



Association of pet-keeping in home with self-reported asthma and asthma-related symptoms in 11611 school children from China

Hao-ling Zhang , Bo-yuan Wang , Yun Luo , Yu Li , Chun-sheng Cai , Li-li Huang , Bin-hong He , Jian Cai , Zi-ying Li , Ai-die Mai & Yan Guo

To cite this article: Hao-ling Zhang , Bo-yuan Wang , Yun Luo , Yu Li , Chun-sheng Cai , Li-li Huang , Bin-hong He , Jian Cai , Zi-ying Li , Ai-die Mai & Yan Guo (2020): Association of pet-keeping in home with self-reported asthma and asthma-related symptoms in 11611 school children from China, Journal of Asthma, DOI: [10.1080/02770903.2020.1818772](https://doi.org/10.1080/02770903.2020.1818772)

To link to this article: <https://doi.org/10.1080/02770903.2020.1818772>

 View supplementary material 

 Published online: 28 Sep 2020.

 Submit your article to this journal 

 Article views: 8

 View related articles 

 View Crossmark data 



Association of pet-keeping in home with self-reported asthma and asthma-related symptoms in 11611 school children from China

Hao-ling Zhang, MPH^a, Bo-yuan Wang, MEng^a, Yun Luo, MMed^a, Yu Li, MPH^a, Chun-sheng Cai, MMed^a, Li-li Huang, MMed^a, Bin-hong He, MMed^a, Jian Cai, BMed^a, Zi-ying Li, BMed^b, Ai-die Mai, BMed^c, and Yan Guo, MMed^a

^aZhongshan Center for Disease Control and Prevention, Zhongshan, Guangdong Province, China; ^bGuangdong Pharmaceutical University, Guangzhou, Guangdong Province, China; ^cGuangdong Medical University, Dongguan, Guangdong Province, China

ABSTRACT

Objective: We conducted a cross-sectional study to investigate the associations between domestic pets and respiratory health in children.

Methods: We randomly recruited 11,611 school children from Zhongshan, a southern city in China. Information about the respiratory symptoms and disease history of the recruited children, the status of domestic pets, and other related risk factors were collected from March to July 2016.

Results: We identified cat-keeping at home increases the risk of persistent cough (OR, 1.77; 95%CI, 1.03–3.05); poultry-keeping at home increases the risk of current asthma (OR, 3.87; 95%CI, 1.08–13.92) and allergic rhinitis (OR, 1.84; 95%CI, 1.01–3.37); sleeping with pets increases the risk of persistent phlegm (OR, 5.04; 95%CI, 1.05–24.28), doctor-diagnosed asthma (OR, 3.35; 95%CI, 1.31–8.57) and current asthma (OR, 4.94; 95%CI, 1.05–23.31) in children.

Conclusions: Cat-keeping and molds on the wall of the house had the multiplicative and additive interaction in doctor-diagnosed asthma. In conclusion, pet-keeping increased the risk of respiratory symptoms in children.

ARTICLE HISTORY

Received 10 March 2020
Revised 3 August 2020
Accepted 30 August 2020

KEYWORDS

Asthma; pets; interaction; molds; children; China

Practical implications

The relationship between exposure to pet animals and asthma and asthma-related symptoms in children is controversial. Inconsistent with other cross-sectional studies mostly conducted in developed countries, our study indicates that exposure to animals may increase the occurrence of asthma and asthma-related symptoms in children, and the association strengthens with higher levels of animal exposure. When exposed to both cats and molds, there are positive interactions on doctor-diagnosed asthma. These findings support the view that measures should be taken to reduce exposure to animals and molds for preventing asthma and asthma-related symptoms among children in China.

1. Introduction

Asthma is the most common chronic disease in children, and is more prevalent in high-income countries. In recent years, global disparities in asthma have been reducing with increasing prevalence in low and

medium-income countries (1). The prevalence of asthma in Chinese children also showed a clear upward trend (2,3). The National Pediatric Asthma Collaborative Group conducted three national large-scale epidemiological surveys about asthma among urban children in 1990, 2000, and 2010. The results showed that the prevalence of asthma in Chinese children was 0.96%, 1.66% and 2.38%, respectively. In 2010, the total prevalence of asthma in children under 14 years old increased by 43.4% and 147.9%, respectively compared with 10 years ago and 20 years ago (4). Asthma not only seriously affects the quality of life of children, but also brings a large economic burden to families, and consumes medical and health resources of the country.

The development of asthma depends on a variety of factors (5–7). Global Asthma Prevention Initiative (GINA) reported that risk factors of asthma were divided into host factors and environmental factors, the latter including domestic pets (8). With the development of social economy, more children are having

CONTACT Yan Guo  13928190496@163.com  Public Hygiene & Food Hygiene Dept, Zhongshan Center for Disease Control and Prevention, 70 Changjiang Road, East district, Guangdong 528400, China.

 Supplemental data for this article can be accessed at [publisher's website](#).

© 2020 Taylor & Francis Group, LLC

more chances to contact with pets in their living environment. However, results of previous studies on the effect of domestic pet exposure on childhood asthma were not consistent. Some studies showed that domestic pets increased the risk of allergic respiratory diseases such as asthma (9–13), because of increased levels of allergens in the air released by saliva, skin, and hair follicles of pets (14). On the contrary, developed countries found that domestic pet exposure in childhood reduced risks of asthma, especially in early life (15–18). Pet exposure in early life increased levels of endotoxin in indoor air, which was a protective factor for asthma (19–21). Whereas, some studies showed no association between domestic pet exposure and childhood asthma (22).

In addition, children are exposed to domestic indoor environment for a long time. A study with 10784 elementary students showed that home-decorations, environmental tobacco smoke and molds on the wall increased the risk of doctor-diagnosed asthma or asthma symptoms (23). A case-control study from Canada found that high molds levels in dust samples from play and mattress areas were a risk factor for asthma in children (24). Similarly, studies from America, Sweden showed that exposure to molds or dampness increased the risk of asthma or respiratory illness (25–27). A retrospective cohort study found that adding new furniture during early childhood and pregnancy could be risk factors for childhood asthma (28). However, whether these domestic environmental factors have interactions with pet keeping is still unclear.

Therefore, we conducted a cross-sectional study among children to examine whether domestic pet exposure was associated with asthma and asthma-related symptoms, and assess the joint effect of pet keeping and domestic environmental factors.

2. Material and methods

2.1. Study population

This was a cross-sectional study to investigate the association between domestic pets and respiratory health in children. During March to July 2016, a random-cluster sampling method was used for selecting children from urban areas of Zhongshan city. 13516 children of 5 elementary and 5 junior high schools were selected from 267505 children of 181 elementary and 47 junior high schools in Zhongshan city. There were 886 children not willing to participant in or lost to follow up. Therefore, 12630 children participated in this study and handed in questionnaires. If there were more than 3 blanks in the questionnaire, we considered it unqualified and did not include it for analysis.

A total of 1019 questionnaires were unqualified and the questionnaire pass rate was 91.93%. Finally, we included 11611 children in this study (6087 boys and 5,524 girls) (Figure 1).

2.2. Questionnaire survey

The internationally standardized questionnaire ATS (American Thoracic Society) was adopted and revised according to actual situations of China. The questionnaire included demographic information (children's gender and age, parent's education, family income, etc.), children's asthma and asthma-related symptoms (persistent cough, persistent phlegm, wheezing, doctor-diagnosed asthma, current asthma and allergic rhinitis), as well as domestic pets (types and numbers of pets, slept with pets or not, fetal exposure, exposure before 2 years old), house renovation within two years and decoration methods, other indoor environmental pollution (passive smoking, kitchen fumes, molds, cockroaches, etc.), children's school environment and other questions related to premature birth, breastfeeding and so on. The purpose of the survey was explained to parents and informed contents were obtained. The questionnaire was distributed to and filled out by parents or guardians. All questionnaires were collected after one week.

This study protocol was in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the School of Public Health at Sun Yat-sen University.

2.3. Definitions of asthma and asthma-related symptoms

The following asthma and asthma-related symptoms were defined according to the ATS diagnostic criteria:

- *Persistent cough*: Analyzing the questions helped us to determine whether the child had been coughing for more than 3 months, with or without a cold, on most days (4 days a week).

For example: Question A: "Does your child often cough when he/she has a cold?"; B "Does your child cough even if he/she doesn't have a cold?"; C "Dose he/she have a cough for more than three months one year, and more than four days a week?". If parents answered "yes" to all the above questions, their child was suffering from persistent cough.

- *Persistent phlegm*: Phlegm-related questions determined whether children coughed up sputum or mucus

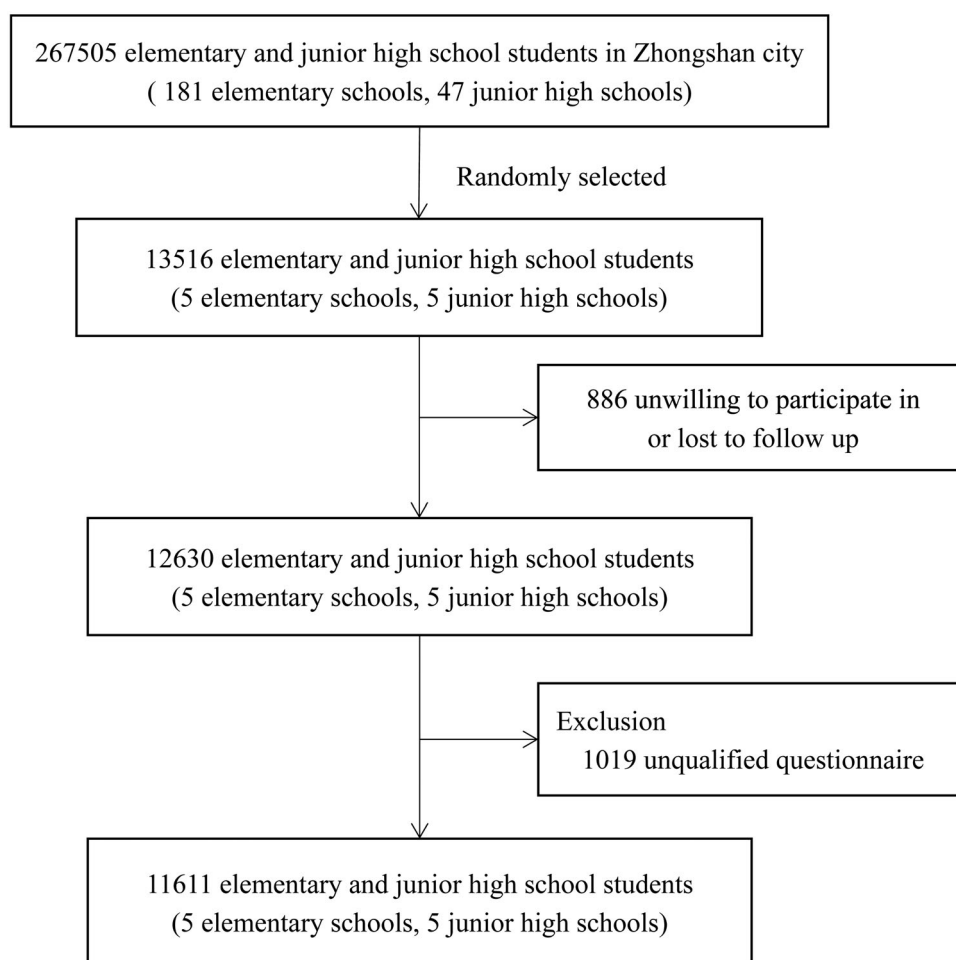


Figure 1. Participant flow diagram for analysis of asthma and asthma-related symptoms.

for more than 3 months on most days (4 days a week) with or without a cold. For example: Question A: "When your child has a cold, does he/she always snore or cough sputum?"; B "Does your child snore or cough sputum even if he/she doesn't catch a cold?"; C "Dose he/she have sputum for more than three months one year, and more than four days a week?". If the parent's answer to A or B was "yes" and C's answer was "yes", the child had a persistent phlegm.

- **Wheezing:** Wheezing-related questions determined whether children had a whistling sound (that is, wheezing sound) when breathing with or without a cold. For example: Question A: "Does your child have a whistling sound (that is, wheezing sound) when breathing?". If the parent's answer was "yes", the child was considered as wheezing.
- **Doctor-diagnosed asthma:** Questions related to doctor-diagnosed asthma determined whether children had been diagnosed with asthma (or asthmatic bronchitis or pediatric asthma) by a doctor. For example: Question A: "Did a doctor ever give your child a diagnosis of asthma (or asthmatic bronchitis

or pediatric asthma)?". If the parent's answer was "yes", the child had a doctor-diagnosed asthma.

- **Current asthma:** Questions related to current asthma determined whether children had been diagnosed with asthma by a doctor and had had asthma attacks or treatment for asthma or asthmatic bronchitis in the last two years. For example: a child who had been diagnosed with asthma by a doctor, plus Question A: "Has the child had an asthma attack in the past two years?"; B "In the past two years, has the child been treated for asthma or asthmatic bronchitis or wheezing?". If one of the answers to question A or B was "yes", the child had current asthma.
- **Allergic rhinitis:** Questions related to allergic rhinitis determined whether children had been diagnosed with allergic rhinitis by a doctor. For example: Question A: "Did a doctor ever diagnose your child as allergic rhinitis?"; B "Did your child is diagnosed to be allergic to a substance?, if yes, what the substance is?". The answer to question A was "yes", or the answer to question B was yes and

the allergen was one or more of “food”, “drug”, “dust”, “pollen”, “detergent”, “other”. The child was considered to have allergic rhinitis.

2.4. Statistical analysis

The database was built using Epi Data 3.1. General descriptive analysis, chi-square test and multivariate unconditional logistic regression analysis were performed by SPSS 20.0 statistical software. Taking $\alpha = 0.05$ as the test level, all $P < 0.05$ indicated that the results were statistically significant. Each odds ratio (OR) value was described by 95% confidence intervals (95% CIs). We calculated the self-reporting rate of six outcome indicators for children's asthma and asthma-related symptoms (persistent cough, persistent phlegm, wheezing, doctor-diagnosed asthma, current asthma, allergic rhinitis). The chi-square test was used to compare self-reporting rates of these outcome indicators among different gender and age groups, and the chi-square trend test was used to analyze whether the trend of each disease and symptom with age was statistically significant. The chi-square test was also used to analyze the influence of domestic pets, different species of domestic pets (cats, dogs, birds, poultry) and different ways of contacting with domestic pets (current pet-keeping, sleeping with pets, children's exposure to pets before two years old, mothers' exposure to pets during pregnancy) on children with asthma and asthma-related symptoms. We further used multi-factor unconditional logistic regression, taking persistent cough, persistent phlegm, wheezing, doctor-diagnosed asthma, current asthma, and allergic rhinitis as dependent variables, taking cats, dogs, birds, farm animals, sleeping with pets and children's exposure to pets before two years old as independent variables to analyze. At the same time, in the logistic regression model, children's gender, age, parents' education, family income, premature birth, feeding method, passive smoking, passive smoking during pregnancy, maternal smoking during pregnancy, children's passive smoking before two years old, kitchen fume, molds on the wall of the house, cockroaches' haunting the house, housing renovation within two years, housing decoration (paint, wall paint

or wallpaper, new furniture), and school laying plastic track were used as confounding factors. The multivariate adjusted OR values were used to discriminate independent factors affecting asthma and asthma-related symptoms in children. We decided to introduce these variables based on different literature resources after selecting these variables on a recommended basis for a preliminary univariate analysis. Multivariate unconditional logistic regression analysis used the entry method to screen risk factors. The standard for variables entering the model is 0.05, and the standard for rejecting the model is 0.10.

In addition, we also calculated the index of the multiplicative interaction of two factors and their confidence intervals, and the index of three evaluations of additive interactions (RERI, the relative excess risk due to interaction; AP, the attributable proportion due to interaction; and S, the synergy index) proposed by Rothman (29). The dependent variables, independent variables A, B and product terms A&B were placed into the unconditional logistic regression model. The P and OR values of the product terms were used to evaluate the multiplication interaction on children's asthma and asthma-related symptoms. The parameter estimation and covariance matrix of the logistic regression model when calculating the multiplication interaction can be placed into the Excel table compiled by Andersson et al. (30) to obtain the evaluation index of additive interaction. If there is no additive interaction between the two factors, the confidence interval of RERI and AP contains 0, and the confidence interval of S contains 1. At the same time, we referred to the R software statement program written by Xu Minrui et al. (31) to achieve the calculation of multiplicative and additive interaction indicators, and compared it with Andersson's method.

3. Results

There were 11 611 children in this study, including 6087 boys (52.4%) and 5524 girls (47.6%), from 5 to 18 years old. The mean age was 11.49 (standard deviation: 2.66). 662 (5.70%) children had been diagnosed with asthma by doctors, 3356 (28.90%) children had allergic rhinitis, 169 (1.46%) had current asthma, 331

Table 1. Self-report rates of children's asthma and asthma-related symptoms of different genders in Zhongshan.

Characteristic	N	Persistent cough Cases(%)	Persistent phlegm Cases(%)	Wheezing Cases(%)	Doctor-diagnosed asthma Cases(%)	Current asthma Cases(%)	Allergic rhinitis Cases(%)
Female	5524	158(2.86)	58(1.05)	313(5.67)	251(4.54)	63(1.14)	1452(26.29)
Male	6087	173(2.84)	81(1.33)	492(8.08)	411(6.75)	106(1.74)	1904(31.28)
χ^2		0.003	1.930	26.211	26.267	7.291	35.153
P -value		0.95	0.17	<0.01	<0.01	0.01	<0.01
Total	11611	331(2.85)	139(1.20)	805(6.93)	662(5.70)	169(1.46)	3356(28.90)

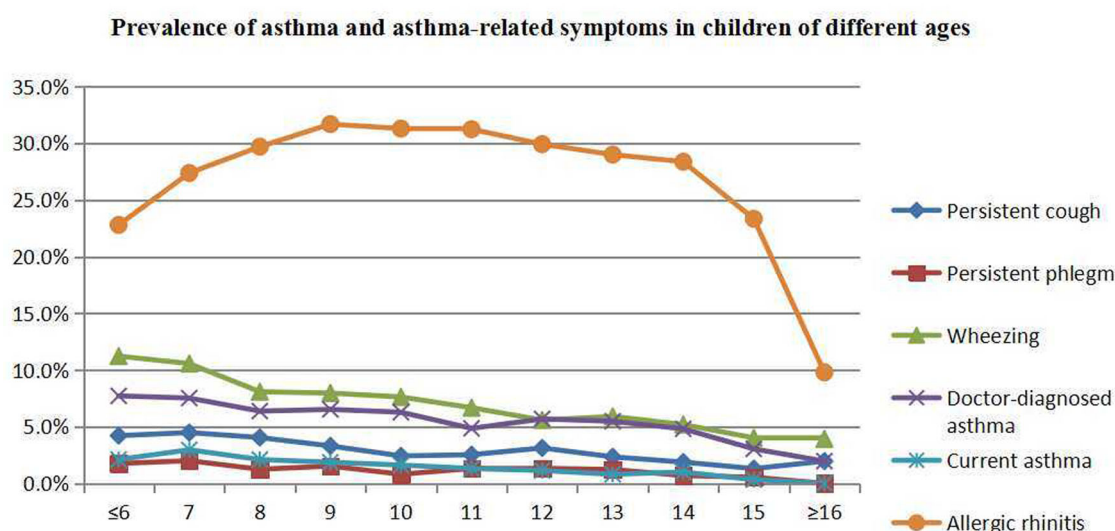


Figure 2. The Prevalence of asthma and asthma-related symptoms in children of different ages.

Table 2. ORs (95%CI) of asthma-related symptoms and doctor-diagnosed asthma in relation to pets exposure in Zhongshan ($n = 11611$).

Characteristic		Persistent Cough	Persistent Phlegm	Wheezing	Doctor-diagnosed Asthma	Current Asthma	Allergic Rhinitis
Keeping pets now	OR (95%CI)	1.23 (0.94-1.62)	1.19 (0.78-1.82)	1.06 (0.88-1.28)	0.99 (0.80-1.22)	1.29 (0.89-1.88)	1.11 (1.00-1.23)
Sleeping with pets	OR (95%CI)	3.32 ^a (1.01-10.91)	5.22 ^a (1.24-21.99)	1.3 (0.40-4.26)	3.57 ^a (1.47-8.65)	4.27 ^a (1.02-17.96)	1.03 (0.49-2.15)
Exposure to pets before two years old	OR (95%CI)	1.41 (0.91-2.17)	1.78 (0.98-3.23)	1.17 (0.86-1.59)	1.28 (0.93-1.77)	1.84 ^a (1.07-3.14)	1.18 (0.98-1.40)
Exposure to pets during pregnancy	OR (95%CI)	1.56 (0.95-2.57)	0.84 (0.31-2.28)	1.15 (0.79-1.67)	1.02 (0.67-1.57)	1.23 (0.57-2.64)	1.16 (0.93-1.44)
Type of pets							
Cat-keeping	OR (95%CI)	1.77 ^a (1.06-2.96)	1.54 (0.68-3.53)	1.20 (0.80-1.79)	1.43 (0.95-2.15)	1.71 (0.83-3.51)	1.20 (0.95-1.51)
Dog-keeping	OR (95%CI)	0.98 (0.66-1.45)	1.19 (0.68-2.07)	1.11 (0.87-1.42)	0.92 (0.69-1.22)	1.35 (0.83-2.18)	1.05 (0.91-1.21)
Bird-keeping	OR (95%CI)	1.32 (0.58-3.00)	0.51 (0.07-3.66)	0.88 (0.46-1.68)	1.21 (0.65-2.24)	0.42 (0.06-3.00)	0.95 (0.67-1.34)
Poultry-keeping	OR (95%CI)	0.76 (0.10-5.51)	0.99 (0.99-0.99)	1.64 (0.65-4.16)	2.03 (0.80-5.14)	4.79 ^a (1.47-15.60)	1.90 ^a (1.06-3.40)

^a P values < 0.05.

poultry: Chickens, ducks and geese.

(2.85%) had persistent cough, 139 (1.20%) had persistent phlegm, and 805 (6.93%) reported wheezing.

Table 1 shows the self-reporting rate of asthma and asthma-related symptoms in children of different genders. The self-reporting rate of persistent cough in boys (2.84%) was slightly lower than that in girls (2.86%), and the self-reporting rate of persistent phlegm in boys (1.33%) was higher than that in girls (1.05%), but the difference was not significant ($P > 0.05$). The self-reporting rate of wheezing, doctor-diagnosed asthma, current asthma and allergic rhinitis in boys (8.08%, 6.75%, 1.74%, 31.28%) were higher than that in girls (5.67%, 4.54%, 1.14%, 26.29%), and the difference was significant ($P < 0.05$).

The self-reporting rate and distribution of children's asthma and asthma-related symptoms of all age

groups are shown in Figure 2. With age increasing, the self-reporting rate of asthma and asthma-related symptoms showed a downward trend except for allergic rhinitis. Children under 7 years old generally had higher self-reporting rates of these diseases. For allergic rhinitis, the self-reporting rate in children under 9 years old kept increasing, then slowly decreased from 9 to 14 years old, and decreased significantly after 14 years old.

Table 2 shows the ORs (95%CI) of children with asthma and asthma-related symptoms in relation to pets exposure. The results showed a positive association between children sleeping with pets and the self-reporting rate of persistent cough, persistent phlegm, doctor-diagnosed asthma and current asthma ($P < 0.05$). Exposure to pets before two-years old was positively

Table 3. Results of a multivariate analysis of children's asthma and asthma-related symptoms.

Characteristic		Persistent cough	Persistent phlegm	Wheezing	Doctor-diagnosed asthma	Current asthma	Allergic rhinitis
Cat-keeping	<i>P</i>	0.04	—	—	—	—	—
	OR	1.77	—	—	—	—	—
	(95%CI)	(1.03-3.05)	—	—	—	—	—
Poultry-keeping	<i>P</i>	—	—	—	—	0.04	0.05
	OR	—	—	—	—	3.87	1.84
	(95%CI)	—	—	—	—	(1.08-13.92)	(1.01-3.37)
Sleeping with pets	<i>P</i>	—	0.04	—	0.01	0.04	—
	OR	—	5.04	—	3.35	4.94	—
	(95%CI)	—	(1.05-24.28)	—	(1.31-8.57)	(1.05-23.31)	—

The co-variables are children's gender, age, filler's education, family income, premature birth, feeding method, exposure to pets during pregnancy, exposure to pets before two years old, Cooker hood, molds on the wall of the house, cockroaches' haunting the house, housing renovation within two years, decoration method (paint, floor leather, floor, carpet, wall paint or wallpaper, new furniture), passive smoking, passive smoking during pregnancy, maternal smoking during pregnancy, children's passive smoking before two years old, school laying plastic track, different species of domestic pets and different ways of contacting with domestic pets; "—" means no significant OR and *P*.

Table 4. ORs (95%CI) of interaction of cat-keeping and Molds on the wall of the house and children's Doctor-diagnosed asthma.

Characteristic		Doctor-diagnosed asthma
The multiplicative scale		3.21(1.36-7.60) ^a
The addition scale	RERI	3.31(0.08 ~ 6.54) ^a
	AP	0.69(0.45 ~ 0.93) ^a
	S	8.02(1.71 ~ 37.64) ^a

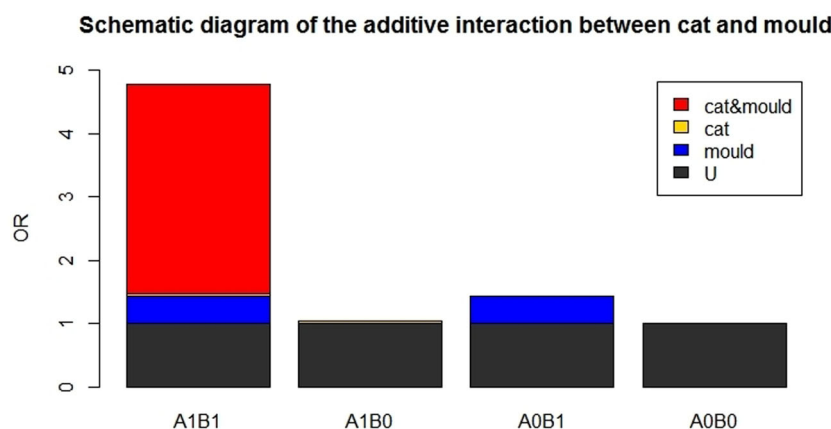
^a*P* < 0.05.

associated self-reporting rate of current asthma (*P* < 0.05). Further, we analyzed how types of pets influenced asthma-related symptoms in children and we found a positive correlation between keeping cats at home and children with persistent cough (*P* < 0.05). Higher self-reporting rates of current asthma and allergic rhinitis were associated with domestic poultry (*P* < 0.05).

Multivariate logistic regression was further used to analyze the effects of different types of domestic pets and different ways of contact with domestic pets on children's asthma and asthma-related symptoms. (Table 3). The univariate logistic regression was provided as Supplement 1. After excluding the confounding factors, the risk of persistent cough in children exposed to cat-keeping was 1.77 times of that in children not

exposed to cat-keeping. Poultry-keeping was a risk factor of children's current asthma and allergic rhinitis. The risk of current asthma and allergic rhinitis in children exposed to poultry-keeping increased by 287% and 84% compared with non-exposed children. Sleeping with pets increased the risk of persistent cough (OR:5.04, 95%CI: 1.05–24.28), doctor-diagnosed asthma (OR: 3.35, 95%CI: 1.31–8.57), and allergic rhinitis (OR: 4.94, 1.05–23.31).

Table 4 shows the interaction of cat-keeping and molds on the wall of the house on children's asthma and asthma-related symptoms. On the multiplicative scale, we found that cat-keeping and molds had a positive interaction for doctor-diagnosed asthma. The OR (95%CI) was 3.21 (1.36–7.60), which meant simultaneous exposure to cat-keeping and molds increased the risk of doctor-diagnosed asthma compared to exposure to cat-keeping or molds alone. On the additive scale, there is an additive interaction between cat-keeping and molds on the wall of the house for doctor-diagnosed asthma, its RERI > 1, which indicated that their combined effect was greater than the sum of the individual effects (Figure 3). The comparison showed that results of the two methods of calculating interactions were almost identical.

**Figure 3.** Using R software to analyze the interaction of cat-keeping and molds on the wall of the house.

4. Discussion

This study indicated that pet-keeping was associated with higher odds of asthma and asthma-related symptoms in children, especially in those keeping cats, poultry as pets or sleeping with pets. In addition, children exposed to both cat-keeping and molds had higher self-report rates of doctor-diagnosed asthma than exposed to cat-keeping or molds alone.

Current research results are controversial whether domestic pets had a harmful or protective effect on the occurrence of childhood asthma (12). Studies have confirmed that allergic reactions to dogs or cats increased the risk of asthma in children (32). In recent years, the number of pet-raising families in Zhongshan has increased. In this survey, 16.88% families kept pets in Zhongshan city, higher than 15.8% pet-friendly families (33) in Liaoning province. The study from Liaoning province showed that self-reporting rates of asthma and asthma-related symptoms were higher than that of children without pets at home, except for doctor-diagnosed asthma (33). Investigations conducted in Guangxi have shown exposed to domestic dogs increased the risk of asthma by 2.39 times in children (34). The survey results of four cities in Liaoning Province showed that children exposed to domestic fur pets were 3.49 times more likely to develop asthma than non-exposed children (9).

Previous researches have generally concluded that pet secretions and skin sputum increased the amount of allergens in the air, which was a risk factor of allergic respiratory diseases such as asthma in children (35–37). Some scholars hold different views. Perzanowski et al. (38) and Henriksen et al. (39) suggested that pets keeping was a protective factor for asthma. Increased endotoxin levels in the air of household pets and exposure to endotoxin in infants and young children was a protective factor for asthma, which might be related to early exposure to microbial substances' endotoxin and inhibition of immunoglobulin IgE antibody production, thereby reducing the risk of allergic diseases (19,40). However, these protective effects might be confused by parents' avoidance of certain types of pets keeping (18,41–43).

In this study, with further research on different domestic pets, we found that cats keeping at home could increase the risk of persistent cough in children ($P < 0.05$); poultry keeping at home also increased the risk of current asthma and allergic rhinitis in children ($P < 0.05$), which was similar to the results of Dong et al. (44) showing cats and poultry keeping increased the risk of asthma and asthma-related symptoms in children. Different species of domestic pets have

different influence on children's asthma and asthma-related symptoms. The possible reason may be that different species of pets produce different allergens, and some allergens are easy to cause diseases. Allergens produced by cats tend to remain in the air for more than half a year even after removal of cats (45). Besides, it might be related to sensitization and endotoxin released by cats, which is much higher than those of dogs (46). At present, there are still few studies revealing the effects of poultry pets such as farm animals on children's respiratory diseases. Dong et al. (47) found that among children who grew up in rural areas and were exposed to farm animals in early stages of life, such exposure enhanced and improved children's autoimmune system gradually and reduced the incidence of asthma and asthma-related symptoms. However, with further development of urbanization in China, there are few opportunities for children to get in contact with poultry animals, and only a few families keep farm animals and other poultry as pets indoors. Reduction of poultry and microbial exposure might increase the risk of asthma and asthma-related symptoms. Our study found that poultry-keeping increased the risk of current asthma and allergic rhinitis in children.

Our research on different ways of contacting domestic pets showed that sleeping with pets could significantly increase the risk of persistent phlegm, doctor-diagnosed asthma, and current asthma ($P < 0.05$). These results were generally in agreement with a study conducted in Shenyang, China (48), which showed that exposure to pets before two years old increased the risk of asthma and asthma-related symptoms. Similarly, a research conducted at Shanghai, China also supported that exposure to pets in early life could increase the risk of asthma (43). However, some studies found that early pet exposure was a protective factor for childhood asthma. Oberle's research in Germany (49) showed that the risk of asthma was significantly lower with intensive contact with cats in the first year of life, and keeping cats in the bedroom might lead to more intense endotoxin exposure. Another study (50) showed that the umbilical cord blood IgE levels of the mothers who kept cats or dogs at home during pregnancy were lower than those of mothers who did not keep pets after excluding 158 mothers and children who purposefully avoided keeping pets at home.

Considering the complex and diverse factors of host and environmental exposure, there might be interactions between various factors. From our results, the interaction between molds and raising of cats was significant. When we used the unconditional logistic regression model to analyze the influence of molds on

the wall and cats keeping on doctor-diagnosed asthma, we included a two-factor product term in the regression equation and found that molds on the wall was a risk factor for doctor-diagnosed asthma ($P < 0.01$; OR = 1.43, 95%CI: 1.2 0 ~ 1.71), while there was no correlation between cats keeping and doctor-diagnosed asthma ($P > 0.05$). However, the OR on the multiplicative scale was 3.21 (95%CI: 1.3 6 ~ 7.60) with a positive interaction, indicating that exposure to molds and cats had combined effects, which was greater than the estimated influence of molds alone and cats keeping alone. Rothman (51) believed that the evaluation of biological interactions should be based on addition rather than multiplication scales. For the additive scale, RERI was 3.31 (95%CI: 0.0 8 ~ 6.53), indicating that the combined effect of molds on the wall of the house and cats keeping was greater than the sum of the two factors alone, and there was also an orthogonal interaction on a relative scale. The reason might be that several biologically active molecules of molds, such as mycotoxins and (1 → 3)- β -D-glucan etc., which had immune suppression and stimulation effects, especially for children (52,53). The endotoxin released by cats had high sensitization, increasing the risk of asthma in children.

Strengths of our study include large sample, detailed information on pet-keeping and confounding factors, and consideration of interaction effects of pet-keeping and molds on asthma and asthma-related symptoms. There were also some limitations. Firstly, this was a cross-sectional study, so the time relationship between exposure and results was difficult to confirm. We could only explain the association between pet exposure and asthma and asthma-related symptoms in children, but we could not prove that pet exposure is the cause of asthma and asthma-related symptoms in children. Secondly, our results were based solely on the responses to the questionnaire. We were unable to determine whether families without pets had chosen to give up pets keeping because of asthma and asthma-related symptoms among family members. This pet evasive behavior could bias our results, and if the pet was selectively removed, the relationship we observed were underestimated. Thirdly, this study was based on self-reported data, so there might be recalling bias and not so accurate as measured data. Fourthly, we did not consider genetic factors, which might cause confounding, a significant risk factor for asthma and asthma-related symptoms.

5. Conclusions

Our results suggested that pet-keeping was associated with higher odds of asthma and asthma-related

symptoms in children, especially in those keeping cats, poultry as pets and sleeping with pets. In addition, children exposed to both cat-keeping and molds had higher self-report rates of doctor-diagnosed asthma than exposed to cat-keeping or molds alone. In general, further studies of interactions between risk factors of asthma and asthma-related symptoms are essential for understanding the development of asthma.

Acknowledgements

The authors acknowledge the cooperation of participants in this study who had been very generous with their time and assistance. We are also grateful to the anonymous reviewers for their very insightful and constructive comments.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

Funding

This study was supported by grants from the Zhongshan Municipal Science and Technology Project (grant no. 2017B1001).

References

1. Asher I, Pearce N. Global burden of asthma among children. *Int J Tuberc Lung Dis.* 2014;18(11): 1269–1278. doi:10.5588/ijtld.14.0170.
2. Chen Y, Wong GW, Li J. Environmental exposure and genetic predisposition as risk factors for asthma in China. *Allergy Asthma Immunol Res.* 2016; 8(2): 92–100. doi:10.4168/aa.2016.8.2.92.
3. Guo X, Li Z, Ling W, Long J, Su C, Li J, Liang S, Su L. Epidemiology of childhood asthma in mainland China (1988–2014): a meta-analysis. *Allergy Asthma Proc.* 2018; 39(3):15–29. doi:10.2500/aap.2018.39.4131.
4. Liu CH, Hong JG, Shang YX, Sun J, Duolikun-Muzhapaer Shan MN, Gao Y, Ren XM, Liu CS, Zhang YJ. Comparison of asthma prevalence in children from 16 cities of China in 20 years (in Chinese). *Chinese J Pract Pediatr.* 2015; 30(8):596–600.
5. Beasley R, Semprini A, Mitchell EA. Risk factors for asthma: is prevention possible? *Lancet.* 2015; 386(9998): 1075–1085. doi:10.1016/S0140-6736(15)00156-7.
6. Hallit S, Raherison C, Waked M, Hallit R, Layoun N, Salameh P. Validation of the mini pediatric asthma quality of life questionnaire and identification of risk factors affecting quality of life among Lebanese children. *J Asthma.* 2019; 56(2):200–211. doi:10.1080/02770903.2018.1441417.
7. Hallit S, Raherison C, Abou Abdallah R, Hallit R, Salameh P. Correlation of types of food and asthma diagnosis in childhood: a case-control study. *J*

- Asthma. 2018;55(9):966–974. doi:[10.1080/02770903.2017.1379535](https://doi.org/10.1080/02770903.2017.1379535).
8. Bateman ED, Hurd SS, Barnes PJ, Bousquet J, Drazen JM, FitzGerald JM, Gibson P, Ohta K, O'Byrne P, Pedersen SE, et al. Global strategy for asthma management and prevention: GINA executive summary. *Eur Respir J*. 2008; 31(1):143–178. doi:[10.1183/09031936.00138707](https://doi.org/10.1183/09031936.00138707).
9. Dong GH, Ma YN, Ding HL, Jin J, Cao Y, Zhao YD, He QC. Pets keeping in home, parental atopy, asthma, and asthma-related symptoms in 12,910 elementary school children from northeast China. *Indoor Air*. 2009; 19(2):166–173. doi:[10.1111/j.1600-0668.2008.00576.x](https://doi.org/10.1111/j.1600-0668.2008.00576.x).
10. Zheng T, Niu S, Lu B, Fan X, Sun F, Wang J, Zhang Y, Zhang B, Owens P, Hao L, et al. Childhood asthma in Beijing, China: a population-based case-control study. *Am J Epidemiol*. 2002; 156(10):977–983. doi:[10.1093/aje/kwf127](https://doi.org/10.1093/aje/kwf127).
11. Salo PM, Xia J, Johnson CA, Li Y, Avol EL, Gong J, London SJ. Indoor allergens, asthma, and asthma-related symptoms among adolescents in Wuhan, China. *Ann Epidemiol*. 2004; 14(8):543–550. doi:[10.1016/j.annepidem.2003.09.015](https://doi.org/10.1016/j.annepidem.2003.09.015).
12. Hugg TT, Jaakkola MS, Ruotsalainen R, Pushkarev V, Jaakkola JJ. Exposure to animals and the risk of allergic asthma: a population-based cross-sectional study in Finnish and Russian children. *Environ Health*. 2008;7(1). doi:[10.1186/1476-069X-7-28](https://doi.org/10.1186/1476-069X-7-28).
13. Huang Ly Y, Long Z. Risk of childhood asthma in Wuhan city (in Chinese). *Chin J Appl Clin Pediatr*. 2014;29(13):1025–1028.
14. Ahluwalia SK, Matsui EC. Indoor environmental interventions for furry pet allergens, pest allergens, and mold: looking to the future. *J Allergy Clin Immunol Pract*. 2018;6(1):20–21.
15. Ownby DR, Johnson CC, Peterson EL. Exposure to dogs and cats in the first year of life and risk of allergic sensitization at 6 to 7 years of age. *JAMA*. 2002; 288(8):963–972. doi:[10.1001/jama.288.8.963](https://doi.org/10.1001/jama.288.8.963).
16. Xu Ph ML, Tao FB. Relationship between pet ownership and asthma of children aged 6–7 in Germany (in Chinese). *Chin J Public Health*. 2006;22(8):1001–1002.
17. O'Connor GT, Lynch SV, Bloomberg GR, Kattan M, Wood RA, Gergen PJ, Jaffee KF, Calatroni A, Bacharier LB, Beigelman A, et al. Early-life home environment and risk of asthma among inner-city children. *J Allergy Clin Immunol*. 2018;141(4):1468–1475. doi:[10.1016/j.jaci.2017.06.040](https://doi.org/10.1016/j.jaci.2017.06.040).
18. Nafstad P, Magnus P, Gaarder PI, Jaakkola JJ. Exposure to pets and atopy-related diseases in the first 4 years of life. *Allergy*. 2001;56(4):307–312. doi:[10.1034/j.1398-9995.2001.00881.x](https://doi.org/10.1034/j.1398-9995.2001.00881.x).
19. Kramer MS, Matush L, Bogdanovich N, Dahhou M, Platt RW, Mazer B. The low prevalence of allergic disease in Eastern Europe: are risk factors consistent with the hygiene hypothesis? *Clin Exp Allergy*. 2009; 39(5):708–716. doi:[10.1111/j.1365-2222.2009.03205.x](https://doi.org/10.1111/j.1365-2222.2009.03205.x).
20. Kerkhof M, Wijga AH, Brunekreef B, Smit HA, de Jongste JC, Aalberse RC, Hoekstra MO, Gerritsen J, Postma DS. Effects of pets on asthma development up to 8 years of age: the PIAMA study. *Allergy*. 2009; 64(8):1202–1208. doi:[10.1111/j.1398-9995.2009.02016.x](https://doi.org/10.1111/j.1398-9995.2009.02016.x).
21. Finn C. Early immune development, atopy and asthma insights from ATS 2001, May 18–23, San Francisco. *Respir Res*. 2001;2(5):E002.
22. Lødrup Carlsen KC, Roll S, Carlsen K-H, Mowinckel P, Wijga AH, Brunekreef B, Torrent M, Roberts G, Arshad SH, Kull I, GALEN WP 1.5 'Birth Cohorts' working group, et al. Does pet ownership in infancy lead to asthma or allergy at school age? Pooled analysis of individual participant data from 11 European birth cohorts. *PLoS One*. 2012;7(8):e43214. doi:[10.1371/journal.pone.0043214](https://doi.org/10.1371/journal.pone.0043214).
23. Dong G-H, Ma Y-N, Ding H-L, Jin J. Effects of housing characteristics and home environmental factors on respiratory symptoms of 10,784 elementary school children from Northeast China. *A Epidemiol*. 2008;76: 82–91.
24. Oluwole O, Kirychuk SP, Lawson JA, Karunanayake C, Cockcroft DW, Willson PJ, Senthilselvan A, Rennie DC. Indoor mold levels and current asthma among school-aged children in Saskatchewan, Canada. *Indoor Air*. 2017;27(2):311–319. doi:[10.1111/ina.12304](https://doi.org/10.1111/ina.12304).
25. Sinclair R, Russell C, Kray G, Vesper S. Asthma Risk Associated with Indoor Mold Contamination in Hispanic Communities in Eastern Coachella Valley, California. *J Environ Public Health*. 2018;2018: 9350370. doi:[10.1155/2018/9350370](https://doi.org/10.1155/2018/9350370).
26. Vesper S, Wymer L. The relationship between environmental relative moldiness index values and asthma. *Int J Hyg Environ Health*. 2016;219(3):233–238. doi:[10.1016/j.ijheh.2016.01.006](https://doi.org/10.1016/j.ijheh.2016.01.006).
27. Thacher JD, Gruziova O, Pershagen G, Melen E, Lorentzen JC, Kull I, Bergstrom A. Mold and dampness exposure and allergic outcomes from birth to adolescence: data from the BAMSE cohort. *Allergy*. 2017;72(6):967–974. doi:[10.1111/all.13102](https://doi.org/10.1111/all.13102).
28. Zhang J, Sun C, Liu W, Zou Z, Zhang Y, Li B, Zhao Z, Deng Q, Yang X, Zhang X, et al. Associations of household renovation materials and periods with childhood asthma, in China: A retrospective cohort study. *Environ Int*. 2018;113(APR):240–248. doi:[10.1016/j.envint.2018.02.001](https://doi.org/10.1016/j.envint.2018.02.001).
29. Hallqvist J, Ahlbom A, Diderichsen F, Reuterwall C. How to evaluate interaction between causes: a review of practices in cardiovascular epidemiology. *J Intern Med*. 1996;239(5):377–382. doi:[10.1046/j.1365-2796.1996.431782000.x](https://doi.org/10.1046/j.1365-2796.1996.431782000.x).
30. Andersson T, Alfredsson L, Källberg H, Zdravkovic S, Ahlbom A. Calculating measures of biological interaction. *Eur J Epidemiol*. 2005;20(7):575–579. doi:[10.1007/s10654-005-7835-x](https://doi.org/10.1007/s10654-005-7835-x).
31. Xu Dq MR, Zhou YH, Shi SY, Qin P, Tao Y. Interaction analysis of logistic regression model using R software (in Chinese). *Chin J Health Stat*. 2017; 34(4):670–672.
32. Brunekreef B, Von Mutius E, Wong G, Odhiambo J, Garcia-Marcos L, Foliaki S, Group IPTS, ISAAC Phase Three Study Group. Exposure to cats and dogs, and symptoms of asthma, rhinoconjunctivitis, and eczema. *Epidemiology*. 2012;23(5):742–750. doi:[10.1097/EDE.0b013e318261f040](https://doi.org/10.1097/EDE.0b013e318261f040).

33. Qian Z, Dong G-H, Ren W-H, Simckes M, Wang J, Zelicoff A, Trevathan E. Effect of pet ownership on respiratory responses to air pollution in Chinese children: The Seven Northeastern Cities (SNEC) study. *Atmos Environ*. 2014;87:47–52. doi:[10.1016/j.atmos-env.2014.01.010](https://doi.org/10.1016/j.atmos-env.2014.01.010).
34. Jie Xie SD, Li H, Huang HL, Dong GH. Epidemiological survey of the effects of domestic fur pets on asthma and asthma-like symptoms in children (in Chinese). *Chin J Health Stat*. 2010;27(2):161–162.
35. Mendy A, Wilkerson J, Salo PM, Cohn RD, Zeldin DC, Thorne PS. Exposure and sensitization to pets modify Endotoxin Association with asthma and wheeze. *J Allergy Clin Immunol Pract*. 2018;6(6):2006–2013.e4.
36. Gergen PJ, Mitchell HE, Calatroni A, Sever ML, Cohn RD, Salo PIM, Thorne PS, Zeldin DC. Sensitization and exposure to pets: the effect on asthma morbidity in the US population. *J Allergy Clin Immunol Pract*. 2018;6(1):101–107.e2. doi:[10.1016/j.jaip.2017.05.019](https://doi.org/10.1016/j.jaip.2017.05.019).
37. Almqvist C. High allergen exposure as a risk factor for asthma and allergic disease. *Clin Rev Allergy Immunol*. 2005;28(1):25–41. doi:[10.1385/CRIAI:28:1:025](https://doi.org/10.1385/CRIAI:28:1:025).
38. Perzanowski MS, Ronmark E, Platts-Mills TA, Lundback B. Effect of cat and dog ownership on sensitization and development of asthma among preteen-age children. *Am J Respir Crit Care Med*. 2002;166(5):696–702. doi:[10.1164/rccm.2201035](https://doi.org/10.1164/rccm.2201035).
39. Henriksen AH, Holmen TL, Bjermer L. Sensitization and exposure to pet allergens in asthmatics versus non-asthmatics with allergic rhinitis. *Respir Med*. 2001;95(2):122–129. doi:[10.1053/rmed.2000.1004](https://doi.org/10.1053/rmed.2000.1004).
40. H Pohlabein SJ, Böhm J. Exposure to pets and the risk of allergic symptoms during the first 2 years of life. *J Invest Allergol Clin Immunol*. 2007;17(5):302–308.
41. Bornehag CG, Sundell J, Hagerhed L, Janson S. and the DBH Study Group. Pet-keeping in early childhood and airway, nose and skin symptoms later in life. *Allergy*. 2003;58(9):939–944. doi:[10.1034/j.1398-9995.2003.00050.x](https://doi.org/10.1034/j.1398-9995.2003.00050.x).
42. Naydenov K, Popov T, Mustakov T, Melikov A, Bornehag CG, Sundell J. The association of pet keeping at home with symptoms in airways, nose and skin among Bulgarian children. *Pediatr Allergy Immunol*. 2008;19(8):702–708. doi:[10.1111/j.1399-3038.2008.00721.x](https://doi.org/10.1111/j.1399-3038.2008.00721.x).
43. Huang C, Hu Y, Liu W, Zou Z, Sundell J. Pet-keeping and its impact on asthma and allergies among preschool children in Shanghai, China. *Chin Sci Bull*. 2013;58(34):4203–4210. doi:[10.1007/s11434-013-5679-4](https://doi.org/10.1007/s11434-013-5679-4).
44. Dong H-ID G-h, Ma Y-n, Jin J, Cao Y, Zhao Y-d, He Q-c. Asthma and asthma-related symptoms in 16 789 Chinese children in relation to pet keeping and parental atopy. *J Invest Allergol Clin Immunol*. 2008;18(3):207–213.
45. Shah R, Grammer LC. Chapter 1: an overview of allergens. *Allergy Asthma Proc*. 2012;33(3):2–5. doi:[10.2500/aap.2012.33.3531](https://doi.org/10.2500/aap.2012.33.3531).
46. Almqvist C, Egmar AC, van Hage-Hamsten M, Berglund N, Pershagen G, Nordvall SL, Svartengren M, Hedlin G, Wickman M. Heredity, pet ownership, and confounding control in a population-based birth cohort. *J Allergy Clin Immunol*. 2003;111(4):800–806. doi:[10.1067/mai.2003.1334](https://doi.org/10.1067/mai.2003.1334).
47. Dong WYZ, Su W, Sheng J, Yz Li SC, Yu J. Shao Study on the relationship between multi-factor exposure of infants in early childhood and the incidence of asthma in Shanghai suburbs (in Chinese). *Journal of Clinical Pediatrics*. 2012;30:1139–1143.
48. Wu YL CC, Chen LR, Chen Y, Liu YQ, Ren WH, Dong GH. Interactive effects of domestic pets and obesity on asthma and asthma-like symptoms in children (in Chinese). *Chin J Health Stat*. 2015;32(2):295–297.
49. Oberle D, Mutius E, Kries R. Childhood asthma and continuous exposure to cats since the first year of life with cats allowed in the child's bedroom. *Allergy*. 2003;58(10):1033–1036. doi:[10.1034/j.1398-9995.2003.00285.x](https://doi.org/10.1034/j.1398-9995.2003.00285.x).
50. Aichbhaumik N, Zoratti EM, Strickler R, Wegienka G, Ownby DR, Havstad S, Johnson CC. Prenatal exposure to household pets influences fetal immunoglobulin E production. *Clin Exp Allergy*. 2008;38(11):1787–1794. doi:[10.1111/j.1365-2222.2008.03079.x](https://doi.org/10.1111/j.1365-2222.2008.03079.x).
51. Rothman KJ, Sander G, Timothy LL. *Modern epidemiology*. 3rd ed. Lippincott (UK): Lippincott, Williams, & Wilkins; 2008.
52. Garrett Prr MH, Hooper MA, Abramson MJ, *, Hooper BM. Indoor airborne fungal spores, house dampness and associations with environmental factors and respiratory health in children. *Clin Exp Allergy*. 2010;28(4):459–467. doi:[10.1046/j.1365-2222.1998.00255.x](https://doi.org/10.1046/j.1365-2222.1998.00255.x).
53. Tischer C, Chen CM, Heinrich J. Association between domestic mould and mould components, and asthma and allergy in children: a systematic review. *Eur Respir J*. 2011;38(4):812–824. doi:[10.1183/09031936.00184010](https://doi.org/10.1183/09031936.00184010).

1 **SUPPLEMENT 1**

2

3 **Table.** Comparison of positive rates of asthma and asthma-related symptoms among children and adolescents with different characteristics

Characteristic		N	Persistent cough Cases(%)	Persistent phlegm Cases(%)	Wheezing Cases(%)	Doctor-diagnosed asthma Cases(%)	Current asthma Cases(%)	Allergic rhinitis Cases(%)
Gender	Female	5524	158(2.86)	58(1.05)	313(5.67)	251(4.54)	63(1.14)	1452(26.29)
	male	6087	173(2.84)	81(1.33)	492(8.08 ^a)	411(6.75 ^a)	106(1.74 ^a)	1904(31.28)
age (year)	5~12	7160	244(3.40 ^a)	58(1.05)	572(7.99 ^a)	453(6.33 ^a)	135(1.89 ^a)	2137(29.85 ^a)
	13~18	4451	87(2.00)	100(1.40 ^a)	233(5.23)	209(4.7)	34(0.67)	1219(27.39)
filler's education	<higher school	2332	55(2.36)	31(1.33)	124(5.32 ^a)	128(5.49)	25(1.07)	579(24.83 ^a)
	≥higher school	9279	276(2.97)	108(1.16)	681(7.34)	534(5.75)	144(1.55)	2777(29.93)
family income	<CNY 100,000	5925	161(2.72)	66(1.11)	357(6.03 ^a)	319(5.38)	71(1.20 ^a)	1617(27.29 ^a)
	≥CNY 100,000	5686	170(2.99)	73(1.28)	448(7.88)	343(6.03)	98(1.72)	1739(30.58)
cat-keeping	NO	11280	315(2.79 ^a)	133(1.18)	778(6.90)	636(5.64)	161(1.43)	3248(28.79)
	YES	331	16(4.83)	6(1.81)	27(8.16)	26(7.85)	8(2.42)	108(32.63)
poultry-keeping	NO	11565	330(2.85)	139(1.20)	800(6.92)	657(5.68)	166(1.44 ^a)	3336(28.85)
	YES	46	1(2.17)	0(0.00)	5(10.87)	5(10.87)	3(6.52)	20(43.48)
Sleeping with pets	NO	11577	328(2.83 ^a)	137(1.18 ^a)	802(6.92)	656(5.66 ^a)	167(1.44 ^a)	3346(28.90)
	YES	34	3(8.82)	2(5.88)	3(8.82)	6(17.64)	2(5.88)	10(29.41)

Characteristic		N	Persistent cough Cases(%)	Persistent phlegm Cases(%)	Wheezing Cases(%)	Doctor-diagnosed asthma Cases(%)	Current asthma Cases(%)	Allergic rhinitis Cases(%)
Exposure to pets before two years old	NO	11020	308(3.79)	127(1.15)	758(6.88)	620(5.63)	154(1.40 ^a)	3166(28.73)
	YES	591	23(3.98)	12(2.03)	47(7.95)	42(7.11)	15(2.54)	190(32.15)
molds on the wall of the house	NO	9151	237(2.59 ^a)	112(1.22)	557(6.09 ^a)	476(5.20 ^a)	119(1.30 ^a)	2496(27.28 ^a)
	YES	2460	94(3.82)	27(1.10)	248(10.08)	186(7.56)	50(2.03)	860(34.96)
passive smoking	NO	8023	209(2.61 ^a)	73(0.91 ^a)	522(6.51 ^a)	425(5.30 ^a)	108(1.35)	2301(28.68)
	YES	3588	122(3.40)	66(1.84)	283(7.89)	237(6.61)	61(1.70)	1055(29.40)
children's passive smoking before two years old	NO	10111	266(2.63 ^a)	100(0.99 ^a)	645(6.38 ^a)	536(5.30 ^a)	132(1.31 ^a)	2855(28.24 ^a)
	YES	1500	65(4.33)	39(2.60)	160(10.67)	126(8.40)	37(2.47)	501(33.40)
maternal smoking during pregnancy	NO	11579	329(2.84)	137(1.18 ^a)	802(6.93)	660(5.70)	169(1.46)	3350(28.93)
	YES	32	2(6.25)	2(6.25)	3(9.38)	2(6.25)	0(0.00)	6(18.75)
passive smoking during pregnancy	NO	10473	285(2.72 ^a)	111(1.06 ^a)	693(6.62 ^a)	576(5.50 ^a)	142(1.36 ^a)	2972(28.37 ^a)
	YES	1138	46(4.04)	28(2.46)	112(9.84)	86(7.56)	27(2.37)	384(33.74)
housing renovation within two years	NO	3655	82(2.24 ^a)	41(1.12)	213(5.83 ^a)	181(4.95 ^a)	47(1.29)	917(25.09 ^a)
	YES	7956	249(3.13)	98(1.23)	592(7.44)	481(6.05)	122(1.53)	2439(30.66)
new furniture	NO	7786	201(2.58 ^a)	94(1.21)	475(6.10 ^a)	428(5.50)	105(1.35)	2106(27.05 ^a)
	YES	3825	130(3.40)	45(1.18)	330(8.63)	234(6.12)	64(1.67)	1250(32.68)

Characteristic		N	Persistent cough Cases(%)	Persistent phlegm Cases(%)	Wheezing Cases(%)	Doctor-diagnosed asthma Cases(%)	Current asthma Cases(%)	Allergic rhinitis Cases(%)
paint	NO	9160	235(2.57 ^a)	110(1.20)	585(6.39 ^a)	498(5.44 ^a)	115(1.26 ^a)	2532(27.64 ^a)
	YES	2451	96(3.92)	29(1.18)	220(8.98)	173(7.06)	54(2.20)	824(33.62)
Cooker hood	NO	785	20(2.55)	11(1.40)	32(4.08 ^a)	39(4.97)	6(0.76)	163(20.76 ^a)
	YES	10826	311(2.87)	128(1.18)	773(7.14)	623(5.75)	163(1.51)	3193(29.49)
cockroaches' haunting the house	NO	3624	75(2.07 ^a)	39(1.08)	154(4.25 ^a)	149(4.11 ^a)	34(0.94 ^a)	879(24.25 ^a)
	YES	7987	256(3.21)	100(1.25)	651(8.15)	513(6.42)	135(1.69)	2477(31.01)
school laying plastic track	NO	1339	31(2.32)	14(1.05)	73(5.45 ^a)	68(5.08)	14(1.05)	353(26.36 ^a)
	YES	10272	300(2.92)	125(1.22)	732(7.13)	594(5.78)	155(1.51)	3003(29.23 ^a)
premature birth	NO	10818	295(2.73 ^a)	129(1.19)	719(6.65 ^a)	596(5.51 ^a)	159(1.47)	3080(28.47 ^a)
	YES	793	36(4.54)	10(1.26)	86(10.84)	66(8.32)	10(1.26)	276(34.80)
Breastfeeding	YES	6694	168(2.51)	70(1.05 ^a)	396(5.92 ^a)	339(5.06)	83(1.24)	1817(27.14 ^a)
	NO	2223	64(2.88)	37(1.66)	158(7.11)	128(5.76)	33(1.24)	610(27.44)

4 a:*P*-value < 0.05.

5

6