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SHORT REPORT

Trend in Antimicrobial Resistance of *Staphylococcus aureus*: Results from the China Antimicrobial Surveillance Network (CHINET) in the Last 15-Year-Period Reports (2005–2019)

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Abstract: In this report, we analyze the trends in antimicrobial resistance of *Staphylococcus aureus* according to the last 15-year-period reports of the China Antimicrobial Surveillance Network (CHINET). It is encouraging that there is a decreasing MRSA proportion in the infection of adults as well as better activity of non-beta-lactam agents in vitro in recent years. However, childhood MRSA infection as well as the tigecycline-resistant MRSA isolate in China deserves increasing concern.

Keywords: *Staphylococcus aureus*, antimicrobial resistance, China Antimicrobial Surveillance Network

Staphylococcus aureus (*S. aureus*) is a notorious opportunistic-pathogen responsible for a considerable section in a variety of infectious diseases, some of which are lethal. Antibiotic resistance surveillance can provide effective information in the clinical therapy of *S. aureus* infection for physicians. The consecutive microbiological surveillance among clinically significant isolates (such as *S. aureus*) has been ongoing in mainland China since 2005, named the China Antimicrobial Surveillance Network (CHINET). More and more hospitals from various provinces in China have participated in this programme since 2005. In the 2019 report, there were 36 tertiary hospitals from over 20 provinces or autonomous regions. Moreover, antimicrobial resistance of over 100,000 no-duplicate *S. aureus* isolates from routine laboratory work were submitted until 2019, which were informative to clinical physicians in treatment. Herein, we deciphered a trend of antimicrobial resistance among *S. aureus* from CHINET according to the last 15-year-period (2005–2019) reports, for physicians to develop a strategy in optimizing their approach of *S. aureus* infections.

All the data was downloaded from the website of the China Antimicrobial Surveillance Network (http://www.chinets.com). In vitro antimicrobial susceptibility of *S. aureus* isolates were determined by modified Kirby-Bauer disk diffusion method according to the Clinical and Laboratory Standards Institute (CLSI) guidelines. *S. aureus* ATCC 25923 was used as a quality control. Tigecycline (TGC) was evaluated according to the US FDA standard.

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A total of 132,284 non-duplicate clinical isolates of *S. aureus* (including methicillin-sensitive *S. aureus*, MSSA and methicillin-resistant *S. aureus*, MRSA) was submitted during the 15-year surveillance period, 54,438 (41.15%) of which were MRSA, according to CHINET. The overall MRSA rate decreased from 69% in 2005 to 31.4% in 2019, and the prevalence of MRSA strains in adult cases had a similar trend that peaked in 2005 (85.8%) and then declined over the following 15 years (2019, 31.7%). The MRSA rate in children's infection cases has grown several times, peaking at 33.4% (2014), and has been stable at about 30% in the last 4-year period. Since 2012, the proportion of MSSA have been overweight than MRSA on CHINET. Regarding antimicrobial resistance, erythromycin (ERY) exhibited poor activity in MRSA (resistance rate over 70% since 2005) as well as MSSA (resistance rate over 45% since 2005) in this series of reports. Clindamycin (CLI) also exhibited low-to-moderate antimicrobial susceptibility in both MRSA (resistance rate over 50% since 2005) and MSSA (resistance rate over 20% since 2005). There is an abrupt growth in gentamicin (GEN) resistant MRSA isolates in 2006 (from 36.3% to 89.3%), but GEN has shown increased activity in vitro against MRSA since then. Levofloxacin (LEV) presented an extremely high resistance rate fr[illegible]005 to 2012 (over 80%). Antimicrobial activ[illegible] of MR[illegible] in GEN, LEV, and rifampicin (RIF) h[illegible] gradually improved since 2012. Som[illegible] o[illegible] the tested antimicrobials reveale[illegible] a hig[illegible]r res[illegible]ce ratio in MRSA isolate rather [illegible]an MSSA of the same time

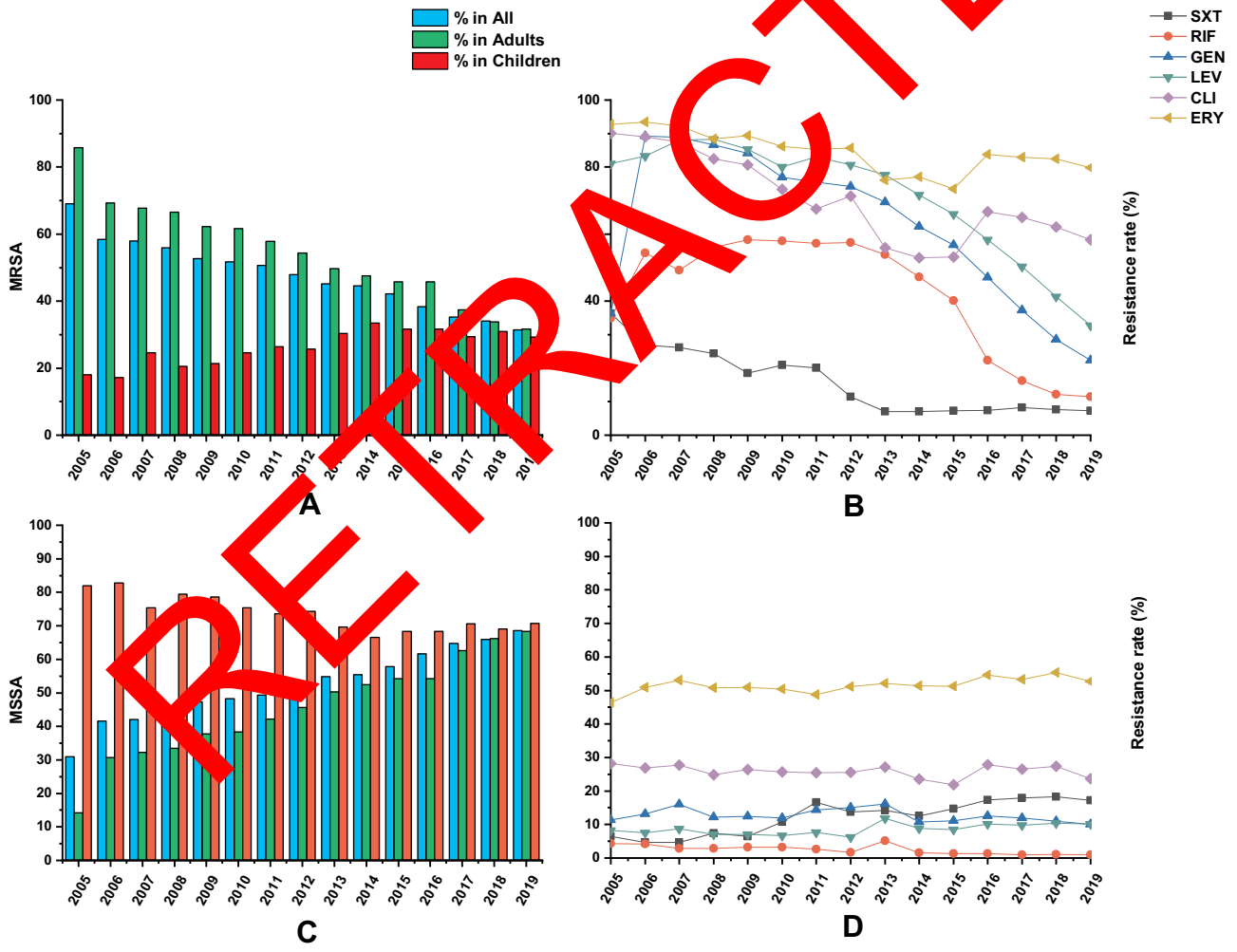

Figure 1 Trend in Antimicrobial Resistance of MRSA as well as MSSA in last 15-year-period CHINET reports (2005–2019). (**A** and **C**) The prevalence of MRSA and MSSA in adults and children, respectively. (**B** and **D**) The non-beta-lactam antibiotic agent resistance of MRSA and MSSA, respectively.
Notes: TGC resistant rate was firstly reported in 2019, which is 0.7% in MRSA and 0.1% in MSSA (not shown in figure). Only tertiary hospitals data was included in 2019.
Abbreviations: ERY, erythromycin; CLI, clindamycin; GEN, gentamicin; LEV, levofloxacin; RIF, rifampicin; SXT, trimethoprim–sulfamethoxazole.

point, including RIF, GEN, LEV, CLI, and ERY, but trimethoprim–sulfamethoxazole (SXT) was not. Notably, it was the first time that CHINET reported TGC resistant MRSA on 2019 (0.7%). All *S. aureus* isolates were found to be susceptible to vancomycin, teicoplanin, and linezolid (Figure 1).

The CHINET Antimicrobial Surveillance Program has been ongoing since its inception in 2005 and the trends in MRSA proportion have declined in the last 15-year report, which is consistent with other regional as well as national surveillance programs, such as SENTRY.[2] The noteworthy decreasing of MRSA isolate in the infection of adults is encouraging, but there has been concern about the considerable proportion in children, as it has greatly enhanced from 17.2% (2005) to 29.3% (2019), peaking at 33.4% in 2014. Moreover, it has stably contributed to about 30% of *S. aureus* infection in recent years, which indicated increased focus on infection prevention and stronger control interventions on children should be taken.

It is also encouraging that most of the non-beta-lactam agents exhibited better and better activity in vitro in recent years, both in MRSA and MSSA, but there is a high resistance rate of ERY, suggesting its potential t[illegible] failure of *S. aureus* infection. There is no surveil[illegible]nce about the TGC susceptibility of *S. aureus* [illegible] CHIN[illegible] report until 2019. However, our pre[illegible]ous a[illegible]d othe[illegible] work has revealed the low TGC resis[illegible]nce rat[illegible] of MRSA before 2019.[3,4] Perhaps detailed r[illegible]earch [illegible]GC resistant MRSA should be under perfo[illegible]d as there [illegible] scanty data about its molecular relatedn[illegible]ss, re[illegible]tant pattern, and virulence genes profiling in [illegible]hina. In sum[illegible]ary, we elucidated the trend of antimi[illegible]obial a[illegible]ong *S. aureus* based on the last 15-year-perio[illegible] CHI[illegible]ET report. Perhaps further insight about [illegible]ildhoo[illegible] MRSA [illegible]fection as well as TGC resistant M[illegible]RSA [illegible]olates [illegible] C[illegible]na should be warranted in the fut[illegible].

Limitations

All the data was from CHINET, which indicated that those data of the hospital beyond this program may be ignored.

Data Sharing Statement

The data that supported this study was based on available data.

Acknowledgment

We gratefully acknowledge the contributions of the members of CHINET for collection of [illegible]olates tested in the last 15 years (http://w[illegible]w.chine[illegible].com/Data/AntibioticDrugFast).

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Disclosure

The authors [illegible]port no conflicts of interest in this work.

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