

Pediatric patch testing in a multi-ethnic Asian population: A retrospective review

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Abstract

Background: Pediatric allergic contact dermatitis (ACD) is increasingly prevalent. Patch testing is the gold-standard diagnostic investigation. The aims of our study were to describe the clinical profile of pediatric patients with ACD in a multi-ethnic Asian population and identify the common contact allergens.

Methods: This was a retrospective study involving children and adolescents aged 16 years or younger with clinically suspected ACD who underwent patch testing between January 2007 and March 2020 at two institutions in Singapore. Information pertaining to their demographics, atopy history, clinical presentation, and patch test results was analyzed.

Results: A total of 252 patients were included. The mean age was 10.9 years (1.0–16.7 years). The majority were Chinese (79.8%) and girls (57.5%). Many (66.3%) had atopic dermatitis (AD), which was mild. The most common presentation was an acral eczematous rash. The sensitization rate was 50.0%. The most frequent reactions were to nickel sulfate (49.2%) and fragrance mix (19.1%). The overall rate of relevant positive patch tests was 72.5%. Patients with AD were less likely to have a reaction to fragrance mix ($p = .019$) and more likely to have a reaction to disperse blue ($p = .041$). Compared to younger children, adolescents were less likely to have a positive patch test ($p = .008$). Indians were also less likely to have a positive reaction ($p = .004$).

Conclusion: Metals and fragrances were the most common allergens causing childhood ACD in Singapore. Patients with AD were less likely to be sensitized to fragrances and more likely to be sensitized to disperse blue dye.

KEYWORDS

allergic contact dermatitis, Asia, patch testing, pediatric

1 | INTRODUCTION

Allergic contact dermatitis (ACD) is an inflammatory skin disorder. It is caused by a biphasic T cell-mediated delayed hypersensitivity reaction.¹ In the sensitization phase, the hapten from the allergen first comes in contact with epidermal Langerhans cells. These cells then migrate to the regional lymph nodes where they interact with naive T lymphocytes that become primed and undergo clonal expansion into effector and memory cells. The elicitation phase results in a cytotoxic T cell-mediated response when recurrent exposure to the contact allergen is found.

Patch testing is the gold-standard diagnostic investigation for ACD and can be safely done in children.² ACD is estimated to affect 20% of children.² However, the true prevalence may be underestimated due to lack of recognition.² Current literature suggests that contact sensitization may occur in early childhood and varies among geographical populations.^{3,4} Only a few studies have been conducted in Asia.^{4,5} Furthermore, the relationship between ACD and atopic dermatitis (AD) is unclear.⁶

The aims of our study were to describe the clinical profile of pediatric patients with ACD in a multi-ethnic Asian population in Singapore and identify the common contact allergens causing ACD. We also explored whether there was any significant association between ACD and age, gender, race, and AD.

2 | METHODS

This was a retrospective study involving children and adolescents aged 16 years old or younger with clinically suspected ACD in Singapore. The patients were reviewed by dermatologists and underwent patch testing between January 2007 and March 2020 at two local institutions—a specialized dermatologic center (National Skin Centre, NSC) and a tertiary children's hospital (KK Women's & Children's Hospital, KKH). Information pertaining to their demographics, atopy history, clinical presentation, and patch test results was retrospectively obtained from medical records and analyzed.

All patients included in the study had been tested with a standard series of contact allergens or other clinically relevant allergens that were either part of a supplemental series of allergens or from selected items belonging to the patient. On average, approximately 25 patches were applied on each child. The common contact allergens tested in both centers were identified and analyzed. The standard series of contact allergens is detailed in Table A1.

The allergens were applied on the patient's back over healthy skin and removed after 48 h of occlusion. Results were interpreted at 72 h, and reactions were assessed according to the International Contact Dermatitis Research Group scoring system. All patients from NSC were routinely reviewed on Day 7 for delayed reactions. At KKH, patients were recalled for another reading between Days 5 and 7 if delayed reactions were suspected. Patients with positive reactions were considered sensitized. Further information on

relevance was available from one center, and those of present or past relevance were considered relevant (Table A2).

Statistical analysis was performed using R version 3.5.3 software.⁷ Pearson's chi-square test was used to test the factors associated with at least 1 positive patch test, with *p*-values considered statistically significant if $<.05$. Multivariable Firth's logistic regression analysis was performed to examine the association between ACD and age, gender, race, and AD. Adjusted odds ratio (OR) with 95% confidence interval (CI) was reported. Ethics approval was obtained for the study.

3 | RESULTS

3.1 | Demographics

A total of 252 patients were included in our study. 107 boys (42.5%) and 145 girls (57.5%) were present. The majority (201/252, 79.8%) were Chinese. The mean age was 10.9 years (range 1.0–16.7 years, SD 3.6 years). Patients were categorized into 3 age groups: pre-school children aged 0–6 years, school-age children aged 7–12 years and adolescents aged 13–16 years. Most were school-age children (113/252, 44.8%), followed by adolescents (95/252, 37.7%). Pre-school children accounted for 17.5% (44/252) of the study population.

3.2 | Atopy history

Atopic dermatitis was present in 66.3% (167/252) of patients, while 9.9% (25/252) and 27.8% (70/252) had asthma and allergic rhinitis, respectively. Of the patients with AD, most (157/167, 94.0%) had mild AD involving less than 10% body surface area (BSA) and were treated with topicals only. Meanwhile, 3.6% (6/167) had moderate AD involving at least 10% BSA or requiring phototherapy, and 2.4% (4/167) had severe AD requiring treatment with systemic immunosuppressants. The demographic information and atopy history of all patients are summarized in Table 1.

3.3 | Clinical presentation

The most common sites of dermatitis were the hands (63/252, 25.0%) and feet (52/252, 20.6%). Other sites involved were the head and neck regions (49/252, 19.4%), upper limbs (44/252, 17.5%), lower limbs (48/252, 19.1%), trunk (18/252, 7.1%), and perineum (13/252, 5.2%). 9 patients (3.8%) with generalized involvement were found. Most patients (176/187, 94.1%) presented with an eczematous rash. Other morphologies noted include pigmentary, urticarial, and nodular lesions. Patients with at least one positive patch test were compared with those without any positive test results, and no significant difference in clinical presentation between the two groups was found. The clinical presentation of all patients is summarized in Table 2.

TABLE 1 Summary of demographics and atopy history of all patients ($N = 252$)

Characteristic	Number	Percentage
Gender		
Male	107	42.5%
Female	145	57.5%
Race		
Chinese	201	79.8%
Malay	24	9.5%
Indian	17	6.7%
Other	10	4.0%
Age (Mean: 10.9 years, SD 1.0–16.7 years)		
Pre-school children (0–6 years old)	44	17.5%
School-age children (7–12 years old)	113	44.8%
Adolescents (13–16 years old)	95	37.7%
Atopy history		
Asthma	25	9.9%
Allergic rhinitis	70	27.8%
Atopic dermatitis (AD)	167	66.3%
Mild AD	157/167	94.0%
Moderate AD	6/167	3.6%
Severe AD	4/167	2.4%

3.4 | Patch test results

A total of 126 patients (50.0%) had at least one positive patch test. The most frequent positive reactions were to nickel sulfate (62/126, 49.2%), fragrance mix (24/126, 19.1%), potassium dichromate (17/126, 13.5%), colophony (17/126, 13.5%), and balsam of Peru (17/126, 13.5%). Relevance of positive results was assessed in 69 patients, with 72.5% (50/69) having at least one relevant positive patch test, with relatively high rates for nickel sulfate and fragrance mix. Table 3 provides details on the frequencies of positive patch tests to individual contact allergens and compares the results of patients with and without AD.

3.5 | Multivariate analysis

No significant association between AD and having at least one positive patch test, adjusting for age, gender and race was found. However, patients with AD were less likely to have a reaction to fragrance mix ($p = .019$; adjusted OR 0.3; 95% CI 0.1–0.8) and more likely to have a reaction to disperse blue ($p = .041$; adjusted OR 8.7; 95% CI 1.1–1105.2). In terms of race, with Chinese as the reference group, Indians were less likely to have at least one positive patch test ($p = .004$; adjusted OR 0.2; 95% CI 0.1–0.6). In terms of age, with

TABLE 2 Clinical presentation—site and morphology of rash

Site of rash	All patients ($n = 252$) ^a	At least 1 positive patch test ($n = 126$)	No positive patch test ($n = 126$)	<i>p</i> -value
Hands	63 (25.0%)	38 (30.2%)	25 (19.8%)	.081
Feet	52 (20.6%)	26 (20.6%)	26 (20.6%)	1.00
Head (scalp, face, eyes, lips, ears, neck)	49 (19.4%)	24 (19.1%)	25 (19.8%)	1.00
Lower limbs (excluding feet)	48 (19.1%)	23 (18.3%)	25 (19.8%)	.872
Upper limbs (excluding hands)	44 (17.5%)	21 (16.7%)	23 (18.3%)	.868
Trunk (chest, abdomen, back)	18 (7.1%)	8 (6.4%)	10 (7.9%)	.808
Perineum (genitalia, groin, buttocks)	13 (5.2%)	8 (6.4%)	5 (4.0%)	.571
Generalized (involves all major categories)	9 (3.8%)	5 (3.9%)	4 (3.2%)	1.00
Morphology of rash	All patients ($n = 187$) ^b	At least 1 positive patch test ($n = 92$)	No positive patch test ($n = 95$) ^c	<i>p</i> -value
Eczematous	176 (94.1%)	84 (91.3%)	92 (96.8%)	.129
Pigmentary	6 (3.2%)	3 (3.3%)	3 (3.2%)	1.00
Urticarial	3 (1.6%)	2 (2.2%)	1 (1.1%)	.617
Nodular	1 (0.5%)	1 (1.1%)	0	.492
Maculopapular	1 (0.5%)	1 (1.1%)	0	.492
Acneiform/follicular	0	0	0	NA
Other ^d	1 (0.5%)	1 (1.1%)	0	.492

^aPatients may present with rash at more than 1 site.

^bData were only available for 187 patients.

^cOne patient presented with 2 rash morphologies.

^dPainful ulcers on oral mucosa.

TABLE 3 Frequency of positive patch tests and relevant positive patch tests to individual contact allergens, and comparison between patients with and without AD (N = 126)^a

Allergens	Total positive patch tests ^b	Total relevant positive patch tests ^{c,d}	Present relevant positive patch tests ^d	Patients with AD (n = 83)	Patients without AD (n = 43)	p-value (adjusted)
Nickel sulfate	62 (49.2%)	27/37 (73.0%)	24/37 (64.9%)	44 (53.0%)	18 (41.9%)	.294
Fragrance mix	24 (19.0%)	9/12 (75.0%)	8/12 (66.7%)	12 (14.5%)	12 (27.9%)	.019
Potassium dichromate	17 (13.5%)	6/11 (54.5%)	6/11 (54.5%)	13 (15.7%)	4 (9.0%)	.425
Colophony	17 (13.5%)	4/5 (80.0%)	4/5 (80.0%)	9 (10.9%)	8 (18.6%)	.256
Balsam of Peru	17 (13.5%)	4/8 (50.0%)	3/8 (37.5%)	11 (13.3%)	6 (14.0%)	.589
Methylchloroisothiazolinone and methylisothiazolinone (MCI/MI)	10 (7.9%)	7/8 (87.5%)	6/8 (75.0%)	7 (8.4%)	3 (7.0%)	.823
Formaldehyde	9 (7.1%)	4/7 (57.1%)	3/7 (42.9%)	7 (8.4%)	2 (4.7%)	.676
Disperse blue	9 (7.1%)	4/8 (50.0%)	4/8 (50.0%)	9 (10.8%)	0 (0%)	.041
Paraben mix	9 (7.1%)	3/6 (50.0%)	3/6 (50.0%)	8 (9.7%)	1 (2.3%)	.183
Methyldibromoglutaronitrile	8 (6.4%)	5/7 (71.4%)	4/7 (57.1%)	5 (6.0%)	3 (7.0%)	.668
Paraphenylenediamine (PPD)	5 (4.0%)	1/4 (25.0%)	1/4 (25.0%)	5 (6.0%)	0 (0%)	.151
Neomycin sulfate	5 (4.0%)	1/4 (25.0%)	0/4 (0%)	3 (3.6%)	2 (4.7%)	.722
Lanolin	4 (3.2%)	2/3 (66.7%)	0/3 (0%)	3 (3.6%)	1 (2.3%)	.940
Thiuram	3 (2.4%)	3/3 (100%)	2/3 (66.7%)	3 (3.6%)	0 (0%)	.262
Propylene glycol	3 (2.4%)	2/3 (66.7%)	2/3 (66.7%)	3 (3.6%)	0 (0%)	.758
Mercapto mix	3 (2.4%)	0/1 (0%)	0/1 (0%)	2 (2.4%)	1 (2.3%)	.983
Quinolone	2 (1.6%)	0/2 (0%)	0/2 (0%)	1 (1.2%)	1 (2.3%)	.499
Disperse orange	2 (1.6%)	0/2 (0%)	0/2 (0%)	2 (2.4%)	0 (0%)	.445
Aluminum	1 (0.8%)	1/1 (100%)	1/1 (100%)	1 (1.2%)	0 (0%)	.945
Mercaptobenzothiazole	1 (0.8%)	1/1 (100%)	1/1 (100%)	0 (0%)	1 (2.3%)	.336
Tixocortol-21-pivalate	1 (0.8%)	0/1 (0%)	0/1 (0%)	1 (1.2%)	0 (0%)	1.000

^aTotal number of patients with at least 1 positive patch test.

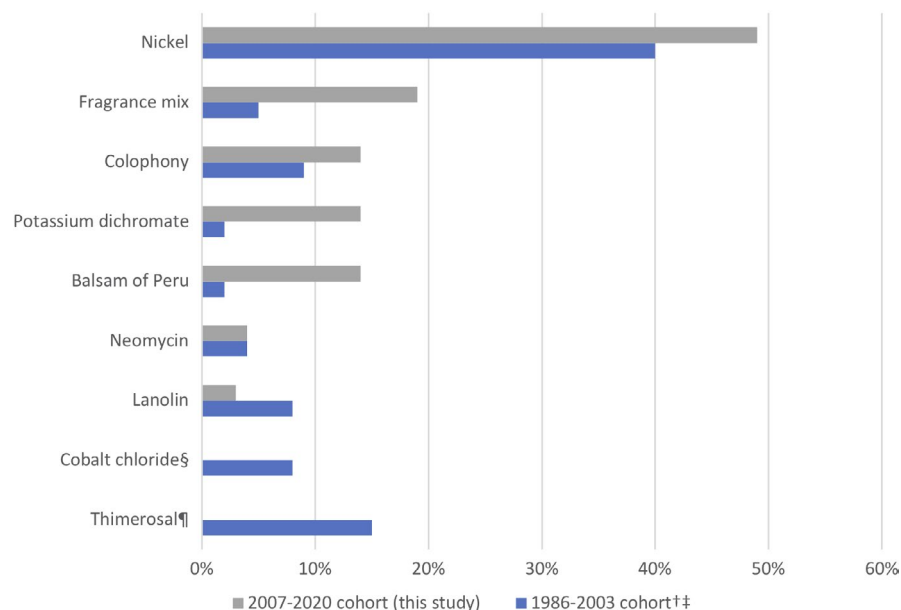
^bPatients may have positive patch test reactions to more than 1 allergen.

^cPositive patch tests of present and past relevance.

^dAnalysis was limited to 1 center due to data availability.

Bold indicates the values are statistically significant as p-value is <.05.

FIGURE 1 Comparison of patch test results among children and adolescents in Singapore over time. [†]Patients included were 20 years old and younger. [‡]Most common allergens were nickel, thimerosal, colophony, lanolin, cobalt, fragrance mix, and neomycin. [§]Not in standard series; 2 patients were patch tested and both were negative. [¶]Adjusted for removal of thimerosal in November 1998



pre-school children as the reference group, adolescents were less likely to have at least one positive patch test ($p = .008$; adjusted OR 0.4; 95% CI 0.2–0.8). No significant association between gender and positive patch tests was seen.

4 | DISCUSSION

Pediatric ACD is increasing in prevalence. A meta-analysis done found that studies published after 1995 have reported higher rates of positive patch tests.^{8,9} In recent years, unique patch test series have been developed to facilitate diagnosis and management of ACD in children.^{8,10} Our rates of sensitization and relevant positive patch tests are similar to other studies published in the past decade.^{8,11,12}

The profile of contact allergy in Singapore has evolved over time. A review by Goon et al in 2006 found that the most common allergens were nickel sulfate (40%), thimerosal (15%), and colophony (9%).⁵ Our results suggest an increased prevalence in contact allergy to nickel sulfate and fragrance mix compared to this previous study (Figure 1). One reason for the high percentage of positive patch tests to nickel is the lack of measures to limit nickel concentrations in nickel containing products in Asian countries.¹³ The high pre-test probability among our pediatric patients may also be a contributing factor.⁸

Few studies on pediatric ACD have been conducted in Asia.^{4,5} Variations in contact sensitization patterns due to cultural differences have been highlighted.¹⁴ In addition, Asians may have increased genetic predisposition for AD.¹⁵ Jacob et al reported that Asian American children who underwent patch testing were almost twice as likely to have concomitant AD compared to Caucasian Americans.¹⁵ Further studies on contact allergy in Asian populations will be valuable.

The relationship between AD and ACD is often debated.¹⁶ It was hypothesized that AD patients were less likely to have ACD due to the Th2-skewed immune response.^{16,17} However, some studies

demonstrated that children with AD had higher sensitization rates due to impaired skin barrier and increased exposure to topical treatments.^{17,18} Our study showed that overall, no statistically significant association was found. However, most of our patients had mild AD and thus less skin barrier impairment, although studies have demonstrated conflicting results on the relationship between severity of AD and contact sensitization.^{16,18}

Several studies have reported that children with AD may have differing sensitization rates to specific allergens.^{15,17,19} Our study showed that patients with AD had a significantly increased frequency of reactions to disperse blue and reduced frequency of reactions to fragrance mix. A study involving over 2000 Italian children also demonstrated an increased frequency of positive patch test reactions to disperse blue in those with AD.²⁰ We hypothesize that the skin barrier dysfunction in AD could have resulted in increased sensitization to disperse blue dye on clothing.

Fragrance is a common sensitizer, and several studies have reported increased reactions in patients with AD.^{16,17} However, a retrospective review by Clemmensen et al found that patients with AD had significantly less positive patch test reactions to fragrances.²¹ In the systematic review by Simonsen et al, the authors demonstrated that fragrance allergy was less common in children with AD who did not have aggravating skin symptoms. They hypothesized that this could be due to use of fragrance-free topicals from early childhood.¹⁶ This likely explains the relatively lower rates of fragrance sensitization among our patients with AD.

Our study demonstrated that contact sensitization was less likely to occur in adolescents compared to pre-school children. This is in contrast to studies that reported increased contact sensitization with age, which is believed to be due to accumulation of environmental exposures.^{17,22} Younger children are perceived to have less exposure and reduced responsiveness to contact allergens due to an immature immune system. However, the prevalence in younger children may be under-reported as they are less often patch tested.²²

A few studies have shown increased rates of contact allergy among younger children.^{23,24} Toys were identified as sources of hapten exposure.²² Furthermore, infants may be at higher risk of sensitization due to thinner skin and a larger surface area to body weight ratio.¹⁷ The high pre-test probability in this age group may also be a contributing factor.

Our results did not demonstrate any significant association with gender. This finding has been reflected in other studies.²⁴ However, increased rates of ACD among girls have been reported, especially to nickel sulfate, a common material found in jewelry.^{1,22} Therefore, this association needs to be clarified in future studies. Finally, our study demonstrated that Indians were less likely to have a positive patch test reaction. A local study conducted more than 30 years ago involving mostly adults demonstrated no significant difference in prevalence of contact allergy among racial groups.²⁵ Otherwise, this association has not been explored, possibly due to the limited number of publications on childhood ACD in Asia.

The main strength of our study is that it is a multi-center study involving Asian children with ACD, a population that is uncommonly described. By reviewing patch test data over the past decade, we obtained updated information on the common contact allergens causing pediatric ACD in Singapore. Our study has its limitations. Firstly, as it was a retrospective review, data were limited to the information available. Another limitation was the small number of positive reactions to individual contact allergens; thus, results were less precise. We attempted to increase our study population size by involving patients from two institutions. Finally, when interpreting patch test reactions at 72 h, there is a possibility of missing delayed positive reactions, or erroneously reading initial irritant reactions as positive. While it is ideal to perform patch test readings at 48 h, 96 h, and on Day 7 for everyone, it will likely undermine compliance.

5 | CONCLUSION

Metals and fragrances were the most common allergens causing childhood ACD in Singapore. Patients with AD were less likely to be sensitized to fragrances and more likely to be sensitized to disperse blue dye. Patch testing should be considered in patients with persistent dermatitis despite treatment, especially since it is difficult to distinguish patients with ACD from those without based on clinical presentation alone.

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None.

CONFLICT OF INTEREST

We declare that we do not have any conflict of interest.

AUTHOR CONTRIBUTION

All authors contributed to the conception and design of the study, acquisition, interpretation and analysis of data, and drafting and revising the manuscript critically.

CONSENT STATEMENT

Approval was obtained for this study.

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REFERENCES

1. Mortazavi H, Ehsani A, Sajjadi SS, Aghazadeh N, Arian E. Patch testing in Iranian children with allergic contact dermatitis. *BMC Dermatol*. 2016;16(1):10.
2. Tam I, Yu JD. Allergic contact dermatitis in children: recommendations for patch testing. *Curr Allergy Asthma Rep*. 2020;20(9):41.
3. Belloni Fortina A, Romano I, Peserico A, Eichenfield LF. Contact sensitization in very young children. *J Am Acad Dermatol*. 2011;65(4):772-779.
4. Zafirir Y, Trattner A, Hodak E, et al. Patch testing in Israeli children with suspected allergic contact dermatitis: a retrospective study and literature review. *Pediatr Dermatol*. 2018;35(1):76-86.
5. Goon ATJ, Goh CL. Patch testing in Singapore children and adolescents: our experience over 18 years. *Pediatr Dermatol*. 2006;23(2):117-120.
6. Rodrigues DF, Goulart EMA. Patch-test results in children and adolescents: systematic review of a 15-year period. *An Bras Dermatol*. 2016;91(1):64-72.
7. R Core Team. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing; 2019. <https://www.R-project.org/>
8. Felmingham C, Davenport R, Bala H, et al. Allergic contact dermatitis in children and proposal for an Australian Paediatric Baseline Series. *Australas J Dermatol*. 2020;61(1):33-38.
9. Bonitsis NG, Tatsioni A, Bassioulas K, Ioannidis JPA. Allergens responsible for allergic contact dermatitis among children: a systematic review and meta-analysis. *Contact Dermatitis*. 2011;64:245-257.
10. Yu JD, Atwater AR, Brod B. Pediatric baseline patch test series: pediatric contact dermatitis workgroup. *Dermatitis*. 2018;29(4):L206-212.
11. Zug KA, Pham AK, Belsito DV, et al. Patch testing in children from 2005–2012: results from the North American contact dermatitis group. *Dermatitis*. 2014;25(6):345-355.
12. Goldenberg A, Mousdicas N, Silverberg N, et al. Pediatric dermatitis registry inaugural case data. *Dermatitis*. 2016;27(5):293-302.
13. Goon ATJ, Goh CL. Metal allergy in Singapore. *Contact Dermatitis*. 2005;52(3):130.
14. Boonchai W, Iamtharachai P, Sunthornpalin P. Prevalence of allergic contact dermatitis in Thailand. *Dermatitis*. 2008;19(3):142-145.
15. Jacob SE, McGowan M, Silverberg NB, et al. Pediatric contact dermatitis registry data on contact allergy in children with atopic dermatitis. *JAMA Dermatol*. 2017;153(8):765-770.
16. Simonsen AB, Johansen JD, Deleuran M, et al. Contact allergy in children with atopic dermatitis: a systematic review. *Br J Dermatol*. 2017;177(2):395-405.
17. Borok J, Matiz C, Goldenberg A, et al. Contact dermatitis in atopic dermatitis children – past, present and future. *Clin Rev Allergy Immunol*. 2019;56(1):86-98.
18. Ozceker D, Haslak F, Dilek F, et al. Contact sensitization in children with atopic dermatitis. *Allergol Immunopathol (Madr)*. 2019;47(1):47-51.
19. Milam EC, Jacob SE, Cohen DE. Contact dermatitis in the patient with atopic dermatitis. *J Allergy Clin Immunol Pract*. 2019;7(1):18-26.

20. Belloni Fortina A, Fontana E, Peserico A. Contact sensitization in children: a retrospective study of 2614 children from a single center. *Pediatr Dermatol*. 2016;33(4):399-404.
21. Clemmensen KKB, Thomsen SF, Jemec GBE, et al. Pattern of contact sensitization in patients with and without atopic dermatitis in a hospital-based clinical database. *Contact Dermatitis*. 2014;71(2):75-81.
22. de Waard-van der Spek FB, Andersen KE, Darsow U, et al. Allergic contact dermatitis in children: which factors are relevant? (review of the literature). *Pediatr Allergy Immunol*. 2013;24(4):321-329.
23. Schena D, Papagrigoraki A, Tessari G, Peroni A, Sabbadini C, Girolomoni G. Allergic contact dermatitis in children with and without atopic dermatitis. *Dermatitis*. 2012;23(6):275-280.
24. Seidenari S, Giusti F, Pepe P, et al. Contact sensitization in 1094 children undergoing patch testing over a 7-year period. *Pediatr Dermatol*. 2005;22(1):1-5.
25. Goh CL. Epidemiology of contact allergy in Singapore. *Int J Dermatol*. 1988;27(5):308-311.

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APPENDIX

TABLE A1 List of contact allergens used for patch testing^a

No.	Allergen	Concentration	Vehicle
1	Balsam of Peru	25.00%	Pet
2	Colophony	20.00%	Pet
3	Budesonide	0.01%	Pet
4	Neomycin Sulfate	20.00%	Pet
5	Nickel Sulfate	5.00%	Pet
6	Paraben mix	16.00%	Pet
7	Paraphenylenediamine (PPD)	1.00%	Pet
8	Potassium dichromate	0.50%	Pet
9	Mercapto mix	2.00%	Pet
10	Quinoline mix	6.00%	Pet
11	Lanolin Alcohol	30.00%	Pet
12	Thiuram mix	1.00%	Pet
13	Epoxy Resin	1.00%	Pet
14	Fragrance Mix 1	8.00%	Pet
15	Fragrance Mix 2	14.00%	Pet
16	Betamethasone-17-valerate	1.00%	Pet
17	Tixocortol-21-pivalate	0.10%	Pet
18	Methylchloroisothiazolinone and methylisothiazolinone (MCI/MI)	0.01%	Aq
19	Methyldibromoglutaronitrile	0.50%	Pet
20	Quaternium 15	1.00%	Pet
21	Formaldehyde	1.00%	Aq
22	Propylene glycol ^b	5.00%	Pet
23	Disperse Blue 106 ^b	1.00%	Pet
24	Disperse Blue 124 ^b	1.00%	Pet
25	2-Mercaptobenzothiazole (MBT) ^b	2.00%	Pet
26	4-tert-Butylphenolformaldehyde Resin (PTBP) ^b	1.00%	Pet
27	Disperse orange 3 ^c	1.00%	Pet
28	Aluminum ^c	2.00%	Pet
29	Propolis ^d	10.00%	Pet
30	4-Chloro-3-cresol ^d	1.00%	Pet
31	Flavine ^d	0.50%	Pet
32	Sesquiterpene Lactone Mix ^d	0.10%	Pet
33	Lyrals ^d	5.00%	Pet
34	Cobalt Chloride ^d	1.00%	Pet

^aAllergens included in standard series used in both centers unless otherwise specified.

^bAllergen included in standard series in 1 center and supplemental series in the other center.

^cAllergen included in supplemental series in both centers.

^dAllergen included in standard series or supplemental series in 1 center only.

TABLE A2 Classification used to assess relevance of positive patch tests

Present	The allergen is causing the current dermatitis
Past	The allergen had caused dermatitis in the past, but did not cause the current dermatitis
Exposed	The allergen had been encountered before by the patient, but the patient did not develop dermatitis at that time
Unknown	No known exposure to the allergen