

The Impact of the COVID-19 Pandemic on a PICU in China that did not Admit COVID-19 Patients: A Retrospective Study

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Abstract

Background

The unprecedented COVID-19 pandemic has been spreading for more than one and a half years.

However, it is unclear whether the pandemic influenced admission in pediatric intensive care units (PICUs) that never received COVID-19 patients during the early major outbreak in China.

Methods

A retrospective study was conducted in a PICU in a tertiary hospital in Chengdu, southwestern China. We sought to describe the trend of admission number from pre-epidemic years (2018 and 2019) to 2021. We explored the impact of the COVID-19 outbreak on PICU admission characteristics by including all patients younger than 18 years admitted to the PICU between January 23 and April 8 in 2020 and those admitted in the same time periods in pre-epidemic years and in 2021.

Results

The percentage of patients admitted to the PICU from the Chengdu region increased from 34.2 percent in 2019 to 40.4 percent in 2020, whereas that from other provinces decreased from 11.7 percent in 2019 to 5.8 percent in 2020 ($P = 0.012$). The median length of stay (LOS) in the PICU was significantly longer in the 2020 cohort (4.0 days) than in the 2019 cohort (2.0 days) ($P < 0.001$); the median hospital LOS was also significantly longer in the former (12.0 days) than in the latter (8.0 days) ($P < 0.001$). Both hospital outcomes ($P = 0.005$) and primary diagnosis distributions ($P = 0.025$) between the 2020 and 2019 cohorts were significant.

Conclusions

In a PICU that never received COVID-19 patients, the onset of the 2020 major outbreak was accompanied by changes in the composition of regions of patients, longer PICU and hospital stays, an increased proportion of unauthorized discharge and death, and a larger proportion of neoplasms, nervous system diseases and injury.

Background

Since the report of unexplained viral pneumonia cases in December 2019, the coronavirus disease 2019 (COVID-19) pandemic resulting from person-to-person transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has been spreading for more than one and a half years [1]. As of August 1, 2021, more than 197 million COVID-19 cases had been confirmed worldwide, including at least 4.2 million deaths. According to real-time data from Johns Hopkins Coronavirus Resource Center (CRC), more than 4.0 billion SARS-CoV-2 vaccine doses have been administered globally [2]. In mainland China, after the early devastating nationwide COVID-19 outbreak centered in Wuhan city of Hubei Province, several rounds

of localized recrudescence occurred along the timeline, and more or fewer imported COVID-19 cases have been reported continuously to date.

In general, the intensive care unit (ICU), including the pediatric ICU (PICU), has played a crucial role during the COVID-19 outbreak as a department of caring for critically ill patients infected by SARS-CoV-2 [3, 4]. From January 23 to April 8, 2020, a series of strict communicable disease control-related intervention measures were implemented in Wuhan city to contain the rapid spread of COVID-19 early in the outbreak [5, 6]. In the same period, closely analogous intervention measures expanded to almost all of China. However, the early major outbreak was relatively less severe in areas of China outside of Hubei Province [7], where the majority of ICUs never admitted COVID-19 patients while maintaining relatively routine operation for non-COVID-19 patients requiring intensive care. Numerous reports worldwide have emerged about admission characteristics or clinical management of ICUs caring for hospitalized COVID-19 patients [4, 8–11], yet there are limited data about admission characteristics of PICU in China that were not set up to receive COVID-19 patients. Hence, it remains unclear whether such a pandemic influence the admission characteristics of PICUs not receiving COVID-19 patients in an area of China outside Hubei Province.

Methods

Research design and ethics approval

We performed a single-center study of children (under the age of 18) admitted to a multidisciplinary pediatric intensive care unit (PICU) in the West China Hospital of Sichuan University. West China Hospital of Sichuan University is a tertiary comprehensive hospital with 4,300 beds in Chengdu city, Sichuan Province. This large referral center provides care for a population of approximately 90 million people per year who live in the southwest region of China. The PICU admission data used in this research were accessed from Hospital Information System (HIS) medical records with assistance from the full-time information technology staff (FITS) at the West China Hospital of Sichuan University. The Ethics Committee of the West China Hospital of Sichuan University approved this study. Patient informed consent was waived because of the retrospective and descriptive nature of the study.

Investigated Time Period And Data Acquisition

We included all patients younger than 18 years old who were admitted to the PICU from January 2018 to April 2021. We explored the overall trend of the number of admissions to the PICU. On this basis, we extracted all PICU admission records during four investigated time periods (2018 cohort, 2019 cohort, 2020 cohort, and 2021 cohort) between January 23 and April 8 of each year from 2018 to 2021. This time period completely overlapped with the time span when the whole country was implementing stringent administrative lockdown measures during the early major outbreak in 2020, as mentioned above.

The extraction and coding process of the admission records was conducted by FITS. The process of data conversion and classification was assigned to be manipulated by trained investigators to ensure the

reliability of the data by cross-checking. Available variables extracted from records comprise three major parts, including patient demographics (total admission number, age, sex, ethnicity, and source of region), hospitalization features (admission route, length of stay, hospital outcomes, and total hospitalization expenses) and primary diagnosis distribution. According to the current administrative division of China, regions referring to the place of residence of admitted patients were classified as Chengdu and non-Chengdu regions in Sichuan Province and other provinces. The primary diagnosis distribution refers to the classification of all primary diagnoses of admitted patients in each investigated time period. Primary diagnosis was recognized and classified using the corresponding code of the same named entry in the records according to the International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10, CM) [12].

Statistical analysis

Continuous variables with a nonnormal distribution are described as the median with 25% and 75% quartiles (IQR, interquartile range). All categorical variables are expressed as counts (constituent ratios). Age, length of stay (LOS), and total hospitalization expenses as continuous variables were compared between the four investigated groups using one-way analysis of variance and two-by-two comparisons between groups after rank transformation. The chi-squared test was applied to analyze categorical data. All statistical analyses were performed using SPSS 26.0 for Windows (SPSS Inc., Chicago, IL, USA). A 2-sided P value < 0.05 was considered to be statistically significant.

Results

The general trend of admission number from January 2018 to April 2021 in the investigated PICU is displayed in Fig. 1. The range ($R = \text{Max} - \text{Min}$) of admission number in 2020 ($R_{2020} = 77$, minimum and maximum values were 14 cases at T_3 and 91 cases at T_{14} , respectively) was higher than the pre-epidemic two years ($R_{2018} = 30$, $\text{Min}_{2018} = 55$ at T_4 , $\text{Max}_{2018} = 85$ at T_{21} ; $R_{2019} = 37$, $\text{Min}_{2019} = 48$ at T_3 , $\text{Max}_{2019} = 85$ at T_{15}). The trend line of 2020 from T_2 to T_8 appeared at the beginning to a visible decline to the nadir at T_3 (from January 27 to February 9, 2020) and then followed a gradual increase. Data of 1281 admission records in the four investigated time periods were collected and analyzed (Table 1, Table 2). The change in proportions of primary diagnoses is depicted in Fig. 2.

Table 1
All Available Demographics over the Four Investigated Time Periods

Variables	2018	2019	2020	2021	Pvalue		
					2019 vs 2018	2020 vs 2019	2021 vs 2020
Total admission	379	368	225	309			
Age, yr, median (IQR)	1.0 (0, 4.0)	1.0 (0, 4.0)	1.0 (0, 3.0)	2.0 (0, 6.0)	0.066	0.026	< 0.001
Age group, yr, n (%)					0.090	0.113	0.001
<1	179 (47.2)	145 (39.4)	111 (49.3)	104 (33.7)			
1≤, <5	108 (28.5)	132 (35.9)	65 (29.0)	100 (32.4)			
5≤, < 10	47 (12.4)	52 (14.1)	30 (13.3)	59 (19.1)			
10≤, < 18	45 (11.9)	39 (10.6)	19 (8.4)	46 (14.9)			
Sex, n (%)					0.551	0.866	0.037
Female	173 (45.6)	176 (47.8)	106 (47.1)	175 (56.6)			
Male	206 (54.4)	192 (52.2)	119 (52.9)	134 (43.4)			
Ethnic group, n (%)					0.137	0.105	0.297
Han	324 (85.5)	319 (86.7)	191 (84.9)	256 (82.8)			
Tibetan	26 (6.9)	28 (7.6)	14 (6.2)	28 (9.1)			
Yi	29 (7.7)	18 (4.9)	12 (5.3)	20 (6.5)			
Other	0	3(0.8)	8 (3.6)	5 (1.6)			
Region, n (%)					0.957	0.012	0.009
Chengdu	125 (33.0)	126(34.2)	91(40.4)	104(33.7)			
Non-Chengdu in Sichuan	199 (52.5)	192(52.2)	121(53.8)	163(52.8)			

Variables	2018	2019	2020	2021	Pvalue		
					2019 vs 2018	2020 vs 2019	2021 vs 2020
Other provinces	46 (12.1)	43(11.7)	13(5.8)	42(13.6)			
Unknown	9 (2.4)	7(1.9)	0	0			
Abbreviations: IQR, interquartile range							

Table 2

All Available Hospitalization Features and Diagnosis Distributions over the Four Investigated Time Periods

Variables	2018	2019	2020	2021	Pvalue		
					2019 vs 2018	2020 vs 2019	2021 vs 2020
Admission route, n (%)					0.265	0.128	0.013
Emergency	133(35.1)	115(31.3)	84(37.3)	83(26.9)			
Outpatient	246(64.9)	253(68.8)	141(62.7)	226(73.1)			
LOS, day, median (IQR)							
PICU	3.0 (1.0, 5.0)	2.0 (1.0, 4.0)	4.0 (2.0, 7.0)	4.0 (2.0, 7.0)	0.003	< 0.001	0.022
Hospital	12.0 (9.0, 18.0)	8.0 (6.0, 12.0)	12.0 (8.0, 17.0)	11.0 (7.0, 15.0)	< 0.001	< 0.001	0.182
Hospital outcomes, n (%)					0.002	0.005	0.002
Authorized discharge	324 (85.5)	338 (91.8)	189 (84.0)	238 (77.0)			
Authorized transfer	33 (8.7)	8 (2.2)	7 (3.1)	39 (12.6)			
Unauthorized discharge	13 (3.4)	14 (3.8)	25(11.1)	28 (9.1)			
Death	8 (2.1)	5 (1.4)	4 (1.8)	4 (1.3)			
Unknown	1 (0.3)	3 (0.8)	0	0			
Primary diagnosis, n (%)					0.013	0.025	0.221
Malignant neoplasms	13 (3.4)	24 (6.5)	27 (12.0)	30 (9.7)			
Benign neoplasms	6 (1.6)	5 (1.4)	6 (2.7)	12 (3.9)			
Neoplasms of uncertain behavior	14 (3.7)	14 (3.8)	12 (5.3)	8 (2.6)			
Nervous system	23 (6.1)	4 (1.1)	9(4.0)	7 (2.3)			
Circulatory/respiratory system	15 (4.0)	14 (3.8)	7 (3.1)	13 (4.2)			
Digestive system	38 (10.0)	39 (10.6)	20 (8.9)	39 (12.6)			
Certain conditions originating	9 (2.4)	12 (3.3)	3 (1.3)	1 (0.3)			

Variables	2018	2019	2020	2021	P value		
					2019 vs 2018	2020 vs 2019	2021 vs 2020
in the perinatal period							
Congenital malformations	217 (57.3)	219 (59.5)	111 (49.3)	149 (48.2)			
Injury	14 (3.7)	19 (5.2)	14 (6.2)	15 (4.9)			
Other	30 (7.9)	18 (4.9)	16 (7.1)	35 (11.3)			
THE, yuan, median (IQR)	11873.0 (5085.8, 32140.9)	10234.5 (3505.8, 32278.1)	10535.5 (4692.9, 27320.4)	42091.7 (31168.3, 63765.6)	0.299	0.719	< 0.001
Abbreviations: IQR, interquartile range; LOS, length of stay; THE, total hospitalization expense.							

There was no difference in any demographic variable between the 2019 cohort and 2018 cohort: age ($P=0.066$), age group ($P=0.090$), sex ($P=0.551$), ethnic group ($P=0.137$), and region ($P=0.957$) (Table 1). However, age between the 2020 cohort and 2019 cohort was statistically significant ($P=0.026$) (Table 1). Patients admitted in 2021 were older: the median age was 2.0 years in the 2021 cohort versus 1.0 year in the 2020 cohort ($P<0.001$). In addition, ≥ 10 years and younger than 18 years accounted for 14.9 percent in the 2021 cohort and 8.4 percent in the 2020 cohort ($P=0.001$) (Table 1). The percentage of male patients admitted in 2021 decreased compared to that in 2020 ($P=0.037$). Moreover, the percentage of patients admitted to the PICU from the Chengdu region increased from 34.2 percent to 40.4 percent and that from other provinces decreased from 11.7 percent to 5.8 percent between the 2019 and 2020 cohorts, differences that were significant ($P=0.012$). When comparing the 2020 and 2021 cohorts, the percentage of patients admitted to the PICU from the Chengdu region decreased from 40.4 percent to 33.7 percent and that from other provinces increased from 5.8 percent to 13.6 percent, also significant differences ($P=0.009$) (Table 1). There was no significance in certain demographic variables in the 2020 cohort versus the 2019 cohort: age group ($P=0.113$), sex ($P=0.866$), or ethnic group ($P=0.105$).

The percentage of outpatient patients admitted to the 2021 cohort increased compared to that of the 2020 cohort ($P=0.013$) (Table 2). The median PICU LOS was significantly longer in the 2020 cohort (4.0 days) than in the 2019 cohort (2.0 days) ($P<0.001$), and the difference in median PICU LOS between 2021 and 2020 was significant ($P=0.022$). The median hospital LOS was significantly longer in the 2020 cohort (12.0 days) than in the 2019 cohort (8.0 days) ($P<0.001$), though with no statistical significance in hospital LOS between the 2020 and 2021 cohorts ($P=0.182$).

There was no significant difference in median total hospitalization expenses (THE) between the 2019 cohort (10234.5 yuan) and the 2018 cohort (11873.0 yuan) ($P=0.299$) or between the 2020 cohort

(10535.5 yuan) and the 2019 cohort ($P = 0.719$). Nevertheless, the median THE was significantly greater in the 2021 cohort than in the 2020 cohort ($P < 0.001$) (Table 2).

Overall, hospital outcomes were significantly different between the 2020 cohort and 2019 cohort. The proportion of hospital outcomes with unauthorized discharge was greatest in 2020 than in the other three years (Table 2). The primary diagnosis distributions were significantly different considering 2019 versus 2018 and 2020 versus 2019 (Table 2, Fig. 2), though the primary diagnosis distribution between the 2021 cohort and 2020 cohort was not significantly different.

Discussion

On the basis of the primary results of this study, certain demographics and hospitalization features of patients admitted to the investigated PICU changed during the early major outbreak. Our PICU was not set up to receive confirmed COVID-19 cases during the entire COVID-19 outbreak in 2020. The most notable variation was that the PICU admission number showed a visible decline in comparison to that in pre-epidemic years. A similar phenomenon was observed in a study in Northern Italy, in which unplanned and medical PICU admissions markedly decreased during the COVID-19 outbreak [13].

We found that the number of PICU admissions due to emergency and outpatient visits decreased synchronously in 2020. It has been reported that the total number of emergency department (ED) visits during the early pandemic period in the U.S. was 42% lower than that during the same period in 2019 [14]. This suggests a relationship between the decline in the number of PICU admissions due to emergencies and the reduction in ED visits during the COVID-19 outbreak in 2020. Nonetheless, data on admissions to the emergency department in our hospital were lacking. The proportion of admissions to the PICU due to emergency increased in 2020 compared to in pre-epidemic years, but the proportion of PICU admissions via outpatient visits decreased. In contrast, the proportion of PICU admissions via outpatient visits increased significantly in 2021 compared to that in 2020. Furthermore, the percentage of admissions from other provinces decreased in 2020 versus 2019 but increased in 2021 versus 2020. Numerous factors can explain these findings. One reason assumes that at the beginning of last year's outbreak, fear of being infected by SARS-CoV-2 was at an all-time high. People tended to seek medical attention only in cases of emergency while subjectively postponing nonemergency care-seeking behavior. The fact that fear of epidemics significantly influenced people's health care-seeking behavior was expounded during the SARS epidemic in 2003 [15]. Similarly, it has been reported that access to or provision of care was delayed in Italy, possibly due to fear of COVID-19, in 2020 [16]. During the early major outbreak in mainland China in 2020, there was no obvious short-term shortage of medical resources outside the central epidemic area. However, widespread implementation of forced administrative controls impacted people's health care-seeking behavior. This may have influence, either through direct restrictions or through the indirect effect of reducing out-of-home activities, on patient demographic characteristics in the PICU during the same period. Strict traffic controls across the country restricted epidemic residents from seeking medical care off-site, resulting in a relatively higher proportion of local patients in the Chengdu region. It is therefore

possible that intervention measures such as social distancing or home quarantine rather than spread of COVID-19 itself influenced the public's healthcare service choice.

We found that the median LOS in the PICU and the median LOS in the hospital were longer in 2020 than in 2019. At the same time, the proportion of hospital outcomes with unauthorized discharge was greatest in 2020 compared with those in the other three years. Unauthorized discharge means that after adequate communication with medical staff, family members understood that although discontinuing aggressive medical interventions may accelerate a patient's deterioration, they sought to abandon treatment voluntarily. Clinically, unauthorized discharges are often initiated by patient's families when they subjectively recognize that the patient is more likely to have a poor outcome. Therefore, the increase in the proportion of unauthorized discharges may be explained by the assumption that patients admitted to the PICU in 2020 were more severely ill and required longer intensive care treatment. These factors resulted in an increase in unauthorized discharges due to the family's lack of confidence in the patient's recovery. Therefore, the actual mortality rate may be higher than the in-hospital mortality rate because the prognosis of patients who were discharged unauthorizedly is usually poor.

With regard to the distribution of primary diagnoses, the proportion of PICU admissions with a primary diagnosis of malignancy or neoplasms of uncertain behavior was highest in 2020 compared to the other three years. In fact, parents generally are not able to identify malignant tumors and might seek medical care on their own initiative. Therefore, the reasons for the highest proportion of patients with malignancy or neoplasms are more likely to be medical related. For instance, there might be an increase in referrals to tertiary hospitals for further treatment after diagnosis at local hospitals. In addition, pediatric surgeons of the tertiary hospital prioritized admission of patients requiring early treatment during the outbreak and postponed that of patients with slow-progress diseases, leading to an increase in the proportion of malignant tumor cases.

To date, there are still small-scale outbreaks of COVID-19 occurring occasionally in some areas of China. This pandemic has impacted many aspects of society, including the healthcare system. Our study appears to show that the COVID-19 pandemic is still affecting daily work in the PICU. Although it is difficult to specify the endpoint of the unprecedented plague, the formation of an immune barrier with increased vaccination rates may theoretically help relieve the need for masking sooner [17, 18]. In interpreting these results, some limitations should be taken into account. Considering the limitations of single-center research, some results of our study may not be applicable to other geographic regions. Additionally, this study was a retrospective analysis, and a small amount of data was missing. Nevertheless, our study focuses on the PICU, which did not admit COVID-19 patients outside the epicenter during the early major outbreak in China and has received little attention in previous studies.

Conclusion

Our study reveals no significant difference in PICU-admitted patient demographics between pre-epidemic years, though the onset of the COVID-19 outbreak was accompanied by changes in the composition of patient source regions in a PICU that never received COVID-19 patients. Compared to 2019, the length of

stay in both the PICU and hospital was longer during the 2020 major outbreak, the proportion of unauthorized discharge and death increased, and the proportion of neoplasms, nervous system diseases and injury was greater in a PICU that never received COVID-19 patients. Nonetheless, further similar or multicenter studies are needed to strengthen our conclusion.

Abbreviations

COVID-19

Coronavirus disease 2019

FITS

Full-time information technology staff

HIS

Hospital information system

ICU

Intensive care unit

IQR

Interquartile range

LOS

Length of stay

PICU

Pediatric intensive care unit

SARS-CoV-2

Severe acute respiratory syndrome coronavirus 2

THE

Total hospitalization expenses

Declarations

Ethics approval and consent to participate

The Ethics Committee of the West China Hospital of Sichuan University approved this study. Patient informed consent was waived because of the retrospective and descriptive nature of the study.

Consent for publication

Not applicable.

Availability of data and materials

The authors declare that the relevant data supporting the findings of this study are available within the article.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

SYC, YJ, GZ, and XPZ conceived of and designed the study. XG and TQ managed the data and its accessibility. GZ, XPZ, and KYY analyzed the data. GZ wrote the first draft of the manuscript. YZ, HY, and JYZ contributed to the writing of the manuscript. SYC and YJ contributed substantially to its revision. All authors agree with the manuscript results and conclusions and approved the final version of the manuscript.

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Figures

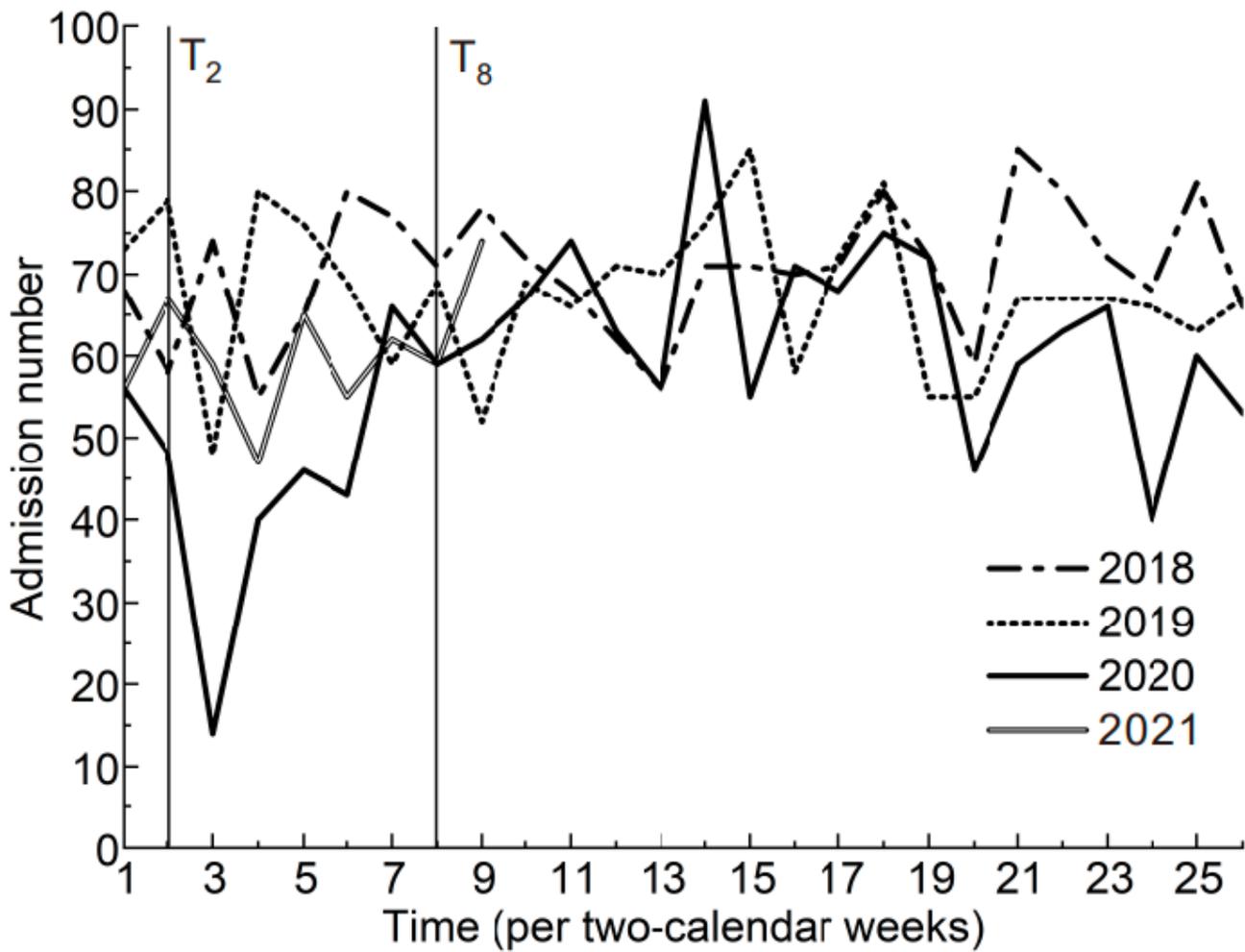


Figure 1

Line chart showing the trend of the number of PICU admissions over time from January 2018 to April 2021. With two calendar weeks as a time point on the X-axis, the 52 calendar weeks in a year were divided into 26 time points. The vertical lines T_2 and T_8 indicate the time points where the start date (January 23) and end date (April 8) of the investigated time period each year were located, respectively.

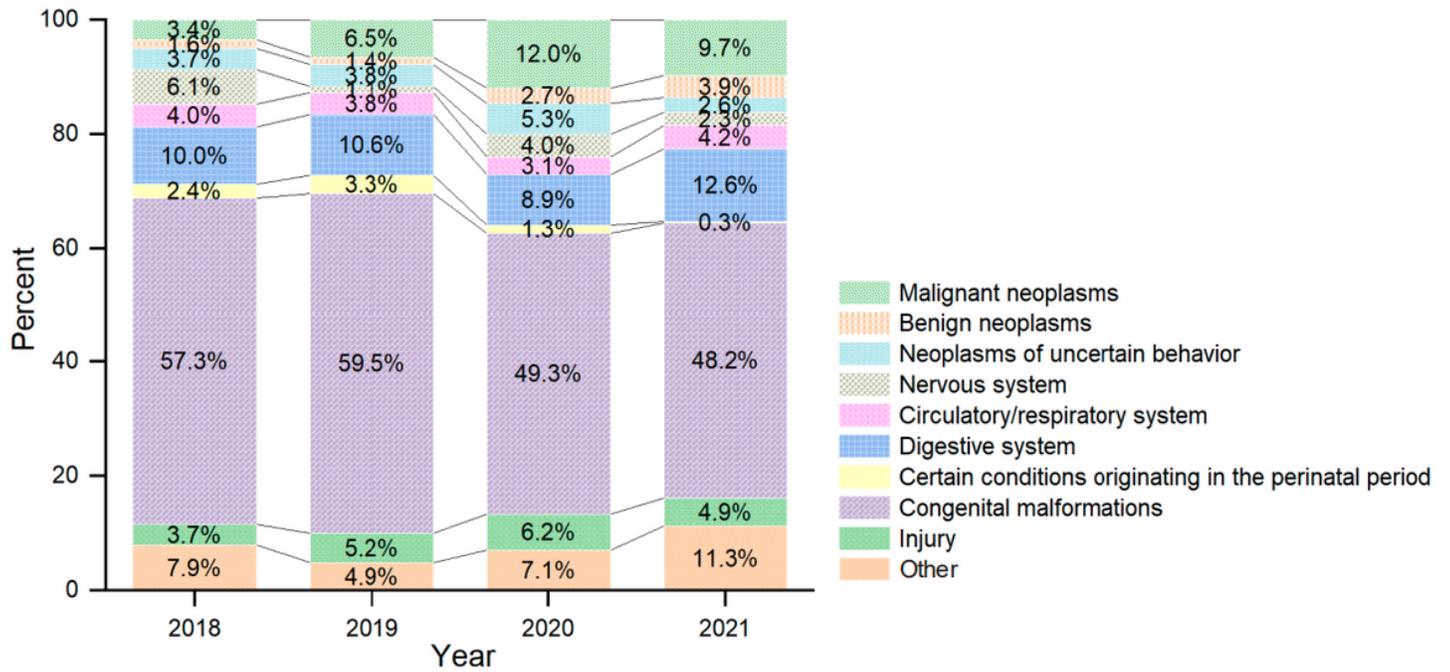


Figure 2

Percentage stacking histogram showing the change in the primary diagnosis distributions over the four investigated time periods.