





Original Article

The impact of the coronavirus disease 2019 pandemic on pediatric hospitalization in Kitami, Japan

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Abstract **Background:** Coronavirus disease 2019 (COVID-19) has drastically changed the recommended activities and environment for patients worldwide. Our aim was to assess the impact of COVID-19 on pediatric hospitalizations in Kitami, Japan.

Methods: A retrospective, single-center study was conducted on hospitalized patients aged 0–14 years at the Japanese Red Cross Kitami Hospital. We compared the incidence of pediatric patients hospitalized in 2020 with those in 2017–2019.

Results: The number of pediatric hospitalized patients dropped significantly in 2020 compared to that in 2017–2019 (median 43.0 vs 78.5 per month, $P < 0.001$). The patients were significantly older in 2020 (4.3 vs 3.4 years, $P < 0.001$). Hospitalization from respiratory (8.5 vs 30.5, $P < 0.001$) and gastrointestinal infections (3.0 vs 6.0, $P = 0.004$) significantly decreased. Admission due to respiratory syncytial virus (0.0 vs 4.0, $P < 0.001$), human metapneumovirus (0.0 vs 1.0, $P = 0.005$), influenza (0.0 vs 0.0, $P = 0.009$), adenovirus (0.0 vs 1.0, $P = 0.003$), and rotavirus infection (0.0 vs 0.0, $P = 0.025$) also decreased significantly. The <1–5 age groups significantly decreased (<1 year old, 6.5 vs 12.5, $P < 0.001$; 1–3 years old, 13.0 vs 29.5, $P < 0.001$; 4–5 years old, 5.5 vs 11.5, $P < 0.001$). Hospitalization due to foreign body ingestions increased significantly in 2020 (1.0 vs 0.0, $P = 0.010$).

Conclusions: The COVID-19 control measures inadvertently reduced the number of hospitalized pediatric patients, especially younger children with respiratory and gastrointestinal infections.

Key words coronavirus, epidemiology, foreign body ingestion, gastrointestinal infection, respiratory infection.

The coronavirus disease 2019 (COVID-19) outbreak caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was first reported in Wuhan, China, towards the end of 2019.¹ It spread worldwide and was declared a pandemic on March 11, 2020 by the World Health Organization.² As a disease that is transmitted by close contact, this pandemic has drastically changed the recommended activities and environment of patients worldwide. Japan had the first case of COVID-19 on January 16, 2020. This resulted in a nationwide temporary closure of all schools from March 2 for approximately 1 month. A state of national emergency was declared in seven urban prefectures on April 7, which later expanded to the entirety of Japan on April 16. Strict quarantine measures were terminated on May 25.

Previous reports have shown a decline in emergency department visits and hospitalizations in the pediatric population

during the COVID-19 pandemic^{3–7}; however, relevant epidemiologic data are limited.

Kitami is a city in Japan with a population of approximately 120 000, and the prevalence of children 0–14 years old is 11%–12%. The Japanese Red Cross Kitami Hospital has a total of 490 beds, and the number of beds in the pediatric ward is 30. There are eight pediatricians in our hospital. Our hospital is the only hospital in Kitami where children can be hospitalized, providing primary, secondary, and tertiary care. The number of hospitalizations in this hospital is therefore reflective of the entire pediatric population in Kitami City and its surrounding municipalities.

In this study, we aimed to describe the impact of COVID-19 on the number of pediatric hospitalizations in Kitami, Japan, to obtain a better understanding of the epidemiological changes to pediatric hospitalization during the COVID-19 pandemic.

Methods

Study design

A retrospective, single-center study was conducted on pediatric hospitalized patients aged 0–14 years at the Japanese

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Red Cross Kitami Hospital, Japan. We compared the frequency of pediatric hospitalized patients admitted in our institution in 2020 with that in 2017–2019. The number of pediatricians was eight or nine, depending on the year. Hospital open days per week did not change during the study period. Our institution did not impose hospitalization restrictions for pediatric patients during the COVID-19 pandemic.

Patients and data acquisition

We collected the following information from medical records: age, sex, date of hospitalization, duration of hospitalization, background to hospitalization, diagnosis, and infectious disease pathogens. Infections were classified as respiratory, gastrointestinal, or other infections. Newborns admitted to the neonatal intensive care unit or growing care unit were excluded from this study.

Identification of pathogens

The following test kit was used for rapid antigen testing: ALSONIC RSV (Alfresa Pharma Corp., Osaka, Japan) for respiratory syncytial (RS) virus, ImunoAce hMPV (TAUNS Laboratories, Shizuoka, Japan) for human metapneumovirus, ImunoAce Flu (TAUNS Laboratories, Shizuoka, Japan) for influenza, ALSONIC Adeno (Alfresa Pharma Corp., Osaka, Japan) for nasopharyngeal adenovirus, QuickNavi™-Norovirus2 (Denka Company Limited, Tokyo, Japan) for fecal norovirus, and Quick Chaser Rota/Adeno (MIZUHO MEDY Corp., Saga, Japan) for fecal rotavirus and adenovirus. *Streptococcus pyogenes* Infection was diagnosed when it was detected in pharyngeal culture. If the antigen test or pharyngeal culture was positive, we diagnosed this as an infection caused by that antigen. If the antigen was already identified by the previous doctor, we diagnosed this as an infection caused by that antigen according to the test result of the previous doctor, and the antigen test was not repeated at our hospital. Each antigen test was performed at the discretion of the attending physician. ImunoAce hMPV (TAUNS Laboratories, Shizuoka, Japan) for human metapneumovirus was available from August 2017. TRCReady SARS CoV-2 (Tosoh Corp., Yamaguchi, Japan) was used for the polymerase chain reaction test of SARS-CoV-2 since May 2020 in our hospital. Other available tests or the policy did not change during the study period.

Statistical analysis

Statistical analyses were performed with EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R 4.0.3 (The R Foundation for Statistical Computing, Vienna, Austria).⁸ More precisely, it is a modified version of R commander (version 2.7-1) designed to incorporate statistical functions frequently used in biostatistics. Categorical variables were described as numbers and percentages, while continuous variables were described as the

median and interquartile range (IQR). The Mann–Whitney test was used to compare two groups of independent, non-parametric numerical data. The χ^2 test was used to compare the proportions for categorical variables. Statistical significance was set at a two-sided *P*-value of <0.05.

Ethical approval

Ethical approval was obtained from the Japanese Red Cross Kitami Hospital Ethics Committee in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Results

Patient demographics are shown in Table 1. A total of 561 patients were admitted to the pediatric ward in our hospital for the year 2020, whereas 909, 957, and 945 patients were admitted in the years 2017, 2018, and 2019, respectively. The number of pediatric hospitalizations dropped significantly in 2020 compared to that in 2017–2019 (median 43.0 vs 78.5 per month, *P* < 0.001). There was no significant change in the number of patients transferred by ambulance in 2020 compared to that in 2017–2019 (median 5.0 vs 6.0 per month, *P* = 0.563). The number of referral patients significantly decreased in 2020 compared to that in 2017–2019 (median 14.5 vs 28.0 per month, *P* < 0.001). The median age and IQR were 4.3 years (IQR: 1.7–8.7 years) in 2020, whereas the median age and IQR were 3.6 years (IQR: 1.3–6.7 years), 3.4 years (IQR: 1.2–6.8 years), and 3.1 years (IQR: 1.3–6.6 years) in 2017, 2018, and 2019, respectively. The pediatric hospitalized patients were significantly older in 2020 than in 2017–2019 (median 4.3 vs 3.4 years, *P* < 0.001). There were no significant changes in the sex ratio (males 59.2% vs 58.8%, *P* = 0.857) and hospital length of stay (median 3.5 vs 4.0 days, *P* = 0.095).

In 2020, hospitalization due to respiratory and gastrointestinal infections significantly decreased compared to that in 2017–2019 (respiratory, median 8.5 vs 30.5 per month, *P* < 0.001; gastrointestinal, median 3.0 vs 6.0 per month, *P* = 0.004), whereas the total of other infections remained unchanged (median 1.5 vs 1.0 per month, *P* = 0.9923). There were four pediatric COVID-19 patients in 2020; all of them tested positive at the Kitami Health Center and were hospitalized at the request of Kitami Health Center. Infectious diseases caused by pathogens such as RS virus, human metapneumovirus, influenza, adenovirus, and rotavirus also decreased significantly in 2020 (RS virus, median 0.0 vs 4.0 per month, *P* < 0.001; human metapneumovirus, median 0.0 vs 1.0 per month, *P* = 0.005; influenza, median 0.0 vs 0.0 per month, *P* = 0.009; adenovirus, median 0.0 vs 1.0 per month, *P* = 0.003; rotavirus, median 0.0 vs 0.0 per month, *P* = 0.025). Although the number of hospitalized patients from infections with *Streptococcus pyogenes* and norovirus decreased in 2020, there were no significant differences compared with that in previous years (*Streptococcus pyogenes*, median 0.0 vs 0.0 per

Table 1 Characteristics of pediatric hospitalized patients

	2017		2018		2019		2017–2019		2020		P-value (*2017–2019 vs *2020)
	Total	Per month median (IQR)	Total	Per month median (IQR)	Total	Per month median (IQR)	Total	Per month median (IQR)	Total	Per month median (IQR)	
Total number of hospitalized patients	909	957	945	2,811	78.5 (69.0–87.3)*	561	43.0 (36.5–55.8)*	<0.001			
Number of patients transported by ambulance	69	68	76	213	6.0 (4.0–7.0)*	62	5.0 (4.0–7.0)*	0.563			
Number of referral patients	307	365	354	1,026	28.0 (24.0–32.0)*	197	14.5 (12.3–20.5)*	<0.001			
Males, n (%)	508 (55.9%)	585 (61.1%)	559 (59.1%)	1,652 (58.8%)*	12.5 (10.0–17.5)*	332 (59.2%)*	6.5 (6.0–8.0)*	0.857			
Age in years, median (IQR)	3.6 (1.3–6.7)	3.4 (1.2–6.8)	3.1 (1.3–6.3)	3.4 (1.3–6.6)*	29.5 (21.0–37.3)*	4.3 (1.7–8.7)*	13.0 (11.3–17.8)*	<0.001			
Infants (< 1 year old)	142	189	165	496	11.0 (8.3–15.0)*	82	5.5 (4.0–7.8)*	<0.001			
Toddlers (1–3 years old)	337	342	377	1,056	18.0 (13.5–23.0)*	185	6.5 (6.0–8.0)*	<0.001			
Preschoolers (4–5 years old)	149	144	131	424	4.0 (3.0–6.0)*	69	4.0 (3.0–4.8)*	<0.001			
Childhood (6–12 years old)	227	221	221	669	3.5 (2.0–6.0)*	180	15.5 (12.0–18.0)*	0.096			
Adolescent (13–14 years old)	54	61	51	166	4.0 (3.0–6.0)*	45	4.0 (3.0–4.8)*	0.198			
Hospital length of stay in days, median (IQR)	3.0 (3.0–5.0)	4.0 (3.0–6.0)	4.0 (3.0–6.0)	4.0 (3.0–6.0)*	30.5 (24.0–37.8)*	106	8.5 (6.0–9.8)*	<0.001			
Number of patients (infections)	340	399	401	1,140	6.0 (5.0–11.0)*	51	3.0 (2.0–5.5)*	0.004			
Respiratory infections	115	110	103	328	1.0 (0.0–2.0)*	20	1.5 (0.3–2.0)*	0.922			
Gastrointestinal infections	21	18	18	57	4.0 (1.0–6.8)*	10	0.0 (0.0–0.0)*	<0.001			
Other infections†	21	18	18	57	1.0 (0.0–3.0)*	1	0.0 (0.0–0.0)*	0.005			
Number of patients (causative agent)	56	60	67	183	0.0 (0.0–2.8)*	0	0.0 (0.0–0.0)*	0.009			
Respiratory syncytial virus	1	28	23	52	1.0 (0.0–3.0)*	4	0.0 (0.0–0.8)*	0.003			
Human metapneumovirus‡	16	16	26	58	0.0 (0.0–1.0)*	2	0.0 (0.0–0.0)*	0.126			
Influenza	30	13	18	61	0.0 (0.0–1.0)*	1	0.0 (0.0–0.0)*	0.110			
Adenovirus	6	8	7	21	0.0 (0.0–1.0)*	0	0.0 (0.0–0.0)*	0.025			
<i>Streptococcus pyogenes</i>	20	8	7	35	0.0 (0.0–1.0)*	4	0.0 (0.0–0.0)*	0.015			
Norovirus	7	10	42	59	0.0 (0.0–0.0)*	0	0.0 (0.0–0.0)*	0.006			
Rotavirus	0	0	0	0	2.0 (1.0–4.0)*	13	1.0 (1.0–1.0)*	0.006			
SARS-CoV-2	0	0	0	0	2.0 (1.0–4.0)*	25	1.0 (1.0–3.0)*	0.136			
Number of patients (disease)	21	57	32	110	2.0 (1.0–3.0)*	7	0.5 (0.0–1.0)*	0.001			
Asthma	42	27	41	110	0.0 (0.0–1.0)*	1	0.0 (0.0–0.0)*	0.163			
Febrile seizures	20	20	26	66	0.5 (0.0–1.0)*	9	1.0 (0.0–1.0)*	0.594			
Kawasaki disease	8	3	3	14	3.0 (1.0–4.0)*	27	2.0 (0.3–3.8)*	0.205			
Intussusception	5	10	9	24	0.0 (0.0–0.8)*	9	1.0 (0.0–1.0)*	0.010			
Appendicitis	40	30	28	98	0.0 (0.0–0.8)*	9	1.0 (0.0–1.0)*	0.010			
Trauma	6	0	4	10							
Foreign body ingestion											

†Urinary tract infections, skin and soft tissue infections, lymphadenitis, conjunctivitis, infectious arthritis, bacteremia, osteomyelitis, and deep abscess were included as other infections.

‡Testing was available from August 2017.

*Shows the numbers in the data compared by p-value between 2017–2019 and 2020.

month, $P = 0.126$; norovirus, median 0.0 vs 0.0 per month, $P = 0.110$). The number of patients diagnosed with Kawasaki disease and asthma also decreased significantly in 2020 (Kawasaki disease, median 0.5 vs 2.0 per month, $P = 0.001$; asthma, median 1.0 vs 2.0 per month, $P = 0.006$). The number of hospitalized patients with intussusception and febrile seizures decreased in 2020, but there was no significant difference compared with that in previous years (intussusception, median 0.0 vs 0.0 per month, $P = 0.163$; febrile seizures, median 1.0 vs 2.0 per month, $P = 0.136$). The number of hospitalized patients with appendicitis and trauma did not change significantly in 2020 (appendicitis, median 1.0 vs 0.5 per month, $P = 0.594$; trauma, median 2.0 vs 3.0 per month, $P = 0.205$). The number of patients admitted due to foreign body ingestion increased significantly in 2020 (median 1.0 vs 0.0 per month, $P = 0.010$).

Since March 2020, the number of hospitalized pediatric patients has decreased over time (Fig. 1a). Respiratory and gastrointestinal infections have decreased since February 2020 (Fig. 1b). Gastrointestinal infections had a temporal outbreak in 2017–2019, but this tendency was not observed in 2020 (Fig. 1b). Since February 2020, pathogens such as RS virus,

human metapneumovirus, influenza, adenovirus, *Streptococcus pyogenes*, norovirus, and rotavirus were rarely detected in hospitalized children. The number of tested cases also decreased significantly in 2020, except for norovirus (Table 2).

The number of hospitalized pediatric patients at each age is shown in Figure 2a. In 2020, the number of hospitalized patients in infants (<1 year old), toddlers (1–3 years old), and preschoolers (4–5 years old) was significantly decreased (infants, median 6.5 vs 12.5 per month, $P < 0.001$; toddlers, median 13.0 vs 29.5 per month, $P < 0.001$; preschoolers, median 5.5 vs 11.0 per month, $P < 0.001$). There was no significant difference in the number of hospitalized patients in the childhood (6–12 years old) and adolescent age groups (13–14 years old; childhood, median 15.5 vs 18.0 per month, $p = 0.096$; adolescent, median 4.0 vs 4.0 per month, $P = 0.198$). At each age, the number of hospitalized patients under 7 years was significantly decreased (0-year-old, median 6.5 vs 12.5 per month, $P < 0.001$; 1-year-old, median 6.5 vs 14.5 per month, $P < 0.001$; 2-year-old, median 4.0 vs 8.0 per month, $P = 0.005$; 3-year-old, median 4.0 vs 6.0 per month, $P = 0.009$; 4-year-old, median 2.0 vs 6.0 per month, $P < 0.001$; 5-year-old, median 3.0 vs 5.0 per month, $P = 0.021$; 6-year-old,

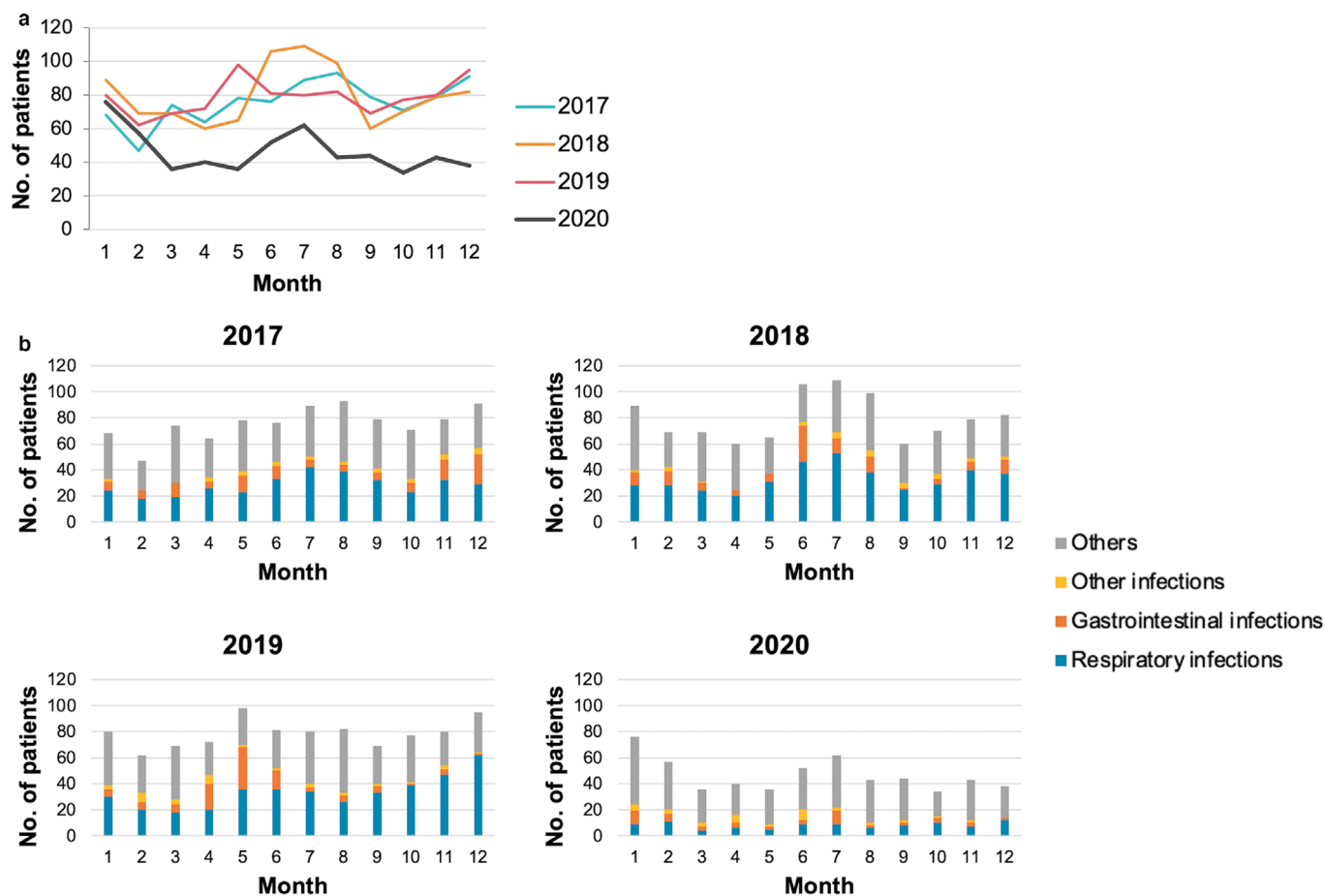


Fig. 1 (a) Changes in the number of pediatric hospitalized patients over time. (b) Changes in the number of pediatric hospitalized patients for each infectious disease and others in each year. (a): (—), 2017; (—), 2018; (—), 2019; (—), 2020. (b): (■), others; (■), other infections; (■), gastrointestinal infections; (■), respiratory infections.

Table 2 The number of tested cases

	2017	2018	2019	2017–2019		2020		P-value (*2017–2019 vs *2020)
				Total	Per month median (IQR)	Total	Per month median (IQR)	
Respiratory infections								
Respiratory syncytial virus (ALSONIC RSV)	71	178	160	409	9.5 (5.3–15.0)*	33	2.0 (1.3–4.0)*	<0.001
Human metapneumovirus (ImunoAce hMPV) [†]	22	192	168	382	12.0 (7.0–19.0)*	40	3.5 (2.0–4.8)*	<0.001
Influenza (ImunoAce Flu)	121	108	151	380	12.0 (4.3–16.0)*	63	5.0 (3.3–7.8)*	0.018
Nasopharyngeal adenovirus (ALSONIC Adeno)	196	214	239	649	16.0 (13.3–23.8)*	110	9.0 (7.5–11.8)*	<0.001
<i>Streptococcus pyogenes</i> (Pharyngeal culture)	284	394	447	1125	28.0 (24.0–38.0)*	168	12.0 (9.3–14.8)*	<0.001
SARS-CoV-2 (TRCReady SARS CoV-2)	0	0	0	0	0.0 (0.0–0.0)*	17	12.0 (9.3–14.9)*	<0.001
Gastrointestinal infections								
Norovirus (QuickNaviTM-Norovirus2)	32	36	58	126	2.0 (1.0–5.0)*	20	1.0 (0.0–2.0)*	0.095
Rotavirus (Quick Chaser Rota/ Adeno)	94	85	101	280	7.0 (4.3–9.0)*	61	4.0 (3.0–6.5)*	0.049
Fecal adenovirus (Quick Chaser Rota/Adeno)	100	95	119	314	7.0 (4.3–11.8)*	60	4.0 (3.0–6.5)*	0.030

[†]Testing was available from August 2017.

*Shows the numbers in the data compared by *p*-value between 2017–2019 and 2020.

median 2.0 vs 5.0 per month, $P = 0.032$; 7-year-old, median 2.5 vs 3.0 per month, $P = 0.039$). In particular, respiratory infections in patients under 7 years of age decreased (Fig. 2b).

Discussion

In this study, we aimed to assess the impact of COVID-19 on the number of pediatric hospitalizations in a single-center institution from Kitami, Japan. According to reports from the National Institute of Infectious Diseases, the number of reported cases of respiratory syncytial virus, human metapneumovirus, influenza, adenovirus, *Streptococcus pyogenes*, norovirus, and rotavirus dropped sharply after the COVID-19 pandemic in Japan.⁹ We observed that pediatric hospitalizations for infectious, gastrointestinal, and respiratory etiologies decreased significantly during the pandemic in Kitami. These changes were similar to those reported in other countries.^{4,6,10}

Several possible factors contribute to the reduction in pediatric hospitalizations in Kitami. First, sufficient COVID-19 transmission preventive practices such as refraining from going outside, maintaining safe social distancing, wearing masks, and thorough hand sanitation may have reduced exposure to other respiratory and gastrointestinal viruses. In our study, we observed that hospitalizations for respiratory infections in children aged 0–7 years have declined in Kitami during the COVID-19 pandemic. This decrease was observed despite nursery schools and kindergartens remaining open in Kitami. Several reports state that standard precautions are essential to prevent the spread of infections.^{11–13} Thorough infection control in nursery schools and kindergartens may have contributed to its decrease. Refraining from using these

facilities and the high hygienic preventive measures of guardians against infectious diseases may also have been a factor in preventing the spread of the infection. Standard precautions may have reduced parent-to-child transmission at home. Second, community-level quarantine measures, such as school closures, may have suppressed the spread of infectious diseases. However, in our study, hospitalization in children >8 years did not decrease after the COVID-19 pandemic. This is probably because children >8 years are less likely to be hospitalized from infection due to the usually milder presentation than those aged <7 years. Third, infections during this period may be underreported because non-severe cases are managed at home. Some patients who were eligible for hospitalization may have improved spontaneously at home after avoiding hospital consultations.

In Kitami City, the first COVID-19 patient was reported on February 22, 2020.¹⁴ A total of 17 SARS-CoV-2-positive cases, including adult cases, were reported in Kitami City in 2020.¹⁴ SARS-CoV-2-positive cases were reported in February ($n = 7$), March ($n = 6$), November ($n = 2$), and December ($n = 2$), but no positive cases were reported from April to October.¹⁴ The higher surge of COVID-19 infection during the early quarter of 2020 may have encouraged more stringent infection control measures within the community, which may have contributed to the decline in pediatric hospitalized patients from March (Fig. 2a).

Viral interference occurs when infection with one viral pathogen inhibits co-infection with another viral microorganism within the same host.^{15–17} Viral interference may also occur in COVID-19,¹⁷ which may have resulted in the decrease in the incidence of other infectious diseases. The

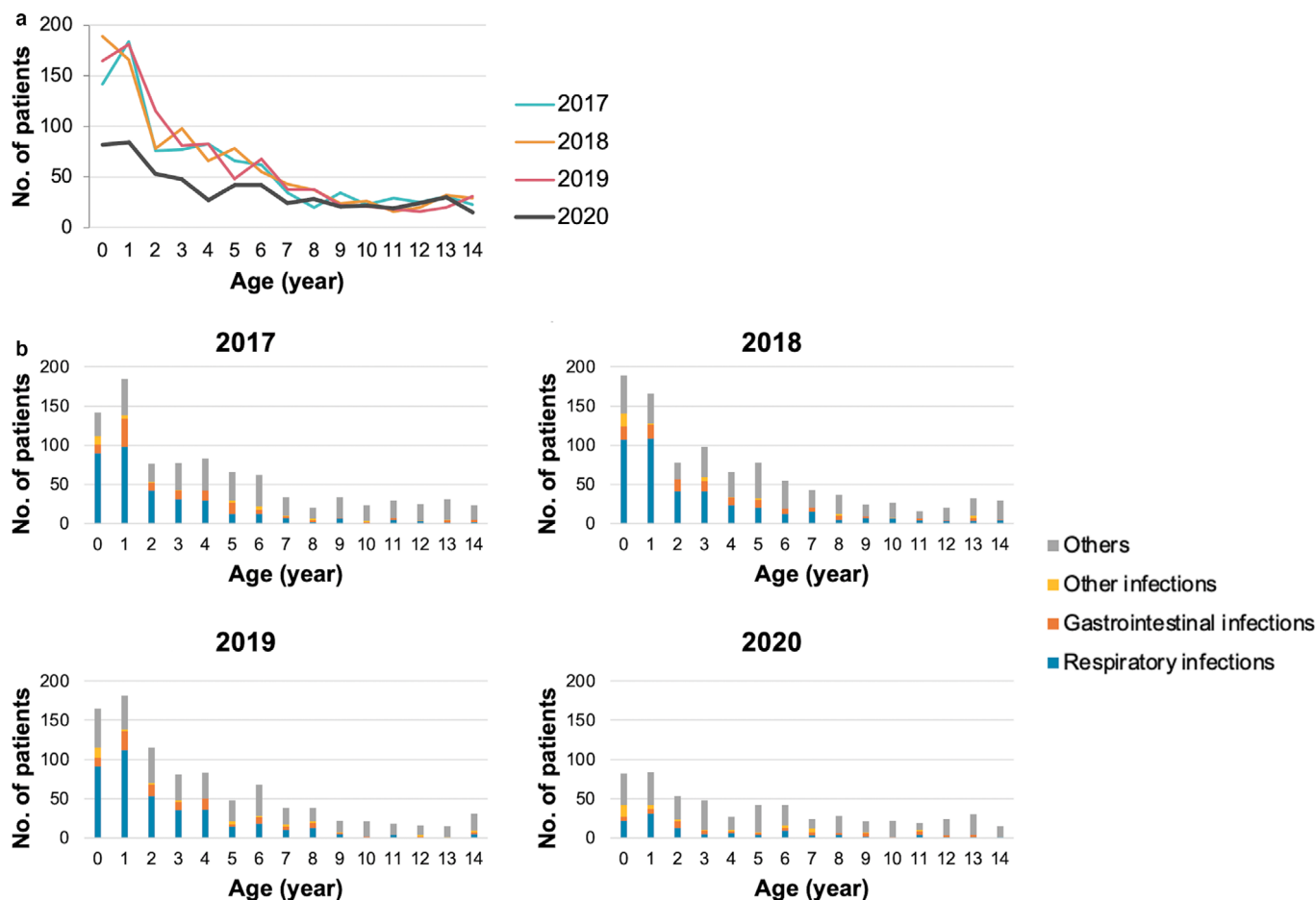


Fig. 2 (a) The number of pediatric hospitalized patients at each age. (b) The number of pediatric hospitalized patients for each infectious disease and others at each age in each year. (a): (—), 2017; (—), 2018; (—), 2019; (—), 2020. (b): (■), others; (■), other infections; (■), gastrointestinal infections; (■), respiratory infections.

COVID-19 outbreak was well-controlled in Kitami with a relatively small incidence. Therefore, viral interference by COVID-19 may not be the primary cause of decreased hospitalization in Kitami from other infectious diseases.

In our study, asthma and Kawasaki disease also decreased significantly in Kitami after the COVID-19 pandemic. The reduction in the number of asthma hospitalizations after the COVID-19 pandemic was consistent with a previous report in Japan.¹⁸ The reduction of exposure to respiratory infections and allergens from the increased hygiene practices may have reduced asthma attacks. It has been previously reported that epidemiological data strongly suggest an infectious etiology for Kawasaki disease.¹⁹ Although an infectious etiology for Kawasaki disease remains unclear, the concomitant decrease in respiratory and gastrointestinal infections may have likewise led to a decrease in Kawasaki disease cases.

Chong *et al.* reported that trauma-related complaints in the emergency department decreased during the lockdown in Singapore.⁴ However, trauma-related hospitalization in the pediatric population did not decrease in Kitami in 2020. Most trauma-related hospitalized patients had fractures that occurred

outside their homes. This may be because strict measures such as lockdowns were not enforced in Japan. On the other hand, accidental ingestion of foreign bodies has increased significantly in 2020. All foreign body ingestions from 2017 to 2020 occurred at home. Increased time spent at home may have contributed to this increase. Thus, it is important to inform the community about the risks of accidental foreign body ingestion while staying at home.

There are some limitations to this study. Our study was a retrospective single-center study, so our findings require corroboration from other facilities for generalization. The decision to perform antigen testing also depended on the physician's decision. Antigen testing was not performed on all infectious cases, thus there may be cases in which the pathogen has not been determined.

In conclusion, we demonstrated changes to the epidemiological patterns of pediatric hospitalizations in Kitami. The COVID-19 infection control measures that focused on proper hygiene practices and social distancing reduced the number of pediatric patients hospitalized for other diseases, especially in infants, toddlers, and preschoolers with respiratory infections.

These findings provide data for decision making in future epidemics. Continuous surveillance of infectious diseases and standard precautions are essential to prevent the spread of not only COVID-19 but also other infectious diseases. After the COVID-19 pandemic ends in the future, continuous appropriate infection control measures may contribute to a sustained reduction in the number of hospitalizations of pediatric patients.

Disclosure

The authors declare no conflict of interest.

Author contributions

Y.M. designed the study and drafted the manuscript. S.I., K.O., S.H., N.S., T.S., and M.M. critically reviewed the manuscript. T.S. critically reviewed the manuscript and gave conceptual advice. All authors read and approved the final manuscript.

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