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Paediatric Hospitalisations During the COVID-19 Outbreak in Japan

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ABSTRACT

Little is known about the trends in paediatric hospitalisations during the pandemic.

Using a large-scale inpatient database from acute-care hospitals in Japan, we analyzed the number of hospitalisations of children aged 1–17 years for weeks 9–21 of 2020 (during the outbreak) vs. 2017-2019 with adjustment for the yearly and weekly trends. Hospitalisation decreased in most major conditions, including communicable diseases and trauma; in contrast, there was no significant reduction in hospitalisations for appendicitis. Further studies are expected to investigate the positive and negative aspects of these reduced hospitalisations.

The COVID-19 pandemic has significantly affected children's environments worldwide. Studies have reported substantial decreases in paediatric emergency department visits and subsequent hospitalisations[1,2]. However, little is known about the overall trends in emergency and non-emergency hospitalisations during the pandemic. We investigated the nationwide changes in the number of paediatric hospitalisations for major medical and surgical conditions during the COVID-19 outbreak in Japan.

We used the Diagnosis Procedure Combination inpatient database, built by Medical Data Vision Co, Ltd (Tokyo, Japan)[3]. The database includes de-identified demographic/clinical information collected from Japanese acute-care hospitals for per-diem reimbursement. We aggregated the number of hospitalisations of children aged 1–17 years per week across 272 continuously observed hospitals during the calendar weeks 1–21 of 2020 (January 1, 2020, to May 26, 2020) and the same periods in 2017–2019. We included only patients admitted for ≤30 days (accounting for 99% of the paediatric hospitalisations in our dataset) because our dataset could not observe patients who were hospitalised for more than 30 days from week 21 of 2020.

We described weekly trends in (A) total paediatric hospitalisations and those with a primary diagnosis of one of nine selected conditions, based on the date of admission. We used the six most common medical conditions (determined based on *International Classification of Diseases 10* code by our internal investigation using the 2017–2020 dataset), including (B) food allergy, (C) acute lower respiratory infections (ALRI) except COVID-19, (D) Kawasaki disease (KD), (E) intestinal infectious diseases (IID), (F) febrile convulsions, (G) asthma, and three surgical conditions, including (H) appendicitis, (I) inguinal hernia and (J) trauma. We also examined hospitalisations with a primary diagnosis of COVID-19 among (K) children and (L) all ages to illustrate the status of the COVID-19 epidemic in Japan.

We employed a "difference-in-differences" model using Poisson regression to estimate the changes in the number of hospitalisations during the COVID-19 outbreak. It included a variable for each week, the year indicator (2017–2020), and an interaction variable between the outbreak status (week 9–21; the government requested nationwide cancellation of large-scale events and school closures in week 9 of 2020) and the indicator for the year 2020.

The average number of paediatric hospitalisations per week during weeks 9–21 decreased from 2,132 in 2017–2019 to 1,314 in 2020, a reduction of 38.4% (adjusted incidence rate ratios [aIRR], 0.60; 95% confidence interval [CI], 0.53–0.69; p<0.001) (**Figure 1** and **Table 1**). The average number of hospitalisations per week during weeks 9–21 decreased in 2020 compared with 2017–2019 for food allergy (aIRR, 0.61), for ALRI (aIRR, 0.39), for KD (aIRR, 0.77), for IID (aIRR, 0.22), for febrile convulsions (aIRR, 0.69), for asthma (aIRR, 0.37), for inguinal hernia (aIRR, 0.80), and for trauma (aIRR, 0.68). We found no evidence that the number of hospitalisations for appendicitis decreased.

There were significant decreases in paediatric hospitalisations across Japanese acute-care hospitals during the COVID-19 outbreak, especially concerning conditions related to communicable diseases and trauma, but not for appendicitis. These declines may partly suggest a reduced burden of paediatric disease, possibly due to non-pharmaceutical interventions. However, it is unclear to what extent the postponed/avoided hospital care explained these reduced hospitalisations, and further studies are expected to investigate the positive and negative aspects of the pandemic on children's health.

Limitations of this study include the patient population, which did not cover all the medical facilities in Japan. Nevertheless, our dataset covered as many as 272 acute-care hospitals, and the underlying patterns may be similar across the country. Second, the detailed mechanisms through which the paediatric hospitalisations decreased remain unknown.

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3 Abe K, Miyawaki A, Nakamura M, *et al.* Trends in hospitalizations for asthma during the COVID-19 outbreak in Japan. *J Allergy Clin Immunol Pract* Published Online First: 14 October 2020. doi:10.1016/j.jaip.2020.09.060

Author contributions: KS and AM had full access to the data in the study and takes responsibility for the accuracy and integrity of the data and its analyses.

Study concept and design: all authors.

Acquisition, analysis or interpretation of data: All authors.

Drafting of the manuscript: KS and AM.

Critical revision of the manuscript for important intellectual content: All authors.

Statistical analyses: KS and AM.

Administrative, technical or material support: all authors.

Study supervision: AM.

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Competing interests: MN is one of the board of directors in Medical Data Vision and received a personal salary from it outside of this study. HN supported Medical Data Vision in algorithm construction and received personal fee outside this study.

Ethics approval: Ethics Board of the University of Tokyo approved this study (approval no: 2020105NI).

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Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Data availability statement: Data are available on reasonable request. Due to the contractual restrictions between the authors and the Medical Data Vision, the data are available on request.

Figure 1. Trends in the number of hospitalisations of children across 272 acute-care hospitals in Japan, overall and by condition during weeks 1–21 in 2017–2020.

Abbreviations: ALRI, acute lower respiratory infections; KD, Kawasaki disease; IID, intestinal infectious diseases. We illustrated weekly paediatric hospitalisations, overall, and for each common condition across the 272 acute-care hospitals in Japan (A-J). We also showed trends in hospitalisations for COVID-19 among children (K) and all ages (L), using *International Classification of Diseases 10* code U071 and B342. B342 was used for reimbursement for COVID-19 hospitalisations before April 2020.

Table 1. Change in the number of paediatric hospitalisations during the COVID-19 outbreak in Japan

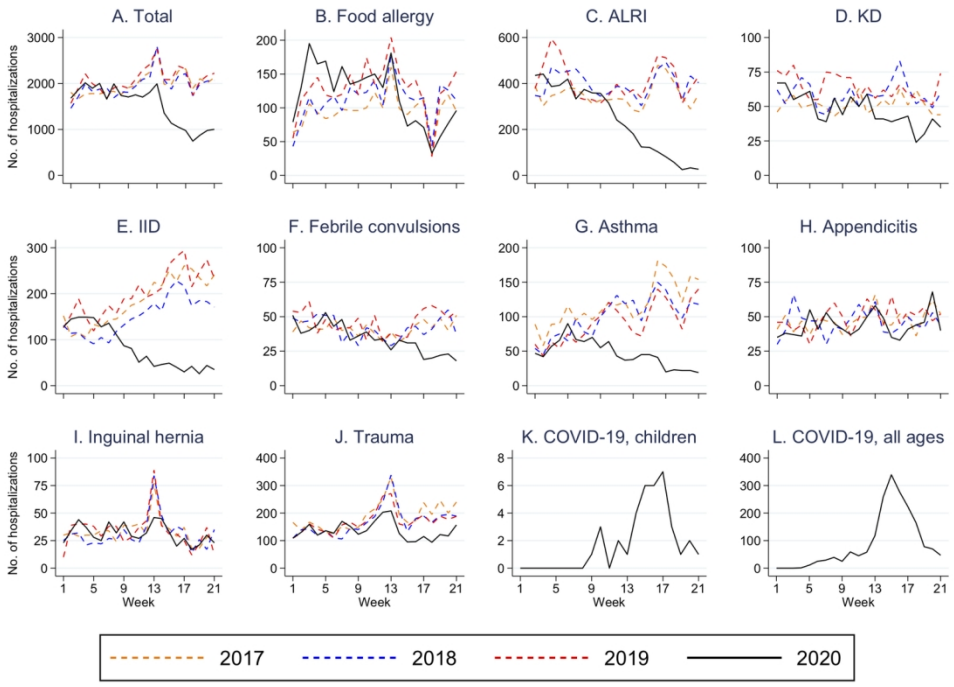
Condition‡	No. of hospitalisations per week*		Difference between 2017-2019 vs. 2020		Adjusted incidence rate ratio†		
	Weeks 9-21 of 2017-2019	Weeks 9-21 of 2020	Count	% change	Estimate	95% CI	P value
Total	2132	1314	-818	-38.4	0.60	0.53, 0.69	<0.001
Food allergy	119	103	-16	-13.1	0.61	0.52, 0.70	<0.001
ALRI	379	145	-235	-61.9	0.39	0.26, 0.58	<0.001
KD	58	42	-16	-27.4	0.77	0.67, 0.89	<0.001
IID	209	49	-160	-76.5	0.22	0.17, 0.29	<0.001
Febrile convulsions	42	28	-14	-33.2	0.69	0.57, 0.84	<0.001
Asthma	120	36	-84	-69.7	0.37	0.29, 0.47	<0.001
Appendicitis	49	45	-4	-8.9	0.96	0.82, 1.12	0.59
Inguinal hernia	34	30	-4	-12.2	0.80	0.67, 0.95	0.01
Trauma	199	136	-63	-31.9	0.68	0.61, 0.75	<0.001

CI: confidence interval.

* The numbers of hospitalisations were shown as a weekly average over the corresponding weeks.

†A Poisson regression was applied to estimate adjusted incidence rate ratio with the weekly and the yearly trends adjusted. Huber-White standard errors were used for inference. P<0.05 was interpreted as statistically significant (Stata 16.1).

‡ *International Classification of Diseases 10* codes for the conditions were: T780 and T781 (food allergy); A37, B012, B052, B59, B371, J9–J18 and J20–J22 (ALRI, acute lower respiratory infections); M303 (KD, Kawasaki disease); A00-A09 (IID, intestinal infectious diseases); R560 (febrile convulsions); J45 and J46 (asthma); K35-K37 (appendicitis); K40 (inguinal hernia); S00-S99 and T00-T14 (trauma).



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Key words: COVID-19; Health services research; Epidemiology

ABSTRACT

We evaluated the nationwide overall trends in paediatric hospitalisations including non-emergency hospitalisations during the COVID-19 pandemic. Using inpatient data from 272 acute-care hospitals covering 12.4% of all admissions in Japan, we analyzed the number of hospitalisations of children aged 1–17 years for weeks 9–21 of 2020 (during the outbreak) vs. 2017-2019. Hospitalisation decreased during the COVID-19 outbreak by 38.4% (adjusted incidence rate ratio, 0.60; 95% confidence interval, 0.53-0.69). There were reductions in communicable diseases and trauma, possibly through non-pharmaceutical interventions, but not in appendicitis. This study highlights the importance of reallocating paediatric care resources under the pandemic.

The COVID-19 pandemic has significantly affected children's social environments and access to healthcare services worldwide. Studies have reported substantial decreases in paediatric emergency department visits and subsequent hospitalisations[1-3]. However, little is known about the nationwide overall trends including non-emergency hospitalisations during the pandemic. We investigated the nationwide changes in the number of paediatric hospitalisations for major conditions during the COVID-19 outbreak in Japan.

We used a de-identified inpatient claims database, collected under Diagnosis Procedure Combination/Per-Diem Payment System, built by Medical Data Vision Co, Ltd (Tokyo, Japan)[4]. Briefly, this payment system is part of public health insurance reimbursement system in Japan[5], and therefore, the database consists of demographic/clinical information of all the hospitalisations for each hospital. The database included 272 Japanese acute-care hospitals that consented to data utilisation (covering 12.4% of all admissions into acute-care hospitals in Japan in January 2019). We aggregated the weekly number of hospitalisations of children aged 1–17 years during the calendar weeks 1–21 of 2020 (January 1 to May 26) and the same periods in 2017–2019. We included only patients admitted for ≤30 days (accounting for 99% of the paediatric

hospitalisations in our dataset) because our dataset could not observe patients who were hospitalised for more than 30 days from week 21 of 2020.

We described weekly trends in total paediatric hospitalisations and those with a primary diagnosis of one of nine selected conditions, based on the date of admission. We used nine common conditions (determined based on *International Classification of Diseases 10* code), including food allergy, acute lower respiratory infections (ALRI) except COVID-19, Kawasaki disease (KD), intestinal infectious diseases (IID), febrile convulsions, asthma, appendicitis, inguinal hernia and trauma. We also examined hospitalisations with a primary diagnosis of COVID-19 to illustrate the epidemic in Japan.

We employed a "difference-in-differences" model using Poisson regression to estimate the changes in the number of hospitalisations during the COVID-19 outbreak. It included a variable for each week, the year indicator (2017–2020), and an interaction variable between the outbreak status (week 9–21; the government requested nationwide cancellation of large-scale events and school closures in week 9 of 2020) and the year indicator for 2020.

The weekly mean number of paediatric hospitalisations during weeks 9–21 decreased from 2,132 in 2017–2019 to 1,314 in 2020, a reduction of 38.4% (adjusted incidence rate ratios, 0.60; 95% confidence interval, 0.53–0.69) (**Figure 1** and **Table 1**). The weekly mean number of hospitalisations during weeks 9–21 decreased in 2020 compared with 2017–2019 for food allergy (0.61; 0.52-0.70), for ALRI (0.39; 0.26-0.58), for KD (0.77; 0.67-0.89), for IID (0.22; 0.17-0.29), for febrile convulsions (0.69; 0.57-0.84), for asthma (0.37; 0.29-0.47), for inguinal hernia (0.80; 0.67-0.95), and for trauma (0.68, 0.61-0.75). We found no evidence that the number of hospitalisations for appendicitis decreased (0.96; 0.82-1.12).

There were considerable decreases in paediatric hospitalisations across Japanese acute-care hospitals during the COVID-19 outbreak, especially concerning conditions related to communicable diseases and trauma, but not for appendicitis. Our findings may encourage policymakers to reallocate paediatric care resources under the pandemic. There are several possible explanations for these reductions. First, non-pharmaceutical interventions (physical distancing and individual hygiene measures) probably reduced infections. School closures and stay-at-home requests presumably decreased accidents.

Second, deferred/cancelled treatments or examinations may explain the modest decrease in inguinal hernia hospitalisations, especially in week 13 (corresponding to the spring break) of 2020 compared with previous years.

Limitations of this study include the patient population, which did not cover all the Japanese hospitals although our dataset covered 272 acute-care hospitals. Second, the detailed mechanisms through which the paediatric hospitalisations decreased remain unknown.

References

1 Lazzerini M, Barbi E, Apicella A, *et al.* Delayed access or provision of care in Italy resulting from fear of COVID-19. *Lancet Child Adolesc Heal* 2020;**4**:e10–1. doi:10.1016/S2352-4642(20)30108-5

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Author contributions: KS and AM had full access to the data in the study and takes responsibility for the accuracy and integrity of the data and its analyses.

Study concept and design: all authors.

Acquisition, analysis or interpretation of data: All authors.

Drafting of the manuscript: KS and AM.

Critical revision of the manuscript for important intellectual content: All authors.

Statistical analyses: KS and AM.

Administrative, technical or material support: all authors.

Study supervision: AM.

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Abbreviations: ALRI, acute lower respiratory infections; KD, Kawasaki disease; IID, intestinal infectious diseases. We illustrated weekly paediatric hospitalisations, overall, and for each common condition across the 272 acute-care hospitals in Japan (A-J). We also showed trends in hospitalisations for COVID-19 among children (K) and all ages (L), using *International Classification of Diseases 10* code U071 and B342. B342 was used for reimbursement for COVID-19 hospitalisations before April 2020.

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Condition‡	No. of hospitalisations per week*		Difference between 2017-2019 vs. 2020		Adjusted incidence rate ratio†		
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Acute lower respiratory infections	379	145	-235	-61.9	0.39	0.26, 0.58	<0.001
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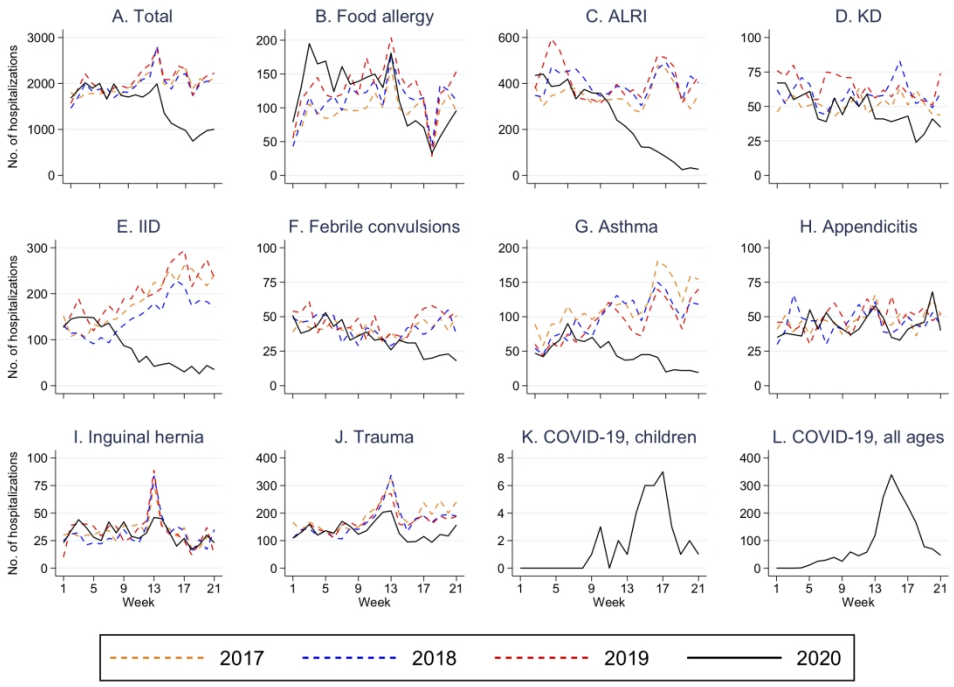

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ABSTRACT

We evaluated the nationwide trends in paediatric hospitalisations including non-emergency hospitalisations during the COVID-19 pandemic in Japan. Using inpatient data from 272 acute-care hospitals covering 12.4% of total hospitalisations of all ages, we analyzed the number of hospitalisations of children (ages 1–17) for weeks 9–21 of 2020 (during the outbreak) vs. 2017-2019. Hospitalisation decreased during the outbreak by 38.4% (adjusted incidence rate ratio, 0.60; 95% confidence interval, 0.53-0.69). There were reductions in communicable diseases and trauma, possibly through non-pharmaceutical interventions, but not in appendicitis. This study highlights the potential importance of reallocating paediatric care resources during the pandemic.

The COVID-19 pandemic has significantly affected children's social environments and access to healthcare services worldwide. Studies have reported substantial decreases in paediatric emergency department visits and subsequent hospitalisations[1-3]. However, little is known about the nationwide overall trends including non-emergency hospitalisations during the pandemic. We investigated the nationwide changes in the number of paediatric hospitalisations for major conditions during the COVID-19 outbreak in Japan.

We used a de-identified inpatient claims database, collected under Diagnosis Procedure Combination/Per-Diem Payment System, built by Medical Data Vision Co, Ltd (Tokyo, Japan)[4]. Briefly, this payment system is part of public health insurance reimbursement system in Japan[5], and therefore, the database consists of demographic/clinical information of all the hospitalisations for each hospital. The database included 272 Japanese acute-care hospitals that consented to data utilisation (covering 12.4% of all admissions into acute-care hospitals in Japan in January 2019). We aggregated the weekly number of hospitalisations of children aged 1–17 years during the calendar weeks 1–21 of 2020 (January 1 to May 26) and the same periods in 2017–2019. We included only patients admitted for ≤30 days (accounting for 99% of the paediatric

hospitalisations in our dataset) because our dataset could not observe patients who were hospitalised for more than 30 days from week 21 of 2020.

We described weekly trends in total paediatric hospitalisations and those with a primary diagnosis of one of nine selected conditions, based on the date of admission. We used nine common conditions (determined based on *International Classification of Diseases 10* code), including food allergy, acute lower respiratory infections (ALRI) except COVID-19, Kawasaki disease (KD), intestinal infectious diseases (IID), febrile convulsions, asthma, appendicitis, inguinal hernia and trauma. We also examined hospitalisations with a primary diagnosis of COVID-19 to illustrate the epidemic in Japan.

We employed a "difference-in-differences" model using Poisson regression to estimate the changes in the number of hospitalisations during the COVID-19 outbreak. It included a variable for each week, the year indicator (2017–2020), and an interaction variable between the outbreak status (week 9–21; the government requested nationwide cancellation of large-scale events and school closures in week 9 of 2020) and the year indicator for 2020.

The weekly mean number of paediatric hospitalisations during weeks 9–21 decreased from 2,132 in 2017–2019 to 1,314 in 2020, a reduction of 38.4% (adjusted incidence rate ratios, 0.60; 95% confidence interval, 0.53–0.69) (**Figure 1** and **Table 1**). The weekly mean number of hospitalisations during weeks 9–21 decreased in 2020 compared with 2017–2019 for food allergy (0.61; 0.52-0.70), for ALRI (0.39; 0.26-0.58), for KD (0.77; 0.67-0.89), for IID (0.22; 0.17-0.29), for febrile convulsions (0.69; 0.57-0.84), for asthma (0.37; 0.29-0.47), for inguinal hernia (0.80; 0.67-0.95), and for trauma (0.68, 0.61-0.75). We found no evidence that the number of hospitalisations for appendicitis decreased (0.96; 0.82-1.12).

There were considerable decreases in paediatric hospitalisations across Japanese acute-care hospitals during the COVID-19 outbreak, especially concerning conditions related to communicable diseases and trauma, but not for appendicitis. Our findings may encourage policymakers to reallocate paediatric care resources during the pandemic. There are several possible explanations for these reductions. First, non-pharmaceutical interventions (physical distancing and individual hygiene measures) probably reduced infections. School closures and stay-at-home requests presumably decreased accidents.

Second, deferred/cancelled treatments or examinations may explain the modest decrease in inguinal hernia hospitalisations, especially in week 13 (corresponding to the spring break) of 2020 compared with previous years.

Limitations of this study include the patient population, which did not cover all the Japanese hospitals although our dataset covered 272 acute-care hospitals. Second, the detailed mechanisms through which the paediatric hospitalisations decreased remain unknown.

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Author contributions: KS and AM had full access to the data in the study and takes responsibility for the accuracy and integrity of the data and its analyses.

Study concept and design: all authors.

Acquisition, analysis or interpretation of data: All authors.

Drafting of the manuscript: KS and AM.

Critical revision of the manuscript for important intellectual content: All authors.

Statistical analyses: KS and AM.

Administrative, technical or material support: all authors.

Study supervision: AM.

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Competing interests: MN is one of the board of directors in Medical Data Vision and received a personal salary from it outside of this study. HN supported Medical Data Vision in algorithm construction and received personal fee outside this study.

Ethics approval: Ethics Board of the University of Tokyo approved this study (approval no: 2020105NI).

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Data availability statement: Data are available on reasonable request. Due to the contractual restrictions between the authors and the Medical Data Vision, the data are available on request.

Figure 1. Trends in the number of hospitalisations of children across 272 acute-care hospitals in Japan, overall and by condition during weeks 1–21 in 2017–2020.

Abbreviations: ALRI, acute lower respiratory infections; KD, Kawasaki disease; IID, intestinal infectious diseases. We illustrated weekly paediatric hospitalisations, overall, and for each common condition across the 272 acute-care hospitals in Japan (A-J). We also showed trends in hospitalisations for COVID-19 among children (K) and all ages (L), using *International Classification of Diseases 10* code U071 and B342. B342 was used for reimbursement for COVID-19 hospitalisations before April 2020.

Table 1. Change in the number of paediatric hospitalisations during the COVID-19 outbreak in Japan

Condition‡	No. of hospitalisations per week*		Difference between 2017-2019 vs. 2020		Adjusted incidence rate ratio†		
	Weeks 9-21 of 2017-2019	Weeks 9-21 of 2020	Count	% change	Estimate	95% CI	P value
Acute lower respiratory infections	379	145	-235	-61.9	0.39	0.26, 0.58	<0.001
Intestinal infectious disease	209	49	-160	-76.5	0.22	0.17, 0.29	<0.001
Trauma	199	136	-63	-31.9	0.68	0.61, 0.75	<0.001
Asthma	120	36	-84	-69.7	0.37	0.29, 0.47	<0.001
Food allergy	119	103	-16	-13.1	0.61	0.52, 0.70	<0.001
Kawasaki disease	58	42	-16	-27.4	0.77	0.67, 0.89	<0.001
Appendicitis	49	45	-4	-8.9	0.96	0.82, 1.12	0.59
Febrile convulsions	42	28	-14	-33.2	0.69	0.57, 0.84	<0.001

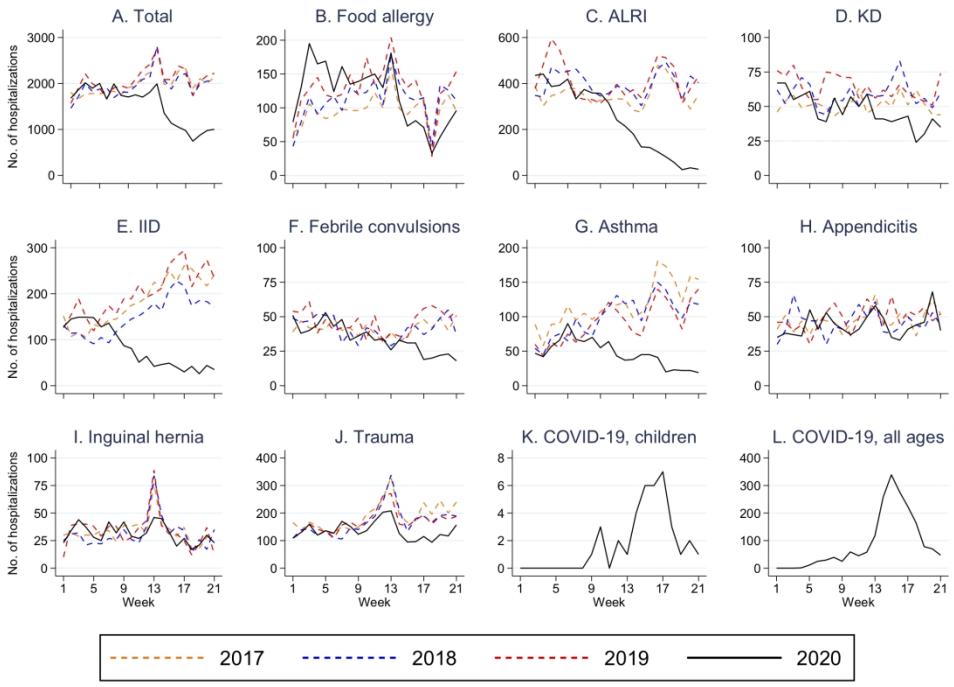
Inguinal hernia	34	30	-4	-12.2	0.80	0.67, 0.95	0.01
Total	2132	1314	-818	-38.4	0.60	0.53, 0.69	<0.001

CI: confidence interval.

* The numbers of hospitalisations were shown as a weekly mean over the corresponding weeks.

†A Poisson regression was applied to estimate adjusted incidence rate ratio with the weekly and the yearly trends adjusted. Huber-White standard errors were used for inference. P<0.05 was interpreted as statistically significant (Stata 16.1).

‡ *International Classification of Diseases 10* codes for the conditions were: A37, B012, B052, B59, B371, J9–J18 and J20–J22 (acute lower respiratory infections); A00-A09 (intestinal infectious diseases); S00-S99 and T00-T14 (trauma); J45 and J46 (asthma); T780 and T781 (food allergy); M303 (Kawasaki disease); K35-K37 (appendicitis); R560 (febrile convulsions); K40 (inguinal hernia).



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