



Direct costs of community-acquired pneumonia for hospitalized children in Shanghai, China from 2018 to 2020: a cross-sectional analysis

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Background: Community-acquired pneumonia (CAP) is an acute respiratory infection with a high clinical and economic burden. Clarifying the burden is important for health policy making. However, there is inadequate data on the economic burden of childhood CAP in China. In this study, the direct disease burden of CAP in children was analyzed using city-level data.

Methods: A cross-sectional study of the direct costs of CAP for hospitalized children aged 28 days to 18 years old in Shanghai from January 2018 to December 2020 was performed. Information, including the hospitalization costs from the first page of the children's hospitalized medical records, was obtained. The direct costs included medical services, diagnostics, medications, and medical supplies. The continuous variables with non-normal distributions are expressed as the median (interquartile range). Comparisons between groups were performed using the Kruskal-Wallis H test. The enumeration data are expressed as the number (percentage), and comparisons between groups were performed using the χ^2 test.

Results: A total of 59 hospitals and 63,614 hospitalized CAP patients were included in this study. Significantly fewer patients were discharged in 2020 than 2018 and 2019 (6,662, 27,943, and 29,009, respectively, $P < 0.001$). Among the patients, 27,741 patients (43.6%) were covered by social medical insurance, 13,509 (21.2%) by commercial health insurance, and 22,364 (35.2%) were self-paying. The annual total direct costs for 2018, 2019, and 2020 were 118.553, 140.865, and 40.064 million Chinese Yuan (CNY), respectively. The average direct costs per hospital stay due to pediatric CAP in Shanghai was 4,707.83 CNY in 2018, a sum that accounted for 7.3% and 16.7% of the per capita disposable income in Shanghai and China in 2018, respectively. The total costs of the group aged < 1 year were significantly higher than those of the other age groups (6,271.1 vs. 3,244.3~4,610.7 CNY, $P < 0.001$). The total costs of severe cases were significantly higher than those of non-severe cases (5,200.6 vs. 3,170.4 CNY, $P < 0.001$). The median duration of hospital stay was 6.0 days (5.0, 8.0).

Conclusions: CAP hospitalization continues to represent a high clinical and economic burden in Shanghai, China. Specialized hospitals, severe cases, and the length of hospital stay were positively correlated with inpatient costs.

Keywords: Community-acquired pneumonia; pulmonary parenchyma; hospitalized children; costs analysis; economic burden

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Introduction

Community-acquired pneumonia (CAP) is an acute infection of the pulmonary parenchyma that occurs in individuals who do not live in long-term care facilities and who are not hospitalized at least 14 days before the onset of symptoms. CAP is associated with significant morbidity, mortality, and the utilization of health service resources around the world. It is estimated that the global annual incidence of CAP is 1% to 12% and the hospitalization rate of CAP is 22% to 50% (1-3). Pneumonia is the leading cause of death in children aged <5 years worldwide (4). It has been estimated there were 0.762 million deaths by pneumonia all over the world, and the cause-specific mortality rate was 5.455 cases per 1,000 live births in 2015 (4). According to data from China Centers for Disease

Control and Prevention (CDC), in 2018, the pneumonia mortality rates in children aged <5 years in urban and rural areas in China were 1.574/1,000,000 and 2.412/1,000,000, respectively, and those in children aged 5–19 years were 0.122/1,000,000 and 0.154/1,000,000, respectively (5), and most of the cases were CAP.

CAP is caused by various pathogens, such as bacteria, viruses, and atypical pathogens, and has a high clinical and economic burden, especially if hospitalization is required. In 2012, it was reported that the estimated average inpatient treatment costs for pneumonia in pediatric patients ranged from 24,332 Philippine Peso (PHP) to 58,294 PHP [United States dollars (US\$) 464–US\$ 1,113] in the Philippines (6). Another study on the disease burden of CAP among children aged <5 years in China showed that the average cost was 5,722 Chinese Yuan (CNY) (US\$ 899.69) (7). The mortality rates do not reach those observed in low and middle-income countries, however, the morbidity and financial burden associated with pneumonia remains significant in developed countries (8). In a large epidemiological study in the US, the annual incidence of CAP requiring hospitalization was 15.7 per 10,000 children (8). There are inadequate data on the economic burden of childhood CAP in China, especially among children aged >5 years. The factors associated with the economic burden of CAP in children include the length of hospital stay, age, severity, and complications (9,10). Clarifying the economic burden of childhood CAP would assist doctors to choose the appropriate diagnosis and treatment and inform public health policies. To our knowledge, this is the first study to monitor the disease burden of CAP in children using city-level data over a long period in China. We present the following article in accordance with the STROBE reporting checklist (available at <https://tp.amegroups.com/article/view/10.21037/tp-22-247/rc>).

Highlight box

Key findings

- Specialized hospitals, severe cases, and the length of hospital stay were positively correlated with childhood community-acquired pneumonia (CAP) inpatient costs in China.

What is known and what is new?

- CAP is an acute respiratory infection with a high clinical and economic burden. However, there is inadequate economic data on childhood CAP in China.
- This study, which was the first study to monitor the disease burden of CAP in children using city-level data over a long period in China, identified the main factors associated with childhood CAP inpatient costs.

What is the implication, and what should change now?

- A more effective hierarchical diagnosis and treatment system is needed. The promotion of a pneumonia-related vaccination might reduce the incidence of CAP and the burden of the disease.

Methods

Study design

This cross-sectional study used administrative data on the direct costs of CAP for children and adolescents aged 28 days to 18 years old, who had been hospitalized in the pediatric wards of Shanghai public hospitals from January 2018 to December 2020. The direct costs included medical services, diagnostics, medications, and medical supplies. The indirect costs to households, which included a loss of working days for parents, transportation, and intangible expenses (11,12), were excluded. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of the Children's Hospital of Fudan University (No. 2022-44), and individual consent for this retrospective analysis was waived.

Inclusion and exclusion criteria

To be eligible for inclusion in this study, the patients had to meet the following inclusion criteria: (I) be a child or adolescent aged 28 days to 18 years who had been hospitalized in a pediatric ward of a Shanghai public hospital; (II) have a principal diagnosis of CAP [International Classification of Diseases, ICD 10th revision coding J15.902 (CAP, non-severe) and J15.903 (CAP, severe)] on the first page of their medical records; and (III) have discharge date from January 1, 2018 to December 31, 2020. Patients were excluded from the study if they met any of the following exclusion criteria: (I) had a diagnosis of tuberculosis; (II) were immunocompromised due to congenital immune deficiency, human immunodeficiency virus infection, antineoplastic or immunosuppressive therapy; and/or (III) had undergone transplant surgery.

Data collection

The Shanghai Pediatric Clinical Quality Control Center (SPQCC) is an organization that focuses on improving pediatric medical security and quality and is led by the Shanghai Municipal Health Commission. In total, 81 public partner hospitals are affiliated with the SPQCC, including all the hospitals with pediatric qualifications in Shanghai; these hospitals were all invited to participate in this study. The partner hospitals include 3 specialized tertiary children's hospitals and 78 general hospitals (39 tertiary hospitals and 39 secondary hospitals).

CAP is a disease monitored by the National Municipal Health Commission for medical quality management. To ensure more effective and efficient management, all partner hospitals are asked to upload the first page of CAP patient's medical records to the data platform of the SPQCC regularly; the patient data is filtered by the partner hospitals before being uploaded to maintain patient anonymity. Under the regulations of the Shanghai Municipal Health Commission, a uniform structured first page medical record form must be used by all hospitals in Shanghai. The structured first page of the medical discharge record form contains 218 fields, covering basic patient demographics (i.e., name, gender, date of birth, age, nationality, birthplace, nation, identification number, address, phone number, zip code, contact name, relationship with contacts, contact number, and contact address), basic hospitalization information (i.e., medical establishment, medical payment method, patients' identification number, admission date, time of confirmed diagnosis, department, ward, discharge date, length of hospital stay, principal discharge diagnosis, other discharge diagnosis, supervising physician, nurse-in-charge, drug allergy, and disease outcome), surgical operation and procedure information (i.e., operation code, name of operation and procedure, surgeon, assistant, notch healing grade, anesthesia method, and anesthetist), and hospitalization direct costs (i.e., total costs, medical service expenses, diagnostic expenses, operating expenses, medicine expenses, and medical supply expenses). The medical service expenses include general medical services, general treatment operations, and nursing fees. The costs of diagnosis include the costs of the pathological diagnosis, laboratory examinations, imaging examinations, and the clinical diagnosis. The medicine expenses include western medicine and traditional Chinese medicine expenses.

Through the SPQCC data platform, we obtained the information from the first page of the medical records of patients with a principal diagnosis of CAP (non-severe and severe) who had been treated from January 1, 2018 to December 31, 2020.

Statistical analysis

All the statistical analyses were performed using the Solutions Statistical Package for the Social Sciences software (SPSS 25.0; SPSS Inc., Chicago, IL, USA). The continuous variables with non-normal distributions are expressed as the median [interquartile range (IQR)], and comparisons between groups were performed using the Kruskal-Wallis

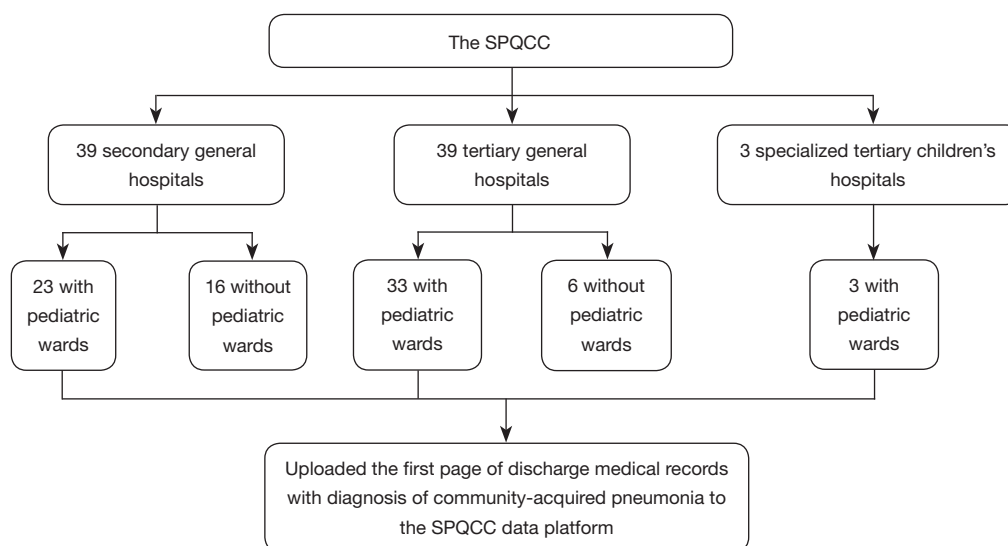


Figure 1 Organizational structure of the SPQCC. SPQCC, Shanghai Pediatric Clinical Quality Control Center.

H test. The enumeration data are expressed as the number (percentage), and the χ^2 test was used to compare the differences in fees among the secondary hospitals, tertiary hospitals, and specialized hospitals. To identify the factors associated with the economic burden, a multiple linear regression analysis was conducted. The logarithm change method was used to transform the variables that were not normally distributed. The dependent variable was the log-transformed total costs of hospitalization. The independent variables included the age of the child, gender, region, season, disease severity, medical payment method, length of hospital stay, and hospital level. No data were missing. A P value <0.05 (2-sided) indicated a statistically significant difference.

Results

Demographic results

Among the 81 partner hospitals, 22 had no pediatric wards; however, the remaining 59 hospitals, including 3 specialized children's hospitals and 56 general hospitals (33 tertiary hospitals and 23 secondary hospitals), uploaded the first page of the CAP discharge medical records to the of SPQCC data platform (Figure 1).

From 2018 to 2020, 63,614 hospital discharges of patients with a principal diagnosis of CAP were recorded among individuals aged 28 days to 18 years. The number

of discharges in 2020 (n=6,662) was significantly fewer than that in 2018 (n=27,943) and 2019 (n=29,009), especially in the secondary hospitals and tertiary hospitals. In total, 34,243 (53.8%) patients were male and 29,371 (46.2%) were female (Table 1).

The patients had a median age of 3.74 years (IQR: 1.83, 5.78). The median age of the patients hospitalized at the specialized hospitals was significantly younger than those of patients hospitalized at the secondary hospitals and tertiary hospitals (2.2, 3.9, and 3.9 years, respectively, $P<0.001$; Table 1). Of all the pediatric patients hospitalized with CAP, those aged 1~3 years accounted for 38.3% (n=24,354) of all admissions, those aged 4~6 years accounted for 33.3% (n=21,157), those aged 7~12 years accounted for 17.9% (n=11,381), those aged <1 year accounted for 9.6% (n=6,134), and those aged 13~18 years accounted for 0.9% (n=588). In the specialist hospitals, infants (aged <1 year) and young children (aged 1~3 years) accounted for the highest proportion of pneumonia patients (35.4% and 31.5%, respectively). In general hospitals, young children (aged 1~3 years) and preschool children (aged 3~6 years) accounted for the highest proportion of pneumonia patients (39.5~39.8% and 35.2~38.0%, respectively) (Table 1).

The patients in the secondary hospitals and tertiary hospitals were mainly from local areas (76.6% and 69.1%, respectively), while the patients in the specialized hospitals were mainly from other provinces and cities (69.3%). As Table 1 shows, winter and spring were the most common

Table 1 Demographic characteristics of the patients

Characteristics	Secondary hospital (n=17,974)	Tertiary hospital (n=35,331)	Specialized hospital (n=10,309)	P
Discharge year, number (%)				
2018	7,925 (44.1)	16,003 (45.3)	4,015 (38.9)	<0.001
2019	8,443 (47.0)	16,292 (46.1)	4,274 (41.5)	
2020	1,606 (8.9)	3,036 (8.6)	2,020 (19.6)	
Gender, number (%)				
Male	9,650 (53.7)	18,952 (53.6)	5,641 (54.7)	0.80
Female	8,324 (46.3)	16,379 (46.4)	4,668 (45.3)	
Age (years), median (IQR)	3.9 (2.4, 5.8)	3.9 (2.1, 5.9)	2.2 (0.5, 5.1)	<0.001
Age distribution (years), number (%)				
<1 (n=6,134)	635 (3.5)	1,846 (5.2)	3,653 (35.4)	<0.001
1~3 (n=24,354)	7,152 (39.8)	13,955 (39.5)	3,247 (31.5)	
4~6 (n=21,157)	6,830 (38.0)	12,430 (35.2)	1,897 (18.4)	
7~12 (n=11,381)	3,244 (18.0)	6,768 (19.2)	1,369 (13.3)	
13~18 (n=588)	113 (0.6)	332 (0.9)	143 (1.4)	
Region, number (%)				
Local	15,773 (76.6)	25,733 (69.1)	3,163 (30.7)	<0.001
Other provinces	2,201 (23.4)	9,598 (30.9)	7,146 (69.3)	
Season, number (%)				
Spring (Mar–May)	5,410 (30.1)	11,341 (32.1)	3,216 (31.2)	<0.001
Summer (Jun–Aug)	4,260 (23.7)	7,879 (22.3)	1,990 (19.3)	
Autumn (Sept–Nov)	3,397 (18.9)	6,819 (19.3)	2,309 (22.4)	
Winter (Dec–Feb)	4,907 (27.3)	9,292 (26.3)	2,794 (27.1)	
Severity, number (%)				
Severe	2,270 (12.6)	9,397 (26.6)	6,929 (67.2)	<0.001
Non-severe	15,704 (87.4)	25,934 (73.4)	3,380 (32.8)	
Means of payment, number (%)				
Social medical insurance	7,973 (44.4)	15,235 (43.1)	4,533 (44.0)	<0.001
Commercial health insurance	2,443 (13.6)	9,218 (26.1)	1,848 (17.9)	
Self-paying	7,558 (42.0)	10,878 (30.8)	3,928 (38.1)	
Disease outcome, number (%)				
Cured or improved	17,615 (98.0)	34,615 (98.0)	10,202 (99.0)	<0.001
Failed	297 (1.7)	485 (1.4)	35 (0.3)	
Discharged against-advice	62 (0.3)	231 (0.7)	72 (0.7)	
Length of hospital stay (days), median (IQR)	6.0 (5.0, 8.0)	7.0 (5.0, 8.0)	5.0 (4.0, 7.0)	<0.001

IQR, interquartile range.

Table 2 Multiple regression analysis of the total hospitalization costs

Variables	Reference	Coefficient	Standard error	t	P
Age		0.059	0.002	28.72	<0.001
Gender					
Male	Female	0.013	0.003	4.74	<0.001
Length of hospital stay		0.747	0.004	204.36	<0.001
Region					
Other provinces	Shanghai	-0.014	0.003	-4.07	<0.001
Season					
Spring	Winter	-0.018	0.004	-4.77	<0.001
Summer		0.016	0.004	4.13	<0.001
Autumn		0.045	0.004	12.63	<0.001
Severity					
Severe	Non-severe	0.196	0.003	60.32	<0.001
Medical payment method					
Commercial health insurance	Social medical insurance	-0.013	0.004	-3.71	<0.001
Self-paying		0.007	0.003	2.22	0.03
Discharge conditions					
Cured or improved	Against-advice discharge	0.094	0.019	5.04	<0.001
		0.072	0.022	3.26	0.001
Hospital level					
Tertiary hospital	Secondary hospital	0.327	0.003	104.01	<0.001
Specialized hospital		1.316	0.006	236.68	<0.001

seasons for CAP in children, and nearly 60% of cases occurred in these seasons.

Among the discharged patients, 27,741 (43.6%) patients were covered by social medical insurance, 13,509 (21.2%) by commercial health insurance, and 22,364 (35.2%) were self-paying (Table 1). The treatment effective rate was 98–99% at all levels of hospitals. The median length of hospital stay was 6.0 days (5.0, 8.0), and that of the specialized hospitals was the shortest (5.0 days, $P<0.001$; Table 1).

Cost results

The annual total direct costs of hospitalization for pediatric CAP for 2018, 2019, and 2020 were 118.553 million CNY (US\$ 18.437 million, using the 2018 average conversion rate of CNY to US\$), 140.865 million CNY (US\$ 21.907 million), and 40.064 million CNY (US\$ 6.231 million), respectively.

The average cost per hospital stay of the 63,614 patients was 4,707.83 CNY (US\$ 732.17), with a median of 3,560.6 CNY (US\$ 553.75) (IQR: 2,547.1, 5,389.3).

The results of the multiple linear regression analysis of the economic burden showed that the main factors for the total hospitalization costs were child age, gender, length of hospital stay, region, season, disease severity, medical payment method, and hospital level (all $P<0.05$). Among which, the length of hospital stay, disease severity, and hospital level had the greatest effects. The longer the length of hospital stay, the higher the inpatient costs. Additionally, patients with severe CAP spent more than those without severe CAP. The hospitalization costs of the specialized hospitals were higher than those of the tertiary or secondary hospitals (Table 2).

Table 3 sets out the costs per hospital stay for the different types of hospitals. The higher the level of the hospital, the

Table 3 Costs per hospital stay due to CAP [median (IQR)]

Characteristics	Total costs [†] (¥)	Medical service (¥)	Diagnostic (¥)	Operation (¥)	Medication (¥)	Medical supplies (¥)
Hospital level						
Secondary hospital (n=17,974)	2,613.1 (2,071.6, 3,353.4)	0 (0.0, 849.0)	507.5 (338.0, 778.0)	0 (0.0, 0.0)	836.9 (574.3, 1,187.8)	106.5 (22.0, 187.7)
Tertiary hospital (n=35,331)	3,635.9 (2,710.6, 4,908.0)	882 (0.0, 1,302.0)	1,007 (586.0, 1,623.0)	0 (0.0, 0.0)	932.3 (617.5, 1,366.8)	252.4 (141.8, 396.5)
Specialized hospital (n=10,309)	8,510.9 (6,359.8, 11,452.4)	1,769 (1,094.0, 3,302.0)	3,970 (2,988.0, 5,112.0)	0 (0.0, 152.0)	1,332.1 (804.4, 2,043.7)	477.0 (315.0, 750.5)
P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Age groups (years)						
<1 (n=6,134)	6,271.7 (3,417.5, 9,564.0)	1,442.9 (622.0, 2,853.8)	2,646.5 (894.0, 4,054.0)	0.0 (0.0, 0.0)	928.6 (570.7, 1,542.8)	431.0 (216.3, 767.0)
1~3 (n=24,354)	3,244.3 (2,384.4, 4,789.4)	812.5 (0.0, 1,288.0)	813.0 (453.0, 1,639.0)	0.0 (0.0, 0.0)	817.7 (556.0, 1,195.8)	219.7 (104.8, 386.4)
4~6 (n=21,157)	3,403.7 (2,521.8, 4,831.7)	806.0 (0.0, 1,209.0)	858.0 (504.0, 1,595.0)	0.0 (0.0, 0.0)	972.6 (653.7, 1,391.0)	202.8 (104.8, 367.0)
7~12 (n=11,381)	3,965.2 (2,843.7, 5,715.2)	825.0 (0.0, 1,296.0)	1,035.0 (586.0, 1,950.0)	0.0 (0.0, 52.0)	1,217.2 (802.6, 1,764.2)	220.7 (105.8, 393.0)
13~18 (n=568)	4,610.7 (3,154.7, 7,482.6)	971.0 (474.9, 1,479.1)	1,436.0 (765.5, 3,100.5)	0.0 (0.0, 174.0)	1,463.3 (938.8, 2,333.9)	193.8 (80.7, 388.5)
P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Severity of disease						
Severe (n=18,596)	5,200.6 (3,426.6, 8,527.2)	1,336.5 (896.5, 2,137.0)	1,910.5 (835.5, 3,536.0)	0.0 (0.0, 90.0)	1,186.1 (768.1, 1,810.5)	352.9 (197.9, 579.0)
Non-severe (n=45,018)	3,170.4 (2,371.1, 4,477.3)	621.4 (0.0, 1,089.6)	757.0 (456.0, 1,361.0)	0.0 (0.0, 0.0)	869.8 (580.4, 1,261.4)	183.9 (87.3, 342.5)
P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

[†], all figures are in Chinese Yuan. CAP, community-acquired pneumonia; IQR, interquartile range.

higher the costs of the medical service, diagnosis, medicine, and medical supplies ($P<0.001$). *Table 3* also sets out the costs per hospital stay for different age groups. The total costs and most specific costs (i.e., the costs for medical services, diagnostics, and medical supplies) of the group aged <1 year were significantly higher than those of other age groups ($P<0.001$). The medicine fee costs of the group aged 13~18 years were significantly higher than those of the other age groups ($P<0.001$).

According to the principal diagnostic code (ICD-10), 45,018 patients (70.77%) were diagnosed as J15.902 (CAP, non-severe) and 18,596 patients (29.23%) were diagnosed as J15.903 (CAP, severe). Among the severe patients, 6,929 (37.26%) were treated at specialized hospitals, 9,397 (50.53%) at tertiary hospitals, and 2,270 at (12.21%) secondary hospitals. *Table 3* sets out the costs per hospital stay for the severe cases and non-severe patients. The total costs and all the specific costs of the severe patients, including the costs of medical services, diagnostics, operations, medications and medical supplies, were significantly higher than those of the non-severe patients ($P<0.001$).

Discussion

CAP is a disease associated with a high clinical and economic burden. The management of CAP patients and its direct costs mainly depend on the need for hospitalization (13). To date, only limited studies have been conducted on the CAP burden in children in Asia, and most of these studies have been conducted on children aged under 5 years (7,14). Thus, the present study sought to analyze the disease burden of CAP in children and adolescents aged 28 days to 18 years, who had been hospitalized in pediatric wards of Shanghai public hospitals, using administrative city-level data from hospital discharge databases.

A total of 63,614 hospital discharges with a principal diagnosis of CAP were recorded from January 2018 to December 2020 in Shanghai public hospital pediatric wards. The number of discharged patients in 2020 ($n=6,662$) was significantly fewer than those in 2018 ($n=27,943$) and 2019 ($n=29,009$), representing a drop of 80.4% in secondary hospitals, 81.2% in tertiary hospitals, and 51.3% in specialized hospitals. The drop might be due to the preventive measures for coronavirus disease 2019 (COVID-19) that were implemented following the global outbreak in late 2019.

The Shanghai government has adopted several pandemic

control measures since January 2020, such as travel restrictions and social distancing measures. For example, the wearing of masks was widely recommended throughout the city in all instances of close person-to-person contact, and children and adolescents were asked to wash their hands frequently at kindergartens and schools. Huang showed that the strategy to prevent the outbreak of COVID-19 was also effective at preventing pediatric CAP in Taiwan where the number of pediatric patients with CAP decreased by an average of 72.3% in 1 year (15). Yamamoto reported a similar situation among adults; that is, the number of patients with CAP began to decrease in February 2020, and was significantly lower than those from the same period for the last 3 years (16).

Before the COVID-19 pandemic, the utilization rate of beds in specialized children's hospitals tended to reach saturation (17). However, the incidence of respiratory infections in children has plummeted since the COVID-19 outbreak. At some general hospitals, the pediatricians became responsible for administering medical care at quarantine sites and children's vaccinations against COVID-19, which resulted in a shortage of pediatricians, which in turn led some general hospitals to close their pediatric wards. Thus, the decline of inpatient numbers at general hospitals was more obvious than that at specialized hospitals. The lockdown might have also substantially changed the help-seeking behaviors of children with CAP. These factors show the effects of public policies on medical behavior to a certain extent.

This study estimated that the average direct costs per hospital stay due to pediatric CAP in Shanghai were 4,707.83 CNY (US\$ 732.17), with a median of 3,560.6 CNY (US\$ 553.75) (IQR: 2,547.1, 5,389.3). Our cost results were consistent with those of a multi-center study of children aged <5 years of age conducted in Heilongjiang, Hebei, Gansu and Shanghai (7), but were higher than those reported for Vietnam, Malaysia, and Indonesia, and lower than those reported for the Republic of Korea and the Philippines (6,14). In the Philippines, the cost of antibiotic therapy played a large role in the hospitalization costs, and this was not affected by the hospital setting (6). A study conducted in Vietnam, Malaysia, Indonesia, and Korea showed that the highest median direct medical costs in all study sites were associated with bacterial CAP hospitalizations (14).

In the present study, the median duration of hospital stay was 6.0 days (5.0, 8.0), which was similar to those reported for Vietnam, Indonesia, and Korea (12), longer than that

reported for the US (8), and much shorter than those reported for adults in Greece, Portugal, and the United Kingdom (13,18,19). Similar to findings of European studies (13,19), the length of hospital stay was positively correlated with the hospital costs.

We found that the costs per hospital stay in specialized hospitals was the highest among different hospital level groups. There may be a number of reasons for this finding. First, pediatric diagnosis and treatment technology resources are mainly concentrated in specialized children's hospitals in Shanghai. According to the results of a pediatric resource survey of municipal hospitals in Shanghai conducted by the SPQCC in 2020, 81.71% of pediatric professional equipment, including ventilators, monitors, and bedside ultrasound equipment, were deployed in specialized hospitals, while only 7.48% were deployed in general hospitals, and 10.81% were deployed in maternal and child health institutions. Additionally, only specialized hospitals are qualified to perform fiberoptic bronchoscopies in children in Shanghai. Following the results of quality control inspections by the SPQCC, all the specialized hospitals can carry out complete respiratory etiological tests, including nucleic acid, antigen, and antibody tests, but most of the general hospitals can only carry out nucleic acid tests for COVID-19, antigen tests for influenza, and pathogen antibody tests for common respiratory etiological tests. In Beijing, the allocation of pediatric personnel, equipment, and technology is similar to that in Shanghai, which is concentrated in specialized tertiary children's hospitals (20). As a result, the medical services, diagnostics, and operation fees of general hospitals were much lower than those of specialized hospitals. Second, infants and severe cases were positively associated with inpatient costs. Being aged <2 years is a risk factor associated with complicated CAP (21). Such patients are at a greater risk for severity and thus receive more comprehensive assessment and monitoring. The present study revealed that the total costs and most specific costs (i.e., the costs for medical services, diagnostics, and medical supplies) of the infant group were significantly higher than those of the other age groups. Similarly, the total costs and all the specific costs of the severe cases, including the costs for medical services, diagnostics, medications, and medical supplies, were significantly higher than those of the non-severe cases. Among all the CAP patients in the specialized hospitals, the proportions of infants and severe cases reached 35.4% and 67.2%, respectively, and were significantly higher than the proportions in the tertiary hospitals and secondary

hospitals. This was the main reason for the higher costs per hospital stay in the specialized hospitals.

The use of specialized hospitals for non-high risk and non-severe cases of CAP can lead to a waste of medical resources and reduce the overall quality of the medical services received by the patients. The Chinese government initiated comprehensive healthcare reforms nationwide in 2009. The major goals of the healthcare reform included improving the ability of the primary healthcare delivery system to provide primary healthcare, managing referrals to specialist hospitals, and piloting public hospital reforms (22). To improve the population's health and to effectively manage health care costs in the long term, a hierarchical diagnosis and treatment system was established (23).

According to the data released by the Shanghai Municipal Statistics Bureau and the State Council of the People's Republic of China, Shanghai's per capita disposable income was 64,183 CNY (US\$ 9,981.8) and the nation's per capita disposable income was 28,228 CNY (US\$ 4,389.7) in 2018 (24,25). This study found that the average direct costs per hospital stay due to pediatric CAP in Shanghai were 4,707.83 CNY (US\$ 732.17), which accounts for 7.3% and 16.7% of the per capita disposable income in Shanghai and China in the same period, respectively.

In general, CAP can be prevented on a large scale by proper vaccinations (26). Presently, several different vaccines are available that are effective in the prevention of CAP, such as the pneumococcal conjugate vaccine (PCV), Hemophilus influenza type b (Hib) vaccine, and influenza vaccine. Research suggests that the use of vaccines can successfully decrease the incidence of the disease, reduce the proportion of severe cases, and shorten the length of hospital stays (27-29). According to a review on the serotype distribution among invasive pneumococcal infections in children aged <5 years in China, the 7-valent PCV covered about 60.2% serotypes and the 13-valent PCV about 87.7% (30). It can be projected that the use of the PCV7 will prevent 425.3 thousands pneumococcal pneumonia cases and save 2.12 billion CNY annually, and the PCV13 will prevent 619.6 thousand cases and save 3.089 billion CNY, without taking into account the PCV costs, other diseases caused by pneumococcus, and the indirect protection provided by such vaccines (7).

Today, there are still several important vaccines that are not in the National Immunization Program (NIP) of China, but that must be paid for by parents, including the PCV, Hib vaccine, influenza vaccine, and rotavirus vaccine. Even

in Shanghai, one of the most developed cities in China, the dose 1 coverage rate was 50.9% for the Hib vaccine and only 11.4% for the PCV, according to 28,141 abstracted pediatric records (31). Of all the children who received dose 1, 79.7% completed the Hib vaccine series, and 91.3% completed the PCV series (31). The vaccine costs and a lack of awareness are probably the greatest barriers to vaccine uptake (31). Thus, the promotion of pneumonia-related vaccinations and the inclusion of the PCV, Hib vaccine, and influenza vaccine in the NIP may reduce the incidence of CAP and the burden of disease.

The payment method also has a certain effect on medical expenses. The present study showed that among the discharged patients, 27,741 (43.6%) were covered by social medical insurance, 13,509 (21.2%) by commercial health insurance, and 22,364 patients (35.2%) were self-paying. The parents of children with medical insurance or commercial insurance were more focused on treatment effectiveness, tended to choose better tests and treatment measures and were less burdened by the medical costs. Conversely, the self-paying parents were more concerned about the costs, and had to reject some relatively expensive medical procedures. Such information is valuable for health policy makers, and may inform future policies.

Limitations

This study was limited by the observational data, which were routinely collected on administrative information systems. The quality of the data collected by the partner hospitals may vary depending on the definition of the disease and the diagnostic codes used.

Conclusions

Hospitalized CAP has a high clinical and economic burden in Shanghai, China. Admissions to specialized hospitals, severe cases, and the length of hospital stay were positively correlated with inpatient costs.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of the Children's Hospital of Fudan University (No. 2022-44), and individual consent for this retrospective analysis was waived.

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