Observational Study

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Monitoring of antimicrobial resistance in respiratory tract pathogens during the COVID-19 pandemic

A retrospective study

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Abstract

To understand the distribution and antimicrobial resistance (AMR) of pathogens in respiratory samples in Changle District People's Hospital in Fujian Province in recent years, and provide empirical guidance for infection control and clinical treatment in the region. A retrospective analysis was conducted on 5137 isolates of pathogens from respiratory samples collected from 2019 to 2022. The AMR patterns were systematically analyzed. For research purposes, the data was accessed on October 12, 2023. A total of 3517 isolates were included in the study, including 811 (23.06%) gram-positive bacteria and 2706 (76.94%) gram-negative bacteria. The top 3 gram-positive bacteria were *Staphylococcus aureus* with 455 isolates (12.94%), *Streptococcus pneumoniae* with 99 isolates (2.81%), and *Staphylococcus hemolytic* with 99 isolates (2.81%). The top 3 gram-negative bacteria were *Klebsiella pneumoniae* with 815 isolates (23.17%), *Pseudomonas aeruginosa* with 589 isolates (16.75%), and *Acinetobacter baumannii* with 328 isolates (9.33%). The proportion of extended-spectrum beta-lactamase (ESBL)-producing *Escherichia coli* and *K pneumoniae* fluctuated between 41.9% and 70.5%, and 18.6% and 20.9%, respectively. The resistance rates of *E coli*, *K pneumoniae*, *P aeruginosa*, and *A baumannii* to carbapenems were 2.36%, 8.9%, 18.5%, and 19.6%, respectively. The prevalence of methicillin-resistant *S aureus* (MRSA) was 48.55%, but it decreased to 38.4% by 2022. The resistance rate of *Staphylococcus haemolyticus* to methicillin was 100%, and 1 case of vancomycin-resistant strain was detected. *K pneumoniae, P aeruginosa, A baumannii,* and *S aureus* are the main pathogens in respiratory samples. Although the resistance rates of some multidrug-resistant strains have decreased, ESBL-producing Enterobacteriaceae, carbapenem-resistant bacteria have still increased. Therefore, it is necessary to strengthen the monitoring of pathogen resistance, promote rational use of antibiotics, and promptly report findings.

Abbreviations: AMR = antimicrobial resistance, CRAB = carbapenem-resistant *Acinetobacter baumannii*, CRECO = carbapenem-resistant *Escherichia coli*, CRKP = carbapenem-resistant *Klebsiella pneumoniae*, CRPA = carbapenem-resistant *Pseudomonas aeruginosa*, ECO = *E. coli*, ESBL = extended-spectrum beta-lactamase, MRSA = methicillin-resistant *Staphylococcus aureus*.

Keywords: antimicrobial resistance, clinical distribution, multidrug resistance, pathogens

1. Introduction

Antimicrobial resistance (AMR) is 1 of the major threats to global health, causing negative impacts in various areas.[1,2] It makes the treatment of common infections more difficult, resulting in high medical costs, longer hospital stays, and increased mortality rates. Despite the widespread recognition and attention to antibiotic resistance, the incidence of multidrug-resistant bacterial infections and their spread continues to rise. Multidrug-resistant bacterial infections have become a global public health problem and a clinical challenge. Therefore, preventing and controlling the spread of multidrug-resistant bacteria is 1 of the biggest challenges in infection control today. Due to the scarcity of new antimicrobial drugs and the increasing resistance of bacteria to multiple antibiotics, multidrug-resistant bacteria (MDR) are increasing, leading to treatment failure and making antibiotic-resistant bacteria a major threat to global health.[3,4] Each year, antibiotic-resistant bacterial infections cause approximately 700,000 deaths globally, and it is estimated that by 2050, this number will exceed 10 million deaths.[5] The mechanisms by which pathogens develop antibiotic resistance include Decreased intracellular antibiotic concentration, Modification of antibiotic targets, and 3. Antibiotic inactivation.[6] Currently, many

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

This study was approved by the institutional ethics board of Fuzhou Changle District People's Hospital. Informed consent was waived as this study only involved analysis of anonymous existing data and records.

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governments, along with the World Health Organization (WHO) and the United Nations (UN), are working together to reduce and prevent the development of resistance and to study the mechanisms of bacterial resistance. This is a battle with no smoke. China has also established the Chinese Antimicrobial Resistance Surveillance System (CARSS) and the China Antimicrobial Resistance Surveillance Network (CHINET) to monitor the resistance of bacteria. However, due to differences in bacterial distribution, detection, and resistance in different regions, empirical antibiotics must be selected based on local bacterial distribution and resistance data. Therefore, the main objective of this study is to evaluate the microbiological spectrum and antibiotic resistance patterns in a general hospital in Fujian Province, in order to guide early diagnosis and the selection of empirical antibiotics in clinical practice, thus reducing the disease burden in the region.

2. Materials and methods

2.1. General information

This retrospective study aimed to investigate the distribution and resistance patterns of pathogens isolated from respiratory samples in a local hospital from 2019 to 2022. Exclusion criteria included fungi, contaminants, or uncommon pathogenic microorganisms. In the end, 3517 cases of pathogenic microorganisms were included. For research purposes, the data was accessed on December 20, 2023. This study was approved by the institutional ethics board of Fuzhou Changle District People's Hospital. Informed consent was waived as this study only involved analysis of anonymous existing data and records.

2.2. Methods

Strict adherence to standard operating procedures for the collection and culture of respiratory samples. The VITEK2 Compact fully automatic bacterial identification and susceptibility testing system was used for identification. The Kirby-Bauer method, minimum inhibitory concentration (MIC) method, or E-test method were used for antimicrobial susceptibility testing, and the Clinical and Laboratory Standards Institute (CLSI) guidelines were used as the standard for interpreting the results.

2.3. Statistical analysis

Counts and percentages were calculated for categorical variables, and χ^2 test was used for analysis. Continuous variables were represented by medians with interquartile range. All data were collected, stored, and sorted in a Microsoft Excel workbook. Data analysis was performed using SPSS 22.0 software, and primphpad 9.0 was used for graphic presentation. A *P* value < .05 was considered statistically significant.

3. Results

3.1. Distribution of common bacterial pathogens

From January 1, 2019, to December 31, 2022, a total of 3517 cases of bacteria isolated from respiratory tract samples were collected in this study. Gram-negative bacteria accounted for 76.94% (2706/3517) of the total, while gram-positive bacteria accounted for 23.06% (811/3517), with gram-negative bacteria being predominant. The top 9 pathogens identified were *Klebsiella pneumoniae* (815/3517; 23.17%), *Pseudomonas aeruginosa* (589/3517; 16.75%), *Staphylococcus aureus* (455/3517; 12.94%), Acinetobacter baumannii (328/3517; 9.33%), *Escherichia coli* (289/3517; 8.21%), *S. maltophilia* (233/3517; 6.62%), *P aeruginosa* (134/3517; 3.81%), *S haemolyticus* (99/3517; 2.81%), and *Streptococcus pneumoniae* (99/3517; 2.81%) (Table 1).

3.2. Distribution of major pathogens according to clinical department

The isolation and detection rates of different pathogens vary greatly among different departments. In the internal medicine ward, apart from *A baumannii* (27.6%), the other 8 pathogens are the most common. Among them, *K pneumoniae* (58.9%), *P aeruginosa* (53.7%), *S aureus* (51.0%), *S. maltophilia* (44.6%), *E coli* (41.7%), and *S pneumoniae* (48.1%) all account for more than 41%. In the surgical department, the occurrence rate of *A baumannii* (36.2%) is higher than that in the pediatric department (15.7%), internal medicine (27.6%), and ICU (20.5%) (*P* < .001) (Fig. 1).

3.3. AMR patterns of the major gram-positive bacteria

As shown in Table 2, 2 strains of Staphylococcus were isolated from respiratory samples: *S aureus* and *S haemolyticus*. Both strains exhibited a resistance rate of over 90% against penicillin G. The resistance to methicillin depends on resistance to oxacillin, resulting in an average methicillin resistance rate of 59.3% for *S aureus* from 2019 to 2022. However, in 2022, the methicillin-resistant *S aureus* (MRSA) decreased to 38.04%. All *S aureus*

Table 1

Common bacterial pathogens isolated from respiratory tract samples, 2019 to 2022.

Pathogen	2019 *N* (%)	2020 *N* (%)	2021 *N* (%)	2022 *N* (%)	Total *N* (%)
Gram-positive organisms					23.06%
Staphylococcus aureus	62 (10.3%)	121 (12.89%)	130 (13.05%)	142 (14.49%)	455 (12.94%)
Staphylococcus haemolyticus	26 (4.32%)	27 (2.88%)	35 (3.51%)	11 (1.12%)	99 (2.81%)
Streptococcus pneumoniae	16 (2.66%)	20 (2.13%)	34 (3.41%)	29 (2.96%)	99 (2.81%)
Other gram-positive organisms	28 (4.65%)	40 (4.62%)	47 (4.72%)	43 (4.39%)	158 (4.49%)
Gram-negative organisms					76.94%
Klebsiella pneumoniae	139 (23.09%)	212 (22.58%)	234 (23.49%)	230 (23.47%)	815 (23.17%)
Pseudomonas aeruginosa	105 (17.44%)	154 (16.4%)	162 (16.27%)	168 (17.14%)	589 (16.75%)
Acinetobacter baumannii	71 (11.79%)	103 (10.97%)	90 (9.04%)	64 (6.53%)	328 (9.33%)
Stenotrophomonas maltophilia	52 (8.64%)	63 (6.71%)	60 (6.02%)	58 (5.92%)	233 (6.62%)
Escherichia coli	41 (6.81%)	80 (8.52%)	80 (8.03%)	88 (8.98%)	289 (8.21%)
Proteus mirabilis	12 (1.99%)	34 (3.62%)	22 (2.21%)	66 (6.73%)	134 (3.81%)
Other gram-negative organisms	50 (8.31%)	85 (9.05%)	102 (10.24%)	81 (8.27%)	318 (9.04%)
Total *N* (%)	602 (17.11%)	939 (26.70%)	996 (28.32%)	980 (27.86%)	3517 (100%)

A/B (%), number resistant/number tested (percentage resistant).

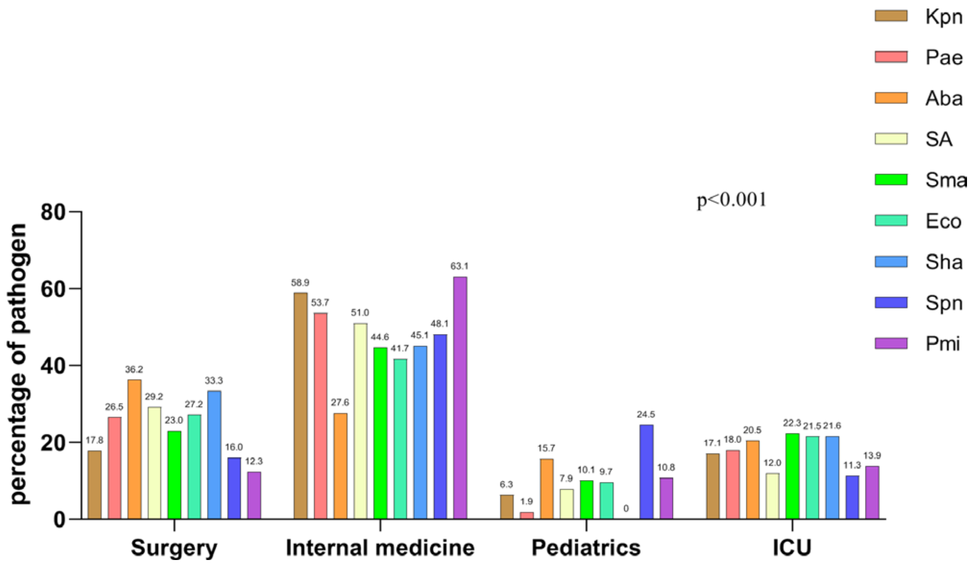

Figure 1. Distribution of major pathogens according clinical departmen 2019 to 2022. Aba = *Acinetobacter baumannii*, Eco = *Escherichia coli*, Kpn = *Klebsiella pneumonia*, Pae = *Pseudomonas aeruginosa*, Pmi = *Proteus mirabilis*, SA = *Staphylococcus aureus*, Sha = *Staphylococcus haemolyticus*, Sma = *Stenotrophomonas maltophilia*, Spn = *Streptococcus pneumonia*.

Table 2

Resistance rates of major gram-positive bacteria, 2019 to 2022.

Antimicrobial agent	*Streptococcus pneumoniae* A/B (%)	*Staphylococcus aureus* A/B (%)	*Staphylococcus haemolyticus* A/B (%)
Oxacillin	–	270/455 (59.3%)	99/99 (100.0%)
Penicillin G	–	426/455 (93.6%)	99/99 (100.0%)
Amoxicillin	36/99 (36.4%)	–	–
Ampicillin	–	–	–
Cefotaxime	31/99 (31.3%)	–	–
Ceftriaxone	31/99 (31.3%)	–	–
telithromycin	0/99 (0.0%)	–	–
Erythromycin	86/92 (93.5%)	284/455 (62.4%)	98/99 (99.0%)
Quinupristin/dalfopristin	–	0/455 (0.0%)	1/99 (1.0%)
Clindamycin	–	258/455 (56.7%)	44/99 (44.4%)
Gentamicin	–	106/455 (23.3%)	84/99 (84.8%)
Ciprofoxacin	–	157/455 (34.5%)	99/99 (100.0%)
Moxifoxacin	0/99 (0.0%)	110/455 (24.2%)	88/99 (88.9%)
Levofoxacin	4/99 (4.0%)	155/455 (34.1%)	99/99 (100.0%)
Rifampin	–	2/455 (0.4%)	24/99 (24.2%)
Nitrofurantoin	–	0/455 (0.0%)	0/99 (0.0%)
Co-trimoxazole	57/99 (57.6%)	132/455 (29.0%)	36/99 (36.4%)
Tetracycline	92/99 (92.9%)	115/455 (25.3%)	52/99 (52.5%)
Vancomycin	0/99 (0.0%)	0/441 (0.0%)	1/99 (1.0%)
Linezolid	0/99 (0.0%)	1/455 (0.2%)	3/99 (3.0%)
Tigecycline	–	0/455 (0.0%)	0/88 (0.0%)
Chloramphenicol	8/97 (8.2%)	–	–

A/B (%), number resistant/number tested (percentage resistant).
A dash (–) indicates that antibiotics were not tested against the isolated pathogens.

strains were sensitive to vancomycin, with 1 case of resistance to linezolid detected. As for *S haemolyticus*, it exhibited resistance rates of 99% to benzylpenicillin, penicillin G, erythromycin, ciprofloxacin, and levofloxacin. One case of resistance to vancomycin and 3 cases of resistance to linezolid were detected. *S pneumoniae* showed resistance rates >92% to erythromycin and tetracycline, but no strains resistant to vancomycin or linezolid were detected.

3.4. AMR patterns of the major gram-negative bacteria

As shown in Table 3, *E coli* exhibited resistance rates exceeding 50% to ampicillin, cefotaxime, ceftriaxone, ampicillin/sulbactam, ciprofloxacin, levofloxacin, amikacin, and sulfamethoxazole/trimethoprim. The proportion of carbapenem-resistant *E coli* (CRECO) isolates was 2.5%. *K pneumoniae*, apart from being natural drug-resistant to ampicillin, showed sensitivity rates exceeding 53% to the other antibiotics tested. However, the proportion of carbapenem-resistant *K pneumoniae* (CRKP) was 17.1%. *P aeruginosa* exhibited sensitivity rates >78% for all antibiotics tested except imipenem, which had a resistance rate of 24.1%. *A baumannii* showed sensitivity rates exceeding 64% to aminoglycosides and fluoroquinolones. However, the resistance rates to ceftazidime, ceftazidime/avibactam, amikacin exceeded 99%. The proportion of carbapenem-resistant *A baumannii* (CRAB) reached 29.9%.

3.5. Trend of antibiotic resistance in key bacteria

As shown in Figure 2, we have observed the trend of antibiotic resistance in key bacteria from 2019 to 2022. The resistance rate of extended-spectrum beta-lactamase (ESBL)-producing *E coli* increased from 41.94% in 2019 to 68.42% in 2022. The resistance rate of CRKP increased from 2.4% in 2019 to 11.04% in 2022. The resistance rate of CRAB has been increasing each year, rising from 6.38% in 2019 to 28.21% in 2022. The resistance rate of MRSA increased from 34.21% in 2019 to 63.38% in 2021 and then decreased to 38.04% in 2022. The resistance trends of other pathogens remained relatively stable.

4. Discussion

The infection caused by multidrug-resistant organisms (MDRO) has resulted in serious social harm due to limited antibiotic options for patients. MDRO infections not only increase the incidence and mortality rates in patients but also impose a significant economic burden.[7] Additionally, implementing preventive isolation measures in hospitals can lead to increased direct and indirect costs, as well as severe negative impacts on patient care.[8,9] In recent years, MDRO infections in different countries and regions have shown an upward trend.[10,11] Therefore, it is necessary to monitor the trends of antibiotic resistance (AMR) in hospitals in the long term and guide clinical anti-infection treatment by analyzing patterns of antibiotic resistance (AMR). Our study results will contribute to the management of this field and help improve global antibiotic policies.

Table 3

Resistance rates of major gram-negative bacteria, 2019 to 2022.

Antimicrobial agent	*Aba* A/B (%)	*Eco* A/B (%)	*Kpn* A/B (%)	*Pmi* A/B (%)	*Pae* A/B (%)	*Sma* A/B (%)
Ampicillin	319/320 (99.7%)	270/288 (93.8%)	811/811 (100.0%)	93/134 (69.4%)		–
Piperacillin	–	–	–	–	55/506 (10.9%)	–
Cefazolin	327/327 (100.0%)	54/67 (80.6%)	65/137 (47.4%)	16/22 (72.7%)		–
Cefuroxime	–	–	–	–	494/502 (98.4%)	–
Ceftriaxone	103/327 (31.5%)	207/288 (71.9%)	317/812 (39.0%)	60/134 (44.8%)	–	–
Ceftazidime	94/328 (28.7%)	85/286 (29.7%)	214/813 (26.3%)	1/134 (0.7%)	126/619 (20.4%)	–
Cefepime	110/328 (33.5%)	65/283 (23.0%)	171/809 (21.1%)	5/131 (3.8%)	60/631 (9.5%)	–
Cefotetan	326/327 (99.7%)	8/286 (2.8%)	138/812 (17.0%)	10/134 (7.5%)	594/605 (98.2%)	–
Ampicillin/Sulbactam	90/327 (27.5%)	167/286 (58.7%)	331/812 (40.8%)	82/134 (61.2%)	–	–
Piperacillin/tazobactam	–	11/288 (3.8%)	137/813 (16.9%)	10/134 (7.5%)	31/597 (5.2%)	–
Tobramycin	75/328 (22.9%)	42/286 (14.7%)	163/813 (20.0%)	42/134 (31.3%)	22/620 (3.5%)	–
Gentamicin	102/327 (31.2%)	120/288 (41.7%)	206/812 (25.4%)	59/134 (44.0%)	33/618 (5.3%)	–
Amikacin	21/328 (6.4%)	16/288 (5.6%)	133/813 (16.4%)	0/134 (0.0%)	7/627 (1.1%)	–
Ciprofoxacin	117/328 (35.7%)	180/288 (62.5%)	279/813 (34.3%)	91/134 (67.9%)	116/632 (18.4%)	–
Levofoxacin	101/328 (30.8%)	166/286 (58.0%)	225/813 (27.7%)	68/134 (50.7%)	95/623 (15.2%)	15/243 (6.2%)
Aztreonam	318/321 (99.1%)	149/288 (51.7%)	271/812 (33.4%)	0/134 (0.0%)	136/597 (22.8%)	–
Co-trimoxazole	92/328 (28.0%)	178/286 (62.2%)	273/812 (33.6%)	95/134 (70.9%)	–	7/244 (2.9%)
Ertapenem	–	7/279 (2.5%)	138/809 (17.1%)	0/134 (0.0%)	–	–
Imipenem	98/328 (29.9%)	5/288 (1.7%)	139/813 (17.1%)	0/133 (0.0%)	154/638 (24.1%)	–
Nitrofurantoin	326/326 (100.0%)	3/286 (1.0%)	186/810 (23.0%)	125/134 (93.3%)	601/603 (99.7%)	–
Minocycline	–	–	–	–	–	0/241 (0.0%)

Aba = *Acinetobacter baumannii*, Eco = *Escherichia coli*, Kpn = *Klebsiella pneumoniae*, Pae = *Pseudomonas aeruginosa*, Pmi = *Proteus mirabilis*, Sma = *Stenotrophomonas maltophilia*.

A/B (%), number resistant/number tested (percentage resistant).

A dash (–) indicates that antibiotics were not tested against the isolated pathogens.

In this study, we collected a total of 3517 cases of bacteria isolated from respiratory samples from 2019 to 2022. Gram-positive bacteria were mainly represented by *S aureus*, while the top 3 gram-negative bacteria were *K pneumoniae*, *P aeruginosa*, *and A baumannii*. This differs from reports in other regions.[12,13] Additionally, there were significant differences in the isolated pathogenic bacteria among different departments, with the detection rate being significantly higher in internal medicine wards compared to surgical wards, pediatric wards, and ICU wards ($P < .001$).

Regarding bacterial resistance, global antibiotic resistance is in a state of rapid deterioration, necessitating action from society as a whole. CRAB, CRECO, carbapenem-resistant *P aeruginosa* (CRPA), and CRKP, among other carbapenem-resistant bacteria, have been increasing in recent years and pose a significant challenge to antibiotic management. Improper use of antibiotics not only leads to the development of antibiotic resistance but also increases healthcare costs and mortality rates. To address the growing problem, it is necessary to update epidemiological data on antibiotic susceptibility to support prevention and treatment efforts.

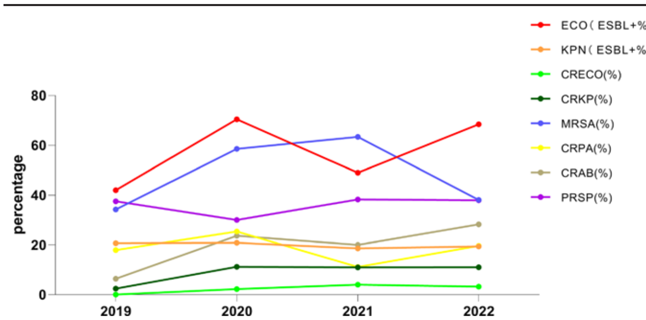

Figure 2. Trends of common multidrug-resistant strains isolated from respiratory tract samples in Changle China, 2019 to 2022. CRAB = *Carbapenem-resistant Acinetobacter baumannii*, CRECO = carbapenem-resistant *Escherichia coli*, CRKP = *carbapenem-resistant Klebsiella pneumoniae*, CRPA = *carbapenem-resistant Pseudomonas aeruginosa*, ESBL = Extended-spectrum beta-lactamase, MRSA = methicillin-resistant *Staphylococcus aureus*, PRSP = penicillin-resistant *Streptococcus pneumoniae*.

In recent years, the occurrence rate of ESBL-producing *E coli* and *K pneumoniae* has continued to rise due to antibiotic overuse, which is a matter of great concern. In our study, we observed that the occurrence rate of ESBL-producing *E coli* in 2019 was 41.94%, which is not significantly different from reports in other developing countries,[14,15] but much higher than the proportion in the United States (10.0%–15.0%).[16] Of note, by 2022, the occurrence rate of ESBL-producing *E coli* had risen to 68.42%, which may be attributed to the excessive use of antibiotics during the COVID-19 pandemic. *K pneumoniae* is also 1 of the most important hospital pathogens, and studies have shown that infections caused by ESBL-producing strains further increase the mortality rate in patients.[17] In our study, the detection rate of ESBL-producing *K pneumoniae* averaged 19.87% during the period from 2019 to 2022, with rates of 20.66%, 20.86%, 18.59%, and 19.35%, respectively, showing no significant increase. However, it is important to note that ESBL-producing *K pneumoniae* can be transmitted through person-to-person contact or environmental sources, making it more prone to outbreaks in hospitals.[18] It has been reported that such outbreaks have occurred in multiple countries, not only in developing countries but also in developed ones,[19–21] leading to further increases in healthcare costs and mortality rates. Therefore, continuous monitoring, preventive measures, and guidance for clinical medication, such as limiting the use of broad-spectrum cephalosporins, are necessary to control outbreaks of ESBL-producing *K pneumoniae* infections[22] and further reduce the resistance.

According to the data from the China Antimicrobial Resistance Surveillance System (CHINET), the incidence rate of CRKP has been increasing year by year in China, rising from 3.0% in 2005 to 25.0% in 2018.[23] Not only in developing countries but also in developed countries, the proportion of CRPA in pneumonia caused by *K pneumoniae* has also rapidly increased.[24]In our study, the proportion of CRKP has been increasing rapidly from 2.4% in 2019 to 11.04% in 2022.

Other countries have also reported a rapid increase in CRKP infections due to the concurrent bacterial infections during the COVID-19 pandemic.[25] The mortality rate of patients infected with CRKP is significantly higher compared to patients infected with carbapenem-sensitive *K pneumoniae* (CSKP),[26] and this is a cause for concern. Our research results are important for hospitals in limiting its transmission and optimizing antibiotic management in order to prevent the continued increase of CRKP.

According to research findings, the prevalence of CRAB in China has increased from 31% to 66.7%, while the prevalence of CRPA has shown a slight decrease over time but worsened from 2015, reaching 30.7% in 2018.[27,28] In our study, the detection rate of CRAB has been increasing year by year, rising from 6.38% to 28.21% since 2019. The average detection rate of CRPA is 18.5%, with no significant overall change in trend. However, based on global trends, the incidence of CRAB and CRPA is expected to increase annually. The frequent use of broad-spectrum antibiotics due to the COVID-19 pandemic further contributes to the rise of carbapenem resistance.[29] These factors pose a major threat to global public health, including increased clinical and economic burden, as well as a lack of effective treatment methods. Among gram-positive bacteria, *S aureus*, including MRSA, is 1 of the main strains. MRSA infections have been increasing every year and play a significant role in healthcare-associated infections. Due to the increase in MRSA infections, antibiotic use has also increased, leading to further increases in the number of MRSA infections. It has been reported that MRSA has developed resistance to most antibiotics.[30] Fortunately, with increased attention to MRSA, China has implemented strict monitoring programs, resulting in a significant decrease in the incidence rate of MRSA from 69.0% in 2005 to 35.3% in 2017.[31] In our study, the incidence rate of MRSA has also decreased to 38.04%. However, significant challenges still remain in the treatment of MRSA. While vancomycin remains the preferred drug for treating severe MRSA infections, there are concerns about its use, and frequent use of vancomycin can lead to the emergence of vancomycin-intermediate *S aureus* (VISA) and vancomycin-resistant *S aureus* (VRSA) strains, further contributing to resistance.[32–34] Fortunately, thus far, we have not found any vancomycin-resistant *S aureus* strains in our study. As for coagulase-negative staphylococci (CoNS), although *S haemolyticus* is typically reported in implantation and contamination forms, resistance to benzylpenicillin has been neglected. However, *S haemolyticus* are also the most common isolates in a hospital in northern India.[35] In our study, the detection rate of *S haemolyticus* is also significant, but the resistance rate to benzylpenicillin has reached 100%. Therefore, strengthening hospital infection control measures is necessary to prevent CoNS infections.

5. Conclusion

During the COVID-19 pandemic, *K pneumoniae*, *P aeruginosa*, *A baumannii*, and *S aureus* are the main pathogens in respiratory samples. Although the resistance rates of some multidrug-resistant strains have shown a decrease, the prevalence of ESBL-producing Enterobacteriaceae, CRKP, and CRAB has increased. Therefore, it is necessary to strengthen the monitoring of pathogen resistance, promote rational use of antibiotics, and promptly report the findings.

6. Limitations

However, our study has some limitations. Firstly, our research only analyzed respiratory samples from a tertiary hospital in Fujian Province, which may have introduced selection bias considering the geographical location. Secondly, our study only focused on the distribution and antibiotic sensitivity of bacteria isolated from respiratory samples, which is also a limitation. Additionally, our study utilized a preliminary and retrospective cross-sectional design, which carries certain limitations. Therefore, multicenter, longitudinal, and prospective studies are needed to validate our findings.

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Author contributions

Conceptualization: Ke Shi.
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Writing – original draft: Tongdeng You, Ke Shi.
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