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Prevalence of healthcare-associated infections and antimicrobial use in China: Results from the 2018 point prevalence survey in 189 hospitals in Guangdong Province

Yu Zhang[a,b], Zhen-Feng Zhong[b,c], Shu-Xian Chen[b,d], Dian-Rong Zhou[a,b], Zheng-Kang Li[a], Yue Meng[a], Jing-Fang Zhou[a], Tie-Ying Hou[a,b,*]

[a] Department of Laboratory, Guangdong Provincial People's Hospital and Guangdong Academy of Medicine Sciences, Guangzhou, China
[b] Guangdong Nosocomial Infection Control and Quality Improvement Centre, Guangzhou, Guangdong, China
[c] Department of Infection Prevention and Control, Guangdong Zhongshan City People's Hospital, Zhongshan, China
[d] Department of Infection Prevention and Control, Guangzhou First People's Hospital, Guangzhou, China

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ABSTRACT

Background: Limited data on healthcare-associated infections (HAIs) are available from the developing world, thus a point prevalence survey was conducted to determine the prevalence of HAIs and antimicrobial use in Guangdong Province, China.
Methods: A standardized methodology for point prevalence surveys on HAIs and antimicrobial use has been developed by the Chinese Nosocomial Infection Control and Quality Improvement Center. The prevalence of HAIs, antimicrobial use, and baseline hospital-level variables were collected in 189 hospitals from June 2017 to May 2018.
Results: Of 5 868 147 patients, 72 976 had one or more HAIs (1.24%), with 82 700 distinct HAIs. The prevalence rates of device-associated infections, including ventilator-associated pneumonia, catheter-associated urinary tract infection, and central line-associated bloodstream infection were 7.92, 2.06, and 0.63 per 1000 catheter-days, respectively. A total of 10 591 (0.18%) HAIs caused by multidrug-resistant organisms were identified. Carbapenem non-susceptibility rates were highest in *Acinetobacter* species (53.86%) and *Pseudomonas aeruginosa* (21.60%). Forty-six percent (2 712 258/5 868 147) of inpatients were receiving at least one antimicrobial during this survey.
Conclusions: This survey indicated the relatively lower prevalence of HAIs but higher antimicrobial using in Guangdong Province compared with other mid to low-income and high-income countries. Further studies are warranted to elucidate which HAI-related indicators are the best measures of HAI performance and thus allow improvements leading to better patient outcomes.

Introduction

Healthcare-associated infections (HAIs) are recognized as the most frequent adverse event threatening patient safety worldwide and can result in prolonged hospital stays, increased costs for patients, and excess deaths (Allegranzi et al., 2011). Additionally, HAIs caused by multidrug-resistant organisms (MDROs) deserve special attention in healthcare facilities, because effective antimicrobial drugs are extremely limited and a high risk of death has been observed among patients with these infections (Boucher et al., 2009). It has been demonstrated that increasing antimicrobial resistance is associated with inappropriate antimicrobial consumption, suggesting that restricting inappropriate antimicrobial prescription may curb the development of antimicrobial resistance (Zhang et al., 2016a; Davido et al., 2016).

The establishment of priorities and strategies for the prevention of HAIs depends on a comprehensive understanding of the epidemiology of these infections. The surveillance of HAIs has increasingly been shown to be effective for both estimating the burden of HAIs and prioritizing strategies for their prevention (Crivaro et al., 2015; Takeshita et al., 2017; Al Nasser et al., 2016). A variety of surveillance strategies exist for enumerating HAIs and to

* Corresponding author at: Laboratory Department, Guangdong Provincial People's Hospital and Guangdong Academy of Medical Sciences, No. 106, 2nd Zhongshan Road, Yuexiu District, Guangzhou 510000, China.
E-mail address: 670293234@qq.com (T.-Y. Hou).

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evaluate the impact of control interventions. Prospective longitudinal surveillance is considered the gold standard method, but such studies are resource-intensive and require a significant number of trained personnel (Rosenthal, 2016). Point prevalence surveys (PPSs), meanwhile, are a practical alternative that require fewer resources and can provide a valuable in-depth snapshot of the burden and epidemiology of HAIs (Llata et al., 2009). The Chinese National Healthcare Associated Infection Surveillance System has conducted regular PPSs of HAIs since 2001 using standardized national HAI definitions to allow geographical and prospective comparisons (Chen et al., 2017). In addition, local and regional PPSs have also been performed in China; however, quite a few of them have been published in peer-reviewed journals and in English (Wang et al., 2017; Zhang et al., 2016b; Xie et al., 2010; Tao et al., 2014).

It is difficult to interpret the rates of HAIs due to the huge discrepancy in socio-economic conditions and gross domestic product (GDP) between the different provinces and regions of China. Guangdong, one of the largest provinces in China, is located in the southernmost part of the country, and the economy of this province has reached the top position in China and the level of middle-income countries (Regional Economic Report, 2019). The Chinese government has made huge efforts in the management of antimicrobial use in recent years. In 2011, coupled with new healthcare reforms, the National Health Commission of the People's Republic of China (NHCPC; formerly the Chinese Ministry of Health) changed strategy and launched a special campaign to promote the rational use of antimicrobials in healthcare settings. This mainly consisted of establishing mandatory management strategies, such as target setting, taskforce organization, and the development of audit and inspection systems (Xiao et al., 2013). The "Guidelines for Clinical Application of Antibiotics" were issued by the NHCPC in 2005, and thoroughly explained the basic principles of antibacterial drug use and preventive use, respectively (Health, 2005). These measures had a positive effect on reducing the irrational use of antimicrobial agents, which had been described in some previously published studies (Xiao et al., 2013; Xiao and Li, 2013; Ren et al., 2016). However, accurate estimates of the burden of HAIs and antimicrobial use in Guangdong Province are not available to date.

To clarify the knowledge gap in the local epidemiology of HAIs and establish priorities and strategies for HAI prevention and appropriate antimicrobial use, the Guangdong Nosocomial Infection Control and Quality Improvement Centre (GNICC) has conducted yearly PPSs in all secondary and tertiary care hospitals of the province since 2017. The objectives of this study were to determine (1) the prevalence of HAIs, (2) the prevalence of antimicrobial use among inpatients, and (3) the prevalence of HAIs caused by MDROs and antimicrobial resistance in Guangdong Province.

Methods

Study design and hospital selection

A single-day cross-sectional design was used in this study. According to the "Hospital Grading Management Regulations" issued by the Chinese Ministry of Health in 1989, medical institutions in China are categorized into primary hospitals, secondary or second class hospitals, and tertiary or third class hospitals, by size, medical facilities, technology, service quality, and level of scientific research. Primary and secondary hospitals are expected to provide basic healthcare services, while tertiary hospitals are referral centers for specialist care with medical teaching and research. All of the 244 secondary and tertiary hospitals in Guangdong Province, including those in the private and public setting, were considered for participation in this survey. Finally, 189 hospitals (77.5%) submitted data to the study center between March and May 2018. The remaining hospitals failed to enroll in this survey for various reasons, such as unable to obtain sufficient administrative support, yet to conduct the surveillance, or conflict with other surveillance programs.

Patient selection and definitions

Inpatients of any age in participating hospitals were eligible for inclusion, and the survey included all inpatients at the hospital at 0:00 h on the survey date and patients who were discharged on the same day. Patients in outpatient areas, emergency departments, psychiatry units, and rehabilitation units, and those who were admitted for less than 48 h were excluded. All eligible patients were identified in the morning census on the survey date.

The definitions employed in the PPS were based on the definition criteria established by the NHCPC in 2001 (2001), which are based on a modified translation of the US Centers for Disease Control and Prevention (CDC) definitions for HAIs (Horan et al., 2008). Infections were categorized into respiratory tract infection (RTI), urinary tract infection (UTI), bloodstream infection (BSI), surgical site infection (SSI), gastrointestinal tract infection (GTI), skin and soft tissue infection (SSTI), and other infections including parotitis, chickenpox, nervous system infections, and deep organ infections (2001). In addition, device-associated HAIs (DA-HAIs), i.e., catheter-associated urinary tract infection (CAUTI), central line-associated bloodstream infection (CLABSI), ventilator-associated pneumonia (VAP), and surgical site infection (SSI), were particularly evaluated in this survey. Antimicrobial use was defined as (1) the presence of any systemic antibiotic or antifungal surgical prophylaxis within a 24-h period before the survey date, or (2) the presence of any systemic antibiotic or antifungal medication on the survey date.

Training and data collection

Patient information was collected on standardized case report forms provided in the "Quality Control Indicators of Hospital Infection Management (2015 edition)" issued by the NHCPC (Quality Control Indicators, 2015). A web-based software system for data collection was developed before the initiation of the survey. All data collectors from the participating hospitals were trained in data collection and the use of the software through a video describing the survey methods and the process of submitting data precisely. The hospitals submitted summary data to the GNICC and to the National Clinical Improvement System. GNICC is affiliated to the Guangdong Provincial People's Hospital and is managed by the Guangdong Provincial Health Commission. The mission of GNICC is to monitor and improve the quality control of nosocomial infection across the whole province, including nosocomial infection surveillance, training, outbreak investigation, and treatment, etc. In 2016, the National Clinical Improvement System, which was developed by the NHCPC with the aim of improving the quality of clinical services in China, proposed that the total burden of HAIs should be measured regularly and in a standardized manner throughout the country.

In addition, antimicrobial use was documented for the survey day. For antimicrobial use, the rates of inpatient antibiotic prescribing, antibiotic prophylaxis in class I wound surgery, and microbiological culture before the use of antimicrobial drugs for treatment purposes should be collected, in order to monitor the quality of antibiotic management in accordance with the "National Program of Antimicrobial Drug Clinical Application Special Rectification Activities" proposed by the NHCPC in 2013 (National Program, 2019).

Hand hygiene (HH) compliance was assessed by measuring the frequency with which HH was performed according to the World Health Organization (WHO) "Five Moments for Hand Hygiene" (Sax et al., 2009). Direct observation was performed by healthcare workers after training and consensus development.

Seven types of MDRO HAIs were assessed in this survey: methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus faecium*, vancomycin-resistant *Enterococcus faecalis*, carbapenem-resistant *Escherichia coli*, carbapenem-resistant *Klebsiella pneumoniae*, multidrug-resistant *Acinetobacter baumannii*, and multidrug-resistant *Pseudomonas aeruginosa*. This survey was part of a mandated quality improvement initiative and did not require ethical approval.

Data analysis

The statistical analysis was performed using IBM SPSS Statistics version 19.0 (IBM Corp., Armonk, NY, USA). The prevalence rates of HAIs and antimicrobial use were reported as the percentage of patients with at least one HAI or receiving at least one antimicrobial agent among the total number of patients, respectively. The prevalence of SSI was described as the number of SSIs per 100 inpatients who underwent a surgical procedure. However, we did not record aspects of the surgical procedure due to a lack of resources. Differences in the prevalence of HAIs in the different hospitals were determined. Significance was established at $p < 0.05$ (two-tailed).

Results

Hospitals and patients

One hundred and eighty-nine hospitals with 5 868 147 patients were finally enrolled in this survey. In total, 27 secondary private hospitals, 85 secondary public hospitals, 13 tertiary private hospitals, and 64 tertiary public hospitals assessed a total of 147 934 patients, 1 719 656 patients, 302 986 patients, and 3 697 571patients, respectively. A large proportion (63.01%) of patients were distributed in tertiary public hospitals, in disproportion with the ratio of corresponding hospitals (33.86%) included (Supplementary material, Table S1).

Prevalence of HAIs

Table 1 summarizes the overall prevalence of HAIs among the different hospitals classified by grade and size. For the 5 868 147 patients, a total of 82 700 HAIs occurring in 72 976 patients were reported. The pooled HAI prevalence was 1.24% (72 976/5 868 147) and the overall frequency of HAIs was 1.41% (82 700/5 868 147). Tertiary public hospitals (1.51%, 55 932/3 697 571) had the highest rate, and the HAI prevalence rates in tertiary private care, secondary public care, and secondary private care hospitals were 0.97% (2 943/302 986), 0.79% (13 617/1 719 656), and 0.33% (484/147 934), respectively; the rates differed significantly from each other (Chi-square = 6231.835, $p = 0.000$).

There was an increasing trend in HAI prevalence, in general, with the increase in number of beds. The rate of HAIs in hospitals with more than 1000 beds was 1.58%, which was higher than that in hospitals with 501–1000 beds (1.08%), hospitals with fewer than 300 beds (0.63%), and hospitals with 301–500 beds (0.59%).

Table 2 summarizes the incidence of class I wound SSI and the prevalence of device-associated HAIs. The pooled incidence of SSI in class I wound surgery was 0.33 per 100 patients, and no obvious variation was observed among hospitals. The rates of device-associated infections, including VAP, CAUTI, and CLABSI, were 7.92, 2.06, and 0.63 per 1000 catheter-days, respectively.

Hand hygiene (HH) compliance and antimicrobial use

Table 3 summarizes the HH compliance and the use of antimicrobial drugs. The overall HH compliance was 74.60%. In general, the public hospitals had higher rates of HH compliance (78.87% in secondary public care and 74.48% in tertiary public care) than the private hospitals (45.01% in secondary public care and 56.88% in tertiary public care).

Three indicators, including the rate of inpatient antibiotic prescribing, rate of antibiotic prophylaxis in class I wound surgery, and submission rate of the specimen before therapeutic use of antibiotics, were applied to monitor the quality of antibiotic management (Quality Control Indicators, 2015). Approximately 46.22% of patients (2 712 258/5 868 147) were receiving at least one antimicrobial agent during the survey. Moreover, of the 2 712 258 patients on antimicrobials for therapeutic purposes, a total of 1 216 176 (44.84%) had microbiology testing conducted before using antimicrobial agents. The overall rate of antibiotic prophylaxis in class I wound surgery was 33.90%, and the tertiary private hospitals had the lowest rate of antibiotic prophylaxis in class I wound surgery compared with the others.

Prevalence of MDRO infections and antimicrobial resistance

A total of 10 591 MDRO HAIs were identified in 5 868 147 patients, and the pooled prevalence of MDROs was 0.18%. The prevalence of MDROs varied by healthcare setting (Table 4). Carbapenem-resistant *A. baumannii* was the most prevalent MDRO, causing 3862 HAIs (0.066%), followed by carbapenem-resistant *P. aeruginosa* (2421 HAIs, 0.041%), MRSA (2397 HAIs, 0.041%), carbapenem-resistant *K. pneumoniae* (887 HAIs, 0.015%), carbapenem-resistant *E. coli* (810 HAIs, 0.014%), vancomycin-resistant *E. faecium* (136 HAIs, 0.002%), and vancomycin-resistant *E. faecalis* (78 HAIs, 0.001%).

Overall, 32.74% of all *S. aureus* were not susceptible to methicillin. Non-susceptibility to carbapenems was present in 2.87% of all *E. coli*, 5.15% of all *K. pneumoniae*, 53.86% of all

Table 1
Prevalence of all types of healthcare-associated infection in Guangdong Province in 2018, by hospital grade.

	All hospitals	Secondary private care	Secondary public care	Tertiary private care	Tertiary public care
Prevalence of infected patients/100 patients, %	1.24	0.33	0.79	0.97	1.51
Prevalence of HAIs/100 patients, %	1.41	0.34	0.85	1.27	1.72
Prevalence of HAIs by hospital size, %					
≤300 beds	0.63	0.32	0.88	0.50	0.39
301–500 beds	0.59	0.38	0.61	0.49	0.62
501–1000 beds	1.08	0.26	0.94	0.70	1.30
>1000 beds	1.58	NA	0.88	1.27	1.62

HAIs, healthcare-associated infections; NA, not available.

Table 2
Rates of surgical site infection in class I wound surgery and device-associated healthcare-associated infections in different hospitals.

	All hospitals	Secondary private care	Secondary public care	Tertiary private care	Tertiary public care
Rate of SSI in class I wound surgery, %	0.33	0.40	0.30	0.33	0.34
Device-associated HAI rate, ‰					
CAUTI/1000 catheter-days	2.06	1.25	2.41	3.60	1.96
CLABSI/1000 catheter-days	0.63	0.94	0.64	0.87	0.61
VAP/1000 catheter-days	7.92	0.92	9.82	15.09	7.52

SSI, surgical site infection; HAI, healthcare-associated infection; CAUTI, catheter-associated urinary tract infection, CLABSI: central line-associated bloodstream infection; VAP, ventilator-associated pneumonia.

Table 3
Hand hygiene compliance and antibiotic management in different grades of hospital.

	All hospitals	Secondary private care	Secondary public care	Tertiary private care	Tertiary public care
Hand hygiene compliance, %	74.60	45.01	78.87	56.88	74.48
Rate of inpatient antibiotic prescribing, %	46.22	51.50	44.42	49.04	46.67
Rate of antibiotic prophylaxis in class I wound surgery, %	33.90	33.47	32.25	26.77	34.88
Rate of microbiology testing before therapeutic use of antibiotics, %	44.84	38.48	44.41	39.70	45.79

Table 4
Targeted multidrug-resistant organism infection rates in different grades of hospital.

MDRO	All patients (n = 5 868 147)	Secondary private care (n = 147 934)	Secondary public care (n = 1 719 656)	Tertiary private care (n = 302 986)	Tertiary public care (n = 3 697 571)
Methicillin-resistant *Staphylococcus aureus*	2397 (0.041%)	80 (0.054%)	378 (0.022%)	116 (0.038%)	1823 (0.049%)
Vancomycin-resistant *Enterococcus faecalis*	78 (0.001%)	2 (0.001%)	29 (0.002%)	2 (0.001%)	45 (0.001%)
Vancomycin-resistant *Enterococcus faecium*	136 (0.002%)	2 (0.001%)	76 (0.004%)	0 (0.000%)	58 (0.002%)
Carbapenem-resistant *Escherichia coli*	810 (0.014%)	15 (0.010%)	155 (0.009%)	5 (0.002%)	635 (0.017%)
Carbapenem-resistant *Klebsiella pneumoniae*	887 (0.015%)	7 (0.005%)	143 (0.008%)	10 (0.003%)	727 (0.020%)
Carbapenem-resistant *Acinetobacter baumannii*	3862 (0.066%)	6 (0.004%)	217 (0.013%)	195 (0.064%)	3444 (0.093%)
Carbapenem-resistant *Pseudomonas aeruginosa*	2421 (0.041%)	3 (0.002%)	145 (0.008%)	126 (0.042%)	2147 (0.058%)
Total	10 591 (0.180%)	115 (0.078%)	1143 (0.066%)	454 (0.150%)	8879 (0.240%)

MDRO, multidrug-resistant organism.

A. baumannii, and 21.60% of all *P. aeruginosa*. The rates of vancomycin resistance for *E. faecalis* and *E. faecium* were 0.52% and 3.68%, respectively (Table 5).

Discussion

This study describes the 2017–2018 point prevalence estimates for HAIs and antimicrobial use, obtained in one of the largest HAI PPSs in the People's Republic of China. In this survey, 1.24% of inpatients in Guangdong had at least one HAI. The overall prevalence of HAIs was lower than that reported previously in China in studies conducted in 2007–2008 in Hubei Province (3.88%) (Xie et al., 2010), in 2014 in Guizhou Province (2.41%) (You et al., 2016), and in 2014 in Beijing City (2.10%) (Zhang et al., 2016b). It is difficult to draw conclusions from these comparisons considering the disparities in case mix, including severity, comorbidities, and length of stay. The survey period could be another reason, because the later the study was conducted, the lower was the prevalence of HAIs; this could be due to the series of management and intervention measures that have been conducted in China.

Table 5
Rates of multidrug-resistant microorganisms for each bacterium.

Pathogen	All strains	Number of multidrug-resistant strains (%)
Staphylococcus aureus	29 319	9599 (32.74)
Enterococcus faecalis	29 808	155 (0.52)
Enterococcus faecium	5272	194 (3.68)
Escherichia coli	65 819	1889 (2.87)
Klebsiella pneumoniae	32 796	1689 (5.15)
Acinetobacter baumannii	25 633	13 806 (53.86)
Pseudomonas aeruginosa	38 153	8241 (21.60)

Differences in data collection could also have contributed to the disparities in prevalence of HAIs. Moreover, the imbalance in socio-economic development level between the provinces and even the cities within a province could also have had an impact on the differences in the prevalence of HAIs. Since Guangdong Province is one of the most developed regions in China, the prevalence of HAIs in this survey was lower than that in other less developed areas reported in previous studies, due to the relatively high investment in healthcare resources (Regional Economic Report, 2019; Brief Report, 2019).

Furthermore, the present study found that the prevalence of HAIs in tertiary care settings, including private and public hospitals, was higher than that in secondary private and public care settings, similar to the findings of the other two surveys conducted in China (Wang et al., 2017; You et al., 2016). Factors attributed to the variation in HAI rates between the different hospitals are complicated. In China, tertiary hospitals, especially those in public care settings, have better medical circumstances and armamentariums than the secondary hospitals, and the staff in tertiary hospitals generally have higher educational qualifications and better skills, which provide advantages in preventing HAIs. On the other hand, patients admitted to tertiary hospitals are usually in a more severe condition and therefore more susceptible to HAIs

than those in secondary hospitals; this could result in higher HAI rates in tertiary hospitals. Moreover, the low level of information-based surveillance of nosocomial infections in secondary hospitals, to some extent, could also lead to a low reporting rate of HAIs. Therefore, it is necessary for the government to invest more funds in secondary and primary hospitals, to upgrade the armamentariums and improve their abilities in information-based HAI surveillance.

DA-HAIs have long been a major focus of HAI prevention in developing countries, as they are mainly considered preventable (Cardo et al., 2010). In this survey, the overall VAP rate was more than two-fold higher than that reported in the United States (7.92 vs. 1.1 per 1000 catheter-days). Similarly, the pooled rate of CAUTI (2.06 per 1000 catheter-days) was nearly two times higher than the rate of 1.30 per 1000 catheter-days reported from the United States. In contrast, the overall CLABSI rate (0.63 per 1000 catheter-days) was lower than the rate reported from the United States (0.90 per 1000 catheter-days) (Dudeck et al., 2015).

Previous studies have implied that a higher socio-economic level (defined as low-income, mid–low-income, and high-income) is correlated with a lower infection risk (Bank, 2014). The high VAP and CAUTI rates found in the present study, when compared with those reported in the United States, could be explained to a great extent by the fact that China is like most mid–low-income countries, with limited resources invested in healthcare settings (Rosenthal et al., 2012). It has been reported that low nurse-to-patient staffing ratios are closely related to high HAI rates because of hospital overcrowding, a lack of medical supplies, and an insufficient number of experienced nurses or trained healthcare workers (Pittet et al., 2008; Rosenthal, 2011). Besides, there are still no legally enforceable regulations for the implementation of infection control programs in China, and even though infection control programs have been conducted by academic organizations, only a small number of hospitals were involved.

Of note, the device use ratio is an extrinsic risk factor for DA-HAI and also a marker of the severity of illness in patients and of patient susceptibility to DA-HAIs (Jarvis et al., 1991); however, this was not available in our survey. On the other hand, the extremely low rate of CLABSI in this study was due to the low proportion of hospitals initiating CLABSI surveillance: 49 of 189 participating hospitals reported the rate of CLABSI as 0.00%.

The “Standards for Nosocomial Infection Management” and “Management of Clinical Application of Antibiotics”, issued by the NHCPC, state that the rate of SSI in class I wound surgery should be less than 1% for hospitals with <100 beds, and less than 0.5% for those with ≥100 beds (Standards for nosocomial infection management, 2001); the inpatient antibiotic prescribing rate and rate of antibiotic prophylaxis in class I wound surgery should not exceed 60% and 30%, respectively, while the rate of microbiology testing before therapeutic use of antibiotics should not be less than 30% (Management of clinical application of antibiotics, 2012). In this survey, the rates of SSI in class I wound surgery in the different types of hospital were all below that benchmark. The pooled rate of inpatient antibiotic prescribing (46.22%) found in this study is significantly higher than that reported in Europe (34.6%) (Zarb et al., 2012), although it is in agreement with the standard in China. Moreover, it was found that the rates of inpatient antibiotic prescribing in tertiary and secondary private care settings were both higher than those in public hospitals. This may warrant increased attention, because the Chinese government has paid more attention to the public care settings than private hospitals in the current situation (Management of clinical application of antibiotics, 2012). It remains necessary to monitor all types of hospital to restrict inappropriate antimicrobial use and ultimately curb the development of antimicrobial resistance.

All hospitals together and the different types of hospital, except for tertiary private care settings, were observed to have slightly higher rates of antibiotic prophylaxis in class I wound surgery than expected, which were similar to previous reports from China (You et al., 2016; Shi Qing-feng et al., 2017; Pan Jing-jing et al., 2016). Of the patients on antimicrobials, 44.84% had microbiological testing done in the context of their use, which was far greater than expected. In addition, it was found that the rates of microbiology testing before therapeutic use of antibiotics in secondary and tertiary public hospitals were higher than those in the private settings, respectively. This is discouraging for private care settings, because it allows potential adaptation of appropriate antimicrobials based on microbiological findings.

In this survey, more than 30% of all *S. aureus* were non-susceptible to methicillin, showing an apparent decreasing trend locally in the past 5 years (CHINET surveillance of bacterial resistance across China, 2017a). Likewise, the prevalence of carbapenem-resistant *A. baumannii* was 53.86%, and this showed a decreasing trend in the past 5 years. Of note, resistance to carbapenems among *Enterobacteriaceae* and resistance to vancomycin among enterococci both appeared to increase significantly during the past 5 years. To fight against these increasing resistance rates, hospital infection control and the management of clinical use of antimicrobial agents should be implemented in our local setting (CHINET surveillance of bacterial resistance across China, 2017b).

There are several limitations to this study that should be acknowledged. First, infections not associated with devices or operative procedures, including *Clostridium difficile* infections and non-ventilator-associated pneumonia, which have been reported to account for a large part of all HAIs in recent studies (Chen et al., 2017; Zarb et al., 2012; Magill et al., 2014), were not evaluated in this survey. Controversy regarding which HAI-related indicators are the best measures of performance and thus the most appropriate for public reporting has continued over the years (Tokars et al., 2004; Humphreys and Cunney, 2008). Relevant examples include device-associated infections, surgical prophylaxis, and SSI (Skjeldestad et al., 2015; Kilan et al., 2017; Pronovost et al., 2006). Nevertheless, expanding surveillance on other HAIs should also be taken into consideration, as a decline in device- and procedure-associated HAIs has been reported (Magill et al., 2014). Second, we were unable to validate the collected data across the 189 hospitals, which might have reduced the quality of this study. Third, we were unable to determine whether the hospitals were using any approaches (bundles) or antibiotic stewardship programs for the prevention of HAIs or MDROs, or the patient to nurse ratios and patient to doctor ratios across hospitals; these are crucial for the comparison of HAI prevalence between different hospitals.

This survey appears to be one of the largest PPSs from China to date. Our survey provides an insight into the burden of HAIs and antimicrobial use in Guangdong Province and could serve as a benchmark for future PPSs. However, repeated PPSs are needed to better understand the trends in epidemiology of HAIs and to highlight the priority areas and targets for quality improvement. In addition, there is also a need for further studies concerning which performance indicators should be chosen for assessment in order to improve the quality of health care and to facilitate benchmarking among regions or countries.

Conflict of interest

All authors report no conflicts of interest relevant to this article.

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