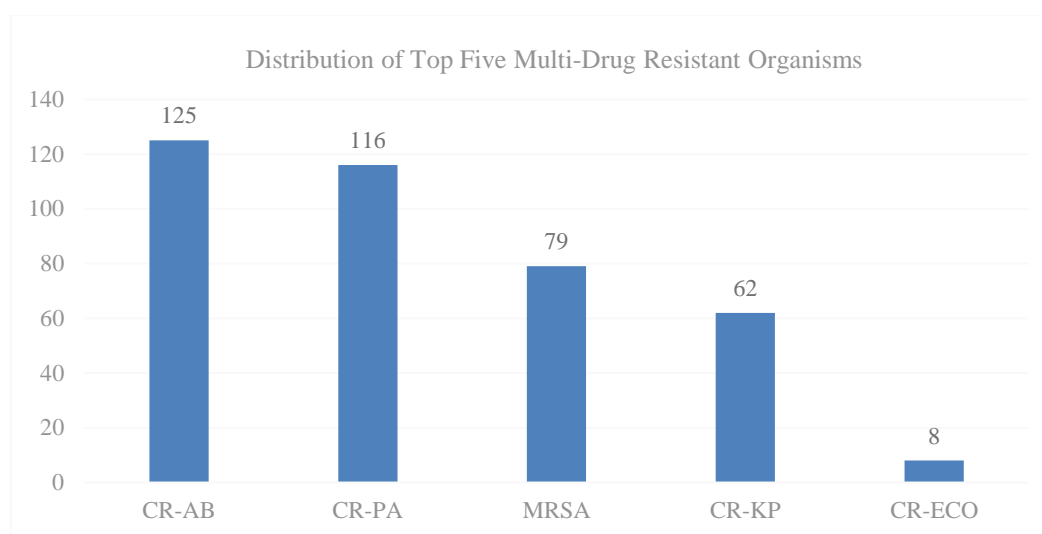
## 3. Results

### 3.1. Bacterial distribution

Among the bacteria detected in 2022, Gram-negative bacteria were the main ones; 516 strains (18.64%) of KP were detected, of which 62 strains (12.02%) were CR-KP; 436 strains (15.75%) of ECO were detected, of which 8 strains (1.83%) were CR-ECO; 342 strains (12.35%) of PA were detected, of which 116 strains (33.92%) were CR-PA; there were 194 strains (7.01%) of AB, of which 125 strains (64.43%) were CR-AB; there were 291 strains (10.51%) of SA, of which methicillin resistance was detected in 79 strains (27.15%); 78 strains (2.82%) of *Enterococcus faecalis* were detected without VRE. The top five MDROs were CR-AB, CR-PA, MRSA, CR-KP, and CR-ECO. See **Table 1** and **Figure 1** for more details.

**Table 1.** Detection of pathogenic bacteria and MDROs

Bacteria name	Detected number (strain)	Detection rate (%)	Multidrug-resistant bacteria	Detected number (strain)	Detection rate (%)
<i>Klebsiella pneumoniae</i>	516	18.64	CR-KP	62	12.02
<i>Escherichia coli</i>	436	15.75	CR-ECO	8	1.83
<i>Staphylococcus aureus</i>	291	10.51	MRSA	79	27.15
<i>Pseudomonas aeruginosa</i>	342	12.35	CR-PA	116	33.92
<i>Acinetobacter baumannii</i>	194	7.01	CR-AB	125	64.43
<i>Enterococcus faecalis</i>	78	2.82	VRE	0	0

**Figure 1.** Distribution of the top five MDROs

### 3.2. Clinical distribution of multi-drug resistant organism

In 2022, CR-AB was mainly distributed in the ICU, CR-PA was mainly distributed in the ICU and 13 other wards, and CR-KP was mainly distributed in 13 wards. The highest number of detected MDRO strains in our hospital was CR-AB, followed by CR-PA, and MRSA.

The top five departments with the highest detection rate of MDRO were the ICU (37.44%), Ward 13 (31.03%), Ward 5 (6.67%), Ward 11 (4.62%), and Ward 10 (3.59%). See **Table 2** and **Figure 2** for detailed results.

**Table 2.** Distribution of multi-drug resistant organism in each ward

Ward	MRSA	CR-KP	CR-PA	CR-AB	CR-ECO	Total
ICU	6	16	48	76	0	146
Ward 4	4	1	0	0	0	5
Ward 5	7	3	7	8	1	26
Ward 6	4	0	0	0	0	4
Ward 7	6	0	1	0	0	7
Ward 8	7	0	1	3	0	11
Ward 9	7	0	0	0	0	7
Ward 10	9	0	0	3	2	14

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Ward	MRSA	CR-KP	CR-PA	CR-AB	CR-ECO	Total
Ward 11	1	0	5	12	0	18
Ward 12	2	0	0	0	0	2
Ward 13	4	42	48	22	5	121
Ward 14	1	0	0	0	0	1
Ward 15	1	0	1	0	0	2
Ward 16	9	0	0	1	0	10
Ward 17	6	0	0	0	0	6
Ward 18	5	0	5	0	0	10
Total	79	62	116	125	8	390

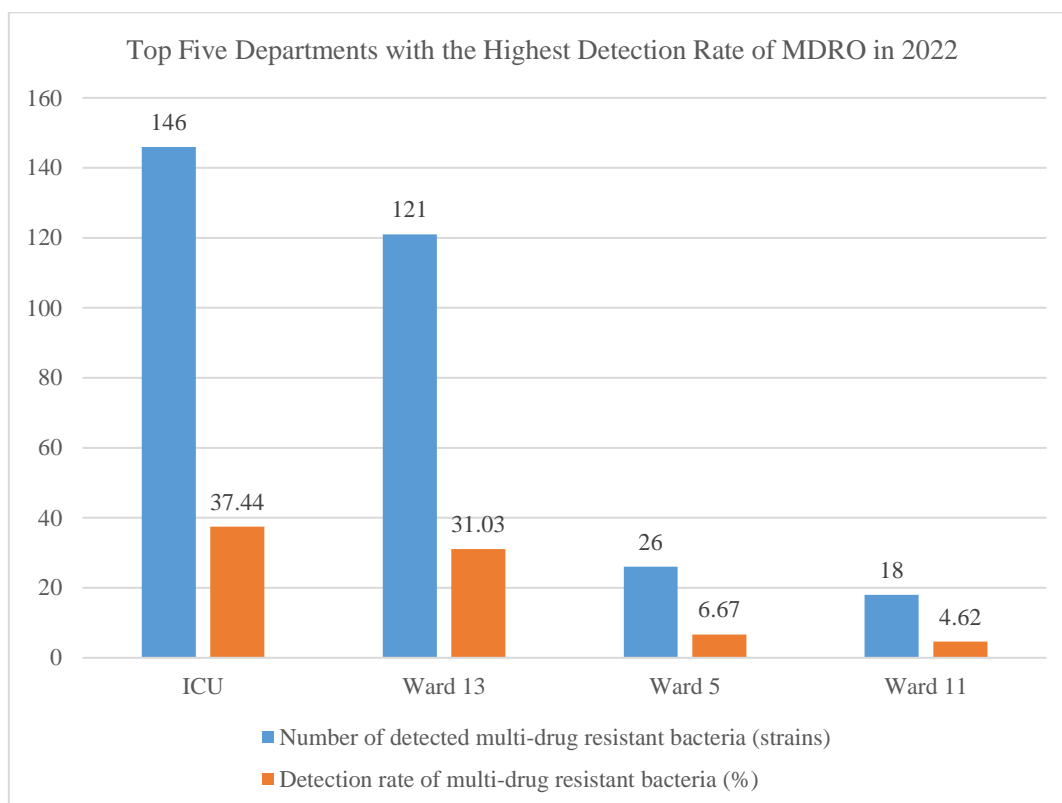
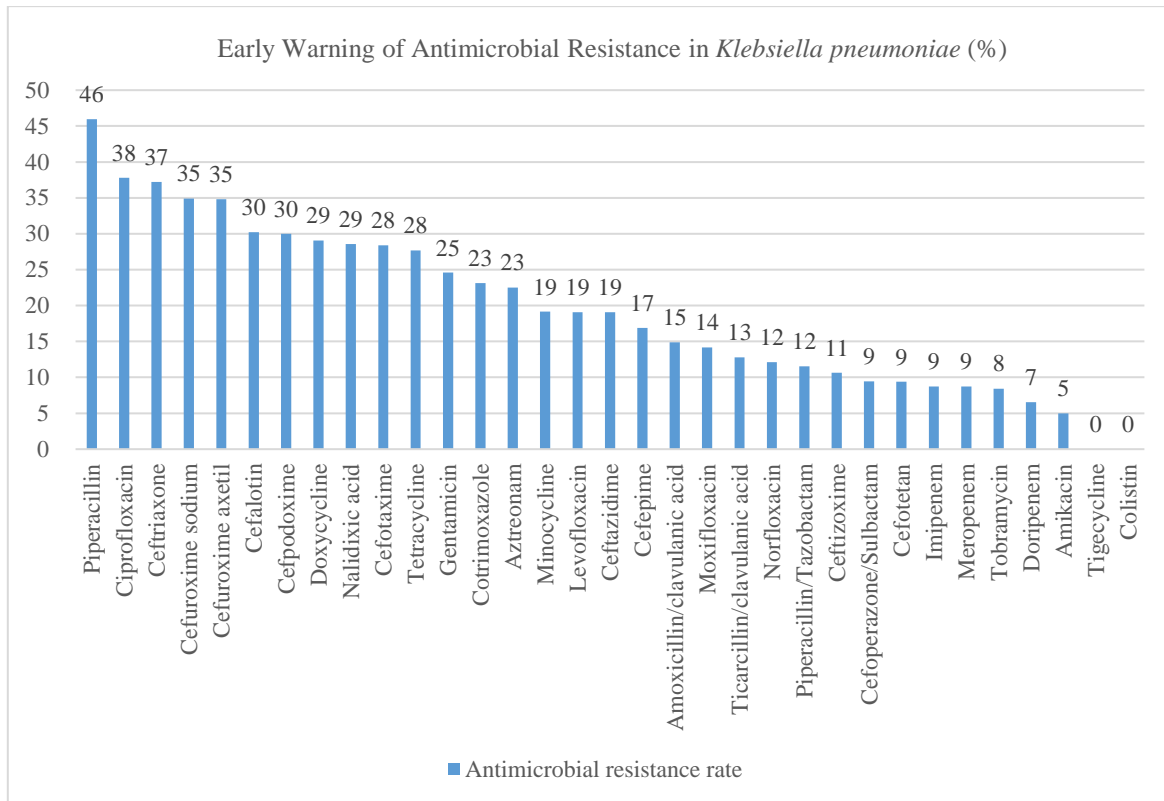


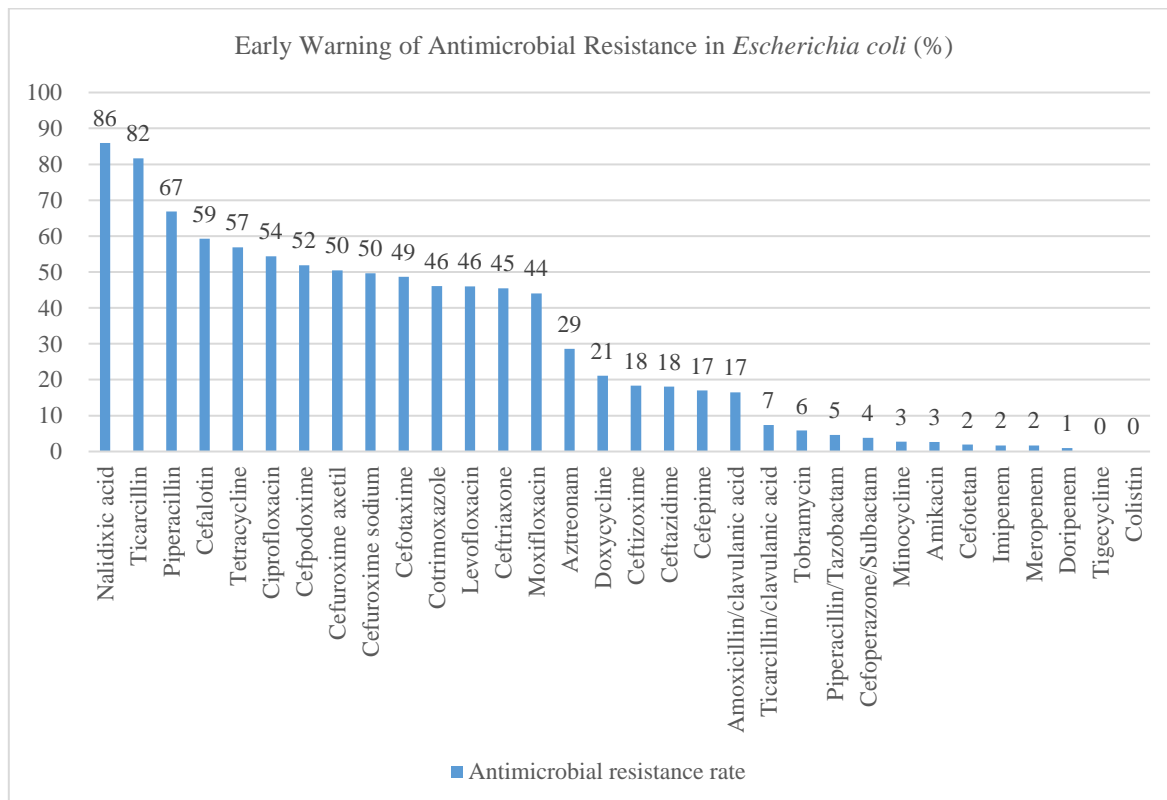
Figure 2. Top five wards with the highest detection rate of MDRO in 2022

### 3.3. Surveillance and early warning of antimicrobial resistance

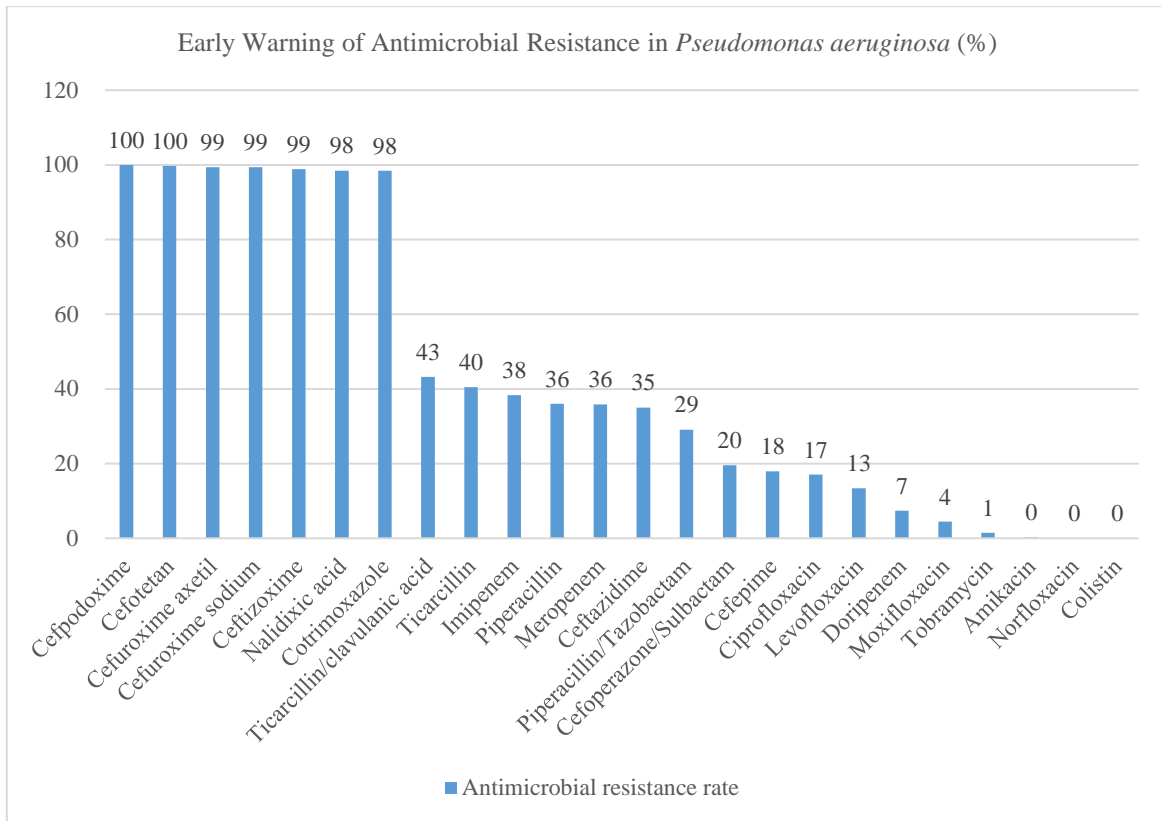
When the antimicrobial resistance rate is within 30%–40%, relevant medical institutions and medical staff should be notified; when the antimicrobial resistance rate is 51%–75%, antibiotics should be used with reference to the results of drug sensitivity tests; when the antimicrobial resistance rate of bacteria reaches more than 75%, the clinical application of antimicrobials should be suspended. The decision to resume the clinical application of antimicrobials is based on the results of antimicrobial resistance surveillance [6]. The ranking of the top five bacteria in proportion is as follows: KP, ECO, PA, SA, and AB. The antimicrobial resistance rate is shown in Figures 3–7.



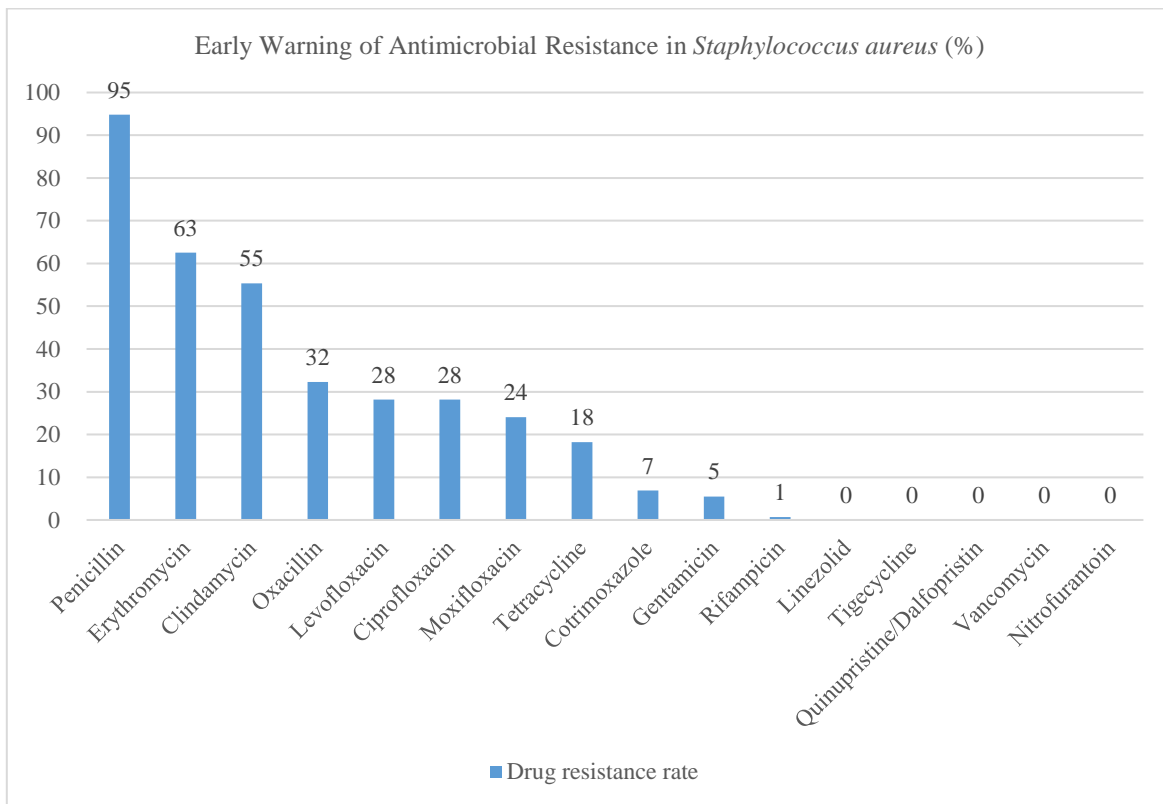
**Figure 3.** Surveillance and early warning of antimicrobial resistance in *Klebsiella pneumoniae*



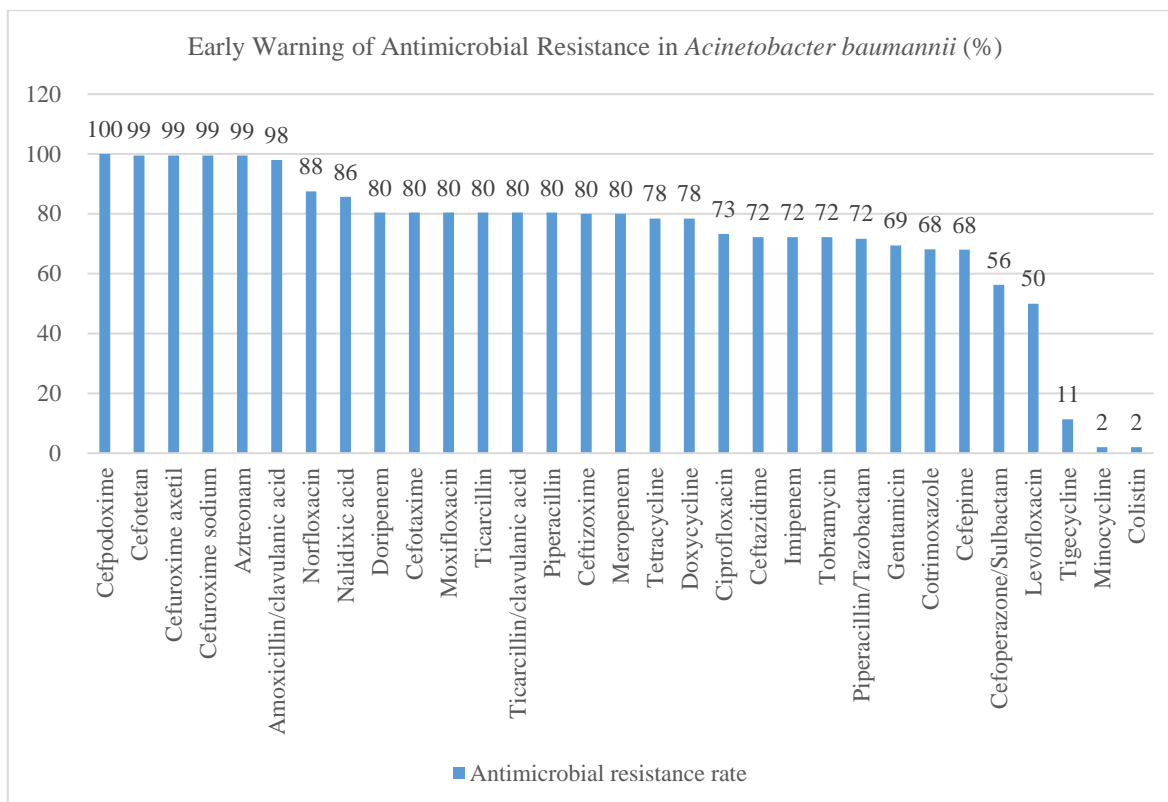
**Figure 4.** Surveillance and early warning of antimicrobial resistance in *Escherichia coli*



**Figure 5.** Surveillance and early warning of antimicrobial resistance in *Pseudomonas aeruginosa*



**Figure 6.** Surveillance and early warning of antimicrobial resistance in *Staphylococcus aureus*



**Figure 7.** Surveillance and early warning of antimicrobial resistance in *Acinetobacter baumannii*

#### 4. Discussion

With the widespread use of antibiotics, multi-drug resistance has become a major clinical issue, which not only leads to increased treatment costs, but also poses a significant threat to life and health [7]. Since 2018, our hospital has carried out quarterly and annual antimicrobial resistance surveillance and early warning work and published it on the hospital office automation OA to provide a basis for clinicians when choosing antimicrobials [8].

In 2022, our hospital isolated and collected 2,769 strains of pathogenic bacteria and 390 strains of MDRO from hospitalized patients. The detection rate of MDRO was 14.08%, which is lower than the detection rate of MDRO (32.07%) in a study by Zhang [9] but similar to the detection rate of MDRO (16.57%) in a study by Qiang [10]. This may be related to the regional differences in the distribution of MDRO. In our study, the top five MDROs were CR-AB (64.43%), CR-PA (33.92%), MRSA (27.15%), CR-KP (12.02%), and CR-ECO (1.83%), which differed from the study by You [11]. This may be due to the difference in MDRO distribution between traditional Chinese medicine hospitals and general hospitals. The department with the highest detection rate of MDRO in our hospital in 2022 was the ICU (37.44%); this finding is consistent with the finding of Xing [12], whose detection rate of MDRO was 30.3% in the ICU. In our hospital, CR-AB was found to be mainly distributed in the ICU. The reason for this may be that CR-AB is resistant to commonly used disinfectants; thus, it is difficult to eradicate it from the ICU environment and the surface of objects when contaminated. CR-AB is one of the most common pathogenic bacteria yet the most difficult to control in hospitals [13]. In addition, most patients admitted to the ICU have low immunity, are in severe states, had undergone major surgery, and are receiving broad-spectrum antimicrobials [14]. The widespread use of carbapenem has a predisposition for a large number of CR-AB. In our hospital, CR-PA was found to be mainly distributed in Ward 13 and the ICU. This may be due to the fact that patients in these wards generally have severe illness, a long course of disease, and low immunity, with some patients needing long-term broad-spectrum antibiotics [15]. CR-KP was also found to be mainly distributed in Ward

13, followed by the ICU. The majority of patients in Ward 13, under the Pulmonology Department, are elderly patients, and most of them have low immunity; this is the cause of CR-KP infection <sup>[16]</sup>. Admission to the ICU, endotracheal intubation, mechanical ventilation, and sputum suction are risk factors for CR-KP <sup>[17]</sup>, which easily lead to the growth of CR-KP in these two wards.

The analysis of the surveillance data in this clinical research showed that in 2022, KP, one of the common clinical opportunistic pathogens, ranked first in our hospital and was found to be sensitive to cephalosporins (cefotaxime, ceftazidime, cefepime, and ceftizoxime), cephalosporin antibiotics (cefotetan), tetracyclines (doxycycline, minocycline, tetracycline, and tigecycline), colistin, co-trimoxazole, aztreonam, quinolones (levofloxacin, norfloxacin, and moxifloxacin), carbapenems (imipenem, meropenem, and doripenem), aminoglycosides (tobramycin and amikacin), amoxicillin/clavulanic acid, ticarcillin/clavulanic acid, piperacillin/tazobactam, cefoperazone/sulbactam, and gentamicin. According to the report, the rate of resistance to cephalosporins (first-generation, cefotaxime and ceftazolin; second-generation, cefuroxime; third-generation, ceftriaxone and cefepime) and quinolones (nalidixic acid and cyclic ciprofloxacin) is between 30% and 40%, while the rate of resistance to ampicillin/sulbactam and piperacillin is between 41% and 50%. Medication should be given cautiously. For urinary tract infection, nitrofurantoin should be selected according to the antibiotic susceptibility results instead of empiric antibiotics. ECO ranked second in our hospital in 2022 and was found to be sensitive to aztreonam, gentamicin, tetracyclines (doxycycline, minocycline, and tigecycline), cephalosporin antibiotics (cefixime, ceftazidime, and cefepime), amoxicillin/clavulanic acid, ticarcillin/clavulanic acid, piperacillin/tazobactam, cefoperazone/sulbactam, aminoglycosides (tobramycin and amikacin), cephalosporins, cefotetan, carbapenems (imipenem, meropenem, and doripenem), and peptides. The rate of resistance to norfloxacin reached 36%. The medical staff in our hospital were notified. The resistance rate to antibacterial drugs, such as ampicillin/sulbactam, co-trimoxazole, quinolones (levofloxacin, moxifloxacin), cephalosporins (cefazolin, cefuroxime, cefotaxime, ceftriaxone, and cefepime), etc., is between 41% and 50% thus they can be used with caution. Antimicrobials should be used promptly if they are discovered. The rate of resistance to piperacillin, ciprofloxacin, tetracycline, and cephalothin is between 51% and 75%. When selecting antimicrobials, antibiotic susceptibility test results should be referred to, and they should not be used empirically. The rate of resistance to ticarcillin, ampicillin, and nalidixic acid is more than 75%; hence, clinicians should actively avoid the use of these antimicrobials. At the same time, the drug department should track it before deciding whether to resume medication. Cefoperazone/sulbactam, piperacillin/tazobactam, cefepime, quinolones (norfloxacin, ciprofloxacin, levofloxacin, and moxifloxacin), gentamicin, aminoglycosides (tobramycin and amikacin), colistin, and other antimicrobial-sensitive PA ranked third in our hospital in 2022. These drugs were used to treat PA, and the medical staff were informed of the resistance rate (between 31% and 40%) to ceftazidime, piperacillin, and carbapenem (imipenem and meropenem). Ticarcillin/clavulanic acid should be used with caution considering the 43% resistance rate. Clinicians should not use antimicrobials with a resistance rate of more than 75%. These antimicrobials include nalidixic acid, cefotetan, and cephalosporins (ceftizoxime, cefuroxime, ceftazidime, and ceftazolin). SA ranked fourth in our hospital in 2022, and its rate of resistance to clindamycin and erythromycin reached 51%–75%. The antibiotic sensitivity test results should be referred to when choosing antimicrobials. The rate of resistance to penicillin was found to be 95%. Therefore, clinicians should avoid using penicillin in such cases. When choosing drugs, it is necessary to pay attention to the antimicrobial resistance rate. Although AB ranked fifth, it has the highest antimicrobial resistance and is only sensitive to three drugs (minocycline, tigecycline, and colistin). The rate of resistance to cefoperazone/sulbactam, ampicillin/sulbactam, piperacillin/tazobactam, ceftazidime, ceftriaxone, cefepime, co-trimoxazole, gentamicin, tobramycin, imipenem, and quinolones (levofloxacin and ciprofloxacin) reached 50%–75%. If these antibiotics are used, the rate of resistance to these antibiotics may increase. On the other hand, the



rate of resistance to tetracyclines (doxycycline), piperacillin, ticarcillin/clavulanic acid, amoxicillin/clavulanic acid, ticarcillin, carbapenem (doripenem and meropenem), cefotetan, quinolones (nalidixic acid, moxifloxacin, and norfloxacin), cephalosporins (cefazolin, cefotaxime, cefuroxime, ceftizoxime, and cefpodoxime) was found to be more than 75%; thus, their use should be avoided. The irrational use of antimicrobials will lead to bacterial resistance.

When using antimicrobials, it is imperative to monitor the antimicrobial resistance of bacteria and make timely announcements and notifications, so as to reduce nosocomial infections, while referring to drug sensitivity results.

Our hospital's inpatients were taken as the research subjects in the present study. By analyzing the hospital's surveillance of MDRO and early warning of antimicrobial resistance of the top five bacteria in the hospital, we provide a basis for the rational use of antibiotics in hospitals through this study. With the aim of reducing nosocomial infection, it is necessary to continuously strengthen the surveillance of MDRO and early warning of antimicrobial resistance, as well as effectively prevent the incipient development of diseases and the ineffectiveness of antibiotics.

### **Disclosure statement**

The authors declare no conflict of interest.

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