Song *et al. Archives of Public Health* (2024) 82:182
https://doi.org/10.1186/s13690-024-01391-5

Archives of Public Health

RESEARCH

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Assessment of antibiotic consumption patterns in hospital and primary healthcare using WHO Access, Watch and Reserve classification (AWaRe) in Sichuan Western China: 2020

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Abstract

Background The Access, Watch, and Reserve (AWaRe) classification of antibiotics was a useful tool to support antibiotic stewardship. However, the AWaRe patterns of antibiotic consumption in Western China were unclear. We aimed to assess the antibiotic consumption patterns using the AWaRe Classification of public hospitals in Sichuan Province Western China.

Methods Antibiotic consumption data of year 2020 were obtained from the Sichuan Province Drug Use Monitoring Platform. We measured the antibiotic consumption (DDDs per 1,000 inhabitants per day, DIDs), calculated the proportion of antibiotic use, the ratio of Access to Watch antibiotics and patterns of antibiotic use by using drug utilization 90%.

Results This analysis included 4452 public health institutions. The antibiotic consumption rate was 10.39 DIDs (Median 8.50, IQR 7.71–12.96). The proportions of Access antibiotic use and Watch antibiotic use were 46.83% (Median 47.49, IQR 44.16–52.02) and 51.20% (Median 51.43, IQR 45.42–54.61), respectively. The Access-to-Watch index was 0.91 (Median 0.92, IQR 0.81–1.15). Amoxicillin (16.85%), cefuroxime (9.21%), cefixime (8.60%%), levofloxacin (8.11%) and metronidazole (6.16%) were the most consumed antibiotics.

Conclusions The proportion of Access antibiotic consumption in Sichuan Western China has not achieved the WHO target of 60%. Overuse of antibiotic is serious in Sichuan. National and regional antibiotics management systems,

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stewardship programs and surveillance of antibiotic consumption based on AWaRe classification are needed to improve antibiotic consumption patterns, curb antibiotic overuse and combat antimicrobial resistance in Western China.

Keywords Drug utilization, Antibiotic resistance, Antimicrobial stewardship, China

Text box 1. Contributions to the literature

This provides the first study that analyzed the patterns of antibiotic consumption in Western China according to the AWaRe framework and revealed the basic characteristics of antibiotic consumption in Sichuan Province

The study showed a low proportion of Access antibiotic consumption and overuse of antibiotics in Sichuan, Western China, emphasizing the need for targeted interventions and further research on improving antibiotic use

The regions with lower incomes in Sichuan consumed more antibiotics and a higher proportion of Access antibiotic consumption, suggesting a correlation between antibiotic consumption and economic level

Introduction

Antibiotic-resistant infections and antimicrobial resistance (AMR) have been a global public health concern. In 2019, antibiotic-resistant infections were responsible for the deaths of 1.27 million people, with an overall 4.95 million deaths associated with complications from resistant bacterial infections [1]. Without immediate action to tackle AMR, it could cause up to 10 million deaths globally per year by 2050 [2]. In addition to the negative impact on health, AMR may also induce significant economic impact, which could be responsible for a loss of 3.8% of the world's annual gross domestic product (GDP) [3]. The rapid development of AMR was primarily caused by the huge antibiotic consumption [4–6], which was generating selection pressure for resistance to evolve. However, antibiotic consumption is still increasing. According to a longitudinal study covering 204 countries, global per-capita antibiotic consumption increased by 46% from 2000 to 2018 [7]. Another study covering 76 countries showed the volume of antibiotic consumption increased by 65%, and the per-capita antibiotic consumption rate increased by 39% from 2000 to 2015 [8].

China, a country with a population of 1.4 billion, has a huge antibiotic consumption. In 2015, the human consumption of antibiotics in China was 3.8 billion DDDs, only lower than in India across the world [9]. To strengthen antimicrobial management, the Chinese government had taken many measures, such as the introduction of guidance for the clinical use of antibiotics, the establishment of national surveillance networks for both antibiotic use and resistance, the implementation of "Special Rectification Activities of Clinical Use of Antibacterial", and the implementation of "National action plan to curb bacterial resistance" [10].

Restricting the use of antibiotics could mitigate AMR, but the lack of access to antibiotics could also cause public health problems [11]. To ensure the accessibility of appropriate antibiotics and reduce the misuse or overuse of antibiotics, WHO introduced the Access, Watch, and Reserve (AWaRe) classification of antibiotics as a tool to optimize antibiotic use in 2017 [12]. The AWaRe Classification framework of antibiotics was formed by three different categories - Access, Watch and Reserve. Access antibiotics are typically used as first or second-choice antibiotics, and offer the best therapeutic value, while minimizing the potential for resistance. Watch antibiotics are only for specific indications due to their higher antimicrobial resistance potential. Reserve antibiotics include antibiotics of last resort, the use of which needs to be highly tailored and monitored to avoid the emergence of resistance to these antibiotics [13]. In 2019, a new category, not recommended antibiotics, was added to the framework encompassing inappropriate fixed-dose combinations of antibiotics that could exacerbate antimicrobial resistance and raise concerns about enhanced toxicity [12].

In recent years, several studies explored global patterns and trends of antibiotic consumption using AWaRe Classification, showing highly variable antibiotic consumption patterns between countries and obvious low utilization of antibiotics from the Access class in China [9, 14–16]. A study, analyzing the changes of antibiotic consumption in Shandong Eastern China using AWaRe Classification, found a continuous decline of Access antibiotic use proportion from 2012 to 2019 and concluded that the pattern of antibiotic consumption was still inappropriate [17]. However, the antibiotic consumption and the AWaRe pattern for other parts of China is unclear and research is extremely lacking, especially for the Western region. Compared to its richer Eastern counterpart, the Western region had inferior socioeconomic development status and more limited health resources, the public health and socioeconomic consequences of (even the same scale of) antibiotic-resistant infections and AMR may be much more severe. Sichuan Province has both the largest economic volume and the largest population in the Western region [18], its significance and representativeness of Western region. In response to the notice of the Health Commission on drug use monitoring in 2019 [19], Sichuan Province carried out drug use monitoring in public health institutions, including antibacterial drugs, which offered a great opportunity for us to do this research. Therefore, this study aimed to investigate the patterns of antibiotic consumption according to AWaRe classification in Sichuan.

Methods

Data sources and procedures

The socioeconomic characteristics of Sichuan province were collected from the "2020 Sichuan Statistics Yearbook" [20]. Sichuan Province, with 21 prefectures, is the most populous province (83.75 million) in Western China and the fifth among all provinces of the country. The GDP per capita in Sichuan Province was 8083$, ranking 16 out of 31 provinces in China [18]. The socioeconomic characteristics of Sichuan province and its 21 prefectures in 2020 are shown in the Supplementary file (Table S1).

The data of antibiotic consumption for the year 2020 were obtained from the Sichuan Province Drug Use Monitoring Platform, by which data were collected by the Health Commission of Sichuan Province, including information on annual drug consumption of all included public health institutions in the province. We extracted consumption data of antibiotics for systemic use (J01 category), while excluding those of antifungal (ATC code: J02), drugs for tuberculosis (ATC code: J04) treatment, antiviral (ATC code: J05), and antibiotics for topical use. Antibiotics were classified into the categories of Access, Watch, Reserve, and Not Recommended according to the 2021 WHO AWaRe classification [21]. Antibiotics that could not be assigned to the AWaRe categories were left unclassified [9].

Outcomes

Five indicators of antibiotic consumption were calculated in the descriptive analyses. The first is the population antibiotic consumption, using the number of defined daily dose (DDDs) per 1,000 inhabitants per day (DIDs). Data in kilograms were converted into DDDs according to Guidelines for ATC Classification and DDD Assignment [22]. As the data of some public healthcare institutions were not available, we calculated the weighted population covered by the public health institutions based on Eq. 1.

$$Y_i = P_i \times \frac{n_i}{N_i} \quad (1)$$

Yi refers to the coverage population, Pi refers to the total population, ni refers to the number of sample institutions, Ni refers to the number of total public health institutions.

The second is the proportion of antibiotics in the AWaRe categories, calculated as the antibiotic consumption per category divided by the total consumption. The third is the Access-to-Watch index which was calculated as the consumption of Access antibiotics divided by the consumption of Watch antibiotics. In addition, amoxicillin index (the DIDs of amoxicillin and phenoxymethylpenicillin divided by the total DIDs) [9] and patterns of antibiotic use by using drug utilization 90% (the number of antibiotics that accounted for 90% of the total antibiotic consumption) [23] were analysed.

Statistical analysis

Medians and IQRs were calculated for population antibiotic consumption rates, proportion of AWaRe antibiotic consumption, and Access-to-Watch index. Stratified analyses of these indicators were conducted by prefectures with varied economic development status. Analysis was conducted using Excel.

Results

This study involved 4452 public health institutions, accounting for 83% of all public health institutions (5364) in Sichuan. Among them, 518 were hospitals, accounting for 75% of all hospitals (690) in Sichuan; 3934 were public primary health institutions, accounting for 84% of all primary health institutions (4674) in this province.

Population antibiotic consumption

Antibiotic consumption characteristics of Sichuan and its 21 prefectures are shown in Table 1. Overall, the antibiotic consumption rate in Sichuan in 2020 was 10.39 DIDs (Median 8.50, IQR 7.71–12.96). And, the antibiotic consumption rate of Access and Watch antibiotics was 4.87 DIDs (Median 4.21, IQR 3.41–6.20) and 5.32 DIDs (Median 4.26, IQR 3.73–6.02), respectively.

Proportion of access or watch antibiotics

The antibiotic consumption patterns and their regional disparities are shown in Fig. 1. The overall proportion of Access antibiotic consumption was 46.83% (median 47.49%, IQR 44.16–52.02%) in Sichuan, ranging from the lowest of 35.33% in Zigong to the highest of 73.26% in Ganzi among the 21 prefectures. Only 14.29% (3/21) of prefectures in the province met the WHO target of Access antibiotics accounting for at least 60% of overall antibiotic consumption. The proportion of Watch antibiotic consumption was 51.20% (median 51.43%, IQR 45.42–54.61%) in Sichuan, ranging from the lowest in Ganzi of 25.58% to the highest in Neijiang of 63.39% among all 21 prefectures.

Reserve antibiotic consumption was very low and the proportion was 0.07% (Median 0.05%, IQR 0.02–0.09%), ranging from the lowest of 0.00% in Guang'an or Neijiang to the highest of 0.31% in Panzhihua. The proportion of Not-recommended antibiotic consumption was 1.49% (Median 1.11%, IQR 0.97–1.72%), ranging from the lowest of 0.35% in Ya'an to the highest of 2.63% in Chengdu.

Table 1 Antibiotic consumption characteristics of Sichuan province and its 21 prefectures, 2020

Region number	Regions	All antibiotics (DIDs)	Access antibiotics (DIDs)	Watch antibiotics (DIDs)	Reserve antibiotics (DIDs)	Not recommended antibiotics (DIDs)
	Sichuan province	10.39	4.87	5.32	0.01	0.15
	5th quintile (highest income)	9.28	3.69	5.32	0.01	0.19
1	Chengdu	8.50	3.08	5.10	0.01	0.22
2	Panzhihua	6.10	2.24	3.40	0.02	0.12
3	Deyang	9.52	4.21	5.18	0.00	0.10
4	Mianyang	12.96	6.00	6.78	0.00	0.14
	4th quintile	6.00	2.50	3.39	0.01	0.08
5	Yibin	5.33	2.61	2.66	0.00	0.05
6	Leshan	7.71	3.41	4.21	0.01	0.06
7	Zigong	5.20	1.84	3.23	0.01	0.07
8	Luzhou	6.03	2.14	3.73	0.00	0.14
	3rd quintile	10.93	5.27	5.55	0.00	0.11
9	Ya'an	17.91	11.81	6.02	0.02	0.06
10	Meishan	9.37	4.45	4.82	0.00	0.10
11	Suining	8.21	4.33	3.73	0.00	0.14
12	Aba	7.72	3.85	3.78	0.00	0.09
13	Neijiang	12.48	4.45	7.91	0.00	0.11
	2nd quintile	11.54	5.77	5.57	0.01	0.16
14	Guang'an	15.16	8.68	6.32	0.00	0.13
15	Nanchong	7.87	3.49	4.21	0.01	0.13
16	Dazhou	8.21	3.79	4.26	0.00	0.14
17	Guangyuan	22.37	11.57	10.46	0.02	0.27
	1st quintile (lowest income)	12.79	7.17	5.41	0.01	0.17
18	Liangshan	10.06	6.20	3.75	0.01	0.08
19	Ganzi	17.07	12.51	4.37	0.00	0.19
20	Ziyang	24.91	12.73	11.77	0.00	0.34
21	Bazhong	6.89	3.59	3.13	0.01	0.15

The proportion of unclassified antibiotic consumption was 0.41% (Median 0.24%, IQR 0.06–0.36%), and ranged from the lowest of 0.03% in Ya'an to the highest of 5.27% in Panzhihua. Among them, cefathiamidine (44.81%), etimicin (17.1%) and ampicillin probenecid (14.07%) were the most consumed unclassified antibiotics.

Antibiotic consumption by drug utilization 90%

It is worth noting that the antibiotics classification between China and the WHO AWaRe framework was different. As shown in Fig. 2, several Access antibiotics were categorized as restricted management classification in China, while Watch antibiotics were categorized as unrestricted management classification in China.

Access-to-Watch index

The Access-to-Watch index was 0.91 (Median 0.92, IQR 0.81–1.15), ranging from the lowest of 0.56 in Neijiang to the highest of 2.86 in Ganzi. Access-to-Watch indexes in 21 prefectures were shown in the Supplementary file (Figure S1).

Amoxicillin index and the patterns of antibiotic use

Amoxicillin was the most consumed antibiotic, accounting for 16.85% of the total antibiotic consumption. The consumption of Penicillin and Amoxicillin/beta-lactamase inhibitor was low, accounting for 3.14% and 5.30%, respectively. The top 90% of antibiotics in consumption proportion by AWaRe Classification is shown in Fig. 2.

Amoxicillin (16.85%), cefuroxime (9.21%), cefixime (8.60%%), levofloxacin (8.11%) and metronidazole (6.16%) were the five most commonly used antibiotics, appearing in the top five antibiotic consumption lists in 100% (21/21), 90.48% (19/21), 85.71% (18/21), 85.71% (18/21) and 47.62% (10/21) of all prefectures respectively, which in all accounted for 48.93% of the total antibiotic consumption in the province. The choices of antibiotics in different prefectures were similar to some extent. The top five antibiotics in consumption proportion in Sichuan province and its 21 prefectures by AWaRe classification are shown in the Supplementary file (Table S2).

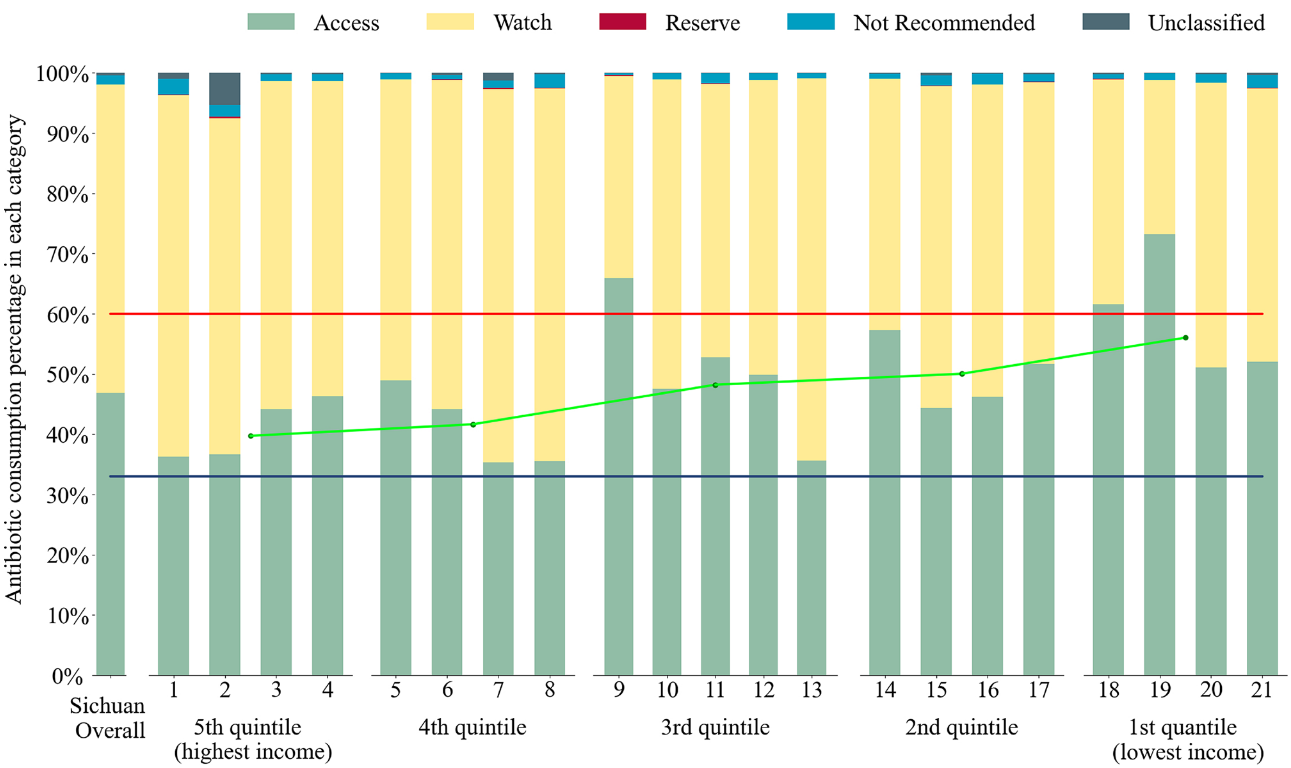

Fig. 1 Percentage of antibiotic consumption in Sichuan province and its 21 prefectures by AWaRe·Classification, 2020 (The red line marks the WHO target of at least 60% Access antibiotics in total antibiotic consumption, the green line marks the average proportion of Access antibiotics in each economic development status, and the blue line marks the average proportion of Access antibiotics in China in 2015 [9]; Prefectures represented by numbers can be found in Table 1)

Discussion

To our knowledge, this is the first study that analyzed the pattern of antibiotic consumption in Western China according to the AWaRe framework, which covers 83% of public health institutions in Sichuan province, including tertiary, secondary, and primary health institutions. It provides the basic characteristics of antibiotic usage in this province and identifies deficiencies and significant regional differences in antibiotic consumption.

There are several important findings of antibiotic consumption patterns in Sichuan Western China. First, the proportion of Access antibiotic consumption was lower than in other countries around the world and fails to meet the WHO target of at least 60% of access antibiotic consumption, though it is at a moderate level compared to other regions in China. In this study, the proportion of Access antibiotic consumption was 46.83% in Sichuan, which was higher than the national estimate of China in 2015 (33.3%) [9] and other provinces in China (Shanxi 40.31% [24], Shandong 45.2% [17]), but still lower than the global average of 60.6% at 2015 [9], the median percentage (68%, range: 22–77%) of 8 high-income countries at 2018 [25] and that in some developing countries, such as 80.3% in public sector of Limpopo province, South Africa [26], 64.8% in Sierra Leone [27]. The Chinese government has established a comprehensive system for antimicrobial stewardship in healthcare institutions [28–30], which produced significant achievements, including the reduction of antibiotic consumption and the reduction of irrational drug use [31–33]. However, this study showed that the proportion of Access antibiotic consumption was not yet achieved the target of WHO, indicating that further exploration is needed to identify the reasons for this result and to develop targeted strategies for improving the patterns of antibiotic consumption.

There may be several reasons why the proportion of Access antibiotic consumption was relatively low in China. First, the antibiotics management classification system in China was different from the WHO AWaRe classification. In China, antibiotics were classified into unrestricted, restricted, and special management categories, and prescription of restricted and special antibiotics was limited so as to improve the rational use of antibiotics [34, 35]. However, as shown in Fig. 2, approximately 10% of total antibiotic consumption, which was classified as WHO Access antibiotics, was categorized as restricted antibiotics; and approximately 35% of total antibiotic consumption, which was classified as WHO Watch antibiotics, was categorized as unrestricted antibiotics in China. This difference may influence the achievement of

Sichuan province 21 prefectures, 4452 institutions (518 hospitals, 3934 primary healthcare institutions)	5th quintile (highest income) 4 prefectures, 937 institutions (162 hospitals, 775 primary healthcare institutions)	4th quintile 4 prefectures, 650 institutions (88 hospitals, 562 primary healthcare institutions)	3rd quintile 5 prefectures, 685 institutions (90 hospitals,595 primary healthcare institutions)	2nd quintile 4 prefectures, 1166 institutions (84 hospitals, 1082 primary healthcare institutions)	1st quantile (lowest income) 4 prefectures, 1014 institutions (94 hospitals, 920 primary healthcare institutions)
Amoxicillin 16.85%	Amoxicillin 13.68%	Amoxicillin 12.50%	Amoxicillin 18.85%	Amoxicillin 17.74%	Amoxicillin 21.87%
Cefuroxime** 9.21%	Cefixime 9.71%	Cefuroxime 9.10%	Metronidazole 10.28%	Cefuroxime 9.29%	Cefuroxime 10.81%
Cefixime 8.60%	Levofloxacin 8.89%	Levofloxacin 9.01%	Cefuroxime 8.94%	Cefixime 9.05%	Cefixime 6.95%
Levofloxacin** 8.11%	Cefuroxime 8.38%	Benzylpenicillin 7.93%	Cefixime 8.41%	Levofloxacin 8.44%	Levofloxacin 6.08%
Metronidazole 6.16%	Amoxicillin/Clavulanic-Acid 6.12%	Cefixime 7.60%	Levofloxacin 7.79%	Amoxicillin/Clavulanic-Acid 7.18%	Cefradine 5.98%
Amoxicillin/Clavulanic-Acid* 5.27%	Metronidazole 5.15%	Metronidazole 5.11%	Ceftriaxone 4.32%	Metronidazole 5.76%	Metronidazole 5.35%
Ceftriaxone** 3.94%	Cefaclor 4.18%	Ceftriaxone 4.79%	Amoxicillin/Clavulanic-Acid 3.29%	Ampicillin 4.14%	Ceftriaxone 4.68%
Cefradine* 2.96%	Azithromycin 3.44%	Amoxicillin/Clavulanic-Acid 3.35%	Cefprozil 2.26%	Ceftriaxone 3.51%	Amoxicillin/Clavulanic-Acid 4.22%
Azithromycin*** 2.46%	Ceftriaxone 3.31%	Cefotaxime 3.18%	Azithromycin 2.25%	Cefradine 2.80%	Benzylpenicillin 3.54%
Ampicillin 2.45%	Ornidazole 2.94%	Cefazolin 2.95%	Ceftazidime 2.18%	Cefotaxime 2.66%	Ampicillin 3.18%
Cefaclor** 2.45%	Clarithromycin 2.49%	Ceftazidime 2.82%	Cefotaxime 2.13%	Cefaclor 2.39%	Gentamicin 2.17%
Benzylpenicillin 2.23%	Cefradine 2.46%	Clindamycin 2.79%	Cefradine 2.07%	Oxacillin 2.10%	Norfloxacin 1.94%
Cefotaxime** 2.15%	Clindamycin 1.87%	Azithromycin 2.40%	Ampicillin 2.03%	Sulfamerazine/Trimethoprim 2.02%	Ornidazole 1.88%
Ornidazole 1.99%	Cefotaxime 1.71%	Piperacillin/Tazobactam 2.15%	Roxithromycin 2.01%	Azithromycin 2.02%	Azithromycin 1.69%
Ceftazidime 1.84%	Ceftazidime 1.65%	Ornidazole 2.07%	Cefaclor 1.97%	Ceftazidime 1.99%	Cefotaxime 1.54%
Cefazolin 1.56%	Cefprozil 1.47%	Ampicillin 2.02%	Cefazolin 1.71%	Norfloxacin 1.58%	Cefazolin 1.32%
Clindamycin* 1.46%	Cefazolin 1.41%	Erythromycin 1.82%	Ornidazole 1.62%	Benzylpenicillin 1.51%	Roxithromycin 1.29%
Clarithromycin** 1.41%	Erythromycin 1.34%	Ceftizoxime 1.72%	Clindamycin 1.11%	Cefazolin 1.18%	Tinidazole 1.07%
Norfloxacin** 1.32%	Moxifloxacin 1.26%	Norfloxacin 1.25%	Nitrofurantoin 1.05%	Ornidazole 1.15%	Clarithromycin 1.07%
Cefprozil** 1.12%	Cefdinir 1.22%	Cefradine 1.21%	Ceftizoxime 1.02%	Clarithromycin 1.01%	Phenoxymethyl Penicillin 1.06%
Roxithromycin** 1.07%	Ceftizoxime 1.09%	Cefaclor 1.08%	Benzylpenicillin 0.98%	Clindamycin 0.90%	Ceftazidime 1.00%
Erythromycin** 1.01%	Piperacillin/Tazobactam 1.06%	Clarithromycin 0.99%	Tinidazole 0.98%	Phenoxymethyl Penicillin 0.77%	Cefaclor 0.99%
Sulfamerazine/Trimethoprim 0.97%	Ampicillin 0.99%	Cefprozil 0.96%	Doxycycline 0.96%	Roxithromycin 0.64%	Clindamycin 0.98%
Oxacillin 0.90%	Norfloxacin 0.96%	Sulfamerazine/Trimethoprim 0.91%	Norfloxacin 0.93%	Cefoperazone/Sulbactam 0.57%	
Piperacillin/Tazobactam 0.87%	Tetracycline 0.95%	Phenoxymethyl Penicillin 0.81%	Piperacillin/Tazobactam 0.89%		
Ceftizoxime 0.86%	Roxithromycin 0.91%				
Gentamicin* 0.77%	Cefoperazone/Sulbactam 0.76%				
Phenoxymethyl Penicillin 0.74%	Doxycycline 0.75%				

Access Watch Not Recommended

Fig. 2 Regional patterns of AWaRe antibiotic consumption in Sichuan province by drug utilization 90%, 2020. Access antibiotics categorized as restricted management classification in China; ** Watch antibiotics categorized as unrestricted management classification in China; *** Azithromycin(oral) and Azithromycin (intravenous injection) were categorized as unrestricted and restricted management classification in China, respectively

WHO's target. Therefore, communication and coordination of the two systems are warranted to align the international and national efforts to improve the pattern of antibiotic consumption, with an appropriate monitoring and feedback system and mechanism.

Second, inappropriate antibiotic prescribing has been highly prevalent in China [36]. Several factors may contribute to this phenomenon, including the misperception of patients who regard antibiotics as a panacea and prefer higher-level (and more expensive) antibiotics, and doctors who prescribe unnecessary antibiotics to patients due to a lack of professional knowledge or wish to satisfy the patients [37]. Education on the rational use of antibiotics for doctors should be valued and encouraged, at least including the specifications and guidelines for infectious diseases. In addition, publicity on antibiotic use for residents was also crucial.

There are significant regional disparities in antibiotic consumption patterns in Sichuan. Low-income regions had higher antibiotic consumption and higher proportions of Access antibiotic consumption than middle- and high-income regions (except for the highest 20% income quantile regions). This phenomenon was also observed in Shandong China [17]. However, different phenomena were observed in global research, which showed that antibiotic consumption increased gradually with the income level of countries, and the proportions of Access antibiotic consumption were similar between high-, up-middle, and low-middle income countries in 2015 [9].

The regional disparities may be caused by multiple factors. First, regions with lower income were more likely to lack qualified physicians in China, which was the biggest barrier to reducing antibiotic overuse [38, 39]. Second, the expectations of patients for antibiotic therapy in low-income regions [40] might be also important causes resulting in higher antibiotic consumption. Thirdly, the weak supervision and a large number of inappropriate antibiotic prescribing in primary health institutions exacerbated antibiotic overuse in low-income regions. Antibiotic stewardship primarily targeted urban tertiary and secondary hospitals instead of primary health institutions during past during the past decade and more than 70% of antibiotic prescriptions were inappropriate in institutions healthcare facilities in China [30, 41]. On the other hand, mobile visits of patients might be the reason why antibiotic consumption in the highest 20% income quantile regions was higher than in the 2nd 20% income quantile regions. Mobile visits of patients from low-income regions to high-income regions for higher-quality treatments were becoming increasingly common [42], which led an overestimation of antibiotic consumption based on population in high-income regions.

Overall, in high-income regions, the problem of underuse of Access and overuse of Watch antibiotics was more serious than its counterparts. While in low-income regions, antibiotic overuse was more prominent, where it was urgent to take measures to curb antibiotic abuse, such as educating patients and physicians on antibiotic use and enlarging the scope of antibiotic stewardship to cover primary health institutions.

The strength of the study lies in the use of hospital drug consumption surveillance data. Several data sources have been used to examine the antibiotic use pattern, including the point prevalence survey data [15] which may not reflect use patterns over a period of time, and drug sales data which may not reliably reflect actual consumption [9]. The hospital drug consumption surveillance data involving nearly all public hospitals and primary health institutions in a vast region in a whole year, providing a more comprehensive and accurate estimate of antibiotic usage patterns than other data sources. Second, the consumption of antibiotics group was calculated according to the internationally recognized WHO AWaRe classification system, which enabled national and international comparisons for problem identification and strategic planning for improvement.

This study has several limitations. First, due to the limitation of the data source, only public health institutions were included, and data from private medical institutions and private pharmacies were lacking in this study. Therefore, the total consumption may be underestimated. However, as public health institutions are the dominant providers of healthcare in China, and weight adjustment of the population has been used, the influence may be minimal. Second, this is a cross-sectional study that examined the antibiotics consumption pattern in 2020, further study could employ longitudinal data to get more insights into the changing trend of AWaRe pattern in this region. Third, this study observed considerable regional disparities. Further studies are warranted to uncover the underlying socioeconomic and health system determinants so that tailored strategies considering local characteristics could be made to promote rational use of antibiotics at the regional and county level.

Conclusion

The proportion of Access antibiotic consumption in Sichuan Western China has not achieved the WHO target of 60%. Overuse of antibiotics is serious in Sichuan. National and regional antibiotics management systems, stewardship programs, and surveillance of antibiotic consumption based on AWaRe classification are needed to improve antibiotic consumption patterns, curb antibiotic overuse, and combat antimicrobial resistance in Western China.

Abbreviations

AMR	Antimicrobial Resistance
AWaRe	Access, Watch, and Reserve
DDD	Defined Daily Dose
DIDs	The number of DDDs per 1,000 inhabitants per day
IQR	Interquartile Range
GDP	Gross domestic product

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13690-024-01391-5.

Supplementary Material 1

Acknowledgements
Not applicable.

Author contributions
Kun Zou, Haoxin Song, Lingli Zhang and Hailong Li initiated and design the study. Haoxin Song and Xiao Liu analyzed the data and wrote the first draft. Kun Zou, Hailong Li, Haotian Fei, Liang Huang and Qin Yu gave comments. All authors revised it critically for important intellectual content and gave their approval of the final version.

Funding
This study was supported by Fundamental Research Funds for the Central University (SCU2022D006), Interdisciplinary medical key project of Sichuan University and National Natural Science Foundation for Young Scholars of China (72004151).

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent to publish
Not applicable.

Competing interests
The authors declare no competing interests.

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Received: 4 April 2024 / Accepted: 4 September 2024
Published online: 14 October 2024

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