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Asthma and Asthma-Related Symptoms in 16 789 Chinese Children in Relation to Pet Keeping and Parental Atopy

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Abstract

Background: The relationship between exposure to animals and allergic respiratory diseases in childhood is controversial, and there is little information about how exposure to pets affects the respiratory health of Chinese children, who have lower rates of asthma.
Objective: To study the association between exposure to pets and doctor-diagnosed asthma and asthma-related symptoms in Chinese children. We also investigated whether genetic propensity as a result of parental atopy modifies these relations.
Methods: A cross-sectional study of 16 789 children was conducted at 24 randomly selected kindergartens and 12 elementary schools in Liaoning province, China. Information on respiratory health and exposure to indoor allergens was obtained by a standard questionnaire from the American Thoracic Society.
Results: In children, exposure to animals was associated with a diagnosis of asthma (adjusted odds ratio [OR], 1.49; 95% confidence interval [CI], 1.30-1.70), wheezing (adjusted OR, 1.37; 95% CI, 1.18-1.60), persistent cough (adjusted OR, 1.71; 95% CI, 1.52-1.91), and persistent phlegm (adjusted OR, 2.26; 95% CI, 1.94-2.64). Parental atopy increased the risk of a diagnosis of asthma (adjusted OR, 3.12; 95% CI, 2.61-3.73) and asthma-related symptoms. There was an interaction between parental atopy and pet exposure in persistent cough and persistent phlegm, but not in doctor-diagnosed asthma.
Conclusions: Pet keeping and parental atopy increased the risk of asthma and allergic respiratory diseases in children. Parental atopy modified the effect of pet exposure in persistent cough and persistent phlegm but not in doctor-diagnosed asthma.

Key words: Asthma. Children. Pets. Parental atopy.

Resumen

Antecedentes: Existe una relación controvertida entre la exposición a los animales y las enfermedades respiratorias en la infancia y hay muy poca información sobre cómo la exposición a los animales domésticos afecta al estado de salud respiratoria de los niños chinos que presentan unos índices menores de asma.
Objetivo: El objetivo fue estudiar la relación entre la exposición a los animales domésticos y el asma, y los síntomas relacionados con el asma en los niños chinos. También examinamos si la predisposición genética como resultado de una atopia de los padres puede modificar estas relaciones.
Métodos: Se llevó a cabo un estudio transversal de 16 789 niños en 24 jardines de infancia seleccionados al azar y 12 escuelas de primaria en la provincia de Liaoning, en China. La información sobre el estado de salud respiratoria y la exposición a los alérgenos de interior se obtuvo mediante el cuestionario habitual de la American Thoracic Society.
Resultados: En el caso de los niños, la exposición a los animales se relaciona con un diagnóstico de asma (Cociente de Posibilidades [CP] ajustado, 1,49; Intervalo de Confianza del 95 % [IC] 1,30-1,70), sibilancia (CP ajustado, 1,37; IC del 95 %, 1,18-1,60), tos permanente (CP ajustado, 1,71; IC del 95 %, 1,52-1,91) y flema persistente (CP ajustado, 2,26; IC del 95 %, 1,94-2,64). La atopia de los padres aumentó el riesgo de un diagnóstico de asma (CP ajustado, 3,12; IC del 95 %, 2,61-3,73) y los síntomas relacionados con el asma.

Encontramos una interacción entre la atopia de los padres y la exposición a los animales para la tos permanente y la flema persistente, pero no para el asma.
Conclusiones: Tener animales domésticos en casa y la atopia de los padres aumenta el riesgo de padecer asma y enfermedades respiratorias alérgicas en los niños. La atopia de los padres modificó el efecto de la exposición a los animales domésticos para la tos permanente y la flema persistente, pero no para el asma.

Palabras clave: Asma. Niños. Animales domésticos. Atopia de los padres.

Introduction

Several studies have investigated the role of pet exposure in the development of allergic diseases among children, but the results of these studies are controversial [1-8]. Hesselmar et al [1] conducted an investigation among Swedish children and found that those exposed to pets during the first year of life had a lower prevalence of allergic rhinitis and asthma in later childhood. Another birth cohort study in the USA [2] concluded that exposure to pets in the first year of life may reduce subsequent risk of allergic sensitization not only to pet allergens, but also to other allergens during childhood. This negative association was more prominent in children with a positive family history of atopy [3]. However, recent data suggest that early-life exposure to pets can diminish the risk of allergic asthma only among children with no family history of atopic disorders [4], and results from the PMSEAD study [5] did not find a protective effect of early pet exposure on asthma or asthma-related symptoms in children or adults. Exposure to pets early in life even increased the risk of asthma symptoms [6,7]. Apelberg et al [8] performed a systematic review to synthesize the evidence of the effect of exposure to pets in the home on the risk of asthma and asthma-related symptoms. They concluded that exposure to pets increases the risk of asthma and wheezing in older children (>6 years) but not in children under 6 years. However, a study from Finland showed that the risk of asthma was lower among adults who kept pets [9].

The role of exposure to pets in childhood asthma seems to vary with geographic region, because children with asthma tend to become sensitized to local allergens [10,11]. However, there is little information about how exposure to pets affects children's respiratory health among non-Western populations, which have lower rates of asthma. In China, the prevalence of asthma and atopic illness has remained very low among the Chinese population on the mainland compared with populations in industrialized countries in the West and in Hong Kong [12,14]. Therefore, we decided to examine the relationship between exposure to pets and children's respiratory health in Liaoning province, China.

As far as genetic factors are concerned, a family history of allergic disease is considered to increase the risk of asthma development [15,16]. Some genetic markers could impose susceptibility to the effects of environmental factors. For example, children whose parents were atopic (1 or both) were more sensitive to environmental tobacco smoke than those without parental atopy [16].

We examined whether self-reported exposures to common indoor allergens were associated with doctor-diagnosed asthma and asthma-related symptoms in a cross-sectional study of children from 3 cities in Liaoning province, northeast China. We also assessed the joint effect of genetic propensity to asthma, measured as parental atopy or asthma, and exposure to pets.

Methods

Participants and Study Procedure

The procedures followed were in accordance with the ethical standards of the Committee on Human Experimentation of China Medical University. We intended to study 19 590 children (2-13 years old) from 12 districts in 3 cities in Liaoning province, China. We actually examined 16 789 children; the response rate was 85.7%. Liaoning province is located in the northeast of China and is home to 14 cities. In April 2007, 3 cities in this province were randomly selected for study: Shenyang, with 5 districts, Dalian, with 4, and Anshan, with 3. Two kindergartens and 1 elementary school were randomly selected from each district of each city. The resulting 24 kindergartens and 12 elementary schools were included. Local study staff informed students about the survey at the participating schools. Teachers were given verbal and written instructions, questionnaires, and forms to record questionnaire distribution and collection. After written parental consent was obtained, parents were invited to a parents' night with the study staff, at which teachers explained the study and the conditions of consent. Teachers were instructed not to urge parents to fill out the questionnaire, as participation was strictly voluntary. Parents who wished to participate completed the questionnaire at home and returned it (via their child) to the teacher in an envelope.

Questionnaire Data

We used the questionnaire to assess the children's respiratory health and potential risk factors such as exposure to indoor allergens. We included questions on respiratory health from the American Thoracic Society Epidemiologic Standardization Project questionnaire, which had already been used in other studies [7,17-19]. This questionnaire had been translated into Chinese for previous studies in other Chinese cities [7,19].

Children's respiratory conditions were determined from questionnaire responses and were defined as follows: a) Doctor-diagnosed asthma: a yes answer to the question "Has a doctor ever diagnosed asthma in this child?" b) Wheezing: a yes

answer to the question "Has this child's chest ever sounded wheezy or whistling when he/she has a cold?" or a yes answer to the question "Has this child's chest ever sounded wheezy or whistling when he/she does not have a cold?" c) Persistent cough: the answers to several cough-related questions which indicate that the child a cough on most days (4 or more days per week) for at least 3 months a year either with or without a cold during the last 12 months; d) Persistent phlegm: the answers to several phlegm-related questions which indicate that the child has seemed congested or brought up phlegm, sputum, or mucus from the chest on most days (4 or more days per week) for at least 3 months a year either with or without a cold during the last 12 months; e) Allergic rhinitis: a yes answer to the question "Has a doctor ever diagnosed allergic rhinitis in this child?"

Current exposure to pet keeping was characterized by questions defining the type and number of animals in the child's household during the past 12 months. We created a categorical variable indicating whether the child was exposed to dogs, cats, birds, farm animals, or other types of animal. We included chickens, ducks, cows, and pigs in the farm animal category. Children who did not have any animals were assigned to the reference category. Parental atopy was defined as a history of maternal or paternal asthma, hay fever, allergic eczema, or allergic conjunctivitis. Information on these categories was obtained in the questionnaire.

Table 1. Characteristics of the Study Population of Kindergarten and Elementary School Children (n = 16 789)

Characteristics	Children, No. (%)
Gender	
Male	8482 (50.5%)
Female	8307 (49.5%)
Asthma and asthma-related symptoms	
Doctor-diagnosed asthma	1086 (6.5%)
Wheezing	906 (5.4%)
Persistent cough	1570 (9.4%)
Persistent phlegm	766 (4.6%)
Allergic rhinitis	1072 (6.4%)
Parental atopic diseases	
Maternal allergy	503 (3.0%)
Paternal allergy	406 (2.4%)
Maternal asthma	128 (0.8%)
Paternal asthma	154 (0.9%)
Any	1039 (6.2%)
Exposure	
No animals	12 405 (73.9%)
Any animals	4384 (26.1%)
Dogs	1698 (10.1%)
Cats	543 (3.2%)
Birds	1141 (6.8%)
Farm animals	791 (4.7%)
Other animals	854 (5.1%)
Environmental tobacco smoke	7840 (46.7%)
Breast feeding	12 727 (75.8%)
Number of rooms < 3	7253 (43.2%)
Home coal use	1003 (6.0%)
Education level of parents < high school	4244 (25.3%)

Statistical Analysis

We calculated the adjusted odds ratios (OR) with 95% confidence intervals (95% CI) for each of the 5 outcome measures (doctor-diagnosed asthma, wheezing, persistent cough, persistent phlegm, and allergic rhinitis) by unconditional logistic regression (Proc Logistic in SAS System for Windows, Version 8.01, SAS Institute, Inc., Cary, North Carolina, United States, USA). The following covariates were assessed as potential confounders: age, gender, breast feeding, city dweller, use of domestic cooking and heating fuels, environmental tobacco smoke (ETS), number of rooms, parental educational level, and family history of allergic disease. We studied the relationship of doctor-diagnosed asthma and asthma-related symptoms to parental atopy and to current exposure to individual pets or any combination of pets.

We stratified the analysis according to pet exposure and parental atopy in 4 exposure categories: (1) no parental atopy and no pets (reference category); (2) no parental atopy but with pets; (3) parental atopy and no pets; and (4) both parental atopy and pets. Independent and joint effects of pet exposure and parental atopy on asthma and asthma-related symptoms were estimated using indicator variables created for each category. We calculated the ORs by contrasting each of the 3 exposure categories with the reference category. Estimates for each of the 3 exposure categories with the reference group were derived from the same logistic regression model, after adjustment for confounders. Statistical significance was 2-sided and set at $P < .05$.

Results

Subjects

The characteristics of the study population are presented in Table 1. The mean (SD) age of the children was 8.6 (2.7) years. Prevalence of doctor-diagnosed asthma, wheezing, persistent cough, and persistent phlegm (Table 1) was consistent with that of previous studies among Chinese children [13,14,19], with 1086 subjects (6.5%) reported to have doctor-diagnosed asthma. Of the doctor-diagnosed asthmatics, 46.4% reported wheezing, 24.7% allergic rhinitis, 33.5% persistent cough, and 22.7% persistent phlegm in the past 12 months. The prevalence of these symptoms was much lower in children without doctor-diagnosed asthma: 2.6% reported wheezing, 5.1% allergic rhinitis, 7.7% persistent cough, and 3.3% persistent phlegm during the past year. A total of 1036 (6.2%) subjects' parents had a history of atopic diseases. The prevalence of pet keeping was higher in subjects with parental atopy than in subjects without parental atopy (28.5% vs 25.9%). The conditions of exposure to pets, parental atopy, and other risk factors in the home environment are shown in Table 1.

Effects of Parental Atopy and Exposure to Pets

Table 2 presents the risk of doctor-diagnosed asthma and asthma-related symptoms in relation to parental atopic disease and the presence of pets in the home. After adjustment for a set of different covariates such as age, gender, breast feeding, environmental tobacco smoke, parents' education levels and

Table 2. Adjusted Odds Ratios (95% Confidence Interval) of Asthma-Related Symptoms and Doctor-Diagnosed Asthma in Relation to Parental Atopy and Current Pet Exposure in Kindergarten and Elementary School Children (n = 16 789)[a]

	Persistent Cough	Persistent Phlegm	Doctor-Diagnosed Asthma	Wheezing	Allergic Rhinitis
Parental atopic diseases					
None	1.00	1.00	1.00	1.00	1.00
Maternal allergy	1.33 (1.01-1.74)	1.32 (0.92-1.91)	1.06 (0.76-1.46)	1.37 (0.99-1.89)	2.60 (1.96-3.46)
Paternal allergy	1.52 (1.14-2.03)	1.51 (1.02-2.23)	2.33 (1.74-3.13)	2.07 (1.51-2.85)	1.87 (1.41-2.49)
Maternal asthma	1.80 (1.12-2.87)	1.77 (0.97-3.22)	5.42 (3.60-8.16)	4.25 (2.69-6.71)	1.05 (0.57-1.94)
Paternal asthma	1.24 (0.76-2.02)	1.91 (1.09-3.34)	4.75 (3.24-6.96)	4.65 (3.07-7.05)	1.85 (1.15-2.96)
Any	1.63 (1.36-1.96)	1.76 (1.38-2.25)	3.12 (2.61-3.73)	3.01 (2.47-3.65)	2.50 (2.06-3.02)
Exposure to pets					
None (reference)	1.00	1.00	1.00	1.00	1.00
Yes	1.71 (1.52-1.91)	2.26 (1.94-2.64)	1.49 (1.30-1.70)	1.37 (1.18-1.60)	1.03 (0.89-1.19)
Type of pet[b]					
Cats	1.59 (1.13-2.24)	2.06 (1.33-3.71)	1.60 (1.09-2.36)	2.06 (1.37-3.11)	1.15 (0.77-1.71)
Dogs	1.36 (1.12-1.65)	1.78 (1.36-2.27)	1.39 (1.12-1,74)	1.43 (1.11-1.84)	0.89 (0.70-1.14)
Birds	1.46 (1.15-1.85)	1.87 (1.36-2.56)	1.12 (0.83-1.52)	1.31 (0.96-1.78)	0.80 (0.57-1.12)
Farm animals	1.76 (1.33-2.33)	2.73 (1.93-3.86)	1.47 (1.03-2.09)	1.73 (1.20-2.49)	1.12 (0.77-1.62)
Other animals	0.87 (0.61-1.24)	1.05 (0.64-1.73)	1.22 (0.84-1.77)	1.19 (0.80-1.77)	0.67 (0.47-1.22)

[a] Odds ratios adjusted for age, gender, breast feeding, use of domestic cooking and heating fuels, environmental tobacco smoke, number of rooms, home decorations, parental education level, and other parental atopy and pet variables.
[b] All odds ratios are computed for subjects with no exposure to animals.

other factors, parental atopy was a strong determinant of doctor-diagnosed asthma (adjusted OR, 3.12; 95% CI, 2.61-3.73) and asthma-related symptoms. The effect of parental atopy on allergic rhinitis was also significant (adjusted OR, 2.50; 95% CI, 2.06-3.02), especially for maternal allergy (adjusted OR, 2.60; 95% CI, 1.96-3.46). Maternal asthma was the strongest predictor of doctor-diagnosed asthma (adjusted OR, 5.42; 95% CI, 3.06-8.16) and asthma-related symptoms, followed by paternal asthma (adjusted OR, 4.75; 95% CI, 3.24-6.96). The presence of pets at home was related to an increased risk of doctor-diagnosed asthma (adjusted OR, 1.49; 95% CI, 1.30-1.70) and asthma-related respiratory symptoms (adjusted OR, 1.71; 95% CI, 1.52-1.91 for persistent cough; adjusted OR, 2.26; 95% CI, 1.94-2.64 for persistent phlegm; adjusted OR, 1.37; 95% CI, 1.18-1.60 for wheezing). While exposure to cats, dogs, and farm animals was strongly related to doctor-diagnosed asthma (adjusted OR, 1.60; 95% CI, 1.09-2.36 for cats; adjusted OR, 1.39; 95% CI, 1.12-1.74 for dogs; adjusted OR, 1.47; 95% CI, 1.03-2.09 for farm animals), the risk of persistent cough, persistent phlegm, and wheezing was also significantly elevated for the presence of cats, dogs, and farm animals. Furthermore, we found a strong association between exposure to birds and persistent cough (adjusted OR, 1.46; 95% CI, 1.15-1.85) and persistent phlegm (adjusted OR, 1.87; 95% CI, 1.36-2.56). However, the effect of exposure to pets on allergic rhinitis was not significant.

Joint Effect of Parental Atopy and Exposure to Pets

Table 3 shows the joint effect of parental atopy and exposure to pets. In subjects without pets, parental atopy alone significantly increased the risk of doctor-diagnosed asthma, with an adjusted OR of 3.37 (95% CI, 2.71-4.18), which corresponds to a 237% excess risk. The effect of pet keeping was significant in subjects with nonatopic parents and an adjusted OR of 1.52 (95% CI, 1.31-1.76), corresponding to a 52% excess risk. The adjusted OR of doctor-diagnosed asthma was 3.91 (95% CI, 2.85-5.36), a 291% excess risk, in subjects with both parental atopy and pets compared with the reference category. On the basis of their independent effects on an additive scale, the combined effect of parental atopy and exposure to pets was just as expected. A similar pattern was also observed in wheezing. The combined effect of parental atopy and exposure to pets (264%) was as expected on the basis of their independent effects (224% and 40%, respectively) on the additive scale (Table 3).

We found an interaction effect between parental atopy and pet exposure on the risk of persistent cough and persistent phlegm in children. In subjects without pets, parental atopy implies a 47% excess risk for persistent phlegm, and in subjects with nonatopic parents, pet keeping results in a 119% excess risk. However, compared with reference subjects, there was a 340% excess risk (adjusted OR, 4.40) for persistent phlegm in subjects with both parental atopy and pets, which was approximately twice their independent effects on the additive scale. A similar pattern was also observed in persistent cough. Among the children with parental atopy, the effects of exposure to pets were not significant with respect to doctor-diagnosed asthma (adjusted OR, 1.23; 95% CI, 0.85-1.79), but they were significant with respect to persistent cough (adjusted OR, 1.59; 95% CI, 1.08-2.34) and persistent phlegm (adjusted OR, 2.92; 95% CI, 1.77-4.82).

Table 3. Adjusted Odds Ratios (95% CI) Confidence Interval of Asthma-Related Symptoms and Doctor-Diagnosed Asthma in Relation to the Joint Effect of Parental Atopy and Exposure to Pets in Kindergarten and Elementary School Children (n=16 789)[a]

	Number of Subjects	Persistent Cough	Persistent Phlegm	Doctor-Diagnosed Asthma	Wheezing	Allergic
Children[c] (reference)[b]	11 662	1.00	1.00	1.00	1.00	1.00
Children[d]	4088	1.71 (1.51-1.93)	2.19 (1.86-2.58)	1.52 (1.31-1.76)	1.40 (1.19-1.65)	1.07 (0.92-1.25)
Children[e]	743	1.67 (1.32-2.10)	1.47 (1.03-2.08)	3.37 (2.71-4.18)	3.24 (2.57-4.08)	2.88 (2.31-3.58)
Children[f]	296	3.12 (2.13-5.16)	4.40 (3.10-6.26)	3.91 (2.85-5.36)	3.64 (2.56-5.19)	1.75 (1.18-2.59)
Children[e] (reference)[g]	743	1.00	1.00	1.00	1.00	1.00
Children[f]	296	1.59 (1.08-2.34)	2.92 (1.77-4.82)	1.23 (0.85-1.79)	1.18 (0.78-1.77)	0.73 (0.47-1.15)

[a] Odds ratios adjusted for age, gender, breast feeding, use of domestic cooking and heating fuels, environmental tobacco smoke, number of rooms, home decorations, parents' education level.
[b] All odds ratios are computed for children with no parental atopy and no pets (reference category).
[c] No parental atopy and no pets (reference category).
[d] No parental atopy but with pets.
[e] Parental atopy and no pets.
[f] Both parental atopy and pets.
[g] Odds ratios are computed for children with parental atopy and no exposure to animals.

Discussion

This study indicated that exposure to pets had adverse effects on respiratory health in this population of Chinese children with a low prevalence of asthma and allergic rhinitis. Associations between asthma, asthma-related symptoms, and exposure to animals were stronger in children without parental atopy. In children with parental atopy, the risk of asthma and asthma-related symptoms was also high for pet keeping, and the effects on persistent cough and persistent phlegm were statistically significant (Table 3).

Several studies have investigated the influence of exposure to allergens on sensitization and the induction of symptoms and have shown that exposure to inhaled allergens exacerbates asthma and other atopies in sensitized individuals, although the process of sensitization may or may not be associated with the onset of clinical symptoms. One meta-analysis [20] evaluated the effects of various environmental factors on the incidence and severity of asthma and concluded that exposure to household allergens is the main risk factor for asthma manifestations, especially with cat allergens, sensitization to which was the strongest independent risk factor for asthma [21]. Ahlbom et al [22] concluded that pet exposure is a strong risk factor in sensitized individuals and recommended that families with an atopic child should avoid getting a pet until the child is 2 years old. Furthermore, a recent study showed that pet keeping may worsen the relationship between air pollution and respiratory symptoms in asthmatic children [23].

Although sensitization to allergens derived from domestic pets has been associated with asthma prevalence and exacerbation, the causal role of indoor allergens in the development of asthma has been challenged. In a recent birth cohort study, Pohlabeln et al [4] found that newborns without a family history of allergic disease had a lower prevalence of asthma at the age of 2 years when their families kept pets. Two cohort studies also suggest that exposure to pets in early life may reduce the risk of developing allergic sensitization and asthma. Hesselmar et al [1] followed up children aged 7 to 8 years from Sweden for 5 years and found that exposure to pets during the first year of life reduced the risk of asthma (adjusted OR 0.34; 95% CI, 0.07-0.77). The results from another cohort study conducted in Norway, including 2531 children followed for 4 years from birth, showed that the adjusted OR of asthma was 0.7 (95% CI, 0.5-1.1) in children with exposure to any pet at birth compared with children in the reference category [24]. Recent data also suggest that both current and childhood farm exposures may play a role in the low prevalence of asthma symptoms observed in adult farmers [25,26]. It has been proposed that high exposure to microbial products such as endotoxin during the first years of life may mediate this protective effect [27,28]. In Western populations, the presence of pets and farm animals may be an important determinant of microbial burden, because increasing levels of hygiene have reduced exposure to microbes [29,30]. Conversely, in non-Western populations, the protective effects of animals may not necessarily be seen, because the microbial burden early in life, irrespective of pets, may be high enough to favor Th1-type immunity [28]. In this Chinese population, microbial burden, including exposure to endotoxin, is likely to be higher during early childhood than among Western populations. Although levels of sanitation have improved in China in recent decades, flush toilets and potable tap water remain uncommon in many areas. For example, open pits in concrete floors are still the standard toilets in many of the schools in this study. However, mechanisms by which exposure to animals can provide protection against atopic diseases such as asthma have not yet been clarified. Another recent hypothesis suggests that the protective effect of animals may also be explained by induced tolerance [21,31,32].

Cultural customs associated with the role of pets in society may influence exposure to pet allergens. For example, in some cultures, animals are domesticated and children may sleep with or near them, whereas in other areas, animals are bred for other purposes and are kept mainly outside the home. Roost et al [3] found that when cats were allowed indoors, cat ownership represented a significant risk for sensitization to cat, whereas this relationship was not clear if cats were kept outdoors. In China, animals are more popular in rural than in urban areas, although they are usually kept outdoors in rural areas. In urban areas of China, most people live in concrete apartment buildings in which animals are usually kept with their owner. Many earlier studies have compared children in urban environments with those in rural environments, which brings many potential confounders into the picture [7,33]. A similar study in children from urban and rural areas of China showed that the risk estimate of doctor-diagnosed asthma for keeping dogs was below unity (OR, 0.85; 95% CI, 0.51-1.40) [7]. In our study, exposure to dogs was strongly related to doctor-diagnosed asthma (OR, 1.39; 95% CI, 1.12-1.74). This suggested that when pet keeping is compared among urban children, it becomes a risk factor.

Individual response to animal exposure in childhood is likely to be influenced by genetic susceptibility [15,16]. The present results show that parental atopy increases the risk of doctor-diagnosed asthma and asthma-related symptoms. We found parental asthma to be the strongest determinant of asthma development in children. Parental allergies also predicted adult-onset asthma and asthma-related symptoms. These findings strongly suggest that genetic background is an important determinant of asthma in children. Therefore, we analyzed whether the effect of animal exposure might differ according to hereditary factors. After stratification on the basis of parental atopy, exposure to pets was associated with an increased risk of diagnosed asthma and asthma-related symptoms in children both with and without a family history of allergic diseases. In our samples, there was an interaction between parental atopy and pet exposure in persistent cough and persistent phlegm, but not in doctor-diagnosed asthma.

Our study is limited in that it was based on questionnaire responses, although most epidemiological studies of asthma rely on recent symptom history and a physician's diagnosis, as these self-reported measures are practical, reproducible, and inexpensive [34,35]. However, as parental atopy is likely to be related to both risk of asthma and pet keeping, we adjusted for parental atopy and elaborated independent and joint effects of parental atopy and exposure to pets. At the same time, the study was introduced to the participants as a study on environmental factors in general, with no special focus on keeping pets, to reduce information bias. As a result, 28.5% of subjects with a family history of allergic diseases had animals, which was higher than the percentage of subjects without a family history of allergic diseases (25.9%).

In conclusion, self-reported exposures to pets contributed independently to asthma and asthma-related symptoms in these Chinese children. Associations between pet keeping and doctor-diagnosed asthma and asthma-related symptoms were stronger in children without parental atopy. Parental atopy modifies the effects of pet exposure not on doctor-diagnosed asthma but on persistent cough and persistent phlegm in children.

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