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Title: Household cleaning products and the risk of allergic dermatitis: A prospective cohort study with primary-school children

Running title: Cleaning products and childhood dermatitis

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Abstract

Background: Household cleaning products are widely used by the public, but limited data have been obtained on whether their use induces allergic dermatitis in children.

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Objective: This study investigated the association between exposure to household cleaning products and allergic dermatitis in primary-school children.

Methods: A prospective cohort study of Hong Kong primary-school children was conducted between 2012 and 2014. A baseline survey was administered to 1,812 students who did not have allergic dermatitis. Information on respiratory symptoms, exposure to household chemical cleaning products and other topics was collected using a self-designed questionnaire. A cumulative chemical burden (CCB) score was calculated for each student by summing the duration of exposure to 14 chemical cleaning products. Principal component analysis was used to identify patterns in the use of these cleaning products. Logistic regression was performed to calculate relative risk (RR) with 95% confidence intervals (CIs) after adjusting for potential confounders.

Results: Eighty-nine (4.9%) of the students surveyed had dermatitis during the follow-up. However, exposure to individual chemical cleaning products was not found to be associated with the children's allergic dermatitis (all $P > 0.05$). In contrast to those in the lowest tertile, neither CCB scores in the middle tertile (RR: 1.16, 95% CI: 0.67 to 2.00) nor those in the highest tertile (RR: 1.24, 95% CI: 0.73 to 2.14) were significantly associated with the risk of allergic dermatitis. The adjusted RR for every 5-unit increment in CCB score was 1.01 (95% CI: 0.98 to 1.03). Four patterns of cleaning-product use were derived, but none were found to be associated with the risk of dermatitis (all $P > 0.05$).

Conclusion: The use of household chemical cleaning products is not associated with the risk of dermatitis in primary-school children.

Keywords: allergic dermatitis; household cleaning products; principal component analysis; children

Introduction

Allergic dermatitis is common in the cleaning industry [1]. Cleaning products contain a wide range of chemicals, some of which may damage keratinocytes and thereby cause irritant dermatitis [1]. Studies have shown that even low concentrations of chemicals may activate keratinocytes to release cytokines and cause dermatitis [2].

Regular contact with a wide range of detergent chemicals is not only common amongst occupational cleaning workers [1, 3, 4]; contact with allergens and irritants in household washing and cleaning products has also been reported [5-7]. Previous surveys have shown that up to 16.5% of household cleaning products contain hazardous chemical products [5, 8]. This figure may even be an underestimation, as products are not always correctly labelled [9].

Children are particularly vulnerable to hazardous chemicals. The prevalence of positive patch tests taken by children referred with suspected allergic contact dermatitis ranges from 27% to 95.6% [10]. Cotton et al. reported the case of a 7-year-old girl with an unusual allergic contact dermatitis due to methylisothiazolinone in laundry detergent [6]. Although a number of epidemiological studies have indicated that the use of household cleaning products has adverse effects on children's respiratory health, with consequences such as asthma, weakened lung function and rhinitis [11-15], little epidemiological research has been conducted on the association between exposure to household cleaning products and the risk of allergic dermatitis in children, despite the widespread use of household cleaning products by the public. We therefore conducted a prospective cohort study to investigate the role of household cleaning-product use in the development of allergic dermatitis in primary-school children.

Methods

Study setting and participants

The data were collected from an ongoing longitudinal prospective cohort study conducted with Hong Kong primary-school children to investigate the effects of air pollution on children's respiratory health. The rationale for this study and the methods used have been described in detail elsewhere [11, 16-18]. Of the 2,299 students from 20 primary schools who completed the

baseline survey and the first round of follow-up (at an interval of approximately 1 year) in 2012–2014, 1,812 (78.9%) students who did not report allergic dermatitis in the baseline survey were included in the current analysis. The study was approved by the Joint Chinese University of Hong Kong–New Territories East Cluster Clinical Research Ethics Committee. The study met the requirements of the Declaration of Helsinki, and written informed consent was obtained on behalf of each student by their parents or guardians.

Data collection

In both the baseline survey and the first follow-up survey, a structured questionnaire was used to collect a wide range of information on social demographics, respiratory symptoms, self-reported doctor-diagnosed disease and factors that affected the air quality in the home environment. Most of the questionnaire items were adopted from the tools of the International Study of Asthma and Allergies in Childhood (ISAAC) [19], American Thoracic Society [20], and the European Community Respiratory Health Survey [21]. The parents or guardians were required to answer the questionnaires with their children at home. In addition to filling in the questionnaire, each student received a simple health examination at school to measure anthropometric parameters and pulmonary function in both the baseline survey and the follow-up survey.

Ascertainment of allergic-dermatitis

Information on the children's experience of allergic dermatitis was collected through the questionnaires completed by their parents or guardians. Allergic dermatitis is generally defined as skin inflammation with clinical symptoms including a red rash, bumps, a burn-like rash on the skin, itchy, painful or burning skin, blisters and leaking fluid. During the survey, an affirmative answer to the question 'Has your child experienced doctor-diagnosed dermatitis in the last 12 months?' was taken to indicate a child suffering from dermatitis. If the response was 'yes', two additional questions were asked to confirm the response: 1) in which month of the last 12 did your child suffer from allergic dermatitis? and 2) in which part of the body did your child suffer from allergic dermatitis? Consistent responses to these three questions were deemed to indicate participants with allergic dermatitis.

Use of household cleaning products

Information on the use of household cleaning products was also collected using the aforementioned structured questionnaire, with details provided in a previous report [11]. Briefly, we collected information on the use of 14 common types of chemical cleaning product (bathroom cleaner, floor cleaner, glass cleaner, kitchen cleaner, tile cleaner, leather cleaner, multipurpose cleaner, non-chlorinated bleach, chlorinated bleach, sanitiser, scented air freshener, unscented air freshener, insecticide and other chemical products). First, the parents were asked 'Have you used the following household cleaning products at home in the previous 12 months?' If the response was 'yes' for any product, information was also collected regarding weekly usage frequency (less than once, 1 to 3 times, 4 to 6 times and 7 or more times) and the average duration of each use (<15 minutes, 15 to 30 minutes, 31 to 45 minutes, 46 to 60 minutes and >60 minutes). In addition, information on the use of clean water only to clean the home environment was collected.

Covariate factors

Information on a wide range of potential confounders collected in the baseline survey was used in the analysis. A questionnaire was used to collect information on age (years), gender, average size of house per member (m^2), presence at home when using cleaning products (yes, no), windows open when using cleaning products (yes, no), presence of a pet at home (yes, no), presence of a plant at home (yes, no), incense or mosquito coil burned at home (yes, no), home renovation (yes, no), passive smoking at home (yes, no), exercise per week (less than once, once or twice, three or more times), education of mother and father (primary school or lower, secondary school, tertiary school or above), parental history of atopic disease (yes, no) and child history of other atopic diseases (yes, no). Each student underwent a simple health examination at school to measure their weight and height; their body mass index (BMI) (kg/m^2) was calculated as weight in kilograms divided by height in square metres. The children's other atopic diseases were defined as doctor-diagnosed wheezing, asthma or rhinitis suffered by the children and self-reported (yes, no) in the follow-up survey.

Statistical analysis

Because information was collected on the weekly habits of use of 14 types of household cleaning product, it might not have been possible to assess the holistic effects of all product types if we had analysed the data separately for each type of product. In addition, a complete exposure profile comprised both usage frequency and duration. We thus constructed a cumulative chemical burden (CCB) score by summing the duration of exposure to the 14 chemical cleaning products during follow-up. Briefly, the categorical variable – use frequency or duration – was converted to a numerical variable using mid-point values (frequencies of 0.5, 2.0, 5.0 and 8.5 were used for the categories of less than once, 1 to 3 times, 4 to 6 times, and 7 or more times, respectively; and duration values of 7.5, 23.0, 38.0, 52.5 and 75 were used for the categories of less than 15 minutes, 15 to 30 minutes, 31 to 45 minutes, 46 to 60 minutes and more than 60 minutes, respectively). Next, CCB scores were calculated using the following formula:

$$CCB = \sum_{i=1}^{14} \left(Fre_i \times Dur_i \times \frac{52}{60} \right) * Time$$

where *CCB* is given in hours, *i* refers to the specific chemical cleaning product, ***Fre*** refers to the weekly frequency of use of a certain chemical product (unit: times/week), ***Dur*** refers to the average duration of each use (unit: minutes/time), and ***Time*** refers to years of follow-up (unit: years). ***Fifty-two*** indicates that a year has 52 weeks (unit: weeks/years). ***Sixty*** indicates that every hour has 60 minutes (unit: minutes/hours).

We used principal component analysis to extract patterns of cleaning-product use for the 14 types of chemical cleaning products and clean water. The factors were labelled based on our interpretation of the data. In the principal component analysis [prcomp package], each pattern score for each student was generated using the regression method. Varimax transformation was adopted to generate a simple structure with greater interpretability. Four patterns of cleaning-product use were derived using eigenvalues (> 1.0), a scree plot, the Kaiser–Meyer–Olkin measure of sampling and Bartlett’s test of sphericity, and by measuring factor interpretability [22, 23]. CCB and pattern scores were converted to categorical variables using the tertile method.

Logistic regression was performed to assess the relationship between the use of cleaning products and the incidence of dermatitis. Unadjusted and adjusted relative risk (RR) and 95%

confidence intervals (95% CI) were calculated using univariate and multivariate models, respectively. In addition, the CCB and pattern score categories were included as numerical variables in the logistic model to test for a linear trend. The effects of every 5-unit increment in CCB score or pattern score on the incidence of dermatitis were also calculated. Sensitivity analysis was conducted for comparison by removing the seven students with CCB scores above 1,200. We also performed subgroup analysis by children's other atopic diseases and parental history of atopic disease.

The statistical analysis was performed using R software (version 3.1.3). *P* values were derived from two-sided statistical tests, and a *P* value of less than 0.05 was considered to indicate statistical significance.

Results

Of the 1,812 children, 89 (4.9%) reported doctor-diagnosed allergic dermatitis and 584 (32.2%) reported other atopic diseases during follow-up. Table 1 presents the general characteristics of the participants at baseline. The mean value (standard deviation) for age was 10.1 (0.9) years, and the mean value (standard deviation) for BMI was 17.3 (3.1) kg/m². Boys made up 48.8% of the students. No significant differences in age were observed between the boys and girls (*P* = 0.484).

Kitchen cleaners (37.33 hours), floor cleaners (32.95 hours) and bathroom cleaners (26.16 hours) were the three most frequently used chemical cleaning products (Supplementary Table S1). The median (inter-quartile) of the CCB score was 101.04 (183.17) hours for boys and 94.75 (167.2) hours for girls; no significant difference was observed between genders (*P* = 0.494). Therefore, the data obtained from boys and girls were analysed together. The median (inter-quartile) of the CCB scores for all students was 97.95 (175.70) hours. Seven students had CCB scores exceeding 1,200 hours. The distribution of CCB scores across the students is shown in Figure 1.

Four cleaning-product use patterns were derived by principal component analysis (Supplementary Table S2). The first factor, which had the highest factor loadings for bathroom cleaners, floor cleaners, glass cleaners, kitchen cleaners, tile cleaners, leather cleaners, multipurpose cleaners and non-chlorinated bleach, was labelled pattern I and explained about

21.0% of the total variance. The second factor, which had the highest factor loadings for chlorinated bleach, sanitisers and scented air fresheners, was labelled pattern II and explained about 10.0% of the total variance. The third pattern, with the highest factor loadings for unscented air fresheners and insecticides, was labelled pattern III and explained about 8.1% of the total variance. The last factor, with the highest factor loading for clean water, was labelled pattern IV and explained about 7.1% of the total variance.

Exposure to each chemical cleaning product was not found to be significantly associated with the risk of allergic dermatitis before and after adjusting for potential confounders (Table 2). Table 3 shows the association between CCB score and incidence of allergic dermatitis. Compared with the students with CCB scores in the lowest tertile, students with CCB scores in the middle tertile (RR: 1.16, 95% CI: 0.67 to 2.00) and the highest tertile (RR: 1.24, 95% CI: 0.73 to 2.14) were not significantly associated with the risk of allergic dermatitis. Similarly, every 5-unit increment in CCB score was not significantly associated with the risk of allergic dermatitis (RR: 1.01, 95% CI: 0.98 to 1.03). The analysis was repeated 14 times, consecutively removing one type of chemical cleaning product, and no significant change was observed in the association between CCB score and incidence of allergic dermatitis (data not shown). Sensitivity analysis yielded similar results after removing seven students with CCB scores exceeding 1,200 hours (Supplementary Table S3).

Before and after adjusting for confounders, no significant association was observed between the risk of allergic dermatitis and any pattern derived with principal component analysis, regardless of whether the pattern score was taken as a continuous variable or a categorical variable (Table 4).

No significant associations were observed between cleaning-product use and allergic dermatitis in the subgroup analysis stratified by parental history of atopic disease or by children's history of other atopic diseases (Supplementary Tables S4-S5).

Discussion

To the best of our knowledge, this is the first cohort study to investigate the relationship between household cleaning products and the incidence of allergic dermatitis in Asian children. We found

that the use of domestic chemical cleaning products is not associated with the risk of allergic dermatitis, after controlling for a wide range of potential confounding factors.

We investigated the effects of household cleaning-product use on the risk of dermatitis in three dimensions. First, we assessed the relationship between the incidence of allergic dermatitis and exposure to 14 individual detergents, but found no association. Second, we used CCB scores to assess the overall effects of the use of the 14 types of cleaning product and found no significant association. Finally, we used principal component analysis to retrieve product-use patterns and assess the relationship between each pattern and the risk of dermatitis. Again, we found no significant association.

In contrast with the results of previous studies, Swain et al. reported that contact dermatitis is most commonly experienced as a result of exposure to non-pod detergents [24]. Allergic dermatitis is fairly frequent among occupational cleaning workers [1, 3]. However, the risk of contracting allergic dermatitis from household cleaning products is low [25]. Laundry detergents appear to be a rare cause of allergic dermatitis [26]. Similarly, our study did not reveal any association between the risk of allergic dermatitis and chemical cleaning product exposure amongst primary-school children. Although fragrance ingredients in cosmetics may lead to allergic dermatitis [27, 28], the risk of contracting a fragrance contact allergy from household cleaning products is low [29]. We consistently failed to find an association between scented air fresheners and the risk of dermatitis.

Chemicals in cleaning products may directly damage keratinocytes and thereby produce irritant contact dermatitis, constituting a potential mechanism of the relationship between cleaning-product use and allergic dermatitis [2]. Contact dermatitis caused by detergents has been observed in professional workers, but not in residents in household environments, primarily because exposure time and exposure dose are much lower for residents than professional workers. It has been reported that more than 50% of the whole cleaning process undertaken by professional cleaning workers is wet work, with hands exposed to water and other skin irritants (e.g., acids, alkaline agents, solvents) for most of the cleaning time [30]. In addition, the target population of our study was children. Their skin is seldom directly exposed to chemical cleaning products, because parents and household workers are more likely to conduct cleaning work than

children. Indirect exposure (via air concentrations of volatile chemicals from cleaning products) is associated with a much lower risk than direct exposure to products via the skin. In contrast, adverse effects on respiratory health, which have been reported in many previous studies to be associated with the use of cleaning products, may result from inhaling low air concentrations of chemicals. The respiratory system is much more sensitive to chemicals than is the skin system. This may also explain the lack of significant associations observed between dermatitis and the use of household cleaning products in this study.

Amongst the strengths of this study are its prospective cohort design, high response rate and adjustment for a wide range of confounders. However, the study had certain limitations. First, the outcome measure was doctor-diagnosed allergic dermatitis self-reported by parents or guardians. The children did not undergo diagnostic patch testing for allergic dermatitis. Second, objective measurement of the chemical levels would be ideal but it is less practical in a study with a large sample. Therefore, a structured questionnaire was used to collect the data for this study. Using questionnaires might result in misclassification of exposure estimates. Generally, this kind of misclassification is random (i.e., non-differential) and may dilute an association. However, we minimised this effect by categorising the exposure into tertiles. Thus, the non-differential misclassification should not affect our conclusion. Further studies with validated and more accurate assessment methods are warranted. Third, we did not identify the specific chemical ingredients of the cleaning products. Therefore, no inferences could be drawn regarding the effects of specific chemicals and/or the joint effects of different chemical ingredients. Finally, despite recruiting a large sample, the incidence of dermatitis was relatively low. We advise future researchers to use larger samples and a longer follow-up period to increase statistical power.

In conclusion, the results of this study indicate that the use of household chemical cleaning products is not associated with the risk of allergic dermatitis in primary-school children.

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Table 1 Basic characteristics of study subjects in baseline survey

Variables	Total (N = 1812)	Non-cases (N = 1723)	Cases (N = 89)	P value
	Mean (SD)			
Age, years	10.1 (0.9)	10.1 (0.9)	10.0 (0.9)	< 0.001 [*]
Body mass index, kg/m ²	17.3 (3.1)	17.2 (3.1)	17.4 (2.7)	< 0.001 [*]
Average size of house for each member, m ²	9.4 (4.0)	9.4 (4.0)	8.7 (3.8)	< 0.001 [*]
	N (%)			
Gender, female	884 (48.8)	837 (48.6)	47 (52.8)	0.503 [†]
Passive smoking at home, yes	400 (22.1)	377 (21.9)	23 (25.8)	0.455 [†]
Pet at home, yes	187 (10.3)	177 (10.3)	10 (11.2)	0.910 [†]
Plant at home, yes	827 (45.6)	791 (45.9)	36 (40.4)	0.369 [†]
Incense/mosquito coil burned at home, yes	450 (42.8)	430 (25.0)	20 (22.5)	0.687 [†]
New furniture or repair work at home, yes	422 (23.3)	398 (23.1)	24 (26.9)	0.476 [†]
Carpet at home	288 (15.9)	274 (15.9)	14 (15.7)	0.980 [†]
Mould at home	672 (37.1)	635 (36.9)	37 (41.6)	0.432 [†]
Weekly physical activity				0.847 [†]
Never/less than once	462 (24.5)	437 (25.4)	25 (28.1)	
Once or twice	1011 (55.8)	963 (55.9)	48 (53.9)	
At least three times	339 (8.7)	323 (18.7)	16 (18.0)	
Education of father				0.193 [†]
Primary school or lower	184 (10.2)	170 (9.9)	14 (15.7)	
Secondary school	1326 (73.2)	1266 (73.4)	60 (67.4)	
Tertiary school or above	302 (16.6)	287 (16.7)	15 (16.9)	
Education of mother				0.015 [†]
Primary school or lower	233 (12.9)	218 (12.7)	15 (16.9)	
Secondary school	1340 (73.9)	1269 (73.6)	71 (79.8)	
Tertiary school or above	239 (13.2)	236 (13.7)	3 (3.3)	
Parent history of atopic disease, yes	628 (34.6)	588 (34.1)	40 (44.9)	0.048 [†]

* T test measuring difference between students who developed allergic dermatitis and students who did not develop allergic dermatitis.

† Chi-square test measuring differences between students who developed allergic dermatitis and students who did not develop allergic dermatitis.

Table 2. Association between exposure to household chemical cleaning products and risk of allergic dermatitis

Chemical cleaning products	Unexposed (No/Yes) *	Exposed (No/Yes)	Unadjusted RR ₁ (95% CI)	Adjusted RR ₂ (95% CI) †	Adjusted RR ₃ (95% CI) ‡
Bathroom cleaners	372/16	1,351/73	1.26 (0.74, 2.26)	1.27 (0.67, 2.58)	1.11 (0.51, 2.57)
Floor cleaners	700/33	1,023/56	1.16 (0.75, 1.82)	1.18 (0.74, 1.92)	1.07 (0.63, 1.86)
Glass cleaners	1,208/59	515/30	1.19 (0.75, 1.86)	1.23 (0.76, 1.95)	1.22 (0.70, 2.08)
Kitchen cleaners	470/25	1,253/64	0.96 (0.61, 1.57)	0.90 (0.53, 1.57)	0.66 (0.35, 1.27)
Tile cleaners	1,245/66	478/23	0.91 (0.55, 1.45)	0.91 (0.55, 1.49)	0.77 (0.43, 1.34)
Leather cleaners	1,481/74	242/15	1.24 (0.68, 2.14)	1.32 (0.71, 2.31)	1.24 (0.63, 2.33)
Multipurpose cleaners	1,093/48	630/41	1.48 (0.96, 2.27)	1.49 (0.94, 2.35)	1.46 (0.88, 2.41)
Non-chlorinated bleach	1,030/51	693/38	1.11 (0.72, 1.70)	1.07 (0.68, 1.68)	0.96 (0.59, 1.56)
Chlorinated bleach	1,305/70	418/19	0.85 (0.49, 1.39)	0.80 (0.46, 1.35)	0.71 (0.39, 1.22)
Sanitisers	918/38	805/51	1.53 (1.00, 2.37)	1.55 (0.98, 2.48)	1.57 (0.95, 2.62)
Scented air fresheners	1,480/76	243/13	1.04 (0.55, 1.84)	1.00 (0.52, 1.80)	0.93 (0.46, 1.75)
Unscented air fresheners	1,669/86	54/3	1.08 (0.26, 3.00)	1.11 (0.26, 3.17)	0.99 (0.22, 3.14)
Insecticides	1,368/70	355/19	1.05 (0.61, 1.72)	0.95 (0.54, 1.59)	0.88 (0.49, 1.51)
Other cleaners	1,713/89	10/0	--	--	--

* 'Unexposed' means that the student was not exposed to a given chemical cleaning product. 'Exposed' means that the student was not exposed to a given chemical cleaning product. 'Yes' represents the number of students with allergic dermatitis. 'No' represents the number of students without allergic dermatitis.

† Adjustment for age, body mass index, gender, average size of house for each member, education of father, education of mother, passive smoking at home, pet at home, carpet at home, mould at home, plant at home, new furniture or repair work at home, incense/mosquito coil burned at home, children's other atopic diseases, parental history of atopic disease and weekly physical activity.

‡ Adjustment for confounders mentioned above and for all 15 cleaners.

Table 3. Association between cumulative chemical burden score and risk of allergic dermatitis

	N (no/yes) *	Unadjusted RR ₁ (95% CI)	Adjusted RR ₂ (95% CI) †
Tertile 1	584/27	1.00	1.00
Tertile 2	568/30	1.14 (0.67, 1.96)	1.16 (0.67, 2.00)
Tertile 3	571/32	1.21 (0.72, 2.06)	1.24 (0.73, 2.14)
P for trend		0.47	0.60
Every 5-unit increment		1.01 (0.99, 1.03)	1.01 (0.98, 1.03)

* N represents the number of students in each category; 'Yes' represents the number of students with allergic dermatitis; 'No' represents the number of students without allergic dermatitis.

† Adjustment for age, body mass index, gender, average size of house for each member, education of father, education of mother, passive smoking at home, presence of pet at home, presence of carpet at home, presence of mould at home, presence of plant at home, presence of new furniture or repair work at home, burn incense/mosquito coil at home, children's other atopic diseases, parental history of atopic disease and weekly physical activity.

Table 4. Association between pattern of cleaning-product usage derived by principal component analysis and risk of allergic dermatitis

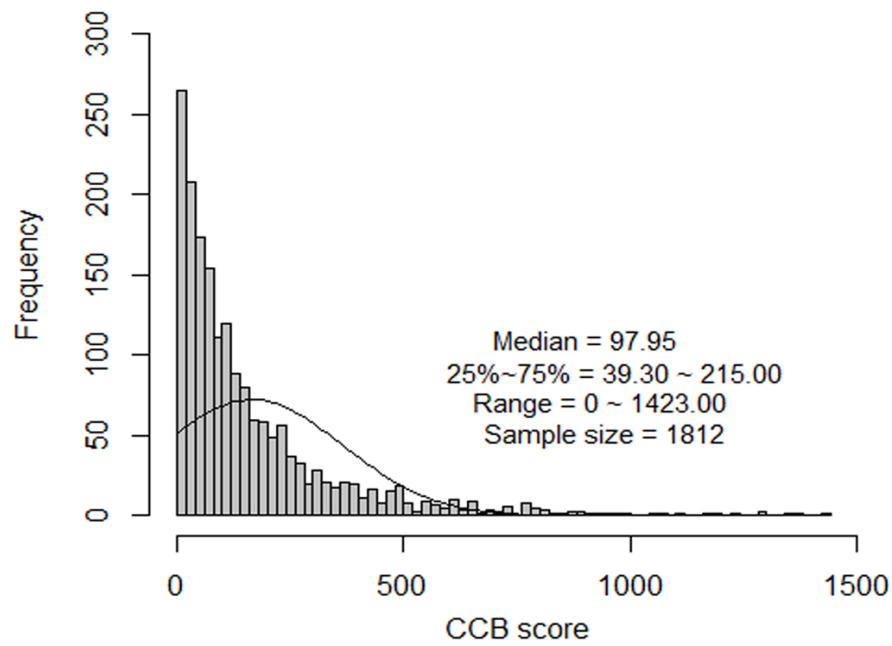
Pattern score	N (No/Yes) *	Unadjusted RR ₁ (95% CI)	Adjusted RR ₂ (95% CI) †	Adjusted RR ₃ (95% CI) ‡
Pattern I				
Tertile 1		1.00	1.00	1.00
Tertile 2	573/31	0.80 (0.46, 1.37)	0.80 (0.46, 1.38)	0.88 (0.50, 1.54)
Tertile 3	579/25	1.07 (0.64, 1.77)	1.08 (0.65, 1.81)	1.34 (0.75, 2.41)
<i>P</i> for trend	571/33	0.79	0.42	0.66
Every 5-unit increment		1.61 (0.64, 3.16)	1.60 (0.64, 3.2)	1.59 (0.62, 3.22)
Pattern II				
Tertile 1		1.00	1.00	1.00
Tertile 2	580/25	1.47 (0.88, 2.51)	1.52 (0.90, 2.61)	1.62 (0.93, 2.87)
Tertile 3	567/36	1.13 (0.65, 1.97)	1.16 (0.66, 2.03)	1.20 (0.68, 2.15)
<i>P</i> for trend	576/28	0.69	0.12	0.33
Every 5-unit increment		0.91 (0.23, 2.24)	0.90 (0.23, 2.3)	0.95 (0.26, 2.31)
Pattern III				
Tertile 1		1.00	1.00	1.00
Tertile 2	577/27	1.24 (0.73, 2.09)	1.18 (0.69, 2.01)	1.17 (0.64, 2.14)
Tertile 3	571/33	1.08 (0.63, 1.85)	1.05 (0.61, 1.82)	1.01 (0.58, 1.77)
<i>P</i> for trend	575/29	0.79	0.55	0.09
Every 5-unit increment		1.33 (0.46, 2.54)	1.41 (0.48, 2.76)	1.41 (0.50, 2.73)
Pattern IV				
Tertile 1		1.00	1.00	1.00
Tertile 2	573/31	0.97 (0.58, 1.62)	0.99 (0.58, 1.67)	1.05 (0.61, 1.80)
Tertile 3	574/30	0.90 (0.53, 1.52)	0.93 (0.54, 1.59)	1.02 (0.58, 1.78)
<i>P</i> for trend	576/28	0.69	0.97	0.52
Every 5-unit increment		0.71 (0.24, 2.05)	0.78 (0.26, 2.23)	0.86 (0.30, 2.27)

* 'N' represents the number of students in each category; 'Yes' represents the number of students with allergic dermatitis; 'No' represents the number of students without allergic dermatitis.

† Adjustment for age, body mass index, gender, average size of house for each member, education of father, education of mother, passive smoking at home, presence of pet at home, presence of carpet at home, presence of mould at home, presence of plant at home, presence of new furniture or repair work at home, incense/mosquito coil burned at home, children's other atopic diseases, parental history of atopic disease and weekly physical activity.

‡ Adjustment for abovementioned confounders as well as the four patterns.

Figure 1. Histogram of CCB scores



Household cleaning products and the risk of allergic dermatitis: A prospective cohort study with primary-school children

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Supplementary files

Table S1. Mean of cumulative exposure time to each cleaning product during follow-up

Table S2. Rotated loading for major factors via principal component analysis

Table S3. Association between risk of allergic dermatitis, CCB score and pattern score after removing seven students with CCB scores exceeding 1200 hours

Table S4. Association between risk of allergic dermatitis, CCB score and pattern score based on parental history of atopic diseases

Table S5. Association between CCB score and risk of allergic dermatitis based on children's history of other atopic diseases

Table S1. Mean of cumulative exposure time to each cleaning product during follow-up

Cleaning product	Mean cumulative exposure time (hours)
Bathroom cleaner	26.16
Floor cleaner	32.95
Glass cleaner	5.89
Kitchen cleaner	37.33
Tile cleaner	7.60
Leather cleaner	2.95
Multipurpose cleaner	13.40
Non-chlorinated bleach	9.35
Chlorinated bleach	5.89
Sanitiser	17.77
Scented air freshener	8.54
Unscented air freshener	1.15
Insecticide	1.94
Other cleaners	2.97
Clean water	73.64

Table S2. Rotated loading for major factors via principal component analysis *

Items	Pattern I	Pattern II	Pattern III	Pattern IV
Bathroom cleaner	0.59	0.22	0.13	0.18
Floor cleaner	0.67	0.10	-0.05	-0.11
Glass cleaner	0.78	0.01	0.00	-0.16
Kitchen cleaner	0.62	0.08	0.13	0.19
Tile cleaner	0.69	0.11	0.04	0.03
Leather cleaner	0.56	0.07	0.02	-0.29
Multipurpose cleaner	0.52	0.38	0.06	0.21
Non-chlorinated bleach	0.57	0.06	0.04	0.21
Chlorinated bleach	0.15	0.64	-0.04	-0.27
Sanitiser	0.21	0.65	-0.02	0.03
Scented air freshener	-0.07	0.48	0.37	0.06
Unscented air freshener	0.02	-0.08	0.70	-0.05
Insecticide	0.12	0.10	0.69	0.04
Other chemical cleaners	-0.05	0.28	-0.23	0.16
Clean water	0.06	0.02	-0.03	0.82
Proportion of variance	3.14	1.52	1.21	1.06
Cumulative variance (%)	21.0	10.0	8.1	7.1
Proportion explained (%)	21.0	31.0	39.1	46.2
Cumulative proportion (%)	45.3	21.9	17.4	15.3
Cumulative Proportion (%)	45.3	67.2	84.7	100.0

* Factor loadings of 0.40 or greater were the dominant components. The Kaiser–Meyer–Olkin factor adequacy was 0.76 (> 0.5 regarded as acceptable). P-value for Bartlett’s test of sphericity was less than 0.001 (< 0.001 accepted).

Table S3. Association between risk of allergic dermatitis, CCB score and pattern score after removing seven students with CCB scores exceeding 1200 hours

	N (No/Yes) *	Unadjusted RR ₁ (95% CI)	Adjusted RR ₂ (95% CI) †
Tertile 1	584/27	1.00	1.00
Tertile 2	568/30	1.14 (0.67, 1.96)	1.15 (0.67, 1.99)
Tertile 3	565/31	1.19 (0.70, 2.03)	1.21 (0.71, 2.10)
<i>P</i> for trend		0.527	0.603
Every 5-unit increment		1.01 (0.99, 1.03)	1.01 (0.98, 1.03)

* 'N' represents the number of students in each category; 'Yes' represents the number of students with allergic dermatitis; 'No' represents the number of students without allergic dermatitis. CCB denotes cumulative chemical burden.

† Adjustment for age, body mass index, gender, average size of house for each member, education of father, education of mother, passive smoking at home, presence of a pet at home, presence of a carpet at home, presence of mould at home, presence of a plant at home, presence of new furniture or repair work, incense/mosquito coil burned at home, children's other atopic diseases, parent history of atopic disease and weekly physical activity.

‡ Adjustment for abovementioned confounders and four patterns.

Table S4. Association between risk of allergic dermatitis, CCB score and pattern score based on parental history of atopic diseases

	N (No/Yes)	Unadjusted RR ₁ (95% CI)	Adjusted RR ₂ (95% CI) [†]
Parental history of atopic diseases (No)			
Tertile 1	403/17	1.00	1.00
Tertile 2	367/20	1.29 (0.67, 2.53)	1.31 (0.67, 2.59)
Tertile 3	353/19	1.28 (0.65, 2.52)	1.34 (0.67, 2.67)
<i>P</i> for trend		0.475	0.431
Every 5-unit increment		1.01 (0.98, 1.04)	1.01 (0.98, 1.04)
Parental history of atopic diseases (Yes)			
Tertile 1	174/9	1.00	1.00
Tertile 2	202/13	1.24 (0.52, 3.08)	1.26 (0.51, 3.19)
Tertile 3	212/18	1.64 (0.74, 3.92)	1.84 (0.79, 4.55)
<i>P</i> for trend		0.226	0.620
Every 5-unit increment		1.01 (0.97, 1.03)	1.01 (0.98, 1.04)

* 'N' represents the number of students in each category; 'Yes' represents the number of students with allergic dermatitis; 'No' represents the number of students without allergic dermatitis. CCB: cumulative chemical burden.

[†] Adjustment for age, body mass index, gender, average size of house for each member, education of father, education of mother, passive smoking at home, presence of pet at home, presence of carpet at home, presence of mould at home, presence of plant at home, presence of new furniture or repair work, incense/mosquito coil burned at home, children's other atopic diseases, parental history of atopic disease and weekly physical activity.

[‡] Adjustment for the abovementioned confounders and the four patterns.

Table S5. Association between CCB score and risk of allergic dermatitis based on children's other atopic diseases

	N(No/Yes)	Unadjusted RR ₁ (95% CI)	Adjusted RR ₂ (95% CI) [†]
Children's other atopic diseases (No)			
Tertile 1	421/14	1.00	1.00
Tertile 2	388/19	1.47 (0.73, 3.03)	1.52 (0.74, 3.18)
Tertile 3	366/20	1.64 (0.82, 3.37)	1.85 (0.91, 3.85)
<i>P</i> for trend		0.165	0.253
Every 5-unit increment		1.01 (0.98, 1.03)	1.01 (0.98, 1.04)
Children's other atopic diseases (Yes)			
Tertile 1	163/13	1.00	1.00
Tertile 2	180/11	0.77 (0.33, 1.76)	0.82 (0.34, 1.96)
Tertile 3	205/12	0.73 (0.32, 1.66)	0.69 (0.29, 1.64)
<i>P</i> for trend		0.459	0.656
Every 5-unit increment		1.00 (0.96, 1.03)	1.00 (0.96, 1.03)

* 'N' represents the number of students in each category; 'Yes' represents the number of students with allergic dermatitis; 'No' represents the number of students without allergic dermatitis. CCB: cumulative chemical burden.

[†] Adjustment for age, body mass index, gender, average size of house for each member, education of father, education of mother, passive smoking at home, presence of pet at home, presence of carpet at home, presence of mould at home, presence of plant at home, presence of new furniture or repair work at home, incense/mosquito coil burned at home, parental history of atopic disease and weekly physical activity.