Microbial Predominance and Antimicrobial Resistance in a Tertiary Hospital in Northwest China: A Six-Year Retrospective Study of Outpatients and Patients Visiting the Emergency Department

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1.Introduction

Increased usage of broad-spectrum antimicrobial treatments leads to microbial resistance to the treatments that were originally sensitive. The increased antimicrobial resistance (AMR) limits treatment options and is considered as a global challenge to public health with increased morbidity, mortality, and healthcare costs [1]. To accurately estimate the challenge, the surveillance of AMR profiling at local, regional, and national levels has been employed to understand the global trends on the type of predominant pathogens and their respective resistance profiling [2]. In China, the surveillance of AMR is established at the hospital, provincial, and national levels. For example, CHINET is one of well-established national surveillance networks for AMR [3–6]. This network
recently reported that the frequency of gram-negative bacilli among clinical isolates was over twice higher than that of gram-positive cocci [3, 4]. In addition, it is critical to recognize that China is a large country with variety of microbial occurrences and AMR profiling. For example, Xiao et al. reported that the percentage of MRSA (methicillin-resistant Staphylococcus aureus) in North Central and South Central China is higher than other regions [7]. The geographic variety is likely associated with regional differences in socioeconomic development [7]. Therefore, the microbial predominance and AMR profiling in a specific region and province is not always consistent with the trend at a national level. Indeed, the surveillance of AMR at the hospital and provincial levels is a valuable complement to the national surveillance. Furthermore, the updated AMR profiling at the hospital and regional levels is particularly important for physicians to determine the adequate empiric antimicrobial therapy in clinical practice. Therefore, the objectives of this study were to analyze the data from a six-year surveillance of AMR at an university affiliated tertiary hospital and to obtain the characteristics of microbial species and their antimicrobial resistances for both surveillance and clinical practice perspectives.

The routine surveillance was mainly focused on hospital-acquired infections, and most specimens were collected from inpatients with severe infections [8], while community-acquired infections from outpatient service were always underreported [2, 8]. Therefore, in our study, we tried to bridge the gap and studied the microbial predominance and AMR profiling in outpatient clinics and emergency department in a specific region of Northwestern China. Our results were also compared with the findings from the CHINET.

2. Materials and Methods

2.1. Data Source. This study was performed at the First Affiliated Hospital of Xi’an Jiaotong University, which is one of the largest hospitals in northwest China. It provides medical and surgical care to the residents of Shaanxi Province with a total population 37.33 million. The institutional review board at the First Affiliated Hospital approved this study (No: XJTU1AF2017LSK-83) and written informed consent was not required because the laboratory tests for microbiology are part of standard care and the patient records were excluded prior to this analysis. Archived laboratory data between 2013 and 2018 were retrieved from the HIS database of the hospital for analysis. A total of 19,028 specimens were collected from the emergency department and 49 outpatient clinics. A full list of these clinics is provided in Table 1. The specimens included urine, blood, prostatic fluid, sputum, pleural effusion and ascites, stool, dialysate, pus, secretion, drainage, cerebrospinal fluid, and bronchoalveolar lavage fluid.

2.2. Isolate Identification. The clinical specimens were processed according to the recommended microbiological procedures as previously described [9–12]. Species were identified through colony morphology, conventional biochemical reactions and/or the use of an automated system (bioMerieux, Marcy l’Etoile, France).

2.3. Antibiotic Sensitivity. Mueller-Hinton agar (MH agar) and MH agar with 5% sheep blood Haemophilus test medium (HTM) was purchased from bioMerieux, Marcy l’Etoile, France. The following ATCC strains were used as references: Escherichia coli (ATCC 25922), Pseudomonas
significant. and a two-sided performed using R 3.6.1 (R Foundation, Vienna, Austria) k"his statistical analysis was clinics, different specimen types, and the antibiotic resis-
tance percentages over time. k"his statistical analysis was

Data from the isolates and the susceptibility testing were analyzed using the WHONET 5.6 software provided by the World Health Organization. k"he following antibiotics were tested against available isolates: piperacillin, oxacillin, ampicillin, ampicillin/sulbactam, piperacillin/tazobactam, cefoperazone/sulbactam, cefazolin, cefuroxime, ceftriaxone, cefepime, ciprofloxacin, levofloxacin, moxifloxacin, amikacin, gentamicin, high level gentamicin, tobramycin, aztreonam, erythromycin, clindamycin, vancomycin, linezolid, tetracycline, trimethoprim/sulfamethoxazole, and tigecycline.

2.4. Statistical Analyses. Data from the isolates and the susceptibility testing were analyzed using the WHONET 5.6 software provided by the World Health Organization. The Cochran-Armitage test was used to study the trends of the specimen numbers submitted from different outpatient clinics, different specimen types, and the antibiotic resistance percentages over time. This statistical analysis was performed using R 3.6.1 (R Foundation, Vienna, Austria) and a two-sided P-value 0.05 was considered as statistically significant.

3. Results

3.1. Specimens' Information. From 2013 to 2018, a total of 19,028 specimens were submitted to the clinical microbiology laboratory from 49 outpatient units. The total number of specimens increased from 2,303 in 2013 to 5,378 in 2018. As observed in Table 1, the number of specimens submitted from each department showed an increase over time. The top three units with the largest number of submissions were Emergency (30.7%), Urology (18.9%), and Nephrology (16.0%). However, only the Emergency and Kidney Transplantation Clinic showed significant increases in the percentage of specimens submitted annually (P < 0.001). Notably, the data from the Breast Surgery Clinic were incomplete and therefore were not included in the analysis. There were no significant differences for the percentages of specimen submission from the Peritoneal Dialysis Clinic. In contrast, all other departments showed a significant decrease in the annual percentage of specimen submission (Table 1).

3.2. The Different Types of Specimens Submitted for the Laboratory Tests of Microbiology. As shown in Table 2, the number of submitted specimens increased annually among different types of specimens, which was consistent with the increase of total number of specimen submission each year in Table 1. Sputum, whole blood, and pus showed a significant increase of specimen submission annually (P < 0.001). In contrast, urine, prostatic fluid, and other types of specimens showed a significant decrease of specimen submission annually (P < 0.001). The submissions of dialysate, peritoneal drainage, and pleural effusion and ascites had no significant changes over the period (P > 0.05).

3.3. The Microbial Growth between Different Types of Specimens. In a total of 19,028 clinical specimens, 4,719 (24.8%) were tested positive for bacterial and fungal growth. The specimen types with high positive rates were peritoneal drainage (67% (219/327)), dialysate (52.7% (267/507)), pus (49.3% (250/507)), and pleural effusion and ascites (31.9% (60/188)), followed by urine (28.9% (1,843/6,383)), prostatic fluid (28.1% (528/1,881)), whole blood (12.9% (405/3,139)), and sputum (9.7% (323/3,314)).

3.4. Common Microbial Isolates and Species. In a total of 4,719 isolates of bacteria and fungi identified, after excluding duplicate isolates obtained from the same patient (each patient was sampled only once), there were 3,849 non-repetitive isolates. These isolates belong to 211 different species, including 1,786 Gram-negative isolates (44.6%), 1,744 Gram-positive isolates (45.3%), 150 fungus isolates (3.9%), and 169 isolates containing other species (4.4%). The most frequently identified Gram-negative species were Escherichia coli, Klebsiella pneumonia and Pseudomonas

| Specimen type | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | P value | Trend |
|---------------|------|------|------|------|------|------|---------|-------|
| N             | %    | N    | %    | N    | %    | N    | %       |       |
| Urine         | 919  | 39.9 | 778  | 31.3 | 805  | 32.6 | 970     | 31.0  | 1.178 | 36.1 | 1.733 | 32.2 | 0.025 |
| Sputum        | 395  | 17.2 | 262  | 10.5 | 393  | 15.9 | 672     | 21.5  | 515   | 15.8 | 1.077 | 20.0 | <0.001 |
| Whole blood   | 231  | 10.0 | 284  | 11.4 | 276  | 11.2 | 511     | 16.3  | 636   | 19.5 | 1.201 | 22.3 | <0.001 |
| Prostatic fluid | 248  | 10.8 | 491  | 19.7 | 321  | 13.0 | 220     | 7.0   | 254   | 7.8  | 348   | 6.5  | <0.001 |
| Pus*          | 29   | 1.3  | 33   | 1.3  | 43   | 1.7  | 81      | 2.6   | 142   | 4.3  | 179   | 3.3  | <0.001 |
| Dialysate     | 29   | 1.3  | 85   | 3.4  | 76   | 3.1  | 74      | 2.4   | 96    | 2.9  | 147   | 2.7  | 0.235 |
| Peritoneal drainage | 9  | 0.4  | 52   | 2.1  | 45   | 1.8  | 82      | 2.6   | 91    | 2.8  | 48    | 0.9  | 0.709 |
| Pleural effusion and ascites | 8  | 0.3  | 25   | 1.0  | 17   | 0.7  | 52      | 1.7   | 31    | 0.9  | 55    | 1.0  | 0.117 |
| Others**      | 435  | 18.9 | 477  | 19.2 | 491  | 19.9 | 465     | 14.9  | 323   | 9.9  | 590   | 11.0 | <0.001 |
| Total         | 2,303| 100.0| 2,487| 100.0| 2,467| 100.0| 3,127   | 100.0| 3,266 | 100.0| 5,378 | 100.0|       |

*Pus was collected from skin and mammary gland. **Others mainly include cerebrospinal fluid, joint fluid, feces, reproductive tract secretions and bone marrow.

Enterococcus faecalis (ATCC 29212), and Enterococcus faecalis (ATCC 29212). An automated system (bioMerieux, Marcy l’Etoile, France) and/or the Kirby–Bauer Disc Diffusion Method were used to test for antimicrobial susceptibility according to the guidelines of the Clinical Laboratory Standards Institute. The sensitivity breakpoint of cefoperazone/sulbactam referred to that of cefoperazone.

The following antibiotics were tested against available isolates: piperacillin, oxacillin, ampicillin, ampicillin/sulbactam, piperacillin/tazobactam, cefoperazone/sulbactam, cefazolin, cefuroxime, ceftriaxone, cefepime, ciprofloxacin, levofloxacin, moxifloxacin, amikacin, gentamicin, high level gentamicin, tobramycin, aztreonam, erythromycin, clindamycin, vancomycin, linezolid, tetracycline, trimethoprim/sulfamethoxazole, and tigecycline.

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The most frequently identified Gram-positive species were Staphylococcus epidermidis, Staphylococcus aureus, Enterococcus faecalis, and Enterococcus faecium. Table 3 shows the number and percentage (%) of bacterial isolates from the outpatient specimens annually between 2013 and 2018. The percentage of S. aureus (P = 0.002) and E. cloacae (P = 0.033) demonstrated a significant increase annually, while S. epidermidis (P < 0.001) and S. haemolyticus (P < 0.001) showed a decrease. Candida albicans (78 isolates) and Aspergillus fumigatus (24 isolates) were the major fungi isolated, followed by Aspergillus flavus (9 isolates), Genus of Mucor and Fusarium (9 isolates), and

| Bacterial species                      | 2013   | 2014   | 2015   | 2016   | 2017   | 2018   | P value | Trend |
|----------------------------------------|--------|--------|--------|--------|--------|--------|---------|-------|
| Escherichia coli                       | 134    | 70.2   | 149    | 66.8   | 128    | 61.0   | 138     | 53.5  |
| Pseudomonas aeruginosa                 | 21     | 11.0   | 24     | 10.8   | 14     | 6.7    | 29      | 11.2  |
| Enterobacter cloacae                   | 9      | 4.7    | 19     | 8.5    | 11     | 5.2    | 18      | 7.0   |
| Acinetobacter baumannii                | 4      | 2.1    | 3      | 1.3    | 7      | 3.3    | 9       | 3.3   |
| Proteus mirabilis                      | 3      | 1.6    | 6      | 2.7    | 5      | 2.4    | 9       | 3.5   |
| Staphylococcus aureus                  | 37     | 18.1   | 81     | 28.1   | 37     | 12.7   | 45      | 17.9  |
| Staphylococcus epidermidis             | 12     | 5.9    | 20     | 6.9    | 20     | 11.0   | 45      | 19.7  |
| Enterococcus faecalis                  | 21     | 10.3   | 33     | 11.5   | 20     | 11.0   | 33      | 13.2  |
| Staphylococcus haemolyticus            | 34     | 16.7   | 39     | 13.5   | 22     | 12.2   | 12      | 5.3   |
| Streptococcus mitis                    | 5      | 2.5    | 2.5    | 15     | 16.5   | 16     | 8.8     | 17.5  |
| Enterococcus faecium                   | 9      | 4.4    | 7      | 2.4    | 10     | 5.5    | 5.5     | 7.5   |
| Others                                 | 14     | 7.3    | 17     | 7.6    | 44     | 21.0   | 48      | 18.6  |
| Total                                  | 191    | 100.0  | 223    | 100.0  | 210    | 100.0  | 258     | 100.0 |

| Antimicrobial agent                     | Staphylococcus aureus (%) (n = 227)* | Staphylococcus epidermidis (%) (n = 268)* | Enterococcus faecalis (%) (n = 193)* | Enterococcus faecium (%) (n = 94)* |
|----------------------------------------|-------------------------------------|------------------------------------------|-------------------------------------|-----------------------------------|
| Penicillins                            |                                     |                                          |                                     |                                   |
| Penicillin G                           | 100.0                               | 96.6                                    | 0.0                                 | 94.7                              |
| Oxacillin                              | 25.1                                | 74.6                                    | **                                  | **                                |
| Ampicillin                             | **                                  | **                                      | 0.0                                 | 94.7                              |
| Fluoroquinolones                       |                                     |                                          |                                     |                                   |
| Ciprofloxacin                          | 17.6                                | 32.1                                    | 23.8                                | 96.8                              |
| Levofloxacin                           | 17.6                                | 40.7                                    | 22.8                                | 94.7                              |
| Moxifloxacin                           | 6.6                                 | 7.5                                     | **                                  | **                                |
| Aminoglycosides                        |                                     |                                          |                                     |                                   |
| Gentamicin                             | 23.3                                | 8.6                                     | **                                  | **                                |
| Gentamicin HLAR                        | **                                  | **                                      | 0.0                                 | 0.0                               |
| Others                                 |                                     |                                          |                                     |                                   |
| Erythromycin                           | 70.5                                | 82.1                                    | 57                                  | 90.4                              |
| Clindamycin                            | 41.4                                | 22                                      | **                                  | **                                |
| Vancomycin                             | 0.0                                 | 0.0                                     | 0.0                                 | 0.0                               |
| Linezolid                              | 0.0                                 | 0.0                                     | 0.0                                 | 0.0                               |
| Tetracycline                           | 41.4                                | 20.1                                    | 66.8                                | 45.7                              |
| Trimethoprim/sulfamethoxazole          | 29.5                                | 64.6                                    | 0.0                                 | 0.0                               |
| Tigecycline                            | 0.0                                 | 0.0                                     | 0.0                                 | 0.0                               |

*The number of non-repetitive isolates for each species. **The result is not available.

aeruginosa, Enterobacter cloacae, Acinetobacter baumannii, and Proteus mirabilis. The most frequently identified Gram-positive species were Staphylococcus epidermidis, Staphylococcus aureus, Enterococcus faecalis, Staphylococcus haemolyticus, Streptococcus mitis, and Enterococcus faecium. Table 3 shows the number and percentage (%) of bacterial isolates from the outpatient specimens annually between 2013 and 2018. The percentage of S. aureus (P = 0.002) and E. cloacae (P = 0.033) demonstrated a significant increase annually, while S. epidermidis (P < 0.001) and S. haemolyticus (P < 0.001) showed a decrease. Candida albicans (78 isolates) and Aspergillus fumigatus (24 isolates) were the major fungi isolated, followed by Aspergillus flavus (9 isolates), Genus of Mucor and Fusarium (9 isolates), and
other Candida species (30 isolates). Other rare bacterial isolates were Corynebacterium (109 isolates), Lactobacillus (36 isolates), anaerobic bacteria (13 isolates) as well as Brucella, Eikenella, Actinomyces, Nocardia, and Non-tuberculous Mycobacteria. Among Corynebacterium, Kroppenstedt Corynebacterium (23 isolates), and Ribbone Corynebacterium (10 isolates) were predominant.

### 3.5. The Antimicrobial Resistance Profile of the Common Pathogens

#### 3.5.1. Staphylococcus spp.
Our study indicated that all of S. aureus isolates in our community were resistant to penicillin (Table 4). However, many S. aureus strains, while resistant to penicillin, remained susceptible to penicillinase-stable penicillin, such as oxacillin. Strains resistant to oxacillin and methicillin were historically termed methicillin-resistant S. aureus (MRSA) [13]. Our study found that the percentage of MRSA isolates was 25.1% during the study period (Table 4) without significant changes annually (Table 5). In contrast, the CHINET reported that the prevalence of MRSA decreased from 69.0% in 2005 to 35.2% in 2017 [3]. The difference between our study and the CHINET is likely due to the lower prevalence of MRSA in community-acquired infections over the period in our study, suggesting the infiltration of MRSA isolates from hospitals to the community is very limited.

As shown in Table 4, less than 30% of S. aureus isolates were resistant to trimethoprim/sulfamethoxazole (29.5%), gentamicin (23.3%), ciprofloxacin (17.6%), levofloxacin (17.6%), and moxifloxacin (6.6%), indicating a minor resistance to fluoroquinolones and aminoglycosides. In comparison, more than 30% of S. aureus isolates were resistant to erythromycin (70.5%), clindamycin (41.4%) and tetracycline (41.4%). Like S. aureus, almost all of S. epidermidis isolates (96.6%) in our community-acquired infections were resistant to penicillin (Table 4). Strains of S. epidermidis that were resistant to oxacillin and methicillin were historically termed methicillin-resistant S. epidermidis (MRSE). Our study showed that the percentage of MRSE isolates was 74.6% during the study period (Table 4) without significant changes annually (Table 5). Less than 30% of S. epidermidis isolates were resistant to clindamycin (22.0%), tetracycline (20.1%), gentamicin (8.6%) and moxifloxacin (7.5%), whereas more than 30% of S. epidermidis isolates were resistant to erythromycin (82.1%), compound sulfamethoxazole (64.6%), levofloxacin (40.7%), and ciprofloxacin (32.1%). These findings indicate a moderate resistance of S. epidermidis to fluoroquinolones and a minor resistance to aminoglycosides. Significantly, all of S. epidermidis and S. aureus isolates collected from our study were sensitive to vancomycin, linezolid, and tigecycline.

#### 3.5.2. Enterococcus spp.
Among Enterococcus species, two major species (Enterococcus faecalis and Enterococcus faecium), were particularly human-specific pathogens. As indicated in Table 4, although the number of isolates of E. faecalis was significantly higher than that from E. faecium (193 isolates vs. 94), E. faecalis isolates were less resistant to most antibiotics compared to E. faecium isolates, including ampicillin (0.0% vs. 94.7%), erythromycin (57.0% vs. 90.4%), ciprofloxacin (23.8% vs. 96.8%), penicillin (0.0% vs. 94.7%), and levofloxacin (22.8% vs. 94.7%); the only exception was tetracycline (66.8% vs. 45.7%). Furthermore, all of E. faecalis and E. faecium isolates collected from our study were sensitive to linezolid, tigecycline, and vancomycin.

#### 3.5.3. Enterobacteriaceae.
Enterobacteriaceae, including E. coli and K. pneumonia, produce extended-spectrum β-lactamases (ESBLs). ESBLs are a group of β-lactamases, which share the ability to hydrolyze β-lactam antibiotics, such as cephalosporins [14]. By using ceftriaxone as a substrate, our study suggested that 60.9% of E. coli isolates and 33.5% of K. pneumonia carried ESBLs (Table 6). Consistent with the ESBLs results, a similar trend was observed for the percentage of E. coli and K. pneumonia isolates resistant to other cephalosporins: cefepime (33.0% vs. 5.9%), cefuroxime (80.7% vs. 23.5%), cefazidime (54.5% vs. 17.6%), and cefazolin (79.5% vs. 17.6%) with the exception of cefotetan (5.7% vs. 0.0%) (Table 6). Less than 30% of E. coli isolates were resistant to tobramycin (21.6%), ceferaze/sulbactam (8.4%), piperacillin/tazobactam (8.0%), and amikacin (2.3%). More than 30% of E. coli isolates were resistant to ampicillin (93.2%), piperacillin (86.4%), ciprofloxacin (80.7%), levofloxacin (76.1%), ampicillin/shubatan (70.5%), trimethoprim/sulfamethoxazole (62.5%), aztreonam (60.2%), and gentamicin (39.8%), indicating a high resistance to penicillins and fluoroquinolones. All of E. coli isolates were sensitive

### Table 5: Annual multidrug resistance percentage (R%) of bacterial isolates from the specimens between 2013 and 2018 from outpatients and patients visiting emergency department.

| Bacterial species | Years | 2013 R% | 2014 R% | 2015 R% | 2016 R% | 2017 R% | 2018 R% | P value | Trend |
|-------------------|-------|---------|---------|---------|---------|---------|---------|--------|-------|
| Escherichia coli  | ESBLs | 62.6    | 59.6    | 57.4    | 59.3    | 56.8    | 59.4    | 0.586  | No change |
|                   | CRE   | 0.0     | 0.0     | 0.0     | 0.0     | 0.0     | —       | 0.843  | No change |
| Klebsiella pneumoniae | ESBLs | 29.2    | 40.5    | 20.0    | 30.0    | 39.3    | 32.5    | 0.935  | No change |
|                   | CRE   | 0.0     | 0.0     | 0.0     | 1.8     | 1.3     | 0.443   | —      | No change |
| Staphylococcus aureus | MRSA | 53.8    | 27.6    | 25.9    | 25      | 25      | 19.2    | 0.191  | No change |
| Staphylococcus epidermidis | MRSE | 88.1    | 83.3    | 78.7    | 94.1    | 72.7    | 75.6    | 0.213  | No change |

* ESBLs (extended spectrum β-lactamases): ESBLs multidrug resistance was evaluated by using ceftriaxone. ** CRE (carbapenem-resistant enterobacteriaceae): CRE multidrug resistance was evaluated by using imipenem and meropenem. # MRSA (methicillin-resistant S. aureus): MRSA multidrug resistance was evaluated by using oxacillin. ** MRSE (methicillin-resistant S. epidermidis): MRSE multidrug resistance was evaluated by using oxacillin.
to imipenem and meropenem. As shown in Table 6, less than 30% of K. pneumonia isolates were resistant to compound sulfamethoxazole (29.4%), ampicillin/shubatan (23.5%), piperacillin (17.6%), ciprofloxacin (11.8%), levofloxacin (11.8%), aztreonam (5.9%), gentamicin (5.9%), imipenem (1.1%), and meropenem (1.1%), indicating a minor resistance to these common antibiotics, such as penicillins and fluoroquinolones. All of the K. pneumonia isolates were sensitive to amikacin, piperacillin/tazobactam, cefoperazone/sulbactam, cefotetan, and tobramycin.

3.5.4. Nonfermentative Bacteria. All of P. aeruginosa isolates were sensitive to fluoroquinolones, including ciprofloxacin and levofloxacin. The P. aeruginosa-resistant isolates to other antibiotics were all less than 30% including aztreonam (22.4%), metopenem (18.7%), imipenem (18.7%), cefazidime (15.0%), piperacillin (14.9%), cefoperazone/sulbactam (10.3%), amikacin (7.5%), piperacillin/tazobactam (7.5%), gentamicin (7.5%), cefepime (7.5%), and tobramycin (7.5%), suggesting a minor resistance to these common antibiotics.

4. Discussion

In this study, we reported the microbial predominance and AMR profiling in a tertiary hospital using retrospective data from outpatient clinics and emergency department in a specific region of Northwestern China over six years. We will discuss our findings in the following five aspects.

4.1. The Medical Value to Study the Distribution of Specimen Submitted between Different Outpatient Clinics and Emergency Department. There are limited publications that compared the number and percentage of specimens submitted to clinical microbiology laboratories between different outpatient clinics. Different from other countries, patients in China can directly visit healthcare services without referral requirements from primary care doctors. Our study showed a trend of increasing number of specimen submissions in each clinic (Table 1), likely associated with the increased population in the communities. The departments of Emergency, Urology, and Nephrology were among the top three clinics that submitted specimens for microbiological studies. Urinary tract infection has been considered the major reason for outpatients to visit the Urology and Nephrology departments [15] and is also one of the major concerns for the Emergency visits [16]. More importantly, our study revealed that only two departments, the Emergency Department and Kidney Transplantation Clinic, demonstrated a significant increase of specimen submitted annually (P < 0.001). This indicates that these two departments, particularly the Emergency Department...

### Table 6: Antimicrobial resistance percentage (%) of top three Gram-negative bacilli among common antimicrobial agents between 2013 and 2018 from outpatients and patients visiting emergency department.

| Antimicrobial agent | Escherichia coli (%) (n = 1035)* | Klebsiella pneumoniae (%) (n = 182)* | Pseudomonas aeruginosa (%) (n = 107)* |
|---------------------|---------------------------------|---------------------------------|---------------------------------|
| Penicillins         |                                 |                                 |                                 |
| Piperacillin        | 86.4                            | 17.6                            | 14.9                            |
| Ampicillin          | 93.2                            | **                              | **                              |
| Cepheps             |                                 |                                 |                                 |
| Cefazolin           | 79.5                            | 17.6                            | **                              |
| Cefuroxime          | 80.7                            | 23.5                            | **                              |
| Ceftriaxone         | 60.9                            | 33.5                            | **                              |
| Ceftazidime         | 54.5                            | 17.6                            | 15.0                            |
| Cefepime            | 33.0                            | 5.9                             | 7.5                             |
| Cefotetan           | 5.7                             | 0.0                             | **                              |
| β-lactam combination agents |                     |                                 |                                 |
| Ampicillin/Shubatan | 70.5                            | 23.5                            | **                              |
| Piperacillin/Tazobactam | 8.0                             | 0.0                             | 7.5                             |
| Cefoperazone/sulbactam | 8.4                             | 0.0                             | 10.3                            |
| Fluoroquinolones    |                                 |                                 |                                 |
| Ciprofloxacin       | 80.7                            | 11.8                            | 0.0                             |
| Levofloxacin        | 76.1                            | 11.8                            | 0.0                             |
| Aminoglycosides     |                                 |                                 |                                 |
| Amikacin            | 2.3                             | 0.0                             | 7.5                             |
| Gentamicin          | 39.8                            | 5.9                             | 7.5                             |
| Tobramycin          | 21.6                            | 0.0                             | 7.5                             |
| Others              |                                 |                                 |                                 |
| Aztreonam           | 60.2                            | 5.9                             | 22.4                            |
| Imipenem            | 0.0                             | 1.1                             | 18.7                            |
| Meropenem           | 0.0                             | 1.1                             | 18.7                            |
| Trimethoprim/sulfamethoxazole | 62.5                           | 29.4                            | **                              |

*The number of non-repetitive isolates for each species. **The result is not available.
Among 3,849 non-

4.2. Relatively Lower Ratio of Gram-Negative Isolates in Our

kidney transplantation is an urgent medical issue in out-

Table 4 and 6 in this study, Gram-negative bacteria, par-

Overall, relatively lower ratio of Gram-negative isolates was

4.5. There Was No Significant Increase in Multidrug-Resistant

Bacteria Observed in Our Communities. Tables 4 and 6 show higher resistance rates between certain bacteria and antibiotics, such as methicillin-resistant Gram-

positive pathogens (MRSA and MRSE) and extended spectrum β lactamases (ESBLs)-resistant Gram-negative pathogens. By using ceftriaxone and oxacillin, Table 5 indicates an annual change of the resistance rate of multidrug-resistant bacteria in recent years. A significant increase of resistance rate would require immediate intervention to investigate the reason. The results in Table 5 suggest that there is no significant increase of multidrug-resistant bacteria, indicating a reasonable prescription of antibiotics in our outpatient and emer-
gency services and successful physician education on the

prevention of antibiotic resistance. The main limitation

in this study was that this was a single-center retro-
spective observational study. It should be cautious to

translate our results to other hospitals. However, the

quality of clinical sampling procedures and techniques

were in general better controlled in a single center than

multiple centers. First, they also allowed us to obtain a

representative specimen in many clinical departments

throughout the hospital. When we repeated the sample

collection and analysis annually, we could observe trends

over a period of time. In addition, a single-center study,

when appropriately performed, is a useful and inex-

pensive surveilling tool to reflect the regional situation

of prevailing microorganisms and their resistance to anti-

microbials. Second, outpatient surveillance is an im-

portant tool to study community-acquired infections. It

should be emphasized that not all outpatient and in-

patients visiting the Emergency Department with in-

fections are contracted from the communities. This is the

reason we only used the term of “community settings” in

this study since the patients seeking medical care in our

outpatient and emergency services come directly from

the community.
Data Availability

All the data are available upon request.

Ethical Approval

This project was approved by the Institutional Review Board of the First Affiliated Hospital of Xi’an Jiaotong University (No: XJTU1AF2017LSK-83).

Consent

Written informed consents cannot be obtained because the laboratory tests for microbiology are part of standard care and the records of the patient’s personal identities were removed prior to data analysis.

Conflicts of Interest

There are no conflicts of interest.

Authors’ Contributions

Caifeng Wang was responsible for study design, funding application, and manuscript writing and managed the study. Jine Lei performed laboratory analysis. Wen Li and Yali Li performed data entry. Juanjuan Gao performed statistical analysis of data. Dancheng Zhang and Fang Li performed data analysis.

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