

Evaluation of Outpatient Antibiotic Use in Beijing General Hospitals in 2015

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Abstract

Background: Medical misuse of antibiotics is associated with the acquisition and spread of antibiotic resistance, resulting in a lack of effective drugs and increased health-care cost. Nevertheless, inappropriate antibiotic use in China remains common and the situation requires urgent improvement. Here, we analyzed the prescriptions of antibiotics and evaluated the rationality of antibiotic use among outpatients in Beijing general hospitals during 2015.

Methods: We collected basic medical insurance claim data from January 1, 2015 to December 31, 2015 in 507 general hospitals of Beijing. A descriptive analysis of outpatient antibiotic prescribing was performed. The Anatomical Therapeutic Chemical Classification/defined daily doses system was used to evaluate the rationality of antibiotic use.

Results: Over the study, an estimated 721,930, 613,520, and 822,480 antibiotics were dispensed in primary, secondary, and tertiary general hospitals corresponding to 5.09%, 5.06%, and 2.53% of all prescriptions, respectively. Antibiotic combinations represented 2.95%, 7.74%, and 10.18% of the total antibiotic prescriptions, respectively. Expenditure for the top twenty antibiotics in primary, secondary, and tertiary general hospitals was RMB 42.92, 65.89, and 83.26 million Yuan, respectively. Cephalosporins were the most frequently prescribed class of antibiotic in clinical practice. The antibiotics used inappropriately included azithromycin enteric-coated capsules, compound cefaclor tablets and nifuratel nysfungin vaginal soft capsules in primary hospitals, amoxicillin and clavulanate potassium dispersible tablets (7:1) and cefonicid sodium for injection in secondary hospitals, cefminox sodium for injection and amoxicillin sodium and sulbactam sodium for injection in tertiary hospitals.

Conclusions: Antibiotic use in Beijing general hospitals is generally low; however, inappropriate antibiotic use still exists. Inappropriately used antibiotics should be subject to rigorous control and management, and public policy initiatives are required to promote the judicious use of antibiotics.

Key words: Antibiotic; General Hospitals; Rationality

INTRODUCTION

The use of antibiotics is known to be the single most important driver of antibiotic resistance. Nevertheless, antibiotic misuse remains common,^[1] particularly in China, which has the world's most rapid growth of antibiotic resistance.^[2,3] The rate of antibiotic prescriptions for both inpatients and outpatients is high in China.^[4] In the primary care system, which comprises a network of mostly rural facilities that are responsible for approximately two-thirds of health-care provision in China, more than 60% of antibiotic prescriptions were found to be inappropriate. The key concerns were the overprescribing of antibiotics. Between 78% and 93% of respiratory infections were treated with antibiotics, a rate that is far in excess of the levels recommended by the World

Health Organization.^[5,6] Antibiotic resistance results in a lack of effective drugs to fight infections, as well as increased health-care cost, prolonged hospital stay, and substantially increased social and economic burdens.^[5]

In 2009, the Chinese government launched a national program of health-care reform and implemented the

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National System for Basic Drugs. One of the goals was to urge the public to seek care scientifically, and safe, effective, and appropriate use of medicines was proposed.^[7] The progression of China's health-care reform and the implementation of the pharmaceutical policy represent a positive change in ensuring the appropriate use of antibiotics in China.^[8] However, the measures adopted to date are far from adequate^[4] and inappropriate use of antibiotics in China remains common.^[6,9] In this study, we analyzed the prescriptions of antibiotics and evaluated the rationality of antibiotic use among outpatients in Beijing's general hospitals during 2015.

METHODS

Data collection

In this study, we collected basic medical insurance claim data from January 1, 2015, to December 31, 2015, in Beijing's 507 general hospitals including 44 tertiary general hospitals, 60 secondary general hospitals, and 403 primary general hospitals. The data covered the patients' demographic information, medicines prescribed (including medicine name, dose, and duration), and expenditure. Stratified random sampling was conducted and 30% of hospitals were selected as the study sample (13 tertiary hospitals, 18 secondary hospitals, and 120 primary hospitals).

Statistical analysis

SQL Server 2008 (Microsoft Corporation Inc., Redmond, WA, USA) was used for the storage, retrieval, and manipulation of all data. SPSS 20.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analyses. $P < 0.05$ was considered statistically significant.

We performed a descriptive analysis of outpatient antibiotic prescribing. The descriptive indexes included antibiotic expenditure, number of antibiotic prescriptions, average cost per antibiotic prescription, antibiotic prescriptions as a percentage of all prescriptions (defined as the number of antibiotic prescriptions divided by the total number of prescriptions), injectable antibiotic prescriptions as a percentage of all antibiotic prescriptions (defined as the number of injectable antibiotic prescriptions divided by the total number of antibiotic prescriptions), and antibiotic combinations as a percentage of all antibiotic prescriptions (defined as the number of antibiotic combination prescriptions divided by the total number of antibiotic prescriptions). Differences in rates among different general hospital ratings were compared using the Chi-squared test.

The Anatomical Therapeutic Chemical Classification/defined daily doses (ATC/DDDs) system developed by the World Health Organization serves as a tool for drug utilization research to improve quality of drug use.^[10] The ATC/DDD system is independent of package size and sales price. It allows comparisons not only within an institution but also within a region, a country, or even internationally.^[10,11] Rationality of antibiotic use was analyzed quantitatively

by calculating the frequency of drug use (DDDs) and drug utilization index (DUI). DDDs were defined as the total amount of drugs prescribed during the study divided by the DDD value. The DDD value increases with the frequency of drug use. DDD values were obtained from the ATC/DDD index (2010) of the WHO Collaborating Center for Drugs Statistics Methodology and the Chinese Pharmacopoeia, 2015.^[10,12] DUI values were defined as DDDs divided by the medication duration. DUI values for an antibiotic exceeding 1.0 indicate the existence of inappropriate use.^[10,11]

RESULTS

Outpatient antibiotic prescriptions in general hospitals in Beijing, 2015

Table 1 provides a description of outpatient antibiotic prescribing in general hospitals in Beijing. In primary general hospitals, 721,930 antibiotics were dispensed, representing 5.09% of all prescriptions and costing RMB 46.98 million Yuan. In secondary general hospitals, 613,520 antibiotics were dispensed, representing 5.06% of all prescriptions and costing RMB 82.58 million Yuan. In tertiary general hospitals, 822,480 antibiotics were dispensed, representing 2.53% of all prescriptions and costing RMB 116.38 million Yuan. The percentage of antibiotic prescriptions among all prescriptions in tertiary hospitals was significantly lower than that in the primary and secondary general hospitals ($\chi^2 = 267,971.360$, $P < 0.01$). The correlation between the proportion of antibiotic prescriptions among all prescriptions and patient age is shown in Figure 1. In primary and secondary hospitals, the proportion of antibiotic prescriptions decreased with increasing patient age. The decrease in the proportion of antibiotic prescriptions was similar for both primary and secondary hospitals. In tertiary hospitals, the proportion of antibiotic prescriptions decreased with patient age up to 70 years, with a subsequent increase with patient age. Furthermore, the initial decrease in the proportion of antibiotic prescriptions for tertiary hospitals was smaller than those observed for primary and secondary hospitals.

Injectable antibiotic prescriptions represented 6.55%, 19.02%, and 21.41% of all antibiotic prescriptions

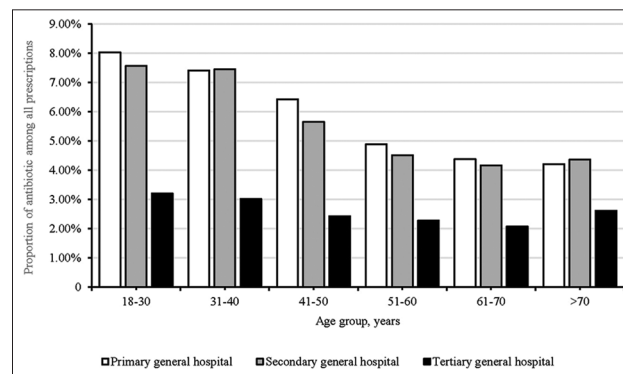


Figure 1: Proportion of antibiotic prescriptions among all prescriptions in Beijing general hospitals by age group.

Table 1: Outpatient antibiotic prescriptions in Beijing general hospitals, 2015

Age (years)	Primary general hospital				
	Antibiotic expenditures (RMB, million Yuan)	Number of antibiotic prescriptions	Average cost per antibiotic prescription (RMB Yuan)	Antibiotic as a percentage of all prescription (%)	Injectable antibiotic as a percentage of all antibiotic prescriptions (%)
18-30	1.76	27,960	62.98	8.03	12.25
31-40	5.29	83,050	63.77	7.41	8.18
41-50	7.62	120,860	63.12	6.42	6.12
51-60	12.87	200,750	64.12	4.88	5.28
61-70	11.07	170,110	65.10	4.37	5.92
>70	8.34	119,200	70.04	4.21	7.56
Total	46.98	721,930	65.08	5.09	6.55

Age (years)	Secondary general hospital				
	Antibiotic expenditures (RMB, million Yuan)	Number of antibiotic prescriptions	Average cost per antibiotic prescriptions (RMB Yuan)	Antibiotic as a percentage of all prescriptions (%)	Injectable antibiotic as a percentage of all antibiotic prescriptions (%)
18-30	6.18	49,100	125.94	7.56	28.85
31-40	12.97	102,280	126.85	7.45	22.19
41-50	13.01	100,500	129.41	5.65	16.81
51-60	19.11	142,150	134.41	4.51	16.27
61-70	16.47	118,460	139.07	4.16	16.22
>70	14.84	101,040	146.86	4.36	20.36
Total	82.58	613,520	134.60	5.06	19.02

Age (years)	Tertiary general hospital				
	Antibiotic expenditures (RMB, million Yuan)	Number of antibiotic prescriptions	Average cost per antibiotic prescription (RMB Yuan)	Antibiotic as a percentage of all prescriptions (%)	Injectable antibiotic as a percentage of all antibiotic prescription (%)
18-30	10.51	90,070	116.71	3.21	21.09
31-40	20.21	167,670	120.57	3.01	18.12
41-50	13.79	108,070	127.61	2.42	15.82
51-60	23.21	160,020	145.02	2.27	19.19
61-70	19.66	130,640	150.46	2.07	20.77
>70	29.00	166,020	174.70	2.61	31.20
Total	116.38	822,480	141.50	2.53	21.41

in primary, secondary, and tertiary general hospitals, respectively, with significantly lower rates in primary hospitals compared with those in secondary and tertiary hospitals ($\chi^2 = 70,785.984, P < 0.01$). The correlation between the proportion of injectable antibiotic prescriptions among all antibiotic prescriptions and patient age is shown in Figure 2. The proportion of injectable antibiotic prescriptions among the total antibiotic prescriptions for all general hospitals decreased initially with increasing patient age, with a subsequent increase observed after the age of 50 years in primary hospitals, 60 years in secondary hospitals, and 40 years in tertiary hospital.

The average cost per antibiotic prescription in primary, secondary, and tertiary general hospitals was RMB 65.08, 134.60, and 141.50 Yuan, respectively. The correlation between average cost per antibiotic prescription and patient age is shown in Figure 3. In primary hospitals, the average cost per antibiotic prescription remained almost constant

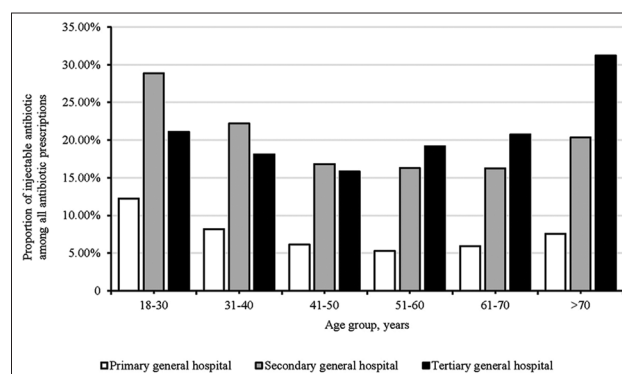


Figure 2: Proportion of injectable antibiotic prescriptions among all antibiotic prescriptions in Beijing general hospitals by age group.

with increasing patient age, while in secondary and tertiary hospitals, it increased with patient age. The increasing average cost per antibiotic prescription of tertiary hospitals was higher than that of secondary hospitals.

Table 2 provides a description of antibiotic combinations prescribed to outpatients in general hospitals in Beijing during 2015. Dual antibiotics combination prescriptions in

primary, secondary, and tertiary general hospitals represented 2.89%, 6.77%, and 8.42% of all antibiotic prescriptions while prescriptions for combinations of three or more antibiotics represented 0.06%, 0.97%, and 1.75% of all antibiotic prescriptions, respectively. Overall, antibiotic combinations prescribed to outpatients were relatively low as a percentage of all antibiotics prescriptions in general hospitals in Beijing, with significantly increasing percentages as the rating of hospitals increased from primary to tertiary ($\chi^2 = 31,911.939$, $P < 0.01$). Dual antibiotic combinations were the most frequently prescribed, accounting for more than 80% of all antibiotic combination prescriptions. The correlation between antibiotic combination prescriptions as a proportion of all antibiotic prescriptions and patient age is shown in Figure 4. In primary hospitals, the percentage of antibiotic combination prescriptions remained almost constant with increasing patient age while the percentage increased with patient age in secondary and tertiary hospitals.

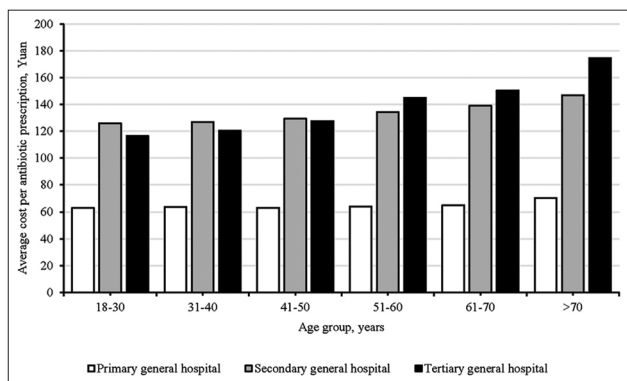


Figure 3: Average cost per antibiotic prescription among outpatients in Beijing general hospitals by age group.

Table 2: Outpatient antibiotic combinations in Beijing general hospitals, 2015

Age (years)	Primary general hospital			
	Single-drug as a percentage of antibiotic prescriptions (%)	Dual combination as a percentage of antibiotic prescriptions (%)	Triple or more combination as a percentage of antibiotic prescriptions (%)	Combination as a percentage of antibiotic prescriptions (%)
18-30	96.86	3.08	0.07	3.14
31-40	96.76	3.17	0.07	3.24
41-50	97.15	2.80	0.06	2.85
51-60	96.99	2.95	0.06	3.01
61-70	97.09	2.86	0.06	2.91
>70	97.22	2.72	0.06	2.78
Total	97.05	2.89	0.06	2.95

Age (years)	Secondary general hospital			
	Single-drug as a percentage of antibiotic prescriptions (%)	Dual combination as a percentage of antibiotic prescriptions (%)	Triple or more combination as a percentage of antibiotic prescriptions (%)	Combination as a percentage of antibiotic prescriptions (%)
18-30	92.69	6.82	0.49	7.31
31-40	92.50	7.03	0.47	7.50
41-50	92.31	7.17	0.52	7.69
51-60	92.56	6.83	0.61	7.44
61-70	93.00	6.17	0.84	7.00
>70	90.58	6.75	2.67	9.42
Total	92.26	6.77	0.97	7.74

Age (years)	Tertiary general hospital			
	Single-drug as a percentage of antibiotic prescriptions (%)	Dual combination as a percentage of antibiotic prescriptions (%)	Triple or more combination as a percentage of antibiotic prescriptions (%)	Combination as a percentage of antibiotic prescriptions (%)
18-30	92.13	7.08	0.79	7.87
31-40	91.20	8.02	0.78	8.80
41-50	90.66	8.22	1.12	9.34
51-60	90.34	8.18	1.48	9.66
61-70	89.54	8.42	2.04	10.46
>70	86.69	9.79	3.53	13.31
Total	89.82	8.42	1.75	10.18

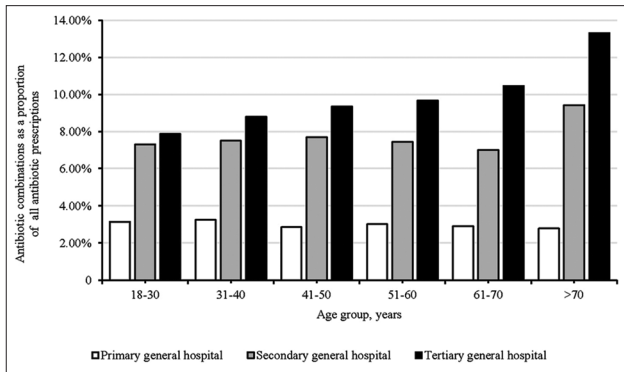


Figure 4: Antibiotic combination prescriptions as a proportion of all antibiotic prescriptions among outpatients in Beijing general hospitals by age group.

Outpatient antibiotic expenditures

Table 3 provides the expenditure for each antibiotic as a proportion of the total antibiotic expenditure in general hospitals in Beijing during 2015. Expenditure for the top twenty antibiotics in primary, secondary, and tertiary general hospitals was RMB 42.92, 65.89, and 83.26 million Yuan representing 91.35%, 79.79%, and 71.54% of the expenditures for the total antibiotic expenditure, respectively. Compared with secondary and tertiary hospitals, antibiotic use in primary hospitals was predominantly confined to the top twenty antibiotics. The top two antibiotics in terms of expenditures were cephalosporins in all three general hospitals' ratings.

Rationality of antibiotic use

Table 4 provides the DDDs and DUI values for outpatient antibiotic prescriptions for general hospitals in Beijing during 2015. To evaluate the rationality of antibiotic use, we calculated the DDDs and DUI values of the top 15 antibiotics in terms of expenditure (with the exception of polymyxin B, for which a DDD value was not assigned). In terms of DDDs rankings, cephalosporins accounted for the top five antibiotics (with the exception of the third most commonly used antibiotic, azithromycin enteric-coated capsules) in primary hospitals, the top six antibiotics in secondary hospitals, and the top eight antibiotics (with the exception of the fifth, fosfomycin trometamol powder) in tertiary hospitals. Thus, cephalosporins represent the most frequently prescribed class of antibiotic in clinical practice and the first choice of antimicrobial agent among clinicians. In primary hospitals, antibiotics with DUI >1 were azithromycin enteric-coated capsules, compound cefaclor tablets and nifuratel nysfungin vaginal soft capsules. In secondary hospitals, antibiotics with DUI >1 were amoxicillin and clavulanate potassium dispersible tablets (7:1) and cefonicid sodium for injection. In tertiary hospitals, antibiotics with DUI >1 were cefminox sodium for injection and amoxicillin sodium and sulbactam sodium for injection.

DISCUSSION

In this study, we analyzed the data for antibiotic prescriptions among outpatients of general hospitals in Beijing during

2015 to evaluate the current situation in terms of antibiotic prescribing patterns and rationality of use in this population.

The results of our analysis showed that antibiotic prescriptions as a proportion of all prescriptions during the study were far below the proportion of antimicrobial agent prescriptions that is recommended 20% by the guidelines for the clinical application of antibiotics in China.^[13] The proportion in tertiary hospitals was lower than that reported nationwide in 2012 (estimated to be 10%).^[14] It was also lower than that reported in another study in Hubei Province.^[15] However, compared with the proportion in the United States^[16] and some European countries,^[17] such as Sweden, where antibiotic prescriptions represent 1.1% of all prescriptions,^[14] the proportion remains high in Beijing tertiary hospitals. In primary general hospitals, the proportion in Beijing was also lower than that in other provinces, such as Jilin and Jiangsu Province.^[5] Compared with other countries, the proportion in Beijing primary general hospitals is relatively higher than that in the United States and other developed countries,^[18] although it is comparable to that in India and South Korea.^[19,20] Antibiotic prescriptions represented significantly higher proportions of all prescriptions in primary and secondary hospitals than that in tertiary hospitals. This shows that antibiotics are more frequently prescribed in the primary care setting, thus increasing the risk of inappropriate antibiotic use. The primary and secondary general hospitals include most of the township health centers and county hospitals. The application of antibiotics in these medical institutions has a great impact on antibiotic resistance in rural areas.^[21] Antibiotic prescriptions as a proportion of all prescriptions showed a decreasing trend with increasing patient age. The morbidity of most diseases increases with patient age, with a concomitant increase in drug use for the disease; therefore, antibiotic prescriptions as a proportion of all prescriptions may show a relative decrease.

The WHO recommends that oral antibiotics should be given priority in antibiotic use and injectable antibiotics should be used only when necessary.^[22] The analysis showed that injectable antibiotic prescriptions as a proportion of all antibiotic prescriptions were lower than recommended by the WHO.^[23] Injectable antibiotic prescriptions as proportions of all antibiotic prescriptions in secondary and tertiary hospitals were significantly higher than that in primary hospitals. In a nationwide study, the proportion is estimated to be 20% in tertiary hospitals, which is similar to that in Beijing, while in Sweden, the proportion is estimated to be only 0.1%.^[14] Injectable antibiotics are absorbed rapidly, with a significant curative effect that mitigates the disease effectively and efficiently. The patients in secondary and tertiary hospitals are usually in a more serious condition than those in primary hospitals. Thus, injectable antibiotics may be more frequently applied in secondary and tertiary hospitals. However, in this setting, the consequences of serious adverse drug reactions are difficult to control.^[24] Therefore, injectable antibiotics should be used only when necessary and the application should be supervised rigorously.

Table 3: Expenditure for each antibiotic as a proportion of the total antibiotic expenditure among outpatients in Beijing general hospitals, 2015 (ranking by proportion)

Primary general hospital		Secondary general hospital		Tertiary general hospital	
Antibiotic	Proportion (%)	Antibiotic	Proportion (%)	Antibiotic	Proportion (%)
Cefuroxime axetil tablets	19.54	Cefixime dispersible tablets	12.75	Cefdinir dispersible tablets	9.00
Compound cefaclor tablets	12.05	Cefdinir dispersible tablets	7.50	Cefoxitin sodium for injection	6.11
Azithromycin enteric-coated capsules	9.54	Cefdinir capsules	5.61	Cefminox sodium for injection	5.95
Cefuroxime axetil dispersible tablets	7.32	Cefmetazole sodium for injection	4.83	Cefuroxime axetil tablets	4.88
Cefotaxime sodium for injection	6.00	Cefoxitin sodium for injection	4.60	Etimicin sulfate injection	4.77
Fosfomicin trometamol powder	5.34	Cefaclor sustained release tablets	4.30	Cefdinir capsules	4.72
Amoxicillin dispersible tablets	4.66	Etimicin sulfate injection	4.25	Cefixime dispersible tablets	4.10
Erythromycin cyclocarbonate tablets	4.62	Cefonicid sodium for injection	3.75	Ceftizoxime sodium for injection	4.07
Cefaclor capsules	4.53	Cefixime capsules	3.38	Ertapenem for injection	3.83
Etimicin sulfate injection	3.62	Cefprozil dispersible tablets	3.37	Fosfomicin trometamol powder	3.83
Etimicin sulfate and sodium chloride injection	3.09	Cefminox sodium for injection	3.34	Cefixime capsules	3.45
Cefuroxime sodium for injection	2.77	Amoxicillin dispersible tablets (7:1)	3.23	Cefotaxime sodium and sulbactam sodium for injection	2.58
Cefonicid sodium for injection	1.34	Cefprozil tablets	2.79	Cefmetazole sodium for injection	2.09
Nifuratel nysfungin vaginal soft capsules	1.30	Nifuratel nysfungin vaginal soft capsules	2.71	Compound polymyxin b ointment	1.81
Clindamycin hydrochloride for injection	1.26	Cefuroxime axetil tablets	2.58	Latamoxef sodium for injection	1.78
Clindamycin phosphate for injection	1.17	Cefuroxime sodium for injection	2.39	Piperacillin sodium and sulbactam sodium for injection (4:1)	1.76
Dirithromycin enteric-coated tablets	0.94	Ceftazidime for injection	2.25	Nifuratel nysfungin vaginal soft capsules	1.74
Amoxicillin dispersible tablets (7:1)	0.85	Cefixime tablets	2.18	Azithromycin tablets	1.73
Amoxicillin dispersible tablets (2:1)	0.77	Azithromycin enteric-coated capsules	2.02	Azithromycin lactobionate for injection	1.71
Erythromycin enteric-coated capsules	0.66	Cefotaxime sodium and sulbactam sodium for injection	1.95	Clarithromycin tablets	1.63
Total	91.36	Total	79.79	Total	71.54

Average cost per antibiotic prescription in primary general hospitals was RMB 65.08 Yuan, which was similar to the cost of RMB 60 Yuan reported in a nationwide survey in 2009.^[25] The average cost per antibiotic prescription in secondary and tertiary hospitals was significantly higher than that in primary hospitals. Two hypotheses may explain this observation. First, patients develop more severe and complicated disease in secondary and tertiary general hospitals than in primary

hospitals, which may lead patients to be treated with more effective drugs or antibiotic combinations at high cost. Second, this could be accounted for the cumulative effects of increased drug prices in secondary and tertiary hospitals that have not completely cancelled the rates of drug price addition,^[26] and also the financial incentives offered to motivate clinicians to prescribe more expensive drugs in some hospitals.^[6]

Table 4: DDDs, DUI values for outpatient antibiotics prescriptions in Beijing general hospitals, 2015 (ranking by DDDs)

Primary general hospital			Secondary general hospital			Tertiary general hospital		
Antibiotic	DDDs (million)	DUI	Antibiotic	DDDs (million)	DUI	Antibiotic	DDDs (million)	DUI
Cefuroxime axetil tablets	10868.01	0.72	Amoxicillin and clavulanate potassium dispersible tablets (7:1)	4912.42	2.41	Cefuroxime axetil tablets	6409.66	0.92
Azithromycin enteric-coated capsules	5778.12	1.18	Cefixime dispersible tablets	3158.84	0.72	Cefdinir dispersible tablets	1520.5	0.27
Cefuroxime axetil dispersible tablets	2860.32	0.60	Cefuroxime axetil tablets	2216.52	0.74	Cefoxitin sodium for injection	1001.71	0.58
Compound cefaclor tablets	2453.61	1.08	Cefaclor sustained release tablets	2006.18	0.66	Cefminox sodium for injection	709.82	1.09
Cefaclor capsules	1647.38	0.54	Cefprozil tablets	1791.07	0.89	Fosfomycin trometamol powder	635.32	0.80
Amoxicillin and clavulanate potassium dispersible tablets	1643.78	0.55	Nifuratel nysfungin vaginal soft capsules	1738.50	0.97	Cefixime dispersible tablets	559.75	0.29
Erythromycin cyclocarbonate tablets	801.3	0.62	Cefprozil dispersible tablets	1525.42	0.87	Cefixime capsules	541.59	0.30
Nifuratel nysfungin vaginal soft capsules	745.56	1.16	Cefdinir dispersible tablets	1273.26	0.38	Cefdinir capsules	502.45	0.19
Fosfomycin trometamol powder	365.56	0.48	Cefdinir capsules	1057.49	0.43	Amoxicillin sodium and sulbactam sodium for injection	404.99	1.21
Cefotaxime sodium for injection	170.4	0.54	Cefixime capsules	634.14	0.45	Cefmetazole sodium for injection	125.12	0.20
Clindamycin hydrochloride for injection	148.83	0.99	Cefonicid sodium for injection	421.19	1.13	Piperacillin sodium and sulbactam sodium for injection (4:1)	116.98	0.34
Cefuroxime sodium for injection	123.15	0.61	Cefoxitin sodium for injection	306.00	0.40	Latamoxef sodium for injection	87.28	0.38
Etimicin sulfate injection	113.73	0.81	Cefminox sodium for injection	303.62	0.63	Ertapenem for injection	72.62	0.32
Etimicin sulfate and sodium chloride injection	100.06	0.76	Cefmetazole sodium for injection	233.08	0.37	Ceftizoxime sodium for injection	65.93	0.10
Cefonicid sodium for injection	93.96	0.97	Etimicin sulfate injection	194.55	0.51	Etimicin sulfate injection	65.11	0.11

DDDs: Defined daily doses; DUI: Drug utilization index.

Prescriptions for antibiotic combinations represent a low proportion of all antibiotic prescriptions although the proportion increased with the rating of the hospital from primary to tertiary. A study showed that almost 30% of all antibiotic prescriptions were for antibiotic combinations in tertiary hospitals in Hubei Province.^[15] The proportion

in Beijing was significantly lower than that in Hubei Province. Antibiotic combinations were prescribed for serious diseases or patients who were infected by multiple microorganisms to provide broad-spectrum antibacterial efficacy.^[27] Inappropriate use of antibiotic combinations may cause adverse events such as increasing the selective

pressure of antimicrobial agents and driving the acquisition of antibiotic resistance.^[28] Thus, the relevant guidelines should be followed rigorously when prescribing antibiotic combinations.

In terms of both DDDs and expenditure rankings, the top-ranking antibiotics were mainly cephalosporins. Second and third generation cephalosporins such as cefixime and cefuroxime axetil were in the majority. This reflects the position of cephalosporins as the first choice of antimicrobial agents, with cephalosporins being the most frequently prescribed class of antibiotic in clinical practice. Cephalosporins have a broad antibacterial spectrum, high antibacterial activity, low toxicity, and are also β -lactamase resistant. Thus, cephalosporins are used extensively in clinical practice.^[29] Because of stability and low price, amoxicillin and clavulanate potassium and azithromycin were also among the top-ranking antibiotics in terms of DDD values in primary and tertiary hospitals.^[30] There were 3, 2, and 2 antibiotics with DUI >1 in primary hospitals, secondary hospitals, and tertiary hospitals, respectively. DUI >1 demonstrates that the medicine is overused in terms of frequency and dose,^[10,11] thus indicating inappropriate use of these antibiotics. This information should be regarded as highly important and the use of these antibiotics should be carefully controlled and managed.

This study had several limitations. First, the study was conducted in a single city, meaning that the results may not be generalizable either provincially or nationally in China. Second, the ATC/DDD system was only used to evaluate antibiotic use among adults and antibiotic use among children and adolescents requires more research.

In conclusion, antibiotic use in Beijing general hospitals is generally low; however, inappropriate antibiotic use still exists. Antibiotics used inappropriately should be subject to rigorous control and management. Public policy initiatives to promote the judicious use of antibiotics are required, such as increased financial support, separation of drug sales from the operation facility, and training of medical professionals.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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