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Paediatric Hospitalisations During the COVID-19 Outbreak in Japan

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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.

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6 The COVID-19 pandemic has significantly affected children's environments
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9 worldwide. Studies have reported substantial decreases in paediatric emergency
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11 department visits and subsequent hospitalisations[1,2]. However, little is known about
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13 the overall trends in emergency and non-emergency hospitalisations during the
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15 pandemic. We investigated the nationwide changes in the number of paediatric
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17 hospitalisations for major medical and surgical conditions during the COVID-19
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19 outbreak in Japan.
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30 We used the Diagnosis Procedure Combination inpatient database, built by Medical
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32 Data Vision Co, Ltd (Tokyo, Japan)[3]. The database includes de-identified
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34 demographic/clinical information collected from Japanese acute-care hospitals for
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36 per-diem reimbursement. We aggregated the number of hospitalisations of children
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38 aged 1–17 years per week across 272 continuously observed hospitals during the
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40 calendar weeks 1–21 of 2020 (January 1, 2020, to May 26, 2020) and the same periods
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42 in 2017–2019. We included only patients admitted for ≤ 30 days (accounting for 99% of
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44 the paediatric hospitalisations in our dataset) because our dataset could not observe
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46 patients who were hospitalised for more than 30 days from week 21 of 2020.
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6 We described weekly trends in (A) total paediatric hospitalisations and those with a
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9 primary diagnosis of one of nine selected conditions, based on the date of admission.
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12 We used the six most common medical conditions (determined based on *International*
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15 *Classification of Diseases 10* code by our internal investigation using the 2017–2020
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18 dataset), including (B) food allergy, (C) acute lower respiratory infections (ALRI)
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21 except COVID-19, (D) Kawasaki disease (KD), (E) intestinal infectious diseases (IID),
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24 (F) febrile convulsions, (G) asthma, and three surgical conditions, including (H)
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27 appendicitis, (I) inguinal hernia and (J) trauma. We also examined hospitalisations with
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30 a primary diagnosis of COVID-19 among (K) children and (L) all ages to illustrate the
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33 status of the COVID-19 epidemic in Japan.
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39 We employed a “difference-in-differences” model using Poisson regression to estimate
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42 the changes in the number of hospitalisations during the COVID-19 outbreak. It
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45 included a variable for each week, the year indicator (2017–2020), and an interaction
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48 variable between the outbreak status (week 9–21; the government requested nationwide
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51 cancellation of large-scale events and school closures in week 9 of 2020) and the
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54 indicator for the year 2020.
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6 The average number of paediatric hospitalisations per week during weeks 9–21
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9 decreased from 2,132 in 2017–2019 to 1,314 in 2020, a reduction of 38.4% (adjusted
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11
12 incidence rate ratios [aIRR], 0.60; 95% confidence interval [CI], 0.53–0.69; $p < 0.001$)
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15 (**Figure 1** and **Table 1**). The average number of hospitalisations per week during weeks
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18 9–21 decreased in 2020 compared with 2017–2019 for food allergy (aIRR, 0.61), for
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21 ALRI (aIRR, 0.39), for KD (aIRR, 0.77), for IID (aIRR, 0.22), for febrile convulsions
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24 (aIRR, 0.69), for asthma (aIRR, 0.37), for inguinal hernia (aIRR, 0.80), and for trauma
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27 (aIRR, 0.68). We found no evidence that the number of hospitalisations for appendicitis
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30 decreased.
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36 There were significant decreases in paediatric hospitalisations across Japanese
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39 acute-care hospitals during the COVID-19 outbreak, especially concerning conditions
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42 related to communicable diseases and trauma, but not for appendicitis. These declines
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45 may partly suggest a reduced burden of paediatric disease, possibly due to
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48 non-pharmaceutical interventions. However, it is unclear to what extent the
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51 postponed/avoided hospital care explained these reduced hospitalisations, and further
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54 studies are expected to investigate the positive and negative aspects of the pandemic on
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57 children's health.
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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.

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
- 2 Pines JM, Zocchi MS, Black BS, *et al*. Characterizing pediatric emergency department visits during the COVID-19 pandemic. *Am J Emerg Med* Published Online First: 23 November 2020. doi:10.1016/j.ajem.2020.11.037
- 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

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6 **Author contributions:** KS and AM had full access to the data in the study and takes
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9 responsibility for the accuracy and integrity of the data and its analyses.
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12 Study concept and design: all authors.
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15 Acquisition, analysis or interpretation of data: All authors.
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18 Drafting of the manuscript: KS and AM.
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21 Critical revision of the manuscript for important intellectual content: All authors.
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24 Statistical analyses: KS and AM.
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27 Administrative, technical or material support: all authors.
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30 Study supervision: AM.
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40 the form of labor service. AM was supported by the Social Science Research Council
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45 Abe Fellowship.
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51 **Competing interests:** MN is one of the board of directors in Medical Data Vision and
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54 received a personal salary from it outside of this study. HN supported Medical Data
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57 Vision in algorithm construction and received personal fee outside this study.
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9 **Ethics approval:** Ethics Board of the University of Tokyo approved this study

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12 (approval no: 2020105NI).
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18 **Patient and public involvement**

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21 Patients and/or the public were not involved in the design, or conduct, or reporting, or
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24 dissemination plans of this research.
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30 **Data availability statement:** Data are available on reasonable request. Due to the
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33 contractual restrictions between the authors and the Medical Data Vision, the data are
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36 available on request.
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7 **Figure 1. Trends in the number of hospitalisations of children across 272**
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9 **acute-care hospitals in Japan, overall and by condition during weeks 1–21 in 2017–**
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11 **2020.**

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18 Abbreviations: ALRI, acute lower respiratory infections; KD, Kawasaki disease; IID,
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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

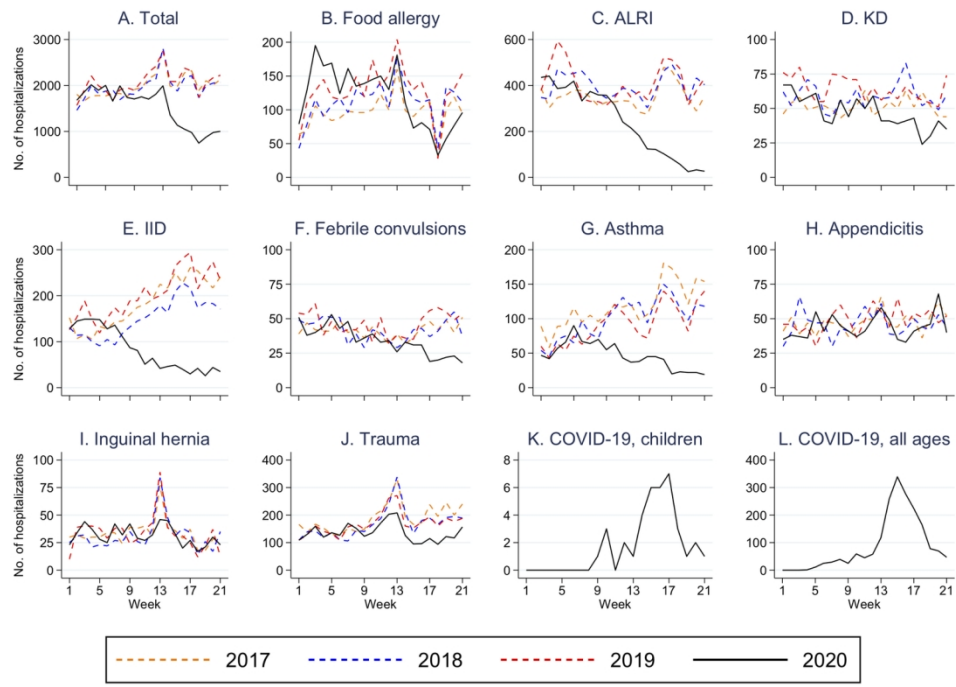
Condition‡	No. of hospitalisations per week*		Difference between 2017-2019 vs. 2020		Adjusted incidence rate ratio†		
	Weeks 9-21 of 2017-2019	Weeks 9-21 of 2020	Count	% change	Estimate	95% CI	P value
Total	2132	1314	-818	-38.4	0.60	0.53, 0.69	<0.001
Food allergy	119	103	-16	-13.1	0.61	0.52, 0.70	<0.001
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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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.

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6 The COVID-19 pandemic has significantly affected children's social environments and
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9 access to healthcare services worldwide. Studies have reported substantial decreases in
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12 paediatric emergency department visits and subsequent hospitalisations[1-3]. However,
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15 little is known about the nationwide overall trends including non-emergency
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18 hospitalisations during the pandemic. We investigated the nationwide changes in the
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21 number of paediatric hospitalisations for major conditions during the COVID-19
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24 outbreak in Japan.
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30 We used a de-identified inpatient claims database, collected under Diagnosis Procedure
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33 Combination/Per-Diem Payment System, built by Medical Data Vision Co, Ltd (Tokyo,
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36 Japan)[4]. Briefly, this payment system is part of public health insurance reimbursement
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39 system in Japan[5], and therefore, the database consists of demographic/clinical
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42 information of all the hospitalisations for each hospital. The database included 272
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45 Japanese acute-care hospitals that consented to data utilisation (covering 12.4% of all
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48 admissions into acute-care hospitals in Japan in January 2019). We aggregated the
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51 weekly number of hospitalisations of children aged 1–17 years during the calendar
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54 weeks 1–21 of 2020 (January 1 to May 26) and the same periods in 2017–2019. We
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57 included only patients admitted for ≤ 30 days (accounting for 99% of the paediatric
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6 hospitalisations in our dataset) because our dataset could not observe patients who were
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9 hospitalised for more than 30 days from week 21 of 2020.
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15 We described weekly trends in total paediatric hospitalisations and those with a primary
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18 diagnosis of one of nine selected conditions, based on the date of admission. We used
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21 nine common conditions (determined based on *International Classification of Diseases*
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24 *10* code), including food allergy, acute lower respiratory infections (ALRI) except
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27 COVID-19, Kawasaki disease (KD), intestinal infectious diseases (IID), febrile
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30 convulsions, asthma, appendicitis, inguinal hernia and trauma. We also examined
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33 hospitalisations with a primary diagnosis of COVID-19 to illustrate the epidemic in
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42 We employed a “difference-in-differences” model using Poisson regression to estimate
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45 the changes in the number of hospitalisations during the COVID-19 outbreak. It
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48 included a variable for each week, the year indicator (2017–2020), and an interaction
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51 variable between the outbreak status (week 9–21; the government requested nationwide
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54 cancellation of large-scale events and school closures in week 9 of 2020) and the year
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9 The weekly mean number of paediatric hospitalisations during weeks 9–21 decreased
10 from 2,132 in 2017–2019 to 1,314 in 2020, a reduction of 38.4% (adjusted incidence
11 rate ratios, 0.60; 95% confidence interval, 0.53–0.69) (**Figure 1** and **Table 1**). The
12 weekly mean number of hospitalisations during weeks 9–21 decreased in 2020
13 compared with 2017–2019 for food allergy (0.61; 0.52-0.70), for ALRI (0.39;
14 0.26-0.58), for KD (0.77; 0.67-0.89), for IID (0.22; 0.17-0.29), for febrile convulsions
15 (0.69; 0.57-0.84), for asthma (0.37; 0.29-0.47), for inguinal hernia (0.80; 0.67-0.95),
16 and for trauma (0.68, 0.61-0.75). We found no evidence that the number of
17 hospitalisations for appendicitis decreased (0.96; 0.82-1.12).
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40 There were considerable decreases in paediatric hospitalisations across Japanese
41 acute-care hospitals during the COVID-19 outbreak, especially concerning conditions
42 related to communicable diseases and trauma, but not for appendicitis. Our findings
43 may encourage policymakers to reallocate paediatric care resources under the pandemic.
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51 There are several possible explanations for these reductions. First, non-pharmaceutical
52 interventions (physical distancing and individual hygiene measures) probably reduced
53 infections. School closures and stay-at-home requests presumably decreased accidents.
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7 Second, deferred/cancelled treatments or examinations may explain the modest decrease
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9 in inguinal hernia hospitalisations, especially in week 13 (corresponding to the spring
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11 break) of 2020 compared with previous years.
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18 Limitations of this study include the patient population, which did not cover all the
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20 Japanese hospitals although our dataset covered 272 acute-care hospitals. Second, the
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22 detailed mechanisms through which the paediatric hospitalisations decreased remain
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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
- 2 Pines JM, Zocchi MS, Black BS, *et al.* Characterizing pediatric emergency department visits during the COVID-19 pandemic. *Am J Emerg Med* Published Online First: 23 November 2020. doi:10.1016/j.ajem.2020.11.037
- 3 Williams TC, MacRae C, Swann O V, *et al.* Indirect effects of the COVID-19 pandemic on paediatric healthcare use and severe disease: a retrospective national cohort study. *Arch Dis Child* Published Online First: 15 January 2021. doi:10.1136/archdischild-2020-321008
- 4 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
- 5 Hayashida K, Murakami G, Matsuda S, *et al.* History and Profile of Diagnosis Procedure Combination (DPC): Development of a Real Data Collection System for Acute Inpatient Care in Japan. *J Epidemiol* 2021;**31**:1–11. doi:10.2188/jea.je20200288

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6 **Author contributions:** KS and AM had full access to the data in the study and takes
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9 responsibility for the accuracy and integrity of the data and its analyses.
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12 Study concept and design: all authors.
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15 Acquisition, analysis or interpretation of data: All authors.
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18 Drafting of the manuscript: KS and AM.
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21 Critical revision of the manuscript for important intellectual content: All authors.
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24 Statistical analyses: KS and AM.
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27 Administrative, technical or material support: all authors.
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30 Study supervision: AM.
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40 the form of labor service. AM was supported by the Social Science Research Council
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7 **Figure 1. Trends in the number of hospitalisations of children across 272**
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9 **acute-care hospitals in Japan, overall and by condition during weeks 1–21 in 2017–**
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11 **2020.**

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18 Abbreviations: ALRI, acute lower respiratory infections; KD, Kawasaki disease; IID,
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Table 1. Change in the number of paediatric hospitalisations during the COVID-19 outbreak in Japan

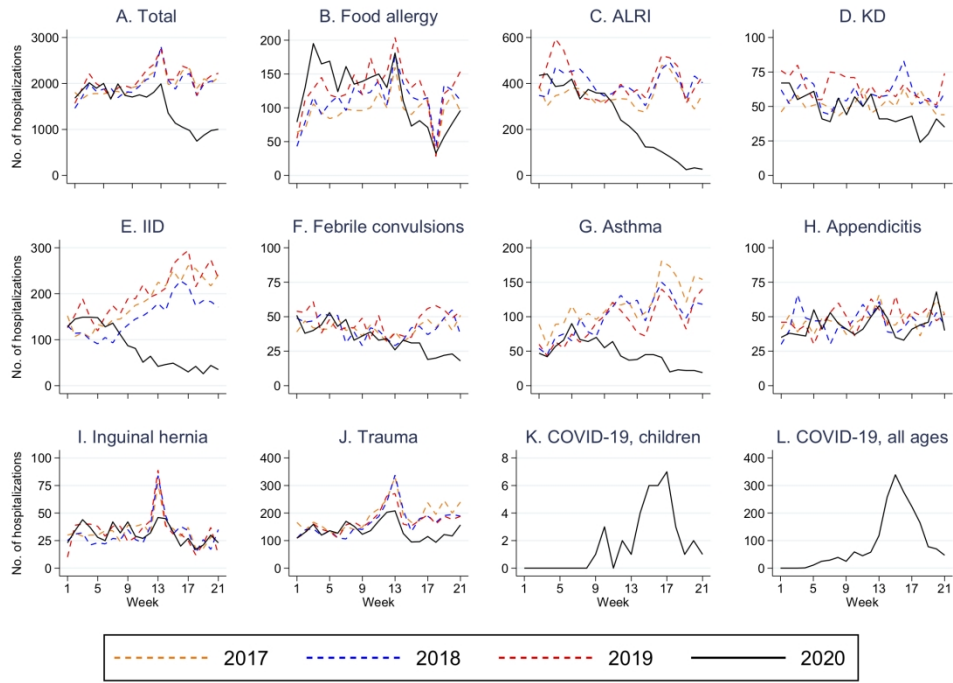
Condition‡	No. of hospitalisations per week*		Difference between 2017-2019 vs. 2020		Adjusted incidence rate ratio†		
	Weeks 9-21 of 2017-2019	Weeks 9-21 of 2020	Count	% change	Estimate	95% CI	P value
	Acute lower respiratory infections	379	145	-235	-61.9	0.39	0.26, 0.58
Intestinal infectious disease	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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Large Decrease in Paediatric Hospitalisations During the COVID-19 Outbreak in

Japan

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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.

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6 The COVID-19 pandemic has significantly affected children's social environments and
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9 access to healthcare services worldwide. Studies have reported substantial decreases in
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12 paediatric emergency department visits and subsequent hospitalisations[1-3]. However,
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15 little is known about the nationwide overall trends including non-emergency
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18 hospitalisations during the pandemic. We investigated the nationwide changes in the
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21 number of paediatric hospitalisations for major conditions during the COVID-19
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24 outbreak in Japan.
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30 We used a de-identified inpatient claims database, collected under Diagnosis Procedure
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33 Combination/Per-Diem Payment System, built by Medical Data Vision Co, Ltd (Tokyo,
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36 Japan)[4]. Briefly, this payment system is part of public health insurance reimbursement
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39 system in Japan[5], and therefore, the database consists of demographic/clinical
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42 information of all the hospitalisations for each hospital. The database included 272
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45 Japanese acute-care hospitals that consented to data utilisation (covering 12.4% of all
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48 admissions into acute-care hospitals in Japan in January 2019). We aggregated the
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51 weekly number of hospitalisations of children aged 1–17 years during the calendar
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54 weeks 1–21 of 2020 (January 1 to May 26) and the same periods in 2017–2019. We
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57 included only patients admitted for ≤ 30 days (accounting for 99% of the paediatric
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6 hospitalisations in our dataset) because our dataset could not observe patients who were
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9 hospitalised for more than 30 days from week 21 of 2020.
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15 We described weekly trends in total paediatric hospitalisations and those with a primary
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18 diagnosis of one of nine selected conditions, based on the date of admission. We used
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21 nine common conditions (determined based on *International Classification of Diseases*
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24 *10* code), including food allergy, acute lower respiratory infections (ALRI) except
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27 COVID-19, Kawasaki disease (KD), intestinal infectious diseases (IID), febrile
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30 convulsions, asthma, appendicitis, inguinal hernia and trauma. We also examined
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33 hospitalisations with a primary diagnosis of COVID-19 to illustrate the epidemic in
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42 We employed a “difference-in-differences” model using Poisson regression to estimate
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45 the changes in the number of hospitalisations during the COVID-19 outbreak. It
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48 included a variable for each week, the year indicator (2017–2020), and an interaction
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51 variable between the outbreak status (week 9–21; the government requested nationwide
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54 cancellation of large-scale events and school closures in week 9 of 2020) and the year
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9 The weekly mean number of paediatric hospitalisations during weeks 9–21 decreased
10 from 2,132 in 2017–2019 to 1,314 in 2020, a reduction of 38.4% (adjusted incidence
11 rate ratios, 0.60; 95% confidence interval, 0.53–0.69) (**Figure 1** and **Table 1**). The
12 weekly mean number of hospitalisations during weeks 9–21 decreased in 2020
13 compared with 2017–2019 for food allergy (0.61; 0.52–0.70), for ALRI (0.39; 0.26–
14 0.58), for KD (0.77; 0.67–0.89), for IID (0.22; 0.17–0.29), for febrile convulsions (0.69;
15 0.57–0.84), for asthma (0.37; 0.29–0.47), for inguinal hernia (0.80; 0.67–0.95), and for
16 trauma (0.68, 0.61–0.75). We found no evidence that the number of hospitalisations for
17 appendicitis decreased (0.96; 0.82–1.12).
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40 There were considerable decreases in paediatric hospitalisations across Japanese acute-
41 care hospitals during the COVID-19 outbreak, especially concerning conditions related
42 to communicable diseases and trauma, but not for appendicitis. Our findings may
43 encourage policymakers to reallocate paediatric care resources during the pandemic.
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50 There are several possible explanations for these reductions. First, non-pharmaceutical
51 interventions (physical distancing and individual hygiene measures) probably reduced
52 infections. School closures and stay-at-home requests presumably decreased accidents.
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9 in inguinal hernia hospitalisations, especially in week 13 (corresponding to the spring
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18 Limitations of this study include the patient population, which did not cover all the
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20 Japanese hospitals although our dataset covered 272 acute-care hospitals. Second, the
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22 detailed mechanisms through which the paediatric hospitalisations decreased remain
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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
- 2 Pines JM, Zocchi MS, Black BS, *et al.* Characterizing pediatric emergency department visits during the COVID-19 pandemic. *Am J Emerg Med* Published Online First: 23 November 2020. doi:10.1016/j.ajem.2020.11.037
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7 **Figure 1. Trends in the number of hospitalisations of children across 272 acute-**
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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
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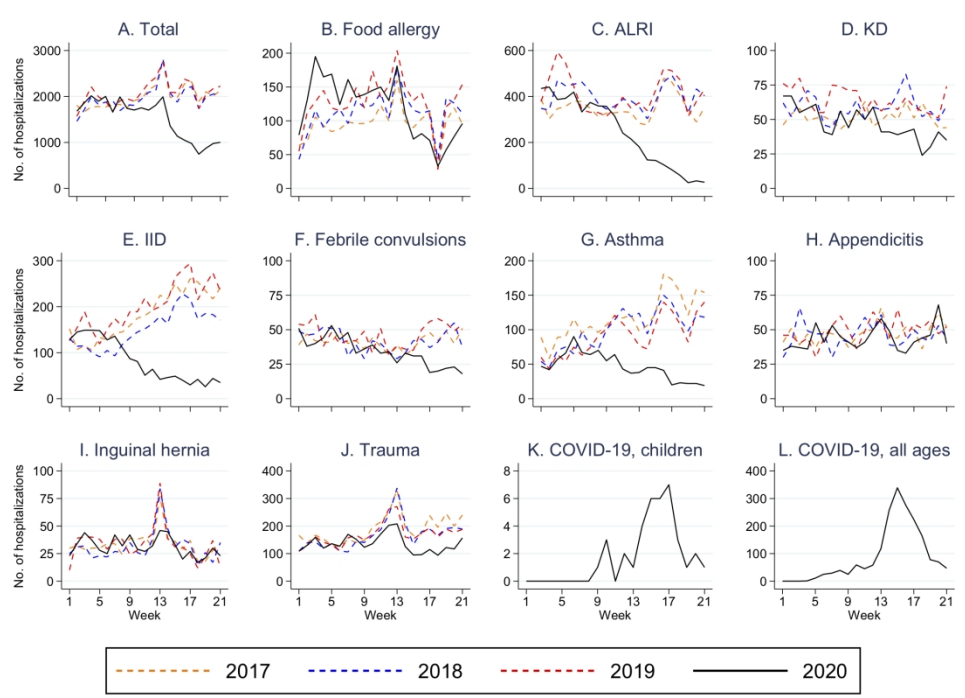
CI: confidence interval.

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