

Accepted Manuscript

Frequent use of household cleaning products is associated with rhinitis in Chinese children

Xudong Liu, Ph.D., Xiang Qian Lao, Ph.D., Claudie Chiu-Yi Wong, Ph.D., Lixing Tan, MPH, Zilong Zhang, M.Sc., Tze Wai Wong, MBBS, Lap-ah Tse, Ph.D., Arthur P.S. Lau, Ph.D., Ignatius T.S. Yu, MBBS

PII: S0091-6749(16)30254-8

DOI: [10.1016/j.jaci.2016.03.038](https://doi.org/10.1016/j.jaci.2016.03.038)

Reference: YMAI 12095

To appear in: *Journal of Allergy and Clinical Immunology*

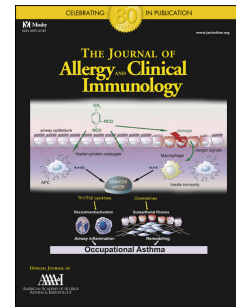
Received Date: 25 September 2015

Revised Date: 26 February 2016

Accepted Date: 3 March 2016

Please cite this article as: Liu X, Lao XQ, Wong CC-Y, Tan L, Zhang Z, Wong TW, Tse L-a, Lau APS, Yu ITS, Frequent use of household cleaning products is associated with rhinitis in Chinese children, *Journal of Allergy and Clinical Immunology* (2016), doi: 10.1016/j.jaci.2016.03.038.

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.



Title page

Title: Frequent use of household cleaning products is associated with rhinitis in Chinese children

Running title: Household cleaning products and rhinitis

Author list: Xudong Liu, Ph.D.¹, Xiang Qian Lao, Ph.D.^{1*}, Claudie Chiu-Yi Wong, Ph.D.¹, Lixing Tan, MPH¹, Zilong Zhang, M.Sc.¹, Tze Wai Wong, MBBS¹, Lap-ah Tse, Ph.D.¹, Arthur P.S. Lau, Ph.D.², Ignatius T.S. Yu, MBBS^{1,3}

Affiliations:

1. JC School of Public Health and Primary Care, The Chinese University of Hong Kong, Hong Kong SAR, China
2. Division of Environment, Hong Kong University of Science and Technology, Hong Kong SAR, China
3. Hong Kong Occupational and Environmental Health Academy, Hong Kong SAR, China

* **Address correspondence to:** Xiang Qian Lao, Ph.D., Assistant Professor; Institute: JC School of Public Health and Primary Care, The Chinese University of Hong Kong; Address: 4/F School of Public Health, Prince of Wales Hospital, Shatin, N.T., Hong Kong SAR, China. Telephone number: +852 22528763. Fax: +852 26063500. E-mail: xqlao@cuhk.edu.hk

Fund sources: The study was funded by the Hong Kong General Research Fund (No. CU11688) and the Health Medical Research Fund (No. 11121101). The founders had no role in the design, analysis or writing of this manuscript.

Author's contribution: XQL conceived and designed this study; CCW, LT and ZZ collected the data under the supervision of XQL and IY; XDL and LT analyzed the data; XDL drafted the manuscript; XQL, AL, TWW, LT and IY edited and reviewed the manuscript. All co-authors provided critical comments and approved the final version. The authors declare that they have no conflict of interests.

Abstract

Background: Despite the popular usage of household cleaning products worldwide, there is no published study investigating the health effects of the products on rhinitis in children.

Objective: To investigate the household use of cleaning products and rhinitis patterns in Chinese children.

Methods: A total of 2,299 children were recruited from 21 primary schools with wide geographical coverage in Hong Kong. Self-administered questionnaires were completed by parents/guardians to collect detailed information on respiratory symptoms and household use of fourteen types of chemical cleaning products as well as clean water. Students were categorized into four mutually exclusive rhinitis patterns (never, occasional, frequent, and persistent). The total chemical burden (TCB) score was used as the exposure indicator by calculating the total time of exposure to the fourteen cleaning products. Multinomial logistic regression was used to assess the relationship between rhinitis patterns and the usage of household cleaning products.

Results: Every 10-unit increment of TCB score was associated with an increase in odds of occasional (odds ratio (OR): 1.21, 95% confidence interval (CI): 1.05 - 1.41), frequent (OR: 1.36, 95% CI: 1.13 - 1.60), and persistent (OR: 1.21, 95% CI: 1.01 - 1.56) rhinitis after adjustment for a wide range of potential confounders. Compared to the children within the lowest tertile of TCB score, the adjusted ORs (95% CI) of occasional, frequent, and persistent rhinitis in children within the highest tertile were 1.29 (1.01 - 1.65), 1.97 (1.40–2.76), and 1.67 (1.10 - 2.54), respectively.

Conclusion: Frequent use of chemical cleaning products at home is associated with an increase in the odds of rhinitis in Chinese primary school children.

Keywords: rhinitis; household cleaning products; school-age children

23

Capsule Summary

24 Household cleaning products are commonly used worldwide and previous studies show an increased
25 risk of rhinitis among cleaning workers. Usage of cleaning products at home may also impact the
26 prevalence of rhinitis in primary school children.

27

Key Messages

28

29

30

- Frequent use of chemical cleaning products at home is associated with an increase in the odds of rhinitis in primary school children.
- Clean water should be preferred for cleaning home environment.

Abbreviations used

- 31
- 32 **TCB score:** Total chemical burden score, defined as the cumulative time of exposure to 14 chemical
- 33 cleaning products.
- 34 **OR:** Odds ratio;
- 35 **CI:** Confidence interval;
- 36 **BMI:** Body mass index
- 37 **PCFA:** principal components and factor analysis
- 38 **ISAAC:** the International Study of Asthma and Allergies in Childhood

Introduction

Household cleaning products are commonly used worldwide to enhance domestic cleanliness and hygiene. Despite their apparent benefits, they can also be of significant concern with regard to indoor air pollution. With their different functions and the various scents added to many of them, a wide range of chemicals could be involved in the active ingredients.¹

Despite their common usage amongst the general population, there is limited information on the health effects of such cleaning products. Occupational exposure to cleaning products has shown that there is an increased risk of asthma and rhinitis among cleaning workers², and this suggests that there is potential hazardous exposure to cleaning products in the general population. Studies in adult women, who are generally the primary users of these household cleaning products in the home, indicate that the frequent use of cleaning products and hypochlorite bleach might be important factors of adult asthma and respiratory symptoms.³⁻⁶ Children are certainly vulnerable because of their longer stay time at home, smaller lung airway, and immature immune system⁷. We speculate that the health impact of the exposure to household cleaning products in children can be significant. Several birth cohorts have shown that the prenatal usage of cleaning products might increase the risk of wheezing, infections, and other respiratory symptoms in early life^{8,9} and in pre-school children^{10,11}. Only a few studies have investigated the respiratory health impact of the current usage of cleaning products and the controversy remains: Nickmilder *et al.* found a protective effect of cleaning products on asthma and allergic sensitization whereas Casas *et al.* showed adverse impacts on wheezing and pulmonary function.¹²⁻¹⁴

To our knowledge, there are no published studies which assess the health impacts of cleaning products on rhinitis in children. Rhinitis is one of the most common respiratory conditions. It is an irritation and inflammation of the mucous membrane lining of the nose, characterized by stuffy nose, runny nose,

sneezing, rhinorrhea, and post-nasal drip for two or more consecutive days and lasting for more than an hour on most days.¹⁵ Rhinitis causes a considerable global burden with significant damage to the economy and it has a remarkable influence on the quality of the life.¹⁶ It has also emerged as a common condition associated with substantial morbidity in childhood.¹⁷⁻¹⁹ The International Study of Asthma and Allergies in Childhood (ISAAC) have reported that the prevalence of life-time rhinitis and current rhinitis has increased significantly in school-age children.²⁰ We therefore investigated the health impacts of common cleaning products on rhinitis in a large population of Chinese children.

Method

Setting and participants

The present data analysis is from an ongoing longitudinal prospective cohort study^{21, 22} that aims to investigate respiratory health effects of indoor air pollution. The sample size was calculated by using EpiTools calculators²³. The rhinitis prevalence in our pilot study was about 20%; The effect size for rhinitis was 1.30 (95% CI: 1.20 - 1.40) among Children²⁴; A total of 2058 students were estimated to reach a statistic power of 90% with the confidence level of 0.95. To compensate for possible attrition and take into account the needs of other research questions, we planned to recruit around 2400 students at the beginning of the study.

During the study, a total of 21 primary schools were randomly selected in the four regions (Hong Kong/outlying islands, Kowloon, New Territories East, and New Territories West) of Hong Kong. To facilitate the spirometry test and the follow-up, all students from grades two to four in each school were invited to participate in the study. A total of 2,477 students were recruited and the baseline data was successfully collected for 2,415 (97.5%) students in 2012 and 2013. We plan to follow up the

students twice during a two-year period (once per year). The first round of follow-up was completed at the end of 2014. One school withdrew from the study during the first round of follow-up but the follow-up data collection was successfully completed for a total of 2,299 children.

In both the baseline and the first follow-up surveys, the parents or guardians of each participant were required to complete a detailed self-administered questionnaire. The questionnaire was composed mainly of items adopted from the questionnaires of the American Thoracic Society, the ISAAC studies, and the European Community Respiratory Health Survey.²⁵⁻²⁸ The questionnaire collected extensive information on each child's respiratory health status, including respiratory symptoms, allergic symptoms, and respiratory problems. Each participant also received a health examination that measured anthropometric parameters and pulmonary function in both baseline and the first follow-up surveys. This study was approved by the Joint Chinese University of Hong Kong–New Territories East Cluster Clinical Research Ethics Committee. The students' parents or guardians were required to sign a written informed consent for their children to participate in the study.

Data collection

Rhinitis

Questionnaires were completed by parents or guardians at baseline and follow-up to collect information on non-infectious rhinitis in the children. Non-infectious rhinitis was defined as affecting those children who have “ever had nasal symptoms such as nasal blockage, sneezing, and running nose as well as itching eye or lachrymation in the absence of common cold in previous 12 months”. Those who answered “yes” were asked to state the months when they suffer from rhinitis. The baseline questionnaire collected information from the previous 12 months before the baseline interview. The

follow-up questionnaire collected information during the one-year follow-up period. The 24-month period was then divided into eight mutually exclusive seasons relevant to Hong Kong's weather: 2012 winter (December 2011–February 2012), 2012 spring (March 2012–May 2012), 2012 summer (June 2012–August 2012), 2012 autumn (September 2012–November 2012), 2013 winter (December 2012–February 2013), 2013 spring (March 2013–May 2013), 2013 summer (June 2013–August 2013), 2013 autumn (September 2013–November 2013). Each student was categorized into one of the four mutually exclusive rhinitis patterns, namely, never (no rhinitis in any season), occasional (had rhinitis in less than three seasons), frequent (had rhinitis in three or more seasons but did not have rhinitis in four or more consecutive seasons), and persistent (had rhinitis in four or more consecutive seasons).

Exposure to household cleaning products

Information on exposure to household cleaning products was collected by the questionnaire. “Did you use the following household cleaning products at home in the previous 12 months?” was one of the required answers of the baseline survey. The 14 common types of chemical cleaning products included: those for cleaning bathroom; floor; glass; kitchen; tiles; leather; multi-purpose cleaners; non-chlorinated bleach; chlorinated bleach; sanitizers; scented air fresheners; non-scented air fresheners; insecticides; and others. If the response was “yes” to any type of these cleaners, then information on the weekly usage frequency (< 1 time, 1–3 times, 4–6 times, and ≥ 7 times) and the average duration of each use (< 15 minutes, 15–30 minutes, 31–45 minutes, 46–60 minutes, and > 60 minutes) were collected. In addition, information on the usage of clean water only for cleaning the home environment was also sought.

Potential confounding factors

Information on a wide range of potential confounders was also collected. We used a questionnaire to collect information on age (years), gender (male and female), average size of house for each member (m^2), present at home when using cleaning products (yes vs no), windows opened when using cleaning products (yes vs no), keeping a pet at home (yes vs no), keeping a plant at home (yes vs no), burning incense or mosquito coil at home (yes vs no), home renovation (yes vs no), passive smoking at home (yes vs no), exercise per week (never/less than once per week, once to twice per week, at least three times per week), education of mother and father (primary school or lower, secondary school, tertiary school or above), and atopic status. Atopic status was defined based on self-reported doctor-diagnosed eczema and/or asthma (yes vs no). In addition, each student received a simple health examination to measure weight and height at school in baseline and follow-up surveys, then body mass index (kg/m^2) was calculated by data from the latest survey. The $\text{PM}_{2.5}$ level (mg/m^3) in the school environment was measured in the first year by using Dust Trak (TSI) aerosol monitor. To address seasonal variation, we conducted two measurements; one was in the cool season (winter and spring), and the other in the warm season (summer and autumn). The average level was used in the present analysis.

Statistical analysis

Statistical analyses were performed by using R-software (version 3.1.2). All p -values were derived from two-sided statistic tests and less than 0.05 was considered to be statistically significant.

As the usage frequency and duration variables were categorical, we used the mid-point value of each category for score calculation (*i.e.*, frequency: we used 0.5, 2.0, 5.0, and 8.5 for < 1 time, 1–3 times, 4–6 times, and ≥ 7 times, respectively; duration: we used 7.5, 23.0, 38.0, 52.5, and 75 for < 15 minutes, 15–30 minutes, 31–45 minutes, 46–60 minutes, and > 60 minutes, respectively). The total chemical burden (TCB) score was calculated to indicate exposure level to the 14 types of chemical cleaning

agents for each participant. The TCB score was defined as the cumulative time of exposure to 14 chemical products, and the formula was: $TCB = \sum_{i=1}^{14} (Fre_i \times Dur_i)$. *Fre* refers to the weekly frequency of usage of a certain chemical product; *Dur* refers to the average duration of each use; and *i* represents the specific chemical cleaning product.

Cleaning products usage patterns were extracted by using the principal components and factor analysis (PCFA) method based on 14 types of chemical cleaning products as well as clean water [Package “princomp”]. The statistical score of each participant in each usage pattern was generated by using the regression method. Orthogonal (varimax) transformation was adopted to achieve simple structure with greater interpretability. In determining the number of factors to retain, eigenvalues (> 1.0), the scree plot construction, Kaiser–Meyer–Olkin measure of sampling, Bartlett’s test of sphericity, and the interpretability of the factors were considered^{29, 30}. Cleaning products with absolute rotated factor loadings ≥ 0.50 are referred to as “dominant components” hereafter. The labeling of factors was based on our interpretation of the data. A positive loading for a cleaning product indicated a direct association with the pattern, whereas a negative loading suggested that the cleaning product contributed inversely to the pattern.

Multinomial logistic regression models (Package “nnet”) were used to assess the relationship between the usage of cleaning products and the rhinitis pattern, with the “never” rhinitis pattern as the reference category. Separate models were conducted by using the score as continuous and categorical variables (tertiles). Stepwise strategy was adopted to select the confounding factors. Unadjusted and adjusted odds ratios (ORs) with 95% confidence intervals (95% CI) were calculated for all rhinitis patterns by comparing them with the “never” rhinitis. The likelihood ratio test statistic was used to determine whether there was linear relationship between TCB score and rhinitis patterns¹⁰. For each rhinitis

pattern there was no evidence against the hypothesis that the effect of the TCB score is linear (occasional rhinitis: $P = 0.039$; frequent rhinitis: $P < 0.001$; persistent rhinitis: $P = 0.001$). Test for trend was performed when the tertile was taken as a numeric variable in the model.

Results

A total of 2,299 children with complete information were included in the analysis. Table 1 presents the general characteristics of the participants at baseline. The mean (S.D.) of age was 10.1 (0.9) years and the mean BMI was 17.9 (3.3) kg/m². 48.5% of the participants were boys.

Regarding the rhinitis pattern, 1,260 (54.8%) students were grouped into “never”, 798 (34.7%) were “occasional”, 135 (5.9%) were “frequent”, and 106 (4.6%) were “persistent” rhinitis sufferers. No significant difference was found between the boys and the girls in the distribution of the rhinitis patterns ($p = 0.443$).

The students had higher exposure to clean water (2.51 hours/week), floor cleaners (1.30 hours/week), kitchen cleaners (1.15 hours/week), and bathroom cleaners (0.91 hours/week), but less exposure to non-scented air fresheners (0.04 hours/week), insecticides (0.07 hours/week), and other chemical cleaners (0.06 hours/week). The weekly exposure duration is presented in Table E1 in the Online Repository. No significant differences were observed between boys and girls (all p values > 0.05).

The TCB score of each participant was calculated based on the aforementioned formula. The median (inter-quartile) of the TCB score was 3.86 (6.34) hours/week for boys and 3.93 (6.18) hours/week for girls. There was no significant difference between boys and girls ($p = 0.723$). Therefore, the combined data of boys and girls were used for data analysis. Figure E1 in the Online Repository displayed the

distribution of the TCB score for all students. Five students had TCB score of more than 50 hours/week.

Four major factors were extracted and labeled as cleaning product usage pattern I, II, III, and IV (Table E2 in the Online Repository). Pattern I was characterized by a higher factor loading of bathroom cleaners, floor cleaners, glass cleaners, kitchen cleaners, tile cleaners, leather cleaners, multi-purpose cleaners, and non-chlorinated bleach; pattern II was characterized by a higher factor loading of non-scented air fresheners and insecticides; pattern III was characterized by a higher factor loading of sanitizers and scented air fresheners; and pattern IV was characterized by a higher factor loading of clean water.

The relationships between rhinitis and the TCB score are presented in Tables 2 and 3. Every 10-unit increase of TCB score was associated with an increase in the odds of occasional rhinitis (OR: 1.21, 95% CI: 1.05 - 1.41), frequent rhinitis (OR: 1.36, 95% CI: 1.13 - 1.60), and persistent rhinitis (OR: 1.12, 95% CI: 1.01 - 1.56) after adjustment for potential confounders (Table 2). Compared to children within the lowest tertile of the TCB score, the adjusted OR (95% CI) of occasional, frequent, and persistent rhinitis in children within the highest tertile was 1.29 (1.01 - 1.65), 1.97 (1.40 - 2.76) and 1.67 (1.10 - 2.54), respectively (Table 3). However, no significant associations were found when comparing the middle tertile with the lowest tertile when adjusting for covariates.

To determine whether a single type of the cleaning products was responsible for any observed effect, the analyses of the association between the TCB score and the rhinitis patterns were repeated 14 times, each time removing one of the product types from the score. In all cases there was no significant change in effect sizes. Sensitivity analysis was conducted by removing the five participants whose TCB score was more than 50 hours/week and no significant change was observed. We also conducted

analysis in atopic and nonatopic students separately, and the results are presented in Tables E3 and E4 in the Online Repository. Significant positive associations were observed in nonatopic students, but no significant association was found in atopic students.

The relationships between rhinitis and four usage patterns of cleaning products are presented in Table 4 and 5. After adjusting for potential confounders, every 1-unit increase of pattern I score was significantly associated with an increase in the odds of occasional rhinitis (OR: 1.12, 95% CI: 1.01 - 1.24), frequent rhinitis (OR: 1.15, 95% CI: 1.01 - 1.30) and persistent rhinitis (OR: 1.03, 95% CI: 1.01 - 1.35); similar results were observed for pattern III, but not for patterns II and IV (Table 4). When TCB was categorized into tertile for analysis, similar results were observed after adjustment for confounders (Table 5).

Because chlorinated bleach exposure was not taken as the principle component in any patterns defined, separated analysis was conducted and the results are shown in Table E5 in the Online Repository. Compared to children within the lowest tertile of score of chlorinated bleach exposure, the adjusted OR (95% CI) of occasional, frequent, and persistent rhinitis in children within the highest tertile was 1.16 (0.92 - 1.46), 1.29 (0.96 - 1.73) and 2.52 (1.73 - 3.66), respectively.

Discussion

Despite the popular usage of household cleaning products, there is a little information on their health effects in primary school children. To our knowledge, this is the first study on the health effects of household cleaning products in Asian children. The results from this large population-based study indicate that frequent use of household cleaning products increases the risk of rhinitis in primary school children, after controlling for a wide range of potential confounding factors.

We also examined whether a single type of chemical product has dominant effects by repeating the analysis 14 times, each time removing the chemical burden score of one type of the cleaning products. No significant change was found in effect sizes, which suggests that the health effects on rhinitis may be synergic or due to the total exposure to all or several types of the cleaning products.

The PCFA method was applied in the present study to extract the usage pattern of the cleaning products. The patterns defined by PCFA can reflect the true exposure models of using cleaning products. Pattern I represented the most common pattern of using household cleaning products and it was significantly associated with frequent/persistent rhinitis. It was expected that there was no relationship between usage pattern IV and rhinitis because pattern IV was characterized by a factor loading of clean water. However, we did not observe a significant relationship for the usage pattern II but a significant relationship for pattern III. We speculated that this phenomenon was possibly related to the exposure level of the chemical agents. The cumulative exposure time of sanitizers (0.60 hours/week) and scented air fresheners (0.32 hours/week) was much larger than that of non-scented air fresheners (0.04 hours/week) and insecticides (0.07 hours/week), which might explain why no significant association was observed for pattern II. In addition to exposure level, the nature of the chemicals of each pattern also matters. To assess the role of the chemicals in each pattern, we adjusted for total pattern exposure level in the model. The significant associations remained for pattern III but disappeared for pattern I. There were no changes for patterns II and IV (data not shown). This suggested that the chemicals in pattern III might be more toxic or volatile and have higher adverse impact on rhinitis.

Chlorinated bleach did not fall into any of the patterns but the usage was not uncommon (0.23 hours/week). Hence, we assessed the effects of usage of Chlorinated bleach separately. Our results are

consistent with Casas' study showing that cleaning bleach has adverse respiratory health effect, but it is contrary to Nickmilder's study showing protective effects.^{13, 14}

We found that TCB score was associated increased risk of rhinitis in nonatopic students. This is in line with the results from the Avon Longitudinal Study of Parents and Children, which show that higher exposure to domestic chemicals during pregnancy was related to persistent wheezing and lung function abnormalities in children without atopy.¹¹ We did not find a significant association in atopic students. This is possibly because the number of atopic students was small in the present study.

Cleaning products consist of a number of chemical ingredients.³¹ It has been concluded that some ingredients, such as propylene glycol and glycol ethers, alkyl phenol ethoxylates, volatile organic compounds, ethylene diamine tetra acetic acid, and nitrilotriacetic acid, have harmful effects.³²⁻³⁵ Although to date there are no published studies which specifically focus on the usage of cleaning products and rhinitis in children, our results are in line with those which have reported the adverse effects of cleaning products on various respiratory health outcomes, such as infection, wheezing, and pulmonary function.⁸⁻¹¹

The present study took into account a number of potential confounding factors (including the information collected in the questionnaire and the air quality measurements in the school environment). Other strengths include a relatively large population of children and 14 types of commonly used cleaning products. In addition, we categorized the rhinitis patterns seasonally instead of monthly, and this may help to reduce misclassification. The frequent/persistent patterns may minimize the confounding effect of accidental stimulus and seasonal variation because they have more serious patterns and the persistent rhinitis pattern was defined as having rhinitis in four or more consecutive seasons. However, there are limitations. Firstly, except for the chlorinated bleach, our study could not

identify specific chemical agents in the cleaning products. Secondly, the temporal relationship was difficult to determine due to the cross-sectional data analysis. Families might have used more cleaning agents because their children had rhinitis. However, we did not find a relationship between the usage of clean water and rhinitis, suggesting that frequent use of cleaning products might not be due to having rhinitis. It is also not appropriate to use cohort design to study rhinitis because rhinitis can occur repeatedly and it is difficult to determine the onset of rhinitis. Cohort study on the relationship between cleaning product and other respiratory outcome (pulmonary function development) may help to determine the temporal relationship. Finally, the objective measurement of the chemical level would be ideal but it is not practical in a study with a large sample size. Many previous epidemiology studies have adopted a questionnaire for exposure information collection, and this approach should not affect our results.

In conclusion, our study indicates that the frequent use of household cleaning products increases the risk of rhinitis, especially of frequent rhinitis and persistent rhinitis, which are the more serious patterns of rhinitis. Because household cleaning products are part of domestic life for most people, their health effects are an important public health problem. More research is warranted to investigate the effects of household cleaning products on various respiratory health outcomes such as wheezing, asthma, and pulmonary function. Our findings suggest that it is necessary to develop healthier cleaning products and we should advise people to prefer clean water for cleaning their home environment.

Acknowledgements:

The authors would like to thank the school principals, teachers, students, and their parents/ guardians for supporting this project. We are also grateful to two anonymous reviewers and the editor for their valuable comments.

References

1. Nazaroff WW, Weschler CJ. Cleaning products and air fresheners: exposure to primary and secondary air pollutants. *Atmos Environ* 2004; 38:2841-65.
2. Folletti I, Zock JP, Moscato G, Siracusa A. Asthma and rhinitis in cleaning workers: a systematic review of epidemiological studies. *J Asthma* 2014; 51:18-28.
3. Zock JP, Plana E, Jarvis D, Anto JM, Kromhout H, Kennedys SM, et al. The use of household cleaning sprays and adult asthma - An international longitudinal study. *Am J Respir Crit Care Med* 2007; 176:735-41.
4. Bernstein JA, Brandt D, Rezvani M, Abbott C, Levin L. Evaluation of cleaning activities on respiratory symptoms in asthmatic female homemakers. *Ann Allergy Asthma Immunol* 2009; 102:41-6.
5. Le Moual N, Varraso R, Siroux V, Dumas O, Nadif R, Pin I, et al. Domestic use of cleaning sprays and asthma activity in females. *Eur Respir J* 2012; 40:1381-9.
6. Zock JP, Plana E, Anto JM, Benke G, Blanc PD, Carosso A, et al. Domestic use of hypochlorite bleach, atopic sensitization, and respiratory symptoms in adults. *J Allergy Clin Immunol* 2009; 124:731-8.
7. Chaudhuri N, Fruchtengarten L. Where the child lives and plays: A Resource Manual for the Health Sector. In *Children's health and the environment – A Global Perspective*. Edited by Pronczuk-Garbino J. Geneva: World Health Organization; 2005.
8. Casas L, Zock JP, Carsin AE, Fernandez-Somoano A, Esplugues A, Santa-Marina L, et al. The use of household cleaning products during pregnancy and lower respiratory tract infections and wheezing during early life. *Int J Public Health* 2013; 58:757-64.
9. Herr M, Just J, Nikasinovic L, Foucault C, Le Marec AM, Giordanella JP, et al. Influence of host and environmental factors on wheezing severity in infants: findings from the PARIS birth cohort. *Clin Exp Allergy* 2012; 42:275-83.
10. Sherriff A, Farrow A, Golding J, Henderson J. Frequent use of chemical household products is associated with persistent wheezing in pre-school age children. *Thorax* 2005; 60:45-9.
11. Henderson J, Sherriff A, Farrow A, Ayres JG. Household chemicals, persistent wheezing and lung function: effect modification by atopy? *Eur Respir J* 2008; 31:547-54.
12. Casas L, Zock JP, Torrent M, Garcia-Esteban R, Gracia-Lavedan E, Hyvarinen A, et al. Use of household cleaning products, exhaled nitric oxide and lung function in children. *Eur Respir J* 2013; 42:1415-8.
13. Casas L, Espinosa A, Borrás-Santos A, Jacobs J, Krop E, Heederik D, et al. Domestic use of bleach and infections in children: a multicentre cross-sectional study. *Occup Environ Med* 2015; 72:602-4.
14. Nickmilder M, Carbonnelle S, Bernard A. House cleaning with chlorine bleach and the risks of allergic and respiratory diseases in children. *Pediatr Allergy Immunol* 2007; 18:27-35.
15. International Consensus Report on the diagnosis and management of rhinitis. International Rhinitis Management Working Group. *Allergy* 1994; 49:1-34.
16. Weiss KB, Sullivan SD. The health economics of asthma and rhinitis. I. Assessing the economic impact. *J Allergy Clin Immunol* 2001; 107:3-8.
17. Ait-Khaled N, Pearce N, Anderson HR, Ellwood P, Montefort S, Shah J. Global map of the prevalence of symptoms of rhinoconjunctivitis in children: The International Study of Asthma and Allergies in Childhood (ISAAC) Phase Three. *Allergy* 2009; 64:123-48.

18. Meltzer EO, Blaiss MS, Derebery MJ, Mahr TA, Gordon BR, Sheth KK, et al. Burden of allergic rhinitis: results from the Pediatric Allergies in America survey. *J Allergy Clin Immunol* 2009; 124:S43-70.
19. Hardjojo A, Shek LP, van Bever HP, Lee BW. Rhinitis in children less than 6 years of age: current knowledge and challenges. *Asia Pac Allergy* 2011; 1:115-22.
20. Montefort S, Ellul P, Montefort M, Caruana S, Muscat HA. Increasing prevalence of asthma, allergic rhinitis but not eczema in 5- to 8-yr-old Maltese children (ISAAC). *Pediatric Allergy and Immunology* 2009; 20:67-71.
21. Lao XQ, Lau APS, Chan AKC, Ho KF, Wong CY, Yu ITS. Prospective cohort study on health effects of school environmental air quality in Hong Kong School Children. *Indoor Air* 2014 - 13th International Conference on Indoor Air Quality and Climate, 2014:687-90.
22. WONG CCY, Lao XQ, CHANG HHL, YU ITS. Exposure to household cleaning products and respiratory health effects in young school children. *ISEE Annual Conference: from local to global: advancing science for policy in environmental health*. Seattle, Washington: ehp, 2014.
23. Sergeant, ESG. Epitools epidemiological calculators. AusVet Animal Health Services and Australian Biosecurity Cooperative Research Centre for Emerging Infectious Disease. Available at: <http://epitools.ausvet.com.au>. 2015.
24. Hong S, Kwon HJ, Choi WJ, Lim WR, Kim J, Kim K. Association between exposure to antimicrobial household products and allergic symptoms. *Environ Health Toxicol* 2014; 29:e2014017.
25. The European Community Respiratory Health Survey II. *Eur Respir J* 2002; 20:1071-9.
26. Burney PG, Luczynska C, Chinn S, Jarvis D. The European Community Respiratory Health Survey. *Eur Respir J* 1994; 7:954-60.
27. Ferris BG. Epidemiology Standardization Project (American Thoracic Society). *Am Rev Respir Dis* 1978; 118:1-120.
28. Asher MI, Anderson HR, Stewart AW, Crane J, Ait-Khaled N, Anabwani G, et al. Worldwide variations in the prevalence of asthma symptoms: the International Study of Asthma and Allergies in Childhood (ISAAC). *Eur Respir J* 1998; 12:315-35.
29. Johnson RA, Wichern DW. *Applied multivariate statistical analysis*. 6th ed. Upper Saddle River, N.J.: Pearson Prentice Hall; 2007.
30. Field AP, Miles J, Field Z. *Discovering statistics using R*. London ; Thousand Oaks, Calif.: Sage; 2012.
31. Nitsch C, Heitland H-J, Marsen H, Schlüssler H-J. Cleansing Agents. In: *Ullmann's Encyclopedia of Industrial Chemistry*: Wiley-VCH Verlag GmbH & Co. KGaA; 2000.
32. Araki A, Kawai T, Eitaki Y, Kanazawa A, Morimoto K, Nakayama K, et al. Relationship between selected indoor volatile organic compounds, so-called microbial VOC, and the prevalence of mucous membrane symptoms in single family homes. *Science of the Total Environment* 2010; 408:2208-15.
33. Wieslander G, Norback D, Lindgren T. Experimental exposure to propylene glycol mist in aviation emergency training: acute ocular and respiratory effects. *Occup Environ Med* 2001; 58:649-55.
34. Wolkoff P, Schneider T, Kildeso J, Degerth R, Jaroszewski M, Schunk H. Risk in cleaning: chemical and physical exposure. *Science of the Total Environment* 1998; 215:135-56.
35. Ott WR, Roberts JW. Everyday exposure to toxic pollutants. *Sci Am* 1998; 278:86-91.

Table 1. General characteristics of the students at baseline

Variables	Value
	Mean (S.D.)
Age, years	10.1 (0.9)
BMI *, kg/m ²	17.9 (3.3)
Average size of house for each member, m ²	13.2 (7.6)
Concentration of PM2.5 in each school (mg/m ³), 10 ⁻¹	1.1 (0.8)
	N (%)
Gender, male	1,114 (48.5)
Present at home when cleaning products used, yes	978 (42.5)
Atopic status, yes	326 (14.2)
Windows opened during cleaning, yes	2,278 (99.1)
Keeping a pet at home, yes	305 (13.3)
Keeping a plant at home, yes	1,207 (52.5)
Burning incense/mosquito coil at home, yes	760 (33.1)
Home renovation, yes	953 (41.5)
Passive smoking at home, yes	580 (25.2)
Exercise per week	
Never/less than once per week	337 (14.7)
Once or twice per week	1,401 (60.9)
At least three times per week	561 (24.4)
Education of father	
Primary school or lower	305 (13.3)
Secondary school	1,626 (70.7)
Tertiary school or above	368 (16.0)
Education of mother	
Primary school or lower	259 (11.3)
Secondary school	1,574 (68.5)
Tertiary school or above	466 (20.3)

* BMI: body mass index, which is equal to weight/height²

Table 2. The relationship between rhinitis pattern and total chemical burden score (Continuous)

	N (%) *	Unadjusted model [†]		Multivariable model [‡]	
		OR (95% CI)	<i>p</i> -value	OR (95% CI)	<i>p</i> -value
Never	1260 (54.8)	1.00	—	1.00	—
Occasional	594 (25.8)	1.26 (1.09, 1.46)	0.002	1.21 (1.05, 1.41)	0.012
Frequent	282 (12.3)	1.46 (1.24, 1.72)	< 0.001	1.36 (1.13, 1.60)	0.001
Persistent	163 (7.1)	1.28 (1.07, 1.64)	0.032	1.12 (1.01, 1.56)	0.037

* N (%): The Number (percentage) of the student in each group

[†] OR for a 10-unit increase in total chemical burden score

[‡] Adjustment for age, body mass index (BMI), gender, present at home when cleaning, average size of house for each member, concentration of PM2.5 in each school, education of father, education of mother, windows open when cleaning, passive smoking at home, keeping a pet at home, keeping a plant at home, home renovation, burning incense/mosquito coil at home, atopic status and frequency of exercise.

Table 3. The relationship between rhinitis pattern and total chemical burden score (Tertile category)

Rhinitis	N*			Unadjusted model [‡]				Multivariable model ^{†§}			
	T1	T2	T3	T2 vs. T1		T3 vs. T1		T2 vs. T1		T3 vs. T1	
				OR(95%CI)	<i>p</i> value	OR(95%CI)	<i>p</i> value	OR(95%CI)	<i>p</i> value	OR(95%CI)	<i>p</i> value
Never	462	431	367	1.00	—	1.00	—	1.00	--	1.00	--
Occasional	193	194	207	1.08 (0.85, 1.37)	0.540	1.35 (1.06, 1.72)	0.014	1.03(0.81,1.31)	0.811	1.29(1.01, 1.65)	0.045
Frequent	68	92	122	1.45 (1.03, 2.04)	0.032	2.26 (1.63, 3.13)	<0.001	1.35(0.96,1.91)	0.088	1.97(1.40, 2.76)	<0.001
Persistent	44	48	71	1.17 (0.76, 1.80)	0.476	2.03 (1.36, 3.03)	0.001	1.08(0.70,1.67)	0.730	1.67(1.10, 2.54)	0.016

* N: The Number of the student in each group. Students were divided into three categories according to the tertiles of the total chemical burden (TCB) scores (T1: Tertile 1; T2: tertile 2; T3: Tertile 3). The cut-off points were 2.41 hours/week and 3.16 hours/week.

[†] Adjustment for age, body mass index (BMI), gender, present at home when cleaning, average size of house for each member, concentration of PM2.5 in each school, education of father, education of mother, windows open when cleaning, passive smoking at home, keeping a pet at home, keeping a plant at home, home renovation, burning incense/mosquito coil at home, atopic status and frequency of exercise.

[‡] *P* value for trend test in unadjusted model was 0.015, < 0.001, < 0.001 for occasional, frequent and persistent rhinitis, respectively.

[§] *P* value for trend test in multivariable model was 0.047, < 0.001, < 0.014 for occasional, frequent and persistent rhinitis, respectively.

Table 4. The relationship between rhinitis patterns and scores of cleaning products usage patterns (continuous)

Rhinitis	N (%) *	Unadjusted model [†]		Multivariable model ^{†‡}	
		OR (95% CI)	<i>p</i> -value	OR (95% CI)	<i>p</i> -value
Pattern I					
Never	1260 (54.8)	1.00		1.00	
Occasional	594 (25.8)	1.14 (1.04, 1.26)	0.008	1.12 (1.01, 1.24)	0.034
Frequent	282 (12.3)	1.20 (1.06, 1.35)	0.003	1.15 (1.01, 1.30)	0.041
Persistent	163 (7.1)	1.11 (0.95, 1.31)	0.197	1.03 (1.01, 1.35)	0.047
Pattern II					
Never	1260 (54.8)	1.00		1.00	
Occasional	594 (25.8)	1.07 (0.97, 1.18)	0.193	1.07 (0.95, 1.19)	0.296
Frequent	282 (12.3)	0.75 (0.57, 0.99)	0.043	0.80 (0.61, 1.04)	0.085
Persistent	163 (7.1)	0.91 (0.68, 1.21)	0.529	0.94 (0.73, 1.21)	0.576
Pattern III					
Never	1260 (54.8)	1.00		1.00	
Occasional	594 (25.8)	1.04 (0.93, 1.16)	0.468	1.03 (0.93, 1.15)	0.583
Frequent	282 (12.3)	1.27 (1.14, 1.41)	<0.001	1.24 (1.11, 1.39)	<0.001
Persistent	163 (7.1)	1.19 (1.04, 1.38)	0.014	1.16 (1.02, 1.35)	0.048
Pattern IV					
Never	1260 (54.8)	1.00		1.00	
Occasional	594 (25.8)	1.01 (0.91, 1.11)	0.907	0.99 (0.89, 1.09)	0.780
Frequent	282 (12.3)	1.20 (0.95, 1.24)	0.003	1.15 (0.97, 1.26)	0.123
Persistent	163 (7.1)	1.10 (0.94, 1.28)	0.254	1.04 (0.88, 1.22)	0.661

* N (%): The Number of the student in each group

[†] OR for a 1-unit increase in pattern score

[‡] Adjustment for age, body mass index (BMI), gender, present at home when cleaning, average size of house for each member, concentration of PM_{2.5} in each school, education of father, education of mother, windows open when cleaning, passive smoking at home, keeping a pet at home, keeping a plant at home, home renovation, burning incense/mosquito coil at home, atopic status and frequency of exercise.

Table 5. The relationship between rhinitis patterns and scores of cleaning products usage patterns (Tertile category)

	N [†]			Unadjusted model			Multivariable model [‡]		
	T1	T2	T3	T2 vs. T1 OR (95% CI)	T3 vs. T1 OR(95%CI)	P _{trend} [§]	T2 vs. T1 OR (95% CI)	T3 vs. T1 OR (95% CI)	P _{trend} [§]
Pattern I									
Never	456	426	378	1.00	1.00	—	1.00	1.00	—
Occasional	192	188	214	1.05 (0.82, 1.33)	1.34 (1.06, 1.71) [*]	0.015	0.99 (0.78, 1.27)	1.26 (0.99, 1.61)	0.063
Frequent	70	99	113	1.51 (1.08, 2.11) [*]	1.95 (1.40, 2.70) ^{***}	< 0.001	1.36 (0.96, 1.92)	1.62 (1.15, 2.28) ^{**}	0.006
Persistent	49	52	62	1.14 (0.75, 1.72)	1.53 (1.22, 2.37) [*]	0.037	1.03 (0.68, 1.58)	1.21 (1.01, 2.17) [*]	0.033
Pattern II									
Never	400	441	419	1.00	1.00	—	1.00	1.00	—
Occasional	191	189	214	0.90 (0.70, 1.14)	1.07 (0.84, 1.36)	0.560	0.93 (0.73, 1.20)	1.09 (0.86, 1.39)	0.474
Frequent	124	79	79	0.58 (0.42, 0.89) [*]	0.61 (0.51, 1.00)	0.061	0.64 (0.56, 1.00)	0.72 (0.55, 1.06)	0.103
Persistent	51	57	55	1.01 (0.68, 1.51)	1.03 (0.69, 1.54)	0.889	1.15 (0.76, 1.74)	1.04 (0.68, 1.58)	0.872
Pattern III									
Never	457	424	379	1.00	1.00	—	1.00	1.00	—
Occasional	190	198	206	1.12 (0.88, 1.43)	1.31 (1.03, 1.66) [*]	0.029	1.10 (0.86, 1.4)	1.27 (0.99, 1.62)	0.059
Frequent	77	87	118	1.22 (0.87, 1.70)	1.85 (1.34, 2.54) ^{***}	< 0.001	1.12 (0.79, 1.58)	1.67 (1.21, 2.33) ^{**}	0.002
Persistent	42	57	64	1.46 (0.96, 2.23)	1.84 (1.22, 2.78) ^{**}	0.004	1.39 (0.90, 2.14)	1.63 (1.07, 2.50) [*]	0.025
Pattern IV									
Never	438	416	406	1.00	1.00	—	1.00	1.00	—
Occasional	198	210	186	1.12 (0.88, 1.41)	1.01 (0.80, 1.29)	0.898	1.08 (0.85, 1.38)	0.97 (0.76, 1.24)	0.823
Frequent	85	80	117	0.99 (0.71, 1.38)	1.48 (0.89, 1.83)	0.110	1.01 (0.71, 1.42)	1.44 (0.94, 1.89)	0.122
Persistent	45	60	58	1.40 (0.93, 2.11)	1.39 (0.92, 2.10)	0.119	1.44 (0.95, 2.20)	1.34 (0.87, 2.05)	0.195

* < 0.05, ** < 0.01, *** < 0.001

[†] N: The Number of the student in each group. Students were divided into three categories according to the tertiles of pattern scores (T1: Tertile 1; T2: tertile 2; T3: Tertile 3). Tertile 1 was taken as the reference

[‡] Adjustment for age, body mass index (BMI), gender, present at home when cleaning, average size of house for each member, concentration of PM_{2.5} in each school, education of father, education of mother, windows open when cleaning, passive smoking at home, keeping a pet at home, keeping a plant at home, home renovation, burning incense/mosquito coil at home, atopic status and frequency of exercise.

[§] P value for trend test.

Repository: Supplementary materials**Table E1. Weekly exposure of the fourteen types of cleaning products and clean water**

	Total [*]	Boys [*]	Girls [*]	P value [†]
Bathroom cleaners	0.91	0.90	0.92	0.897
Floor cleaners	1.15	1.16	1.14	0.989
Glass cleaners	0.22	0.22	0.23	0.857
Kitchen cleaners	1.30	1.32	1.29	0.422
Tile cleaners	0.29	0.31	0.27	0.488
Leather cleaners	0.11	0.11	0.11	0.306
Multi-purposes cleaners	0.48	0.46	0.49	0.168
Non-chlorinated bleach	0.34	0.34	0.34	0.911
Chlorinated bleach	0.23	0.21	0.25	0.651
Sanitizers	0.60	0.56	0.64	0.190
Scented air fresheners	0.32	0.27	0.36	0.093
Non-scented air fresheners	0.04	0.02	0.06	0.211
Insecticides	0.07	0.06	0.09	0.200
Other chemical cleaners	0.06	0.04	0.09	0.241
Clean water	2.51	2.58	2.45	0.896

^{*} Weekly exposure duration of each type of cleaning product, hours/week

[†] P value for Wilcoxon rank-sum test between boys and girls were all > 0.05

Table E2. Rotated loading for the major factors via principle component factor analysis *

	Pattern I	Pattern II	Pattern III	Pattern IV
Bathroom cleaners	0.70	0.15	0.09	0.04
Floor cleaners	0.70	-0.10	0.23	-0.17
Glass cleaners	0.62	0.43	-0.05	-0.05
Kitchen cleaners	0.69	0.04	0.14	0.12
Tile cleaners	0.68	0.10	-0.04	0.00
Leather cleaners	0.54	0.41	-0.04	-0.03
Multi-purposes cleaners	0.50	0.18	0.30	0.20
Non-chlorinated bleach	0.57	-0.05	0.00	0.16
Chlorinated bleach	0.33	0.44	0.24	0.07
Sanitizers	0.25	0.09	0.68	0.04
Scented air fresheners	0.02	-0.09	0.63	0.04
Non-scented air fresheners	0.01	0.75	0.01	0.08
Insecticides	0.10	0.78	0.02	-0.01
Other chemical cleaners	-0.09	0.34	0.43	-0.15
Clean water	0.09	0.05	0.02	0.94
Proportion variance	0.23	0.13	0.09	0.07
Cumulative variance	0.23	0.35	0.44	0.51
Proportion explained	0.44	0.25	0.17	0.14
Cumulative proportion	0.44	0.70	0.86	1.00

* Factor loadings of equal to or more than 0.50 were the dominant components. Kaiser–Meyer–Olkin factor adequacy was 0.867 (> 0.5 regards as acceptable), p-value for Bartlett’s test of sphericity was less than 0.001 (< 0.001 as accept).

Table E3. The relationship between rhinitis pattern and total chemical burden score in stratified analysis (Continuous)

N (%) [*]		Unadjusted model [†]		Multivariable model ^{†‡}	
		OR (95% CI) [†]	<i>p</i> -value	OR (95% CI) ^{†‡}	<i>p</i> -value
Atopic status, No (N=1973)					
Never	1144 (58)	1.00	—	1.00	—
Occasional	504 (25.5)	1.24 (1.06, 1.46)	0.009	1.21 (1.03, 1.43)	0.021
Frequent	211 (10.7)	1.53 (1.26, 1.85)	< 0.001	1.42 (1.17, 1.74)	0.001
Persistent	114 (5.8)	1.36 (1.05, 1.77)	0.019	1.19 (1.02, 1.69)	0.022
Atopic status, Yes (N = 326)					
Never	116 (35.6)	1.00	—	1.00	—
Occasional	90 (27.6)	1.20 (0.87, 1.67)	0.262	1.17 (0.84, 1.62)	0.360
Frequent	71 (21.8)	1.17 (0.83, 1.66)	0.379	1.11 (0.78, 1.60)	0.557
Persistent	49 (15)	0.94 (0.58, 1.52)	0.807	0.91 (0.53, 1.54)	0.713

^{*} N (%): The Number (percentage) of the student in each group

[†] Odds ratio for a 10-unit increase in total chemical burden score

[‡] Adjustment for age, body mass index (BMI), gender, present at home when cleaning, average size of house for each member, concentration of PM_{2.5} in each school, education of father, education of mother, windows open when cleaning, passive smoking at home, keeping a pet at home, keeping a plant at home, home renovation, burning incense/mosquito coil at home and frequency of exercise.

Table E4. The relationship between rhinitis pattern and total chemical burden score in stratified analysis (Tertile category)

	N [*]			T2 vs. T1 [†]		T3 vs. T1 [†]		<i>P</i> _{trend} [‡]	
	T1	T2	T3	OR (95% CI)	<i>p</i> value	OR (95% CI)	<i>p</i> value		
Atopic status, No (N=1973)									
Never	412	391	341	1.00	--	1.00	--	-	
Occasional	169	163	172	0.97 (0.74,1.26)	0.802	1.18 (0.91, 1.54)	0.218	0.228	
Frequent	50	70	91	1.37 (0.92,2.03)	0.123	1.91 (1.30, 2.80)	0.001	0.001	
Persistent	30	31	53	0.95 (0.56,1.61)	0.838	1.69 (1.04, 2.74)	0.035	0.025	
Atopic status, Yes (N = 326)									
Never	49	33	34	1.00	--	1.00	--	-	
Occasional	24	32	34	2.09 (1.01,4.34)	0.047	1.99 (0.98, 4.05)	0.056	0.052	
Frequent	21	24	26	1.87 (0.86,4.09)	0.116	1.70 (0.79, 3.63)	0.173	0.158	
Persistent	15	19	15	1.92 (0.81,4.58)	0.141	1.31 (0.54, 3.20)	0.549	0.504	

* N: The Number of the student in each group. Students were divided into three categories according to the tertiles of the total chemical burden (TCB) scores (T1: Tertile 1; T2: tertile 2; T3: Tertile 3).

[†] Adjustment for age, body mass index (BMI), gender, present at home when cleaning, average size of house for each member, concentration of PM2.5 in each school, education of father, education of mother, windows open when cleaning, passive smoking at home, keeping a pet at home, keeping a plant at home, home renovation, burning incense/mosquito coil at home and frequency of exercise.

[‡] *P* value for trend test by calculating the Wald statistics, including tertile as a continuous variable in the model.

Table E5. The relationship between rhinitis patterns and chlorinated bleach exposure

	N [*]			Unadjusted model [‡]				Multivariable model ^{‡§}			
	T1	T2	T3	T2 vs. T1		T3 vs. T1		T2 vs. T1		T3 vs. T1	
				OR(95%CI)	<i>p</i> value	OR(95%CI)	<i>p</i> value	OR(95%CI)	<i>p</i> value	OR(95%CI)	<i>p</i> value
Never	772	157	331	1.00	--	1.00	--	1.00	--	1.00	--
Occasional	331	92	171	1.36 (1.02, 1.82)	0.034	1.20 (0.96, 1.51)	0.105	1.33(1.00, 1.79)	0.053	1.16(0.92, 1.46)	0.207
Frequent	156	31	95	0.98 (0.64, 1.49)	0.917	1.42 (1.07, 1.89)	0.016	0.96(0.62, 1.47)	0.845	1.29(0.96, 1.73)	0.092
Persistent	61	30	72	2.42 (1.51, 3.86)	<0.001	2.75 (1.91, 3.96)	<0.001	2.32(1.43, 3.77)	0.001	2.52(1.73, 3.66)	<0.001

^{*} N: The Number of the student in each group. Students were divided into three categories according to the tertiles of pattern scores (T1: Tertile 1; T2: tertile 2; T3: Tertile 3). The cut-off points were 0.01 hours/week and 0.20 hours/week.

[†] Adjustment for age, body mass index (BMI), gender, present at home when cleaning, average size of house for each member, concentration of PM_{2.5} in each school, education of father, education of mother, windows open when cleaning, passive smoking at home, keeping a pet at home, keeping a plant at home, home renovation, burning incense/mosquito coil at home, atopic status and frequency of exercise.

[‡] *P* value for trend test in unadjusted model was 0.063, 0.020, <0.001 for occasional, frequent and persistent rhinitis, respectively.

[§] *P* value for trend test in multivariable model was 0.139, 0.105, < 0.001 for occasional, frequent and persistent rhinitis, respectively.

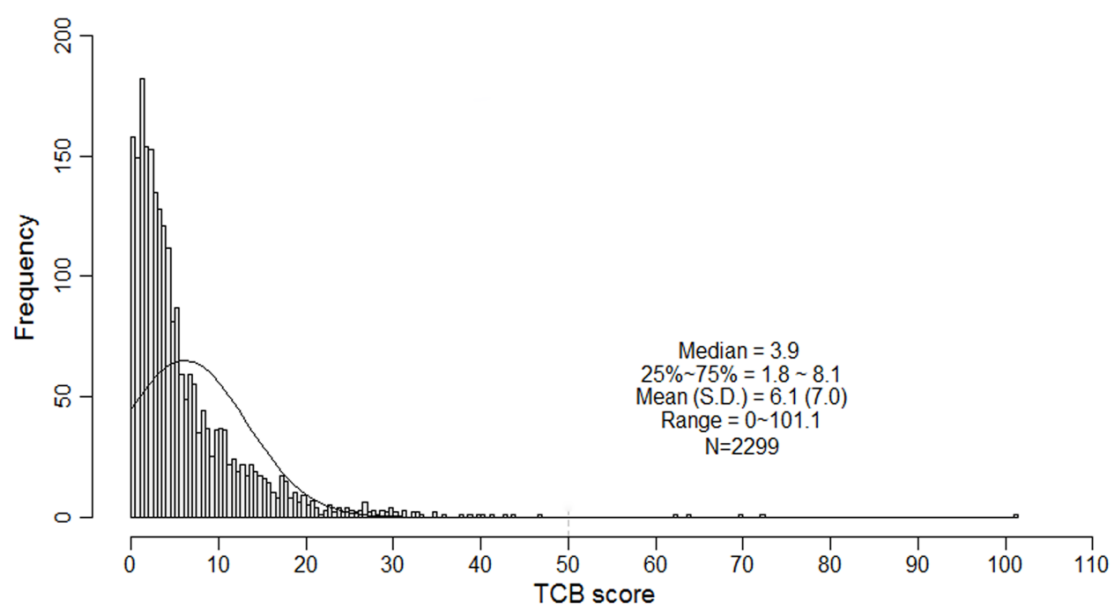


Figure E1. Histogram of total chemical burden (TCB) score