

# Pediatric allergies in Japan: Coronavirus disease pandemic-related risk factors

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## ABSTRACT

**Background:** The coronavirus disease 2019 (COVID-19) pandemic impacted various parts of society, including Japanese children with allergies.

**Objective:** This study investigated risk factors for pediatric allergic diseases associated with the state of emergency owing to the COVID-19 pandemic in Japan, including during school closures.

**Methods:** Parents of pediatric patients (0–15 years) with allergies were enrolled and queried regarding the impact of school closure on pediatric allergies compared to that before the COVID-19 pandemic.

**Results:** A valid response was obtained from 2302 parents; 1740 of them had children with food allergies. Approximately 4% (62/1740) of the parents reported accidental food allergen ingestion was increased compared to that before the COVID-19 pandemic. Accidental ingestion during school closures was associated with increased contact with meals containing allergens meant for siblings or other members of the family at home. The exacerbation rate during the pandemic was highest for atopic dermatitis at 13% (127/976), followed by allergic rhinitis at 8% (58/697), and bronchial asthma at 4% (27/757). The main risk factors for worsening atopic dermatitis, allergic rhinitis, and bronchial asthma were contact dermatitis of the mask area (34/120 total comments); home allergens, such as mites, dogs, and cats (15/51 total comments); and seasonal changes (6/25 total comments), respectively.

**Conclusion:** The main factors affecting allergic diseases were likely related to increased time at home, preventive measures against COVID-19, and refraining from doctor visits. Children with allergies were affected by changes in social conditions; however, some factors, such as preventing accidental ingestion and the management of allergens at home, were similar to those before the COVID-19 pandemic. Patients who had received instructions on allergen avoidance at home before the pandemic were able to manage their disease better even when their social conditions changed.

**Keywords:** Allergic rhinitis; atopic dermatitis; bronchial asthma; coronavirus disease 2019; food allergy; risk factors

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## Introduction

At the beginning of 2020, coronavirus disease 2019 (COVID-19) spread rapidly and had various impacts on society. On March 11, 2020, the World Health Organization declared COVID-19 as a pandemic [1]. Several countries, such as the United States and France, have implemented penalized lockdowns to contain the spread of COVID-19. In Japan, the number of newly infected patients increased from February 2020, and the first peak wave of the pandemic occurred in April 2020, with a maximum of 720 patients identified per day [2].

In Japan, educational institutions, such as kindergartens, elementary schools, junior high schools, and high schools, were requested to close on March 2, 2020, to prevent a pandemic among children; many children were on standby at home [3]. The new school year in Japan begins in April after a 2-week vacation from end-March every year. However, as the request continued until May 21, it was an unusually long vacation for children, and it was not possible to complete graduation or admission. Furthermore, on April 7, 2020, in the Kanto area centered in Tokyo (Tokyo, Kanagawa prefecture, Chiba prefecture, Saitama prefecture), the Kansai area centered in Osaka (Osaka prefecture, Hyogo prefecture), and Kyushu (Fukuoka prefecture), an emergency declaration was issued in 7 cities, which was expanded nationwide on April 16, 2020. People in Japan were asked to reduce person-to-person contact by 70% to 80% for 1 to 2 months, refrain from going out unnecessarily, and promote teleworking [4, 5].

Children in Japan experienced unprecedented lifestyle changes, including changes in the period of school closure from March to May 2020. By analyzing the effects of COVID-19 on patients with allergy, we believed that it would be possible to predict the changes that patients may experience when a similar pandemic occurs in the future. To the best of our knowledge, there has been no comprehensive study conducted thus far that has thoroughly investigated the factors of change that Japan has encountered during the COVID-19 pandemic. Therefore, this study aimed to clarify the effects of this pandemic on pediatric patients with allergies in Japan and the related reasons.

In performing this study, we considered that we could prepare for the future by clarifying the effects of the pandemic and the related factors exacerbating allergies in Japanese children. We conducted a questionnaire survey of parents of pediatric patients with allergies with regular hospital visits in the Kansai area centered on the Osaka Prefecture, one of the areas with the largest number of COVID-19 cases in Japan.

## Materials and methods

### Patients

Parents of patients aged 0 to 15 years who regularly visited the hospital due to allergies for  $\geq 6$  months before the pandemic were included. These patients were diagnosed by doctors specialized in allergies and the following allergies were included: food allergies, bronchial asthma, atopic dermatitis, or allergic rhinitis. Patients who did not have any of the above-listed 4 allergic diseases, those who did not undergo regular visits, or those for whom the answers were from someone other than the parents were excluded.

### Study design

This cross-sectional, questionnaire-based survey was conducted from November 2020 to March 2021. An anonymous

questionnaire survey was requested from all patients' guardians by the medical staff. The attending physician did not select the study participants. The questionnaire was completed during regular hospital visits at each facility. The answered questionnaires collected from the parents of patients were immediately checked by clinical staff, such as research assistances, medical clerks, and pediatric nurses. The study was conducted at 24 facilities in Osaka, Hyogo, and Nara prefectures, where doctors specialize in pediatric allergic diseases. It included general hospitals and clinics.

### Questionnaire survey items

The questionnaire included (1) basic information on the patient's allergies (age, sex, and allergy) and (2) the impact of the pandemic on the child's allergy. The original questionnaire is presented in Supplementary Table 1 <http://links.lww.com/PA9/A10>.

We asked questions regarding the accidental ingestion of food that the child developed an allergy to. If the patient experienced accidental ingestion from March 2 to May 21, 2020, we inquired regarding the details (time, place, and situation). We also asked questions regarding the changes in the frequency of accidental ingestion during the period of school closure, including the state of emergency (hereinafter referred to as the school closure period) compared to those pre-pandemic. Further, we inquired regarding the impact on atopic dermatitis, bronchial asthma, and allergic rhinitis control status during the school closure period, including the state of emergency from March 2 to May 21, 2020, compared to that pre-pandemic. If a change was noted, parents were requested to provide a free description of the probable reason for the change.

### Questionnaire survey time

It was difficult to conduct the questionnaire survey due to restrictions on social activities from March to May 2020. Therefore, we decided to conduct the questionnaire in November 2020 since the COVID-19 pandemic had gradually decreased. We aimed to complete the survey by the end of 2020; however, owing to the large number of facilities included, the survey was only completed in March 2021.

### Questionnaire analysis

SPSS Ver. 22 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. We used the Kolmogorov–Smirnov test to assess the normality of the distribution of continuous variables. We assessed the differences between groups using statistical methods, such as the Chi-square test and the Mann–Whitney U test. A 2-tailed  $P$ -value  $< 0.05$  was considered statistically significant for all the test results.

The content was analyzed using the KH Coder (SCREEN Holdings Co., Ltd, Kyoto, Japan), a text-mining tool. KH Coder is a software for quantitative text analysis or text mining that can be used to analyze various data, such as free descriptions of questionnaires, interview records, and newspaper articles. An analysis of self-administered questionnaires of the effect of the COVID-19 pandemic or SNS data analysis concerning allergies has been reported previously [6, 7]. Using the KH Coder, common words were automatically extracted from the free descriptions, and the top 10 words were confirmed in the order of frequency of appearance.

**Table 1.**  
**Background characteristics of patients and their parents**

Number of responders	N = 2302
Father	172 (7.5%)
Mother	2130 (92.5%)
Number of parents with children with allergy (each considered) (multiple answers available)	
Food allergy	1740 (75.6%)
Bronchial asthma	757 (32.9%)
Atopic dermatitis	976 (42.4%)
Allergic rhinitis	697 (30.3%)
Mean child's age (N = 2623) (range, including siblings; years)	
Food allergy	6 (0–15)
Bronchial asthma	8 (0–15)
Atopic dermatitis	7 (0–15)
Allergic rhinitis	9 (1–15)
Number of children in each age group (N = 2623) (including siblings); 0–3-year: 4–6-year: ≥7-year groups	
Food allergy (0–3-year: 4–6-year: ≥7-year groups)	528: 520: 813
Bronchial asthma (0–3-year: 4–6-year: ≥7-year groups)	273: 306: 508
Atopic dermatitis (0–3-year: 4–6-year: ≥7-year groups)	94: 218: 478
Allergic rhinitis (0–3-year: 4–6-year: ≥7-year groups)	48: 159: 536
Child's sex (N = 2623) (including siblings)	
Boy (N = 1639)	1639 (62.5%)
Girl (N = 964)	964 (36.7%)
NA (N = 20)	20 (0.8%)

### Sub-group risk analysis based on the answers obtained from the questionnaire

We analyzed the data of patients in the age groups of 0 to 3, 4 to 6, and ≥7 years, concerning the risk of accidental ingestion in food allergy. Moreover, we performed exacerbation risk analysis regarding atopic dermatitis and allergic rhinitis. In Japan, children aged 0 to 3 years go to nursery schools or receive home care. Children aged 4 to 6 years mainly go to nursery schools or kindergarten. Further, those aged ≥7 years mainly go to elementary, junior high, or high school. In the sub-group analysis, responses from guardians who had 2 or more children undergoing regular visits for the same allergy treatment were excluded, because it was not possible to determine the child for which they had provided the response.

### Calculation of the number of survey participants

The number of survey participants required was 601 with a response ratio of 0.5, a sampling error of 4%, and a confidence level of 95%. Half of the responders were considered to have food allergies, one-third had bronchial asthma, and one-fourth had allergic rhinitis. The collection rate was expected to be 95%, and 2500 copies were distributed.

### Ethical considerations

Ethical approval for this study (Medical Research Institutional Review Board Approval No. 1054-1) was provided by the Institutional Review Board of the Osaka Habikino Medical Center, 3-7-1, Habikino, Habikino, Osaka 583-8588, Japan (Chairperson Dr. Shoji Hashimoto) in October 2020. We obtained informed consent from all study participants. The submission of a questionnaire was considered to be consent in the study. This study was conducted in accordance with the tenets of the Declaration of Helsinki.

### Results

From November 2020 to March 2021, 2500 copies of the questionnaire were distributed and 2439 copies (98%) were

collected. Of these, 99 were answered by parents of patients with allergic diseases who did not undergo regular medical visits and 38 were answered by non-parents. Therefore, we included the responses to 2302 copies from parents of children who were undergoing regular medical visits. The number of respondents per facility is presented in Supplementary Table 2 <http://links.lww.com/PA9/A11>. We ensured to avoid bias toward any specific hospital based on the number of regular visiting patients.

The backgrounds of the patients are presented in Table 1. Especially, the average age of children for each allergic disease and the number of children having these diseases in each age group are presented.

### Accidental ingestion with food allergies

Among 1740 patients with food allergy, 20 reported accidental ingestion during the school closure period. The total number of cases of accidental ingestions was 20, averaging 7 cases/month (6 in March, 5 in April, and 9 in May). The most common places of accidental ingestion were homes (n = 13), followed by educational institutions and day care centers (n = 3), restaurants (n = 1), and unknown places (n = 3).

### Factors affecting accidental ingestion during school closure

We queried parents if there were any changes in the occurrence of food allergy due to accidental ingestion during the period of school closure compared to that before the COVID-19 pandemic. The most common answer during school closure was “unchanged” for 81% (1402/1740) of cases compared to that before the COVID-19 pandemic, followed by “decreased” or “relatively decreased” for 13% (221/1740), and “increased” or “rather increased” for 4% (62/1740).

The causes affecting accidental ingestion (Q1) are shown in (Table 2). During the school closure period, we analyzed the reasons why the number of accidental ingestions increased compared to that before the COVID-19 pandemic (Q1) (Table 2). Free writing was obtained from 58 of the 62 patients. The top 7 words obtained by the KH Coder included “time,” “home,” “brother,” “sister,” “eating,” “family,” and “increasing.” Free descriptions of the factors that were less frequent than those before the pandemic were obtained from 200 out of 221 patients. The top 10 most frequent words obtained by the KH Coder included “eating out,” “decreasing,” “meal,” “eating,” “school lunch,” “home,” “increasing,” “being careful,” “parents,” and “managing.”

Table 2 shows the typical cause of accidental ingestion. Of note, there were more opportunities for siblings or families to come in contact with sweets and meals containing allergens (N = 26). Moreover, the more time children spent alone or with someone other than their taking care of them, the greater the risk of accidental ingestion (N = 15).

The number of individuals who responded that accidental ingestion of food allergen was more susceptible were as follows: 24/447 in the 0–3-year group, 6/470 in the 4 to 6-year group, and 21/679 in the ≥7-year age group. More opportunities to come in contact with sweets and meals containing allergens for siblings or families were mainly observed in the 0 to 3-year group (75% of the responses; Fig. 1). In contrast, “Increase in the time children spent alone or with someone other than their parents” accounted for 85% of the responses, with a higher proportion observed in the ≥7-year group.

**Table 2.**  
**Answers to questions on accidental ingestion of allergenic foods during school closure**

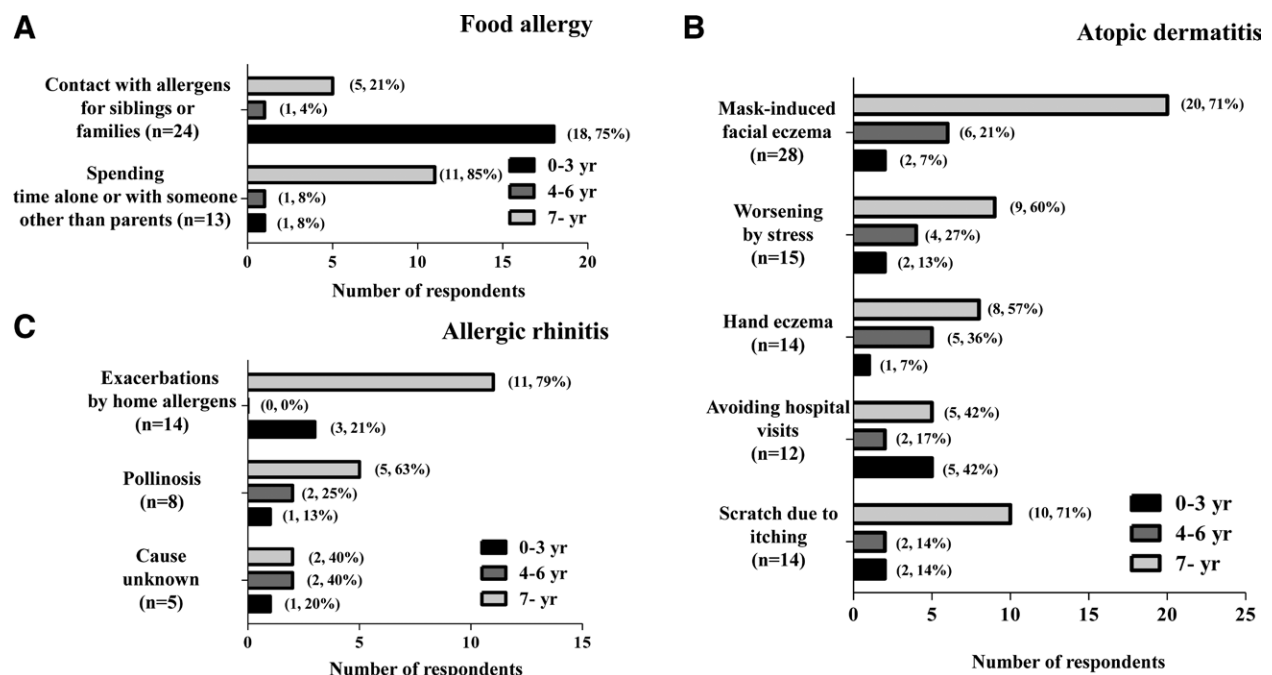
Number of responders	N = 1740
FA-Q1. During the declaration of the State of Emergency, do you feel your child's susceptibility to accidental ingestion changed compared to that before the spread of COVID-19?	
More susceptible	12 (0.7%)
It is somewhat more susceptible	50 (2.9%)
It did not change	1402 (81%)
It is somewhat less susceptible	105 (6.0%)
Less susceptible	116 (6.7%)
Unanswered or invalid	55 (3.2%)
Typical main cause of "less susceptible" or "somewhat less susceptible" (N = 200, including duplicates)	
Frequency of eating out decreased (N = 96).	
Parents could watch their children sufficiently because the time spent at home increased (N = 39).	
Reduced school lunches provided by kindergartens, daycare centers, and schools (N = 33).	
Cooking meals at home more often (N = 32).	
Being careful not to accidentally eat allergens more than usual (N = 22).	
Fewer opportunities to eat with friends (N = 8).	
Typical main causes of "more susceptible" or "somewhat more susceptible" (N = 58, including duplicates)	
More opportunities to come in contact with sweets and meals containing allergens for siblings or families (N = 26).	
Increase of the time children spend alone or with someone other than their parents to take care of them (N = 15).	

### Disease control status of atopic dermatitis, bronchial asthma, and allergic rhinitis during school closure

We queried if there was any impact on the control status of each disease during school closure. The effects for each disease were different, with bronchial asthma and allergic rhinitis having higher rates of improvement than atopic dermatitis. Atopic dermatitis had the highest rate of exacerbation, followed by allergic rhinitis and bronchial asthma ( $P < 0.001$ ). Atopic dermatitis, bronchial asthma, and allergic rhinitis remained "unchanged" in 72% (707/976), 76% (577/757), and 6% (476/697) of the cases; "improved" or "somewhat improved" in 10% (97/976), 15% (113/757), and 16% (108/697); and "worsened" or "rather worse" in 13% (127/976), 4% (27/757), and 8% (58/697), respectively.

### Factors affecting atopic dermatitis

Free descriptions of the causes affecting the worsening of atopic dermatitis were obtained from 116 patients (Table 3). Frequent words extracted by the KH Coder included "mask," "medicine," "stress," "hands," "worsening," "increasing," "shortage," "itching," "time," and "rough." Free descriptions of the factors associated with improved atopic dermatitis were obtained from 89 patients. Frequent words extracted by the KH Coder included "time," "increase," "staying at home," "decrease," "go out," "sweat," "medicine," "less," and "opportunity."



**Figure 1.** Sub-group analysis of typical reason of accidental ingestion of food allergy, exacerbation of atopic dermatitis, and allergic rhinitis. The number of respondents who answered that accidental ingestion of food allergen was more susceptible was 24/447 in the 0–3-year, 6/470 in the 4–6-year, and 21/679 in the ≥7-year age groups; the number of respondents who answered that atopic dermatitis was somewhat worse or worse were 15/206, 28/270, and 58/441 in the 0–3, 4–6, and ≥7-year age groups, respectively. The respondents who stated that allergic rhinitis was somewhat worse or worse were 9/40, 15/148, and 31/441 in the 0–3, 4–6, and ≥7-year age groups, respectively. (A) Food allergy: typical main causes of accidental ingestions are "more susceptible" or "somewhat more susceptible" Contact with allergens for siblings or families: More opportunities to come in contact with sweets and meals containing allergens for siblings or families. Spending time alone or with someone other than their parents: Increase of the time children spend alone or with someone other than their parents to take care of them. (B) Atopic dermatitis: Typical main cause of "worse" or "somewhat worse." Mask-induced facial eczema: Eczema appeared on skin that was in contact with the mask. Worsening by stress: Dermatitis worsened due to stress. Hand eczema: Hand eczema is caused by disinfection and hand washing. Avoiding hospital visits: They refrained from seeing a doctor when there was a shortage of medicine. Scratch due to itching: They were scratched due to itching. Allergic rhinitis: Typical main cause of "worse" or "somewhat worse." Exacerbations by home allergens: They were exacerbated by home allergens (dogs, cats, mites). Pollinosis: Pollinosis was worsened. Cause unknown.

**Table 3.****Answers to questions regarding atopic dermatitis during the school closure period**

Number of responders	N = 976
AD-Q1. During the declaration of the State of Emergency, had your child's atopic dermatitis condition changed compared to that before the spread of COVID-19?	
It improved	22 (2.3%)
It somewhat improved	75 (7.7%)
It did not change	707 (72.4%)
It became somewhat worse	96 (9.8%)
It became worse	31 (3.2%)
Unanswered or invalid	45 (4.6%)
Typical main cause of "improved" or "somewhat improved" (N = 89, including duplicates)	
The time spent at home increased (N = 33).	
They were able to avoid worsening factors (such as sweat, dust, sand, and pollen) since they did not go out (N = 24).	
They were able to use enough ointment externally (N = 22).	
Typical main cause of "worse" or "somewhat worse" (N = 116, including duplicates)	
Eczema appeared on skin parts that were in contact with the mask (N = 34).	
Dermatitis worsened due to stress (N = 19).	
Hand eczema caused by disinfection and hand washing (N = 15).	
They refrained from seeing a doctor when there was a shortage of medicine (N = 14)	
They scratched due to itching (N = 12).	

Those who answered that atopic dermatitis got worse provided the following 5 reasons: Eczema contact with the mask (N = 34), dermatitis due to stress (N = 19), hand eczema by disinfection and hand washing (N = 15), refraining from seeing a doctor (N = 14), and scratched due to itching (N = 12) (Table 3).

In total, 917 responses were included in the sub-group analyses (206, 270, and 441 in the 0 to 3, 4 to 6, and  $\geq 7$ -year age groups, respectively). The number of respondents who answered that atopic dermatitis was somewhat worse or worse were 15/206, 28/270, and 58/441 in the 0 to 3, 4 to 6, and  $\geq 7$ -year age groups, respectively. Exacerbation due to masks was the most common reason in all age groups, but the number of responses in the  $\geq 7$ -year age group was 20, accounting for 71% of the total (Fig. 1). In addition, worsening hand eczema was mainly observed in the 4 to 6 and  $\geq 7$ -year age groups, and there was only 1 case in the 0–3-year age group. Exacerbation owing to avoiding hospital visits was the main reason in the 0–3-year age group, accounting for 42% of the total. Exacerbation due to scratching for itching was observed in 71% of cases in the 7-year age group.

### Factors affecting bronchial asthma

Free descriptions of causes affecting the worsening of bronchial asthma were obtained from 25 patients. The top words obtained by the KH Coder included "season," "time," "increase," "house dust," "infection," "symptoms," "seasonal change," "reason," and "asthma." A free description of why it improved was obtained from 101 patients. The most frequent words obtained by the KH Coder were "decrease," "infection," "opportunity," "catch cold," "mask," "go out," and "home."

Table 4 presents the following 3 reasons for those who responded that bronchial asthma got worse: deteriorated due to the turn of the season (N = 6), worsened by home allergens (factors, such as dogs, cats, house dust, and dust) (N = 5), and unknown cause (N = 4).

A total of 720 responses were included in the sub-group analyses (82, 188, and 450 in the 0 to 3, 4 to 6, and  $\geq 7$ -year

**Table 4.****Answers to questions on the status of bronchial asthma during school closure**

Number of responders	N = 757
BA-Q1. During the declaration of the State of Emergency, had your child's bronchial asthma condition changed compared to that before the spread of COVID-19?	
It improved	37 (5.2%)
It somewhat improved	76 (10.8%)
It did not change	577 (81.6%)
It became somewhat worse	21 (3.0%)
It became worse	6 (0.9%)
Unanswered or invalid	40 (5.7%)
Typical main cause of "improved" or "somewhat improved" (N = 101, including duplicates)	
It became less likely to get infected (N = 52).	
The chances of going out decreased (N = 25).	
They wore a mask (N = 9).	
Typical main cause of "worse" or "somewhat worse" (N = 25, including duplicates)	
Deteriorated due to the turn of the season (N = 6).	
Worsened by home allergens (factors, such as dogs, cats, house dust, and dust) (N = 5).	
Cause unknown (N = 4).	

age groups, respectively). The respondents who answered that bronchial asthma was somewhat worse or worse were 8/82, 4/188, and 12/450 in the 0 to 3, 4 to 6, and  $\geq 7$ -year age groups, respectively.

### Factors influencing allergic rhinitis

Free descriptions of causes affecting the worsening of allergic rhinitis were obtained from 51 patients. The top words obtained by the KH Coder included "time," "increase," "house dust," "home," "many," and "allergy." Free descriptions of why allergic rhinitis improved were obtained from 99 patients. The top words obtained by the KH Coder included "go out," "reduce," "opportunity," "mask," "pollen," "symptoms," "wear," "less," and "medicine."

The main reasons given for worsened allergic rhinitis were as follows: exacerbation by home allergens (dogs, cats, mites) (N = 15), worsened pollinosis (N = 10), and unknown cause (N = 6) (Table 5).

A total of 629 responses (40, 148, and 441 in the 0 to 3, 4 to 6, and  $\geq 7$ -year age groups, respectively) were included in the sub-group analyses. The respondents who stated that allergic rhinitis was somewhat worse or worse were 9/40, 15/148, and 31/441 in the 0 to 3, 4 to 6, and  $\geq 7$ -year age groups, respectively. Exacerbation due to home allergens, such as house dust mite and dogs, was the main factor in the  $\geq 7$ -year age group (79%; Fig. 1).

## Discussion

In this study, we conducted a questionnaire survey on the influence of school closure (March–May 2020) due to the COVID-19 pandemic on children who regularly visit hospitals for allergies in Japan. The causes of change in various diseases were identified using free description data, with a focus on allergic conditions. The factors affecting allergic diseases were thought to be related to increased time at home, preventive measures against COVID-19 infection, and refraining from seeing a doctor.

When queried regarding accidental ingestion related to food allergies, compared to that before the COVID-19 pandemic, the number of patients who answered that the instances decreased

**Table 5.**  
**Answers to questions on the status of allergic rhinitis during school closure**

Number of responders	N = 697
AR-Q1. During the declaration of the State of Emergency, had your child's allergic rhinitis condition changed compared to that before the spread of COVID-19?	
It improved	29 (4.2%)
It somewhat improved	79 (11.3%)
It did not change	476 (68.3%)
It became somewhat worse	48 (6.9%)
It became worse	10 (1.4%)
Unanswered or invalid	58 (8.3%)
Typical main cause of "improved" or "somewhat improved" (N = 99, including duplicates)	
They were at home and did not go out (N = 92).	
They were wearing a mask (N = 12).	
Pollen exposure was reduced (N = 8).	
Typical main cause of "worse" or "somewhat worse" (N = 51, including duplicates)	
They were exacerbated by home allergens (dogs, cats, mites) (N = 15).	
Pollinosis was worsened (N = 10).	
Cause unknown (N = 6).	

during the school closure was higher than that of patients who answered that the instances increased. It has also been reported that the number of accidental ingestions was lower in lockdowns in Israel [8]. From the free descriptions provided, certain factors were less likely to occur, resulting in a decrease in the chances of accidental eating, specifically, a decrease in eating out, the increased attention of the parents, the decrease in school lunches, and the increase in meals at home.

In contrast, parents who found an increase in accidental ingestions stated that the children had more opportunities to have meals intended for their siblings and families or that their children spent more time alone or with non-parental companions. According to a sub-group analysis, in the 0 to 3-year group, increased exposure to food allergens at home may tend to increase the risk of accidental ingestion owing to older siblings or fathers without food allergy staying at home. In contrast, in the  $\geq 7$ -year age group, spending time alone at home with adults other than their parents who are unaware of food allergens was considered to be a risk factor. To prevent accidental ingestion at home, information should be shared in situations where risk increases, to increase awareness. Furthermore, accessing "safe" foods and food allergy-related health services was reported as a problem during the COVID-19 pandemic in Australia [9]. However, purchasing allergen-free foods was not difficult in Japan.

More patients reported worsening of atopic dermatitis than improvement. The risk factors for worsening were contact dermatitis due to mask use, refraining from consultation, stress, rough hands due to disinfection, and itching. Of the 1393 patients who had used masks in the previous week, 273 (19.6%) reported itching on the face [10], while 90.4% of healthcare workers in the ward reported acute hand eczema during the COVID-19 pandemic [11]. Mask-related exacerbation was considered more common in children aged  $\geq 7$  years because a mask was not recommended for those aged  $< 2$  years and children aged 3 to 6 years were considered unable to wear masks properly for a long time. Worsening of hand eczema was mainly observed in the 4 to 6-year and  $\geq 7$ -year age groups, and there was only 1 case in the 0 to 3-year age group. It has been reported that in patients with atopic dermatitis [12], it is necessary to consider using materials and disinfectants that prevent roughening of skin. For example, it is important to select a mask material that does not easily cause eczema or a

disinfectant that protects the skin. Moreover, itching is caused by stress [13]. Therefore, it is necessary to educate patients on how to deal with stress on a daily basis. In addition, one of the worsening factors was the lack of medicine and treatment due to refraining from seeing a doctor. The reason for "avoiding hospital visits" was observed in all age groups. As it has been reported that there is a tendency to refrain from visiting hospitals during a pandemic [14], it was considered necessary for medical professionals to promptly establish a remote medical care system.

Regarding asthma, refraining from going out, masking, and washing hands as a preventive measure against COVID-19 may contribute to the prevention of upper respiratory tract infection and exposure to allergens, such as pollen [15], leading to an improvement in symptoms. The number of hospitalizations or exacerbations for patients with asthma in Japan was reportedly lower in the spring of 2020 than in the pre-COVID-19 era [16-18]. In contrast, Hepkaya et al. reported that there was no change in the asthma control status [19]; however, a meta-analysis reported that asthma control had improved [20].

Allergic rhinitis had the same tendency as asthma [21]. It was thought that refraining from going out during the season when cedar pollen was scattered and wearing a mask when going out led to improvement in the symptoms of rhinitis. Nurses using masks reported marked improvement in allergic rhinitis [22]. Conversely, in addition to the effects of seasons and pollen, exposure to allergens at home was reported to be a risk factor [21]. It was considered necessary to reduce allergen exposure (dogs, cats, and mites) at home and to avoid allergen exposure on a daily basis.

A limitation of this study was that the influencing factors were subject to the subjectivity of the parents, as there may be individual differences in how they feel. In this study, we did not use any validated tool to assess the control status, such as the Asthma Control Test and the Patient-Oriented Eczema Measure. Furthermore, the survey and question timings were different. In addition, only patients who visited the hospital regularly completed the questionnaire, while patients who had not visited the hospital were excluded. Finally, it was not possible to confirm whether the diagnosis was correct because of the anonymous nature of the survey.

In conclusion, pediatric patients with allergies and their families were affected in various ways by changes in social conditions, including school closures, due to the COVID-19 pandemic. The influencing factors were roughly classified into "increased time spent at home," "precautions to prevent COVID-19," and "refraining from seeing a doctor." Some factors, such as prevention of accidental ingestion and measures against allergens at home, noted during the COVID-19 pandemic were similar to those before the COVID-19 pandemic. There is a possibility that some factors that worsened the allergy could have been alleviated by lifestyle changes, regardless of the COVID-19 pandemic.

Based on this analysis of the effects of COVID-19 on patients with allergies, we believe that it will be possible to predict the changes that patients may experience when a similar pandemic occurs in the future. Further research is necessary on whether the unfavorable effects could be suppressed by promptly taking action to control the risk in a similar situation.

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### Conflicts of interest

The authors have no financial conflicts of interest.

### Presentation

None.

### Author contributions

Conceptualization, methodology, and Writing—review and editing: Y.T. (Yuri Takaoka), A.N., A.M., M.H., Y.H., T.K., I.O., Y.T. (Yutaka Takemura), M.K., and K.T.; Data curation and formal analysis: Y.T. (Yuri Takaoka), A.M., and A.N.; Investigation and Resources: Y.T. (Yuri Takaoka), A.N., M.H., Y.H., T.K., I.O., Y.T. (Yutaka Takemura), M.K., S.A., K.A., S.S. (Shinichi Sumimoto), K.B., M.D., M.E., S.F., A.I., M.N., A.N., K.O., S.S. (Satoko Shimizu), Y.S., Y.S. Y.T. (Yukiko Tanaka), Y.T. (Yuko Tanaka), Y.T. (Yuya Tanaka), R.W., and K.Y.; Writing—original draft preparation: Y.T. (Yuri Takaoka); Supervision: M.K. and K.T.; Funding acquisition: A.M., K.T., M.K., and A.N. All authors have read and agreed to the published version of the manuscript.

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