Respiratory health effects of household cleaning products on Hong Kong school children

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KEY MESSAGES

1. Frequent use of household cleaning products is associated with slower growth in the lung function parameter of maximum mid-expiratory flow.
2. Frequent use of household cleaning products is associated with an increased risk of rhinitis.

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Introduction

Indoor air pollution is an important public health issue and has a significant effect on health. Various types of cleaning products are used in households, but concerns have been raised about their effects to indoor air pollution.[1] In particular, products that contain active chemical ingredients.

Few studies have investigated the respiratory health effects related to cleaning products in home environments, and most of which targeted adult populations.[2] Frequent use of cleaning products and hypochlorite bleach may be associated with asthma and respiratory symptoms. Frequent use of chemical-based cleaning products in the prenatal period is associated with persistent wheezing in young children.[3] Exposure during childhood may also affect respiratory health, but another study reported that children aged 10 to 13 years who lived in houses that were regularly cleaned with bleach appeared to have a lower risk of developing asthma.[4]

Methods

This was a prospective cohort study involving 25 primary schools in Hong Kong. All primary three and four students from each school were invited to participate. Of 3100 students invited, 2620 agreed to participate in a baseline survey that included a health examination and self-administered questionnaire. Of the 2620 students, 2330 participated in a follow-up survey after approximately 12 months.

Information about the use of 14 chemical cleaning products was collected. Parents of students were asked: "Have you used the following household cleaning products at home in the past 12 months?". If the response was "yes", additional information about the weekly usage frequency (<1, 1-3, 4-6, and ≥7 times) and the average duration of each use (<15, 15-30, 31-45, 46-60, and >60 minutes) was collected. Information about the use of plain water alone for home cleaning was also collected.

A total chemical burden score was generated to indicate each participant's total exposure level to the 14 types of chemical cleaning agents. Because the frequency and duration of use data were categorical, the midpoint value of each category was used to calculate the total chemical burden score (frequency: 0.5, 2.0, 5.0, and 8.5 corresponded to <1, 1-3, 4-6, and >7 times, respectively; duration: 7.5, 23.0, 38.0, 52.5, and 75 corresponded to <15, 15-30, 31-45, 46-60, and >60 minutes, respectively). The total chemical burden score was defined as the cumulative time of exposure using the following formula:

$$Total\ chemical\ burden = \sum_{i=1}^{14} = (Fre_i \times Dur_i),$$

where *Fre* refers to the weekly frequency of use of a certain chemical product, *Dur* refers to the average duration of each use, and *i* represents the specific chemical cleaning product.

The pulmonary function parameters evaluated included the forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1), and maximum mid-expiratory flow (MMEF). Spirometric tests were performed according to the protocol of the American Thoracic Society. Spirometry assessments were performed with the student in a standing position. All students were required to blow at least three times to yield at least two measurements that were reproducible within 5% for both FVC and FEV_1. The highest FVC and FEV_1 scores were used for analysis. Lung function growths were calculated using the following formula:

$$\frac{\text{Lung function at follow-up - Lung function at baseline}}{\text{Follow-up duration (months) / 12}}$$

Rhinitis, in particular non-infectious rhinitis, was defined as those children who have "ever had nasal symptoms such as nasal blockage, sneezing,

and a runny nose as well as itching eyes or lachrymation in the absence of a common cold in the previous 12 months". Those parents who responded "yes" were further asked: "please indicate the months when your child suffered from rhinitis." Only those children whose responses to two questions were consistent were deemed to have rhinitis during the 12-month follow-up.

The baseline and follow-up questionnaires collected rhinitis information of a period of 24 months, which was divided into eight mutually exclusive seasons. Each student was categorised into one of the four rhinitis patterns: never (no rhinitis in any season), occasional (rhinitis in <3 seasons), frequent (rhinitis in ≥3 seasons but <4 consecutive seasons), and persistent (rhinitis in ≥4 consecutive seasons).

We used multiple linear regression analysis to investigate lung function parameters, and multinomial logistic regression analysis to investigate rhinitis patterns.

TABLE 1. Baseline characteristics of participants

Variables	Value
Age, y	11.3±0.9
Male	1255 (47.9)
Body mass index, kg/m^2	17.3±3.1
Self-reported asthma	100 (3.8)
Rhinitis	1118 (42.7)
Self-reported bronchitis	112 (4.3)
Self-reported bronchiolitis	36 (1.3)
Self-reported pneumonia	31 (1.2)
Atopic status, yes	346 (13.2)
Average area of housing for each household member, m^2	15.2±7.9
Present at home when cleaning products used, yes	1008 (38.5)
Keeping a pet at home, yes	333 (12.7)
Home renovation, yes	746 (28.5)
Passive smoking at home, yes	503 (19.2)

* Data are presented as mean±standard deviation or No. (%) of participants

Results

The mean age of students was 11.3±0.9 years; the mean body mass index was 17.3±3.1 kg/m^2; and 47.9% of the students were boys (Table 1). Increased use of cleaning products was associated (though not significantly) with smaller positive growth in the FEV1 and FVC, but was significantly associated with smaller positive growth in the MMEF, after adjusting for confounders (Table 2). Every 10-unit increase in the total chemical burden score was associated with an increase in the risks of occasional rhinitis (odds ratio [OR]=1.21, 95% confidence interval [CI]=1.05-1.41), frequent rhinitis (OR=1.36, 95% CI=1.13-1.60),

TABLE 2. Associations between lung function growth and the use of household cleaning products

Lung function growth	Total chemical burden score	Basic model (adjusted for age, sex, body mass index, and height growth rate)		Adjusted model (further adjusted for born in Hong Kong or elsewhere, asthma, passive smoking in the household, father's and mother's education levels, and physical activity level)	
		Estimate (95% confidence interval)	P value	Estimate (95% confidence interval)	P value
Forced expiratory volume in the first second, mL	1st tertile	Reference		Reference	
	2nd tertile	-12.3 (-25.6 to 5.9)	0.24	-9.2 (-21.4 to 3.9)	0.40
	3rd tertile	-7.5 (-18.8 to 4.6)	0.35	-6.8 (-11.5 to 3.6)	0.65
	P for trend	-	0.42	-	0.54
	Every 10-unit increase	-8.5 (-15.1 to 10.8)	0.38	-8.1 (-13.7 to 12.7)	0.48
Forced vital capacity, mL	1st tertile	Reference		Reference	
	2nd tertile	-11.7 (-26.8 to 13.4)	0.42	-10.5 (-26.6 to 15.5)	0.57
	3rd tertile	-10.4 (-22.7 to 14.7)	0.12	-9.4 (-19.6 to 17.7)	0.61
	P for trend	-	0.31	-	0.47
	Every 10-unit increase	-16.3 (-29.3 to 1 2.9)	0.65	-14.9 (-22.2 to 14.3)	0.77
Maximum mid-expiratory flow, mL/s	1st tertile	Reference		Reference	
	2nd tertile	-10.7 (-29.8 to -2.5)	0.048	-9.5 (-22.8 to 2.5)	0.52
	3rd tertile	-15.1 (-53.9 to -3.8)	0.039	-13.4 (-42.6 to -4.7)	0.031
	P for trend	-	0.036	-	0.039
	Every 10-unit increase	-19.5 (-63.2 to -8.7)	0.032	-18.1 (-59.7 to -3.6)	0.033

TABLE 3. Association between the rhinitis pattern and total chemical burden score*

Rhinitis pattern	Unadjusted model		Multivariable model	
	Odds ratio (95% confidence interval) for a 10-unit increase in the score	P value	Odds ratio (95% confidence interval) for a 10-unit increase in the score	P value
Never	1.00	-	1.00	-
Occasional	1.26 (1.09-1.46)	0.002	1.21 (1.05-1.41)	0.012
Frequent	1.46 (1.24-1.72)	<0.001	1.36 (1.13-1.60)	0.001
Persistent	1.28 (1.07-1.64)	0.032	1.12 (1.01-1.56)	0.037

* Adopted from Liu X, Lao XQ, Wong CC, et al. Frequent use of household cleaning products is associated with rhinitis in Chinese children. J Allergy Clin Immun 2016;138:754-60.

and persistent rhinitis (OR=1.12; 95% CI=1.01-1.56) after adjusting for potential confounders (Table 3).

Discussion

Among primary school children, the use of household cleaning products correlated with the growth in MMEF, and frequent use of household cleaning products increased the risk of rhinitis. Three lung function parameters were investigated: MMEF, FVC, and FEV_1. MMEF refers to the average expiratory flow over the middle half of the FVC and is an indicator of small airway function. FVC refers to the volume of air that can be forcibly expelled and is an indicator of restrictive ventilatory disorder. FEV_1 refers to the volume of air that can be forcibly expelled during the first second and is an indicator of both large and small airway functions. Our study showed that exposure to cleaning product was associated with a reduction of MMEF growth, suggesting harmful effects to small airway function.

The association between rhinitis and use of cleaning products was robust, even after adjusting for potential confounders. Frequent use of household cleaning products increases the risk of rhinitis. The underlying mechanism between rhinitis and the use of cleaning products remains unclear. Nonetheless, chemical ingredients (including propylene glycol and glycol ethers, alkyl phenol ethoxylates, volatile organic compounds, ethylene diamine tetra acetic acid, and nitrilotriacetic acid) of cleaning products have harmful effects.

Strengths of the present study were (1) a prospective cohort study that could investigate the association between cleaning product and the growth of lung function, (2) taking into account of effects of a wide range of potential confounders, (3) a relatively large sample size, and (4) using primary school children, the most vulnerable group, as study subjects.

Conclusion

Our findings have important public health implications because household cleaning products are common. There is a need to develop healthier cleaning products for households.

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