



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



The impact of COVID-19 on the patterns of emergency department visits among pediatric patients

Seonji Kim, PhD^a, Young Sun Ro, MD, DrPH^{a,b,c,*}, Sung-keun Ko, MSc^a, Taehui Kim, MSc^a, Yun-Suk Pak, PhD^a, So-Hyun Han, PhD^a, Sungwoo Moon, MD, PhD^{a,d}

^a National Emergency Medical Center, National Medical Center, Seoul, Republic of Korea

^b Department of Emergency Medicine, Seoul National University Hospital, Seoul, Republic of Korea

^c Laboratory of Emergency Medical Services, Seoul National University Hospital Biomedical Research Institute, Seoul, Republic of Korea

^d Department of Emergency Medicine, Korea University Ansan Hospital, Ansan, Republic of Korea

ARTICLE INFO

Article history:

Received 28 October 2021

Received in revised form 10 January 2022

Accepted 1 February 2022

Keywords:

COVID-19

Pediatrics

Emergency department utilization

ABSTRACT

Objectives: This study aimed to investigate the patterns of pediatric patients visiting emergency departments (EDs) before and after the COVID-19 pandemic and evaluate the interactive effect between the COVID-19 outbreak and age groups.

Methods: We performed a cross-sectional study using the nationwide emergency patient database in Korea from January 2019 to December 2020. Pediatric patients (≤ 18 years) who visited all 402 nationwide EDs were included. The age- and sex-standardized incidence rates of pediatric ED visits per 1,000,000 person-days were calculated, and the incidence rate ratio (IRR) was calculated. The adjusted odds ratio (aOR) and 95% confidence interval (CI) of in-hospital mortality were calculated by a multivariable logistic regression.

Results: Among 2,808,756 patients, 1,835,045 (65.3%) patients visited before COVID-19, and 973,711 (34.7%) patients visited after the COVID-19 period. The standardized incidence rates of ED visits per 1,000,000 person-days were 589.3 in the before COVID-19 group and 326.9 in the after COVID-19 group (IRR (95% CI): 0.55 (0.53–0.58)). By diagnosis, the IRRs (95% CI) of mental health disorders (0.84 (0.42–1.65)) and self-harm or suicidal attempts (0.99 (0.38–2.59)) were not significant, while the incidence rate of infectious disease was significantly decreased (0.48 (0.42–0.54)). The aOR (95% CI) of in-hospital mortality after COVID-19 was 1.58 (1.44–1.73) compared to that before COVID-19.

Conclusions: During the COVID-19 pandemic, the incidence of pediatric ED visits decreased, and these effects differed by age group. Age-specific policies are needed to ensure that children receive the care they need at the right time.

© 2022 Elsevier Inc. All rights reserved.

1. Introduction

Coronavirus disease 2019 (COVID-19) spread rapidly to many countries, and the World Health Organization (WHO) declared a pandemic on March 11, 2020 [1,2]. Worldwide, more than 278 million cases of COVID-19 and 5.4 million cumulative deaths were reported by the WHO in December 2021 [3,4]. The Centers for Disease Control and Prevention (CDC) in China and the United States estimated that 1.3% and 1.7% of patients diagnosed with COVID-19 were children,

respectively [5,6]. The reported pediatric cases represent 2.2% in Italy (≤ 18 year-old) and 3.3% and 2.9% in Germany and Austria (< 15 year-old), respectively. [7] Although the proportion of children among all COVID-19 patients is known to be relatively small, studies investigating the disease burden of COVID-19 among children are limited.

The COVID-19 outbreak is known to be associated with an unprecedented decline in emergency department (ED) utilization [8–11]. As an effect of the COVID-19 pandemic, there have been daily changes in routine activities and health care delivery [1,12]. Among pediatric patients, health care use has also been affected by policies, such as “stay-at-home” orders and school closures, and the rate of ED visits by children has decreased during the COVID-19 pandemic [13]. Changes in these policies or environments may have different effects depending on the age of the children. Health care delivery for infants and children was mainly related to household and care centers, and delivery for adolescents was affected by school life, education, and social relationships [13,14].

Abbreviations: COVID-19, coronavirus disease 2019; ED, emergency department; IRR, incidence rate ratio; OR, odds ratio; CI, confidence interval.

* Corresponding author at: Department of Emergency Medicine, Seoul National University Hospital, 101 Daehak-Ro, Jongno-Gu, Seoul 03080, Republic of Korea.

E-mail addresses: seonji0316@nmc.or.kr (S. Kim), Ro.youngsun@gmail.com (Y.S. Ro), skko@nmc.or.kr (S. Ko), thkim@nmc.or.kr (T. Kim), yunsuk.pak@nmc.or.kr (Y.-S. Pak), peacehoi@nmc.or.kr (S.-H. Han), sungwoo.moon89@gmail.com (S. Moon).

The emergence of infectious disease had different health effects depending on the age of the pediatric patients [13,15]. Differences in the immune capacity with age in pediatrics influence disease patterns. At a young age, the function of the immune system can decrease due to physiological immaturity, and low immunity increases susceptibility to infections [16]. The infectious outbreak and related policies could have caused decreases in health care use in pediatrics; however, there are limited studies concerning age-specific differences in health care use declines among pediatric patients.

We hypothesize that ED utilization among pediatric patients declined during the COVID-19 pandemic and that the pattern of decline might vary by age group. The purposes of this study were to evaluate the patterns of ED visits among children before and after the COVID-19 pandemic and assess age-specific differences in the effects of the COVID-19 outbreak on pediatric ED visits.

2. Methods

2.1. Study design and setting

A cross-sectional study was conducted using a nationwide emergency patient database. Korea has more than 50 million people and 17 administrative divisions. The Ministry of Health and Welfare designed three levels of ED depending on the availability of human resources, facilities, and equipment. There are 402 nationwide EDs classified into three levels as follows: 38 Level I EDs, 128 Level II EDs, and 236 Level III EDs. Level I and Level II EDs provide the highest level emergency care services. The Ministry of Health and Welfare designated specialized emergency medical centers for trauma and pediatric or mental health diseases. In total, 9 pediatric-specialized EDs were designated in 2016, and 7 additional pediatric-specialized EDs were designated in September 2020.

The COVID-19 infection monitoring and surveillance response system in Korea was initiated on December 31, 2019, when patients with pneumonia of an unknown cause were reported in Wuhan, China [12]. The first case of COVID-19 in Korea was detected on January 20, 2020. During the early phase of the COVID-19 outbreak (February and March 2020), there were several shut down events of the EDs because COVID-19 confirmed cases were detected among the patients admitted to the ED [11]. In March 2020, the Ministry of Health and Welfare designated and operated the Severe Emergency Medical Care Centers (SEMC) to treat appropriately suspected and confirmed COVID-19 patients and to protect other uninfected emergency patients from infection. The information on resources, including available isolation units and beds in the SEMC, was shared in real time through the web-based national emergency care information system [17].

To prevent the spread of COVID-19, the government announced a physical distancing policy on March 22, 2020. As the national crisis warning level increased, the Ministry of Education decided to postpone new semester opening dates for kindergartens and schools on February 2, 2020. As an alternative to closures, the government offered emergency childcare services to kindergartens and online classes to schools. Students have taken online or offline classes since May 20, 2020. The Ministry of Education announced plans of physical attendance for all students starting in the second semester of 2021.

2.2. Data source

This study was conducted using the National Emergency Department Information System (NEDIS) database in Korea from January 2019 to December 2020. The NEDIS is a nationwide database operated by the National Emergency Medical Center under the Ministry of Health and Welfare since 2003. All patient-related information is automatically transferred in real time from each hospital to the central government server. Inaccurate data are filtered by a data processing system. The NEDIS includes the demographic and clinical information of all patients

who visited EDs across the country, such as patient demographics (such as sex, age, residential area, and insurance), symptoms (chief complaints, onset of symptoms, and reason for visit), prehospital factors (ambulance use and prehospital care), and ED (vital signs, triage, emergency operative procedures, diagnosis codes based on the International Classification of Disease 10th Edition-based (ICD-10), disposition, and final clinical outcomes) information [11,18].

2.3. Study population

Pediatric patients (0–18 years old) who visited any of the 402 nationwide EDs before and after the COVID-19 pandemic (January 1, 2019, to December 31, 2019, as before COVID-19 and January 1, 2020, to December 31, 2020, as after COVID-19) were included to compare the impact of the COVID-19 outbreak after controlling for seasonal variations. We excluded patients who visited EDs for nonmedical purposes and did not meet the emergency physician criteria.

2.4. Study outcomes and measurements

The primary outcome was the incidence of ED visits with specific diagnoses (infectious disease, mental health disorders, and injury) [19–21]. Injury includes self-harm or suicidal attempts and violence or assault. The secondary outcome was in-hospital mortality.

The following demographic and clinical variables were collected from the NEDIS: patient demographics (age and sex) and prehospital ED factors (ambulance use, region of ED, level of ED, initial triage, diagnosis, reason for ED visit, intentionality of injury, and dispositions). The patients' age at the ED visit was categorized into the following four groups: 0–1-, 1–6-, 7–12-, and 13–18-year-old groups. The ED regions were classified into the following three categories according to the population density: metropolitan areas, urban areas, and rural areas.

2.5. Statistical analysis

A descriptive analysis of all pediatric patients visiting EDs was performed by age group and specific diagnosis. The age- and sex-standardized incidence rates of pediatric ED visits per 1,000,000 person-days were calculated using the 2020 mid-year census population in the Korean Statistical Information Service (KOSIS) database from Statistics Korea. We calculated the incidence rate difference (IRD) and incidence rate ratio (IRR) before and after the COVID-19 pandemic to estimate the size of the effect of the COVID-19 pandemic on ED visits among pediatric patients by age group and diagnosis.

The adjusted odds ratios (aORs) and 95% confidence intervals (CIs) were calculated by a multivariable logistic regression after adjusting for age, sex, and ED region, which were potential confounders, and an interaction analysis was conducted with an interaction term (COVID-19 periods \times age).

The database construction and statistical analysis were performed using SAS version 9.4 (SAS Institute, Cary, NC, USA). The significance level was 0.05.

2.6. Ethics statement

This study was approved by the Institutional Review Board of the National Medical Center (IRB No. NMC-2021-04-044), and the requirement for informed consent was waived due to the retrospective nature of this study.

2.7. Patient and public involvement statement

The National Emergency Medical Center under the Ministry of Health and Welfare was involved in the design and conduct of this research, but it was not possible to involve patients in our research.

3. Results

We identified 2,808,756 pediatric patients who visited EDs from January 1, 2019, to December 31, 2020. Among them, 1,835,045 patients visited EDs before the COVID-19 period, and 973,711 patients visited EDs after the COVID-19 period (Table 1). By age group, the 1–6-year-old group was the largest at 903,320 (49.2%) before COVID-19 and 429,441 (44.1%) after COVID-19. Although the overall characteristics after COVID-19 decreased by approximately 50% compared to those before COVID-19, ambulance use (125,383 (6.8%) before COVID-19 vs. 80,942 (8.3%) after COVID-19), intensive care unit (ICU) admission (6360 (0.3%) vs. 5283 (0.5%)), and in-hospital mortality (978 (0.1%) vs. 854 (0.1%)) showed a different pattern. By diagnosis, the number of patients with mental health disorders (6750 (0.4%) vs. 5515 (0.6%)), injury (572,574 (31.2%) vs. 389,974 (40.1%)), and self-harm and suicide attempts (3061 (0.2%) vs. 2962 (0.3%)) also slightly decreased after COVID-19 (Table 1, Supplementary Tables 2 and 3).

Table 2 shows the demographic characteristics of pediatric patients visiting EDs by age group. After the COVID-19 period, the proportion of ambulance use increased in all four age groups. The decrease in the number of patients with injury was alleviated in the groups aged 0–12 years. A similar pattern was observed in the number of patients diagnosed with mental health disorders in the 13–18-year-old group. The number of patients seen due to violence or assault among infants (under 1 year old) increased from 14 before the COVID-19 period to 29 after the COVID-19 period. For infectious disease, the number of visits was 289,728 before COVID-19 and 133,273 after COVID-19 (Supplementary Table 1). Regarding mental health disorders, the

Table 1
Demographic characteristics of pediatric patients visiting emergency departments.

	Before COVID-19 (Jan 2019 – Dec 2019)	After COVID-19 (Jan 2020 – Dec 2020)	p-value
Total	1,835,045 (100.0)	973,711 (100.0)	
Age groups, years			<0.01
0–1	143,987 (7.8)	74,593 (7.7)	
1–6	903,320 (49.2)	429,441 (44.1)	
7–12	402,781 (21.9)	223,258 (22.9)	
13–18	384,957 (21.0)	246,419 (25.3)	
Sex			0.29
Male	1037,173 (56.5)	550,983 (56.6)	
Female	797,872 (43.5)	422,728 (43.4)	
Region			<0.01
Metropolitan	1,180,715 (64.3)	603,483 (62.0)	
Urban	556,066 (30.3)	311,888 (32.0)	
Rural	98,264 (5.4)	58,340 (6.0)	
Ambulance use	125,383 (6.8)	80,942 (8.3)	<0.01
Level of ED			<0.01
Level 1	483,610 (26.4)	249,105 (25.6)	
Level 2	870,696 (47.4)	468,363 (48.1)	
Level 3	480,739 (26.2)	256,243 (26.3)	
Patient triage (KTAS)			<0.01
Emergency (level 1–2)	47,983 (2.6)	27,317 (2.8)	
Urgent (level 3)	557,858 (30.4)	275,560 (28.3)	
Less urgent (level 4–5)	1,130,251 (61.6)	621,548 (63.8)	
Unknown	98,953 (5.4)	49,286 (5.1)	
Diagnosis			
Infectious disease	289,728 (15.8)	133,273 (13.7)	<0.01
Mental health disorders	6750 (0.4)	5515 (0.6)	<0.01
Injury	572,574 (31.2)	389,974 (40.1)	<0.01
Self-harm or suicidal attempts	3061 (0.2)	2962 (0.3)	<0.01
Violence or assault	5422 (0.3)	3099 (0.3)	<0.01
Admission	173,220 (9.4)	91,625 (9.4)	0.42
ICU	6360 (0.3)	5283 (0.5)	<0.01
Hospital ward	166,860 (9.1)	86,342 (8.9)	<0.01
In-hospital mortality	978 (0.1)	854 (0.1)	<0.01
ED	637 (0.0)	555 (0.1)	<0.01
Hospital ward	341 (0.0)	299 (0.0)	<0.01

COVID-19, coronavirus disease 2019; Jan, January; Dec, December; ED, emergency department; KTAS, Korean triage and acuity scale; ICU, intensive care unit.

13–18-year-old group was the largest at 5719 (84.7%) before COVID-19 and 4786 (86.8%) after COVID-19 (Supplementary Table 2). After the COVID-19 period, the proportions of admission and in-hospital mortality increased in all three diagnosis groups during the study period (Supplementary Tables 1–3).

The standardized incidence rates of pediatric ED visits per 1,000,000 person-days were 589.3 before the COVID-19 period and 326.9 after the COVID-19 period (Table 3). The IRR (95% CI) of all pediatric ED visits was 0.55 (0.53–0.58). By diagnosis, the IRRs (95% CI) of mental health disorders (0.84 (0.42–1.65)) and self-harm or suicidal attempts (0.99 (0.38–2.59)) were not significant, while the incidence rate of infectious disease was significantly decreased (IRR (95% CI): 0.48 (0.42–0.54)) (Table 3, Figure 1).

The aOR (95% CI) of in-hospital mortality after COVID-19 compared to that before COVID-19 was 1.58 (1.44–1.73) (Table 4). In the interaction analysis performed to evaluate the effect modification of the COVID-19 period by age, the aORs (95% CIs) of in-hospital mortality were 1.75 (1.46–2.09) in the 0–1-year-old group, 1.54 (1.26–1.87) in the 1–6-year-old group, 1.95 (1.54–2.48) in the 7–12-year-old group, and 1.37 (1.18–1.60) in the 13–18-year-old group (P -for-interaction <0.05).

4. Discussion

This cross-sectional study used a nationwide emergency patient database and evaluated the impact of the COVID-19 pandemic on pediatric ED visits and whether these effects differed by age group. During the COVID-19 outbreak, the incidence rates of pediatric patients who visited EDs decreased compared with those in the corresponding period (IRR (95% CI): 0.55 (0.53–0.58)), and there was an interaction effect between the COVID-19 outbreak and age groups on in-hospital mortality (P -for-interaction <0.05). During the COVID-19 pandemic, the proportions of ED visits for mental health diseases and self-harm or suicide attempts in the 13–18-year-old group increased, and the number of ED visits for violence or assault among infants also increased. These results emphasize that the COVID-19 pandemic appears to have significantly different impacts on pediatric patients by age. Age-specific policies are needed to ensure that children receive the care they need at the right time to treat potentially preventable diseases.

Several studies have reported a decrease in ED visits in pediatric patients during the COVID-19 pandemic [22–24]. The absolute number of all pediatric ED visits decreased; however, the patterns of decreases differ by the characteristics of illness. In this study, the proportions of patients with high acuity by triage (2.6% and 2.8%, $p < 0.01$) and those with ambulance use (6.8% and 8.3%, $p < 0.01$) increased, while the total number of ED visits decreased. EDs have attempted to maintain services for pediatric patients with higher acuity during the pandemic.

COVID-19 has affected various pediatric conditions [25,26]. In terms of infectious illnesses, which are the most common reasons for pediatric ED visits, the prevalence in children younger than 6 years decreased in this study. Interventions, such as using masks, school closures, hand-washing, and physical distancing, to reduce the spread of COVID-19 have impacted the reduction in the incidence of other infectious diseases, such as seasonal influenza [25,27]. Self-isolation, quarantine, and worry about COVID-19 transmission in the ED might lead to a decrease in pediatric ED visits [24,25].

There were increases in ED visits for mental health diseases and self-harm or suicidal attempts, especially among the 13–18-year-old group. This result is consistent with the MMWR report from the CDC; the proportion of children's mental health visits increased 44% in 2020 compared with that in 2019 [13]. Many mental disorders occur in childhood, and mental health problems in these groups could be exacerbated by stress and anxiety related to the pandemic, disconnection from school, and sudden disturbances in daily life [28]. This increase also likely occurred because adolescents who usually received mental health

Table 2
Demographic characteristics of pediatric patients visiting emergency departments by age group.

	Age, 0–1		Age, 1–6		Age, 7–12		Age, 13–18	
	Before COVID-19	After COVID-19	Before COVID-19	After COVID-19	Before COVID-19	After COVID-19	Before COVID-19	After COVID-19
Total	143,987 (100.0)	74,593 (100.0)	903,320 (100.0)	429,441 (100.0)	402,781 (100.0)	223,258 (100.0)	384,957 (100.0)	246,419 (100.0)
Sex								
Male	80,410 (44.2)	41,936 (43.8)	506,494 (43.9)	243,846 (43.2)	240,403 (40.3)	132,955 (40.4)	209,866 (45.5)	132,246 (46.3)
Female	63,577 (55.8)	32,657 (56.2)	396,826 (56.1)	185,595 (56.8)	162,378 (59.7)	90,303 (59.6)	175,091 (54.5)	114,173 (53.7)
Region								
Metropolitan	110,927 (77.0)	56,244 (75.4)	602,425 (66.7)	276,270 (64.3)	239,040 (59.3)	127,494 (57.1)	228,323 (59.3)	143,475 (58.2)
Urban	31,404 (21.8)	17,266 (23.1)	265,650 (29.4)	133,964 (31.2)	133,421 (33.1)	77,601 (34.8)	125,591 (32.6)	83,057 (33.7)
Rural	1656 (1.2)	1083 (1.5)	35,245 (3.9)	19,207 (4.5)	30,320 (7.5)	18,163 (8.1)	31,043 (8.1)	19,887 (8.1)
Ambulance use	9304 (6.5)	6457 (8.7)	49,336 (5.5)	27,372 (6.4)	22,354 (5.5)	15,532 (7.0)	44,389 (11.5)	31,581 (12.8)
Level of ED								
Level 1	62,296 (43.2)	31,800 (42.6)	269,327 (29.8)	125,197 (29.2)	84,359 (20.9)	46,860 (21.0)	67,628 (17.6)	45,248 (18.4)
Level 2	72,195 (50.1)	38,218 (51.2)	452,948 (50.1)	217,412 (50.6)	182,755 (45.4)	102,505 (45.9)	162,798 (42.3)	110,228 (44.7)
Level 3	9496 (6.6)	4575 (6.1)	181,045 (20.0)	86,832 (20.2)	135,667 (33.7)	73,893 (33.1)	154,531 (40.1)	90,943 (36.9)
Patient triage (KTAS)								
Emergency (level 1–2)	18,154 (12.6)	10,754 (14.4)	19,114 (2.1)	8770 (2.0)	4341 (1.1)	3030 (1.4)	6374 (1.7)	4763 (1.9)
Urgent (level 3)	63,358 (44.0)	30,039 (40.3)	301,318 (33.4)	119,007 (27.7)	97,150 (24.1)	56,923 (25.5)	96,032 (24.9)	69,591 (28.2)
Less urgent (level 4–5)	61,044 (42.4)	32,837 (44.0)	547,629 (60.6)	285,115 (66.4)	271,616 (67.4)	148,595 (66.6)	249,962 (64.9)	155,001 (62.9)
Unknown	1431 (0.1)	963 (1.3)	35,259 (3.9)	16,549 (3.9)	29,674 (7.4)	14,710 (6.6)	32,589 (8.5)	17,064 (6.9)
Diagnosis								
Infectious disease	20,848 (14.5)	8246 (11.1)	134,418 (14.9)	44,660 (10.4)	70,121 (17.4)	37,379 (16.7)	64,341 (16.7)	42,988 (17.4)
Mental health disorders	49 (0.0)	50 (0.1)	301 (0.0)	161 (0.0)	681 (0.2)	518 (0.2)	5719 (1.5)	4786 (1.9)
Injury	26,244 (18.2)	19,144 (25.7)	269,902 (29.9)	198,580 (46.2)	144,901 (36.0)	91,094 (40.8)	131,527 (34.2)	81,156 (32.9)
Self-harm or suicidal attempts	0 (0.0)	0 (0.0)	6 (0.0)	4 (0.0)	106 (0.0)	85 (0.0)	2949 (0.8)	2873 (1.2)
Violence or assault	14 (0.0)	29 (0.0)	242 (0.0)	161 (0.0)	1037 (0.3)	472 (0.2)	4129 (1.1)	2437 (1.0)
Admission	30,100 (20.9)	17,634 (23.6)	70,830 (7.8)	26,939 (6.3)	33,028 (8.2)	19,494 (8.7)	39,262 (10.2)	27,558 (11.2)
ICU	3264 (2.3)	2681 (3.6)	911 (0.1)	661 (0.2)	638 (0.2)	536 (0.2)	1547 (0.4)	1405 (0.6)
Hospital ward	26,836 (18.6)	14,953 (20.0)	69,919 (7.7)	26,278 (6.1)	32,390 (8.0)	18,958 (8.5)	37,715 (9.8)	26,153 (10.6)
In-hospital mortality								
ED	180 (0.1)	168 (0.2)	137 (0.0)	95 (0.0)	72 (0.0)	76 (0.0)	248 (0.1)	216 (0.1)
Hospital ward	74 (0.1)	61 (0.1)	98 (0.0)	76 (0.0)	57 (0.0)	63 (0.0)	112 (0.0)	99 (0.0)

COVID-19, coronavirus disease 2019; Jan, January; Dec, December; ED, emergency department; KTAS, Korean triage and acuity scale; ICU, intensive care unit.

care were not receiving services on time due to the mitigation policy of COVID-19 [13].

In terms of injury, changes in children's environment, including stay-at-home orders, could pose various threats, such as injuries in the home or child abuse or neglect [23,29]. For example, there was a report of a threefold increase in ED visits for children bitten by dogs [30]. In this study, the number of ED visits due to violence or assault increased from 14 to 29 among infants (younger than 1 year old) after COVID-19.

Uncontrolled emotional stress could increase the risk of young children's exposure to intimate caregiver violence, especially within the family [29,31]. The number of COVID-19 cases has not shown a noticeable decrease, although vaccination has started. There is a strong need to investigate the characteristics of pediatric patients who visit EDs, one of the most vulnerable populations to pandemic disasters, and develop age-specific interventions to correctly utilize the appropriate health care services to treat potentially preventable diseases.

Table 3
Standardized incidence rates of pediatric patients visiting emergency departments by age group and diagnosis.

	Before COVID-19 (Jan 2019 – Dec 2019)		After COVID-19 (Jan 2020 – Dec 2020)		Rate difference		Rate ratio					
	Rate*	95% CI	Rate*	95% CI	Diff	95% CI	Ratio	95% CI				
	Total	589.3	573.0	605.6	326.9	314.5	339.3	-262.4	-282.9	-242.0	0.55	0.53
Age, years												
0–1	1336.5	1204.6	1468.3	771.1	665.3	876.8	-565.4	-734.4	-396.4	0.58	0.49	0.68
1–6	1017.7	977.6	1057.8	512.2	482.9	541.5	-505.5	-555.1	-455.9	0.50	0.47	0.54
7–12	386.7	363.9	409.5	218.5	201.2	235.8	-168.2	-196.8	-139.5	0.57	0.51	0.62
13–18	362.8	340.9	384.7	237.4	219.5	255.4	-125.3	-153.6	-97.0	0.65	0.59	0.72
Diagnosis												
Infectious disease	93.1	86.6	99.6	44.6	40.0	49.2	-48.5	-56.4	-40.6	0.48	0.42	0.54
Mental health disorders	2.2	1.2	3.2	1.8	0.9	2.8	-0.4	-1.7	1.0	0.84	0.42	1.65
Injury	184.2	175.1	193.3	130.9	123.1	138.8	-53.2	-65.3	-41.2	0.71	0.66	0.77
Self-harm or suicidal attempts	1.0	0.3	1.7	1.0	0.3	1.7	0.0	-1.0	1.0	0.99	0.38	2.59
Violence or assault	1.8	0.9	2.7	1.0	0.3	1.7	-0.7	-1.9	0.4	0.59	0.25	1.36

COVID-19, coronavirus disease 2019; Jan, January; Dec, December; Diff, difference; CI, confidence interval.

* Age- and sex-standardized incidence rates per 1,000,000 person-days were calculated using the 2020 mid-year census population.

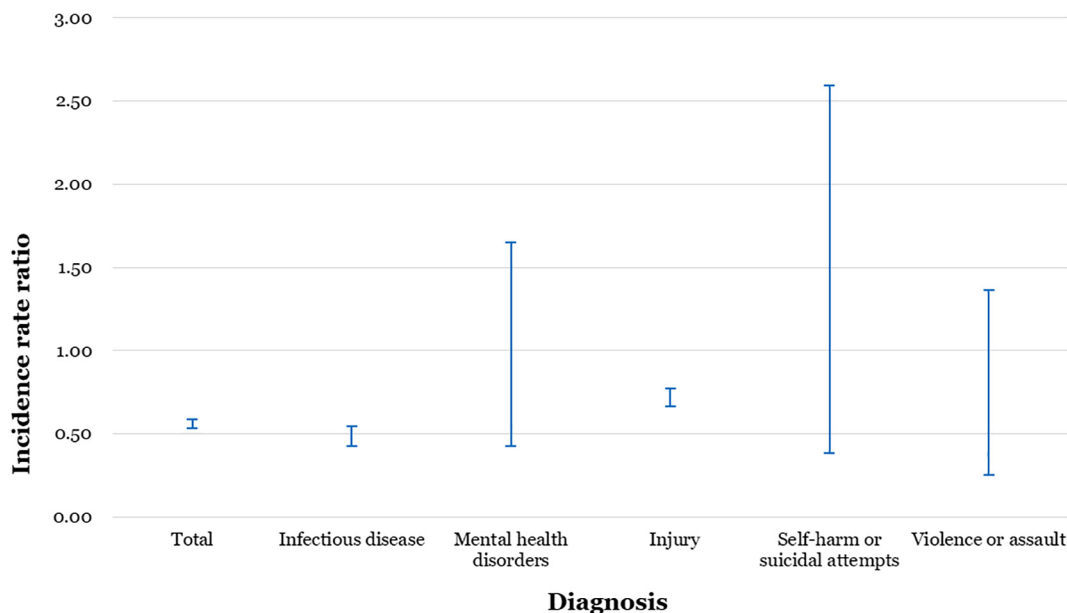


Fig. 1. Standardized incidence rate ratios of pediatric patients visiting emergency departments by diagnosis.

Table 4

The risk of in-hospital mortality after COVID-19 compared to that before COVID-19 among pediatric patients visiting emergency departments

	Odds ratio*	95% CI	
After COVID-19 vs. before COVID-19			
Total population	1.58	1.44	1.73
Interaction effect between COVID-19 periods and age			
0–1	1.75	1.46	2.09
1–6	1.54	1.26	1.87
7–12	1.95	1.54	2.48
13–18	1.37	1.18	1.60

COVID-19, coronavirus disease 2019; CI, confidence interval.

* Adjustment for COVID-19 periods, age, gender and region of emergency departments, *P* for interaction <0.05.

This study has several limitations. First, since this study is an observational study and not a randomized controlled trial, there is a limitation in causal reasoning. Therefore, further studies evaluating causality are needed. Second, patients with mental health diseases were defined based on the diagnosis codes in the NEDIS database. It is impossible to distinguish whether pediatric patients with mental health diseases who visited EDs were previously diagnosed with mental disorders or were newly diagnosed during their visits to the ED. Third, the information concerning self-harm or violence/assault was collected only from Level 1 and Level 2 EDs, and the possibility of underestimation exists.

During the COVID-19 pandemic, the incidence of pediatric ED visits decreased, and these effects differed by age group; the proportions of ED visits for mental health diseases and self-harm or suicidal attempts increased among those aged older than 13 years, and the number of ED visits for violence or assault among infants also increased. Close monitoring and age-specific policies are needed to ensure that children receive the care they need at the right time to treat potentially preventable diseases.

Author contributions

Approval of final manuscript: all authors.

Funding

There was no funding for this study.

Declaration of Competing Interest

The authors have no conflicts of interest to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ajem.2022.02.009>.

References

- [1] Dong Y, Mo X, Hu Y, Qi X, Jiang F, Jiang Z, et al. Epidemiological characteristics of 2143 pediatric patients with 2019 coronavirus disease in China. *J Pediatr*. 2020; 145:e20200702.
- [2] World Health Organization. Timeline: WHO's COVID-19 Response 2020. updated 24 Jan, 2021. Available from: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline#1>.
- [3] World Health Organization. Weekly epidemiological update on COVID-19: World Health Organization. 2021 [updated 6 April. Available from: <https://www.who.int/publications/m/item/weekly-epidemiological-update-on-covid-19-6-april-2021>; 2021.
- [4] Adams JG, Walls RM. Supporting the health care workforce during the COVID-19 global epidemic. *Jama*. 2020;323:1439–40.
- [5] Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention. *Jama*. 2020;323(13): 1239–42.
- [6] Bialek Stephanie, Gierke Ryan, Michelle Hughes AL, McNamara Tamara Piliushvili, et al. Coronavirus disease 2019 in children—United States, February 12–April 2; 2020; 2020.
- [7] Carroll W, Strenger V, Eber E, Porcaro F, Cutrera R, Fitzgerald D, et al. European and United Kingdom COVID-19 pandemic experience: the same but different. *Paediatr Respir Rev*. 2020;35:50–6.
- [8] Garcia S, Albaghdadi MS, Meraj PM, Schmidt C, Garberich R, Jaffer FA, et al. Reduction in ST-segment elevation cardiac catheterization laboratory activations in the United States during COVID-19 pandemic. *J Am Coll Cardiol*. 2020;75(22):2871–2.
- [9] Rodríguez-Leor O, Álvarez BC, Ojeda S, Moreiras JM, Cuevas JRR, Palop RL, et al. Impacto de la pandemia de COVID-19 sobre la actividad asistencial en cardiología intervencionista en España. *REC: Intervent Cardiol*. 2020;2(2):82–9.
- [10] Thornton J. Covid-19: a&E visits in England fall by 25% in week after lockdown. *Br Med J*. 2020;369:m1401.
- [11] Lee DE, Ro YS, Ryoo HW, Moon S. Impact of temporary closures of emergency departments during the COVID-19 outbreak on clinical outcomes for emergency patients in a metropolitan area. *Am J Emerg Med*. 2021;47:35–41.
- [12] Pak Y-S, Ro YS, Kim S-H, Han S-H, Ko S-k, Kim T, et al. Effects of emergency care-related health policies during the COVID-19 pandemic in Korea: a quasi-experimental study. *J Korean Med Sci*. 2021;36:e121.
- [13] Leeb RT, Bitsko RH, Radhakrishnan L, Martinez P, Njai R, Holland KM. Mental health-related emergency department visits among children aged < 18 years during the

- COVID-19 pandemic—United States, January 1–October 17, 2020. *Morb Mort Weekly Report*. 2020;69(45):1675.
- [14] Brady MT. Infectious disease in pediatric out-of-home child care. *Am J Infect Control*. 2005;33(5):276–85.
- [15] Heiber M, Lou WW. Effect of the SARS outbreak on visits to a community hospital emergency department. *Canadian J Emerg Med*. 2006;8(5):323–8.
- [16] Valiathan R, Ashman M, Asthana D. Effects of ageing on the immune system: infants to elderly. *Scand J Immunol*. 2016;83(4):255–66.
- [17] Pak YS, Ro YS, Kim SH, Han SH, Ko SK, Kim T, et al. Effects of emergency care-related health policies during the COVID-19 pandemic in Korea: a quasi-experimental study. *J Korean Med Sci*. 2021.;36(16):e121.
- [18] Jung E, Ro YS, Ryu HH, Do Shin S, Moon SJJokms.. Interaction Effects between COVID-19 Outbreak and Community Income Levels on Excess Mortality among Patients Visiting Emergency Departments, 36; 2021; 13.
- [19] Kim J, Shin SD, Im TH, Lee KJ, Ko SB, Park JO, et al. Development and validation of the excess mortality ratio-adjusted injury severity score using the international classification of diseases 10th edition. *Acad Emerg Med*. 2009;16:454–64.
- [20] Lo CB, Bridge JA, Shi J, Ludwig L, Stanley RM. Children's mental health emergency department visits: 2007–2016. *Pediatrics*. 2020.;145.
- [21] Smith ML, Farkas DK, Sumner JA, Jiang T, Lash TL, Galea S, et al. Associations between adjustment disorder and hospital-based infections in the Danish population. *J Psychosom Res*. 2020.;132:109976.
- [22] Angoulvant F, Ouldali N, Yang DD, Filser M, Gajdos V, Rybak A, et al. Coronavirus disease 2019 pandemic: impact caused by school closure and national lockdown on pediatric visits and admissions for viral and nonviral infections—a time series analysis. *Clin Infect Dis*. 2021;72(2):319–22.
- [23] Chaiyachati BH, Agawu A, Zorc JJ, Balamuth F. Trends in pediatric emergency department utilization after institution of coronavirus disease-19 mandatory social distancing. *J Pediatr*. 2020.;226(274–7):e1.
- [24] Scaramuzza A, Tagliaferri F, Bonetti L, Soliani M, Morotti F, Bellone S, et al. Changing admission patterns in paediatric emergency departments during the COVID-19 pandemic. *Arch Dis Child*. 2020;105(7):704–6.
- [25] Kocher KE, Macy ML. Emergency department patients in the early months of the coronavirus disease 2019 (COVID-19) pandemic—what have we learned? *JAMA Health Forum*. 2020.;1(6):e200705-e.
- [26] DeLaroché AM, Rodean J, Aronson PL, Fleegler EW, Florin TA, Goyal M, et al. Pediatric emergency department visits at US Children's hospitals during the COVID-19 pandemic. *Pediatrics*. 2021.;147(4):e2020039628.
- [27] Sakamoto H, Ishikane M, Ueda P. Seasonal influenza activity during the SARS-CoV-2 outbreak in Japan. *Jama*. 2020;323(19):1969–71.
- [28] Golberstein E, Wen H, Miller BF. Coronavirus disease 2019 (COVID-19) and mental health for children and adolescents. *JAMA Pediatr*. 2020;174(9):819–20.
- [29] Humphreys KL, Myint MT, Zeanah CH. Increased risk for family violence during the COVID-19 pandemic. *Pediatrics*. 2020.;146(1).
- [30] Dixon CA, Mistry RD. Dog bites in children surge during coronavirus Disease-2019: a case for enhanced prevention. *J Pediatr*. 2020;225:231–2.
- [31] Vu NL, Jouriles EN, McDonald R, Rosenfield D. Children's exposure to intimate partner violence: a meta-analysis of longitudinal associations with child adjustment problems. *Clin Psychol Rev*. 2016;46:25–33.