

ORIGINAL RESEARCH

Impact of COVID-19 pandemic waves on pediatric emergency department patients presenting with asthma attacks in Taiwan

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Abstract

The number of pediatric emergency department (PED) visits fell significantly during the coronavirus disease 2019 (COVID-19) pandemic. However, the impact of the ongoing pandemic on PED patients suffering from asthma attacks in Taiwan has not been studied. We thus analyzed patients with asthma attacks visiting a PED during the early stage of the COVID-19 pandemic and the following (resurgent) waves. We retrospectively studied pediatric patients with asthma attacks who visited the PED from 01 January 2019 to 30 September 2021. We retrieved patient numbers, demographic characteristics, triage acuties, medications, and PED dispositions during the various waves of the COVID-19 pandemic. A total of 1842 patients with asthmatic attacks presented to the PED during the study period. PED visits caused by asthmatic attacks declined by 55% after the first COVID-19 outbreak in early 2020 ($p = 0.009$) and fell even more remarkably (by 85%) in mid-2021 ($p = 0.038$), during the time when the numbers of confirmed COVID-19 cases skyrocketed (the second wave). However, neither the high-triage acuity rate nor the rate of admission differed between the two periods ($p = 0.08$ and 0.406 , respectively). However, the proportion of systemic corticosteroid (SCS) prescriptions increased during the pandemic (81.90 vs. 77.77%, $p = 0.029$). The COVID-19 pandemic notably impacted the number of asthmatic PED visits not only during the first peak period but also during the following waves, but asthma severity did not vary over time. Physicians tended to prescribe more SCSs during the pandemic to control respiratory symptoms. We suggest that SCSs should be used cautiously even during the pandemic to minimize their adverse effects.

Keywords

Pediatric emergency department; Asthma; Pediatric; Hospital volume; COVID-19; Corticosteroid

1. Introduction

The wide and rapid spread of coronavirus disease 2019 (COVID-19) changed the way in which communities and groups use emergency departments (EDs) [1, 2]. Lockdown has posed new challenges for primary care practitioners who manage patients by limiting physical examination or employing telehealth consultations [3, 4]. The prevalences of respiratory diseases other than COVID-19 were affected by compulsory mask-wearing, social distancing, and school closures [5–12].

Asthmatics rely on EDs for immediate exacerbation care [13]. Analysis of the Taiwan National Health Insurance Research Database showed that 15.7% of children under 20 years of age have been diagnosed with asthma [14]. Acute asthma exacerbations often require ED attention; there is an average of 27,926 admissions annually in Taiwan [15]. However,

previous studies reported significant reductions in the number of ED visits at the time of the early peak of the COVID-19 pandemic in 2020, especially during the lockdown period [5, 7, 8, 16]. When a pandemic is ongoing (confirmed cases are rising), it is difficult to ensure adequate hospital resources (oxygen and ventilators), to allocate medical personnel, and to manage the isolation and intensive care units that treat confirmed cases [17].

In this study, we posed two questions. First, how has the ongoing pandemic impacted patients who present to a pediatric ED (PED) with asthma attacks? Second, do resurgences (or waves) of COVID-19 infections have the same impact on presentations as the first wave?

2. Methods

2.1 Study design

This multi-center retrospective observational study was conducted at three tertiary teaching hospitals in northern Taiwan. We enrolled pediatric patients with asthma attacks visiting the PED from 01 January 2019 to 30 September 2021.

2.2 Study population

We analyzed electronic health records held in the data repository of the Keelung, Taipei, and Linkou Chang Gung Memorial Hospitals, and identified all children aged 2–18 years who visited the PED with an asthma attack (diagnostic code: J45.XX) and complained of at least one of the following: fever, chest tightness, dyspnea, cough, or an asthma attack at triage. Patients with other known or identifiable heart or lung diseases were excluded (Fig. 1).

The Keelung branch, located in northern Taiwan, is the only tertiary hospital in a 360,000-person municipality; there are 70,000 ED visits annually. The Taipei branch experiences 50,000 ED visits each year. The Linkou branch serves a population of approximately 2.3 million; there are 200,000 ED visits annually [18]. Data from all three branches were collected and analyzed.

Three time periods were evaluated. The pre-epidemic period (P1) ran from 01 January 2019 to 31 December 2019. The first epidemic period (P2) ran from 01 January 2020 to 31 December 2020. The second epidemic period (P3) ran from 01 January 2021 to 30 September 2021.

P2-A was the period from 01 January 2020 to 31 May 2020. P1-A and P3-A were the same periods in 2019 and 2021, respectively. During P2-A, the first patient in Taiwan with a confirmed severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection was diagnosed on 21 January 2020. Thus, P2-A was the first peak of COVID-19 infection in Taiwan, followed by stepwise lifting of COVID restrictions by the Taiwanese government in early June 2020. We defined specific time frames within the study periods (the subdivisions B; from 01 May to 31 July of each year). During this period in 2021 (P3-B), Taiwan experienced a surge in confirmed COVID-19 cases (the government mandated a lockdown of schools and public sites). The P3-B period was compared to the same periods in 2019 and 2020, denoted P1-B and P2-B, respectively.

2.3 Data collection

The primary outcome was the monthly number of PED patients with asthma attacks who visited over the three periods. Demographic data were compared across the periods. We recorded the PED numbers; patient characteristics; and age, sex, triage acuity level, and admission status. We also noted prescriptions of inhaled short-acting- β -agonists (SABAs), systemic corticosteroids (SCSs), and oral β -agonists. Blood data, temperature, heart and respiratory rates, and oxygen saturation were measured at the times of PED triage.

2.4 Statistical analysis

Data were analyzed using SPSS software (ver. 26.0 for Mac; SPSS Inc., Chicago, IL, USA). Categorical variables are pre-

sented as numbers with percentages (descriptive analysis). Data were compared using the Kruskal-Wallis test for continuous variables and Pearson chi-squared or Fisher exact test for categorical variables. A p -value < 0.05 was considered statistically significant.

3. Results

The overall PED numbers were 55,795 in 2019, 30,965 in 2020, and 16,291 in 2021. We enrolled 2178 patients with the diagnostic code J45.XX. Totals of 272 and 64 patients who lacked asthma attacks or who had histories of congenital heart or lung disease were excluded (Fig. 1). A total of 1842 PED visits were made by patients with asthma attacks during the 33-month study period. There were 1030 visits by asthma attack patients in 2019, 580 in 2020, and 232 in 2021. During P2 and P3, all admitted patients were SARS-CoV-2 -negative. The demographic and clinical characteristics of PED visitors are shown in Table 1. There were 1155 boys and 687 girls; the sex ratios were similar in all periods ($p = 0.29$). The median patient age was 5 years. When P1 and P2 data were compared, the PED visits by patients with asthma attacks fell by 43.7% in the latter period. The monthly PED numbers of such patients also differed significantly ($p = 0.001$) (Fig. 2). When we compared the monthly PED visit numbers of asthma attack patients from January to May and May to July, we found significant differences across the 3-year study period ($p = 0.009$ and $p = 0.038$, respectively). The proportions of patients admitted because of asthma attacks were 22.23% in 2019, 24.14% in 2020, and 25.43% in 2021 ($p = 0.406$). The high-triage acuity patient volumes did not differ significantly across the study period ($p = 0.08$). Also, none of the fever, heart or respiratory rate, or oxygen saturation data at the time of PED triage differed significantly across the study period (Table 1). We compared PED visits caused by asthma attacks from January to May (Fig. 2); the number during P1-A was greater than during both P2-A ($p = 0.009$) and P3-A ($p = 0.022$), but no significant difference was apparent between P2-A and P3 ($p = 0.994$).

In terms of P1-B and P3-B, the number of PED visits decreased in P3-B compared to P1-B ($p = 0.013$). Notably, the number of PED visits was lowest in P3-B, during which a virus variant spread quickly, causing the peak of the pandemic in Taiwan.

In terms of vital signs, there was no significant difference in any parameter among the study periods (Table 1).

The medications used before and during the COVID-19 pandemic are listed in Table 2. The use rates of SABA and oral β -agonists did not differ. However, physicians were more likely to prescribe SCSs during the COVID-19 pandemic ($p = 0.029$).

4. Discussion

It was challenging to manage PED patients in respiratory distress during the COVID-19 pandemic. First, it was initially uncertain whether the patients had contracted SARS-CoV-2 or not. Second, changes in how physicians treated and monitored patients posed potential difficulties [19]. Similar to other

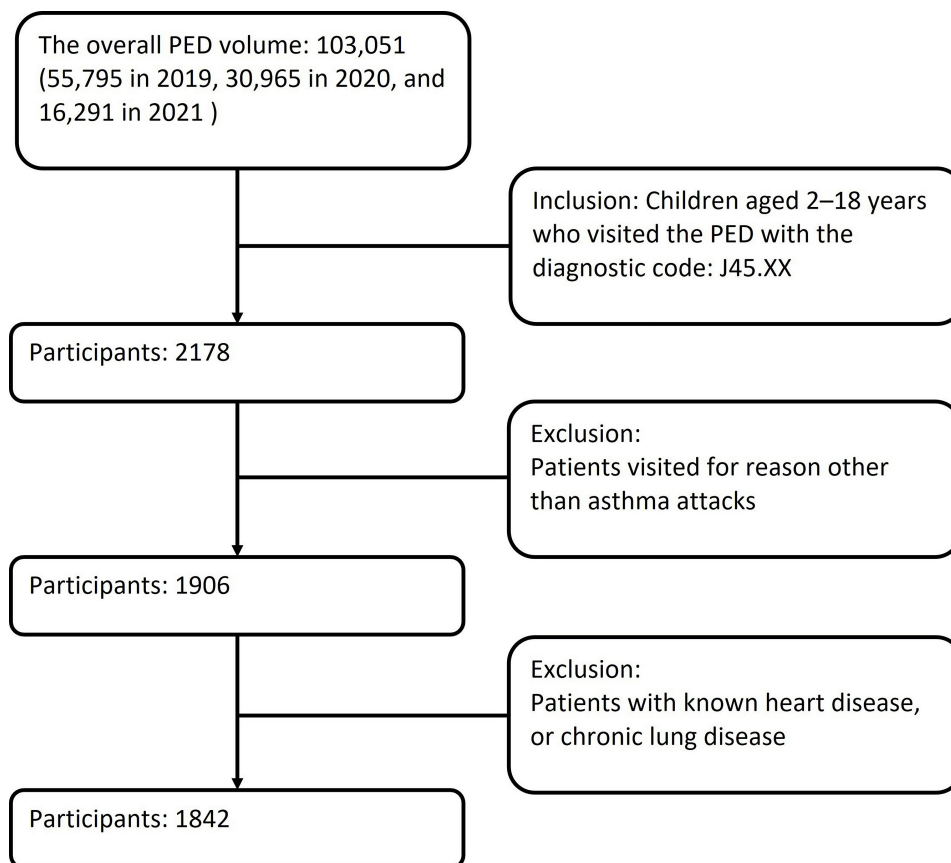


FIGURE 1. Inclusion and exclusion criteria of the study participants. Definition of abbreviation: PED, pediatric emergency department.

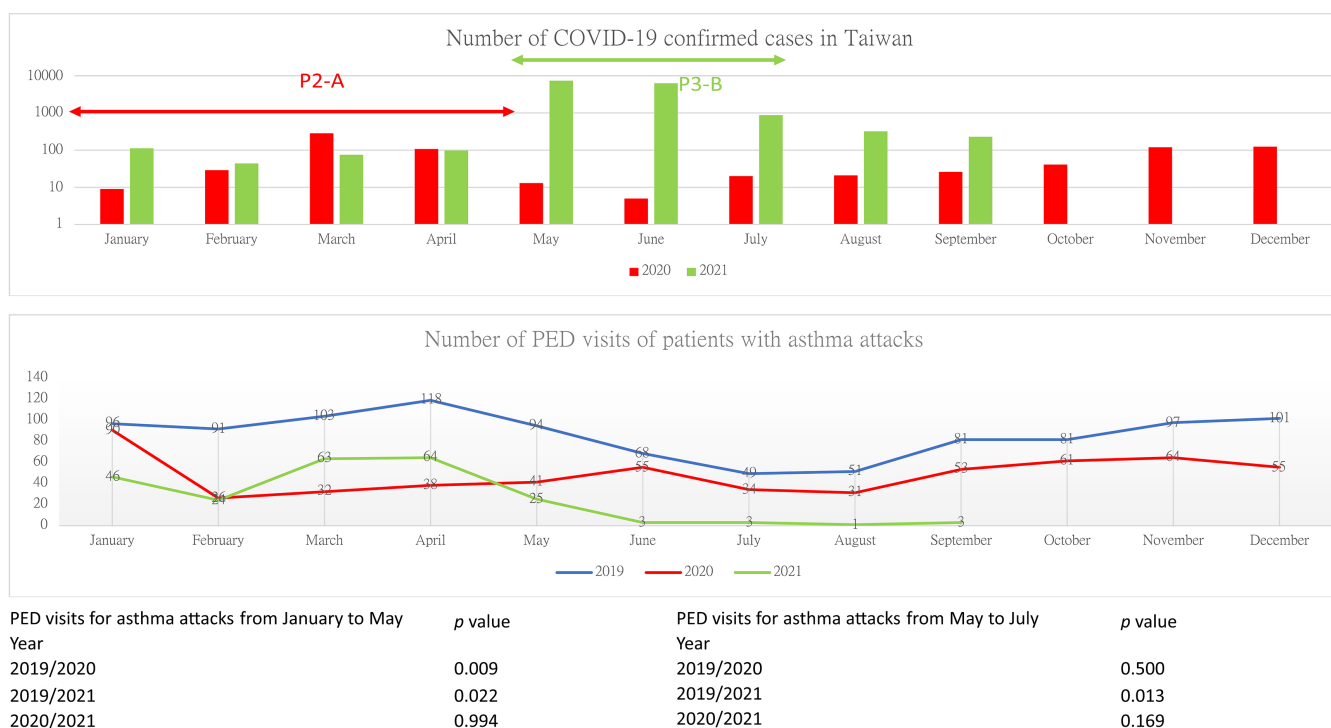


FIGURE 2. Number of COVID-19 confirmed cases, and number of PED visits of patients with asthma attacks. The P2-A period, from 01 January to 31 May in 2020, was the first peak of COVID-19 infection in Taiwan. The P3-B period, from 01 May to 31 July 2021, was defined as the lockdown period. Definition of abbreviation: PED, pediatric emergency department; COVID-19, coronavirus disease 2019.

TABLE 1. Demographic and clinical characteristics of ED visits for an asthma exacerbation in 2019, 2020, and 2021.

Year	2019	2020	2021	<i>p</i> value
N of PED visits for asthma attacks from Jan to Dec	1030	580		0.001
N of PED visits for asthma attacks from Jan to Sep	751	400	232	0.001
N of PED visits for asthma attacks from Jan to May	502	227	222	0.009
N of PED visits for asthma attacks from May to July	211	130	31	0.038
Age, Median, (IQR)	5 (3–7)	5 (4–8)	5 (4–9)	0.218
Age, Year, N (%)				
2year–5year	577 (56.02%)	300 (51.72%)	122 (52.59%)	
6year–11year	363 (35.24%)	224 (38.62%)	80 (34.48%)	
12year–18year	90 (8.74%)	56 (9.66%)	30 (12.93%)	
N(%) of gender				0.29
Girl	368 (35.70%)	227 (39.14%)	92 (39.65%)	
Boy	662 (64.30%)	353 (60.86%)	140 (60.34%)	
Disposition				
Discharge (%)	801 (77.77%)	440 (75.86%)	173 (74.57%)	0.406
Requiring admission (%)	229 (22.23%)	140 (24.14%)	59 (25.43%)	
Triage				0.066
I	85 (8.30%)	23 (3.97%)	16 (6.90%)	
II	269 (26.10%)	134 (23.10%)	63 (27.16%)	
III	533 (51.70%)	353 (60.86%)	125 (53.88%)	
IV	143 (13.90%)	70 (12.07%)	28 (12.07%)	
V	0 (0.00%)	0 (0.00%)	0 (0.00%)	
High acuity triage (Level I & II)	354 (34.37%)	157 (27.07%)	229 (34.05%)	0.08
Vital signs recorded at triage area				
Body temperature, Median, (IQR)	36.6 (36.1–37.2)	36.8 (36.2–37.3)	36.6 (36.0–37.0)	0
Body temperature >38 degree Celsius, N (%)	75 (7.28%)	37 (6.38%)	12 (5.17%)	0.784
Oxygen saturation, %, Median, (IQR)	94 (92–96)	95 (93–96)	94 (92–96)	0.118
Heart rate, beat/min, Median, (IQR)	136 (119–152)	132 (115–148)	134 (113–151)	0.363

Definition of abbreviation: PED = pediatric emergency department. IQR = interquartile range.

TABLE 2. Prescribed medications in the PED before/during COVID-19 pandemic.

	Before COVID-19 pandemic	During COVID-19 pandemic	<i>p</i> value
Prescribed medications in the PED			
SABA, No. (%)	1017 (98.74%)	799/812 (98.40%)	0.54
SCS, No. (%)	801 (77.77%)	665 (81.90%)	0.029
Oral β -agonist, No. (%)	757 (73.50%)	572 (70.44%)	0.159

Definition of abbreviation: PED = pediatric emergency department; SABA = short acting β -agonist; SCS = systemic corticosteroid.

studies, we found that the pandemic reduced the number of PED visits by patients with respiratory tract diseases, including asthma in 2020 [12, 20–22].

As the numbers of confirmed COVID-19 cases increased from May to July 2021 (the P3-B period) in Taiwan, the PED visitor volume decreased to below the levels over the same times in 2020 (the P2-B period) and 2019 (the P1-B period). Possible reasons for the decrease in PED asthmatic attacks include better adherence to asthma medications, avoidance of

healthcare settings because of a fear of contracting COVID-19, improved air quality, less participation in sports and exercise, less exposure to outdoor aero-allergens, and less viral exposure because school and daycare centers were closed [23–27]. Also, caregivers may have been unwilling to bring children to PEDs because of the risk of exposure to COVID-19 in healthcare settings [5, 28].

Asthma attack severity did not worsen during the pandemic [29–32]. Chao *et al.* [32] reported that those presenting with

COVID-19-related complaints experienced higher admission rates. However, Fan *et al.* [30] found that the number of patients with severe asthma decreased. We found that the pandemic did not affect the proportion of patients with high-triage asthma acuity or a need for intensive care unit admission (Table 1). Vital signs (including respiratory and heart rates, and oxygen saturation level) serve as indicators of asthma exacerbation severity. These did not differ significantly before and during the COVID-19 pandemic [33].

As the number of patients with asthma attacks visiting the PED decreased but disease severity did not increase, we propose that medical resources (oxygen and ventilators), medical personnel, and hospital beds can be made available to those in need. SABA typically (effectively and rapidly) relieves acute asthma exacerbations; SABA was universally prescribed regardless of COVID-19 pandemic status [34]. The European Respiratory Review published an update [35] stating that recent or chronic SCS use was not associated with an increased risk of SARS-CoV-2 infection. However, SCS use was in fact a risk factor for a higher-severity COVID-19 infection and mortality. The COVID-19 pandemic affected the attitudes of PED physicians who treated asthma attacks in children [36].

We found that SCS prescriptions increased during the pandemic; we postulate that physicians tended to use more SCSs to control respiratory symptoms and prevent any need for admission. However, as the admission rates, vital signs, and triage acuity levels were similar in each period, we suggest that it was not beneficial to administer more SCSs even in the setting of the COVID-19 pandemic. Moreover, physicians should educate patients on the possible side effects of SCSs if a COVID-19 infection develops.

Our study had several limitations. First, we did not record the clinical symptoms and signs of asthma. We thus cannot comprehensively evaluate the severity of asthma exacerbations. We recorded the changes in PED visits and admissions, not the spirometric results. The latter are more objective and afford individualized evaluations of asthma severity. Second, we recorded only the prescribed medications, not the doses or treatment durations. All data were from third-level centers, *i.e.*, Chang Gung Memorial Hospital-affiliated facilities in only northern Taiwan. Thus, our findings are not fully representative of the general pediatric population. Last, we encountered no patient with both an asthma attack and a confirmed COVID-19 infection; such patients may be more common in countries other than Taiwan. Not all patients were tested for SARS-CoV-2; thus, SARS-CoV-2 co-infection cannot be totally excluded. In future, PED visits by asthmatics may be affected by changes in the status of the SARS-CoV-2 virus pandemic and governmental policies. Governmental and hospital executives must promptly and dynamically reallocate resources if the COVID pandemic worsens and the incidence of other diseases declines.

5. Conclusion

This unique study explored the impact of the COVID-19 pandemic on PED visits by asthmatics in Taiwan. The pandemic reduced the number of PED visits for asthma attacks not only during the first peak period but also the following waves. However, asthma severity did not vary markedly before and

during the COVID-19 outbreak. The pandemic may persist and fluctuate. Thus, similar changes in PED patient numbers may be observed in the future. Valuable resources, including oxygen, ventilators, medical personnel, and beds, can be made available to patients with new-onset global respiratory diseases like COVID-19. Physicians tended to prescribe more SCSs during COVID-19 outbreaks to control respiratory symptoms and to avoid admitting asthma attack patients. Given that the asthma attack severity did not increase, we suggest that SCSs should be cautiously prescribed even in the COVID-19 pandemic era to minimize adverse effects.

AUTHOR CONTRIBUTIONS

HKW and HHC designed the study. ESC collected data. WCC provided assistance and reviewed the references. CWC analyzed the data. HKW and ESC wrote the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was approved by the Chang Gung Medical Foundation Institutional Review Board (approval no. 202101852B0).

ACKNOWLEDGMENT

We thank the peer reviewers for their valuable opinions and suggestions.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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How to cite this article: Hsin-Kuan Wu, En-Shuo Chang, Chien-Wei Cheng, Wei-Che Chien, Hsin-Hui Chou. Impact of COVID-19 pandemic waves on pediatric emergency department patients presenting with asthma attacks in Taiwan. *Signa Vitae*. 2022; 18(6): 27–32. doi:10.22514/sv.2022.045.