

Pets keeping in home, parental atopy, asthma, and asthma-related symptoms in 12,910 elementary school children from northeast China

Abstract The effects of pet exposure and parental atopy on respiratory symptoms were investigated in 12,910 children residing in twelve districts of northeast China. Responses to a self-administered questionnaire completed by parents of children were used to ascertain children with persistent cough, persistent phlegm, doctor-diagnosed asthma, current asthma and current wheeze. Exposure to animals during pregnancy was positively associated with doctor-diagnosed asthma [adjusted odds ratio (ORs), 1.86; 95% confidence interval (CI) 1.35–2.57], current asthma (adjusted OR, 3.06; 95% CI, 1.95–4.81) and asthma-related symptoms. Pet exposure in the first year of life and currently having animals in household were also related to a significantly higher prevalence of doctor-diagnosed asthma and asthma-related symptoms in these children. Associations with respiratory symptoms strengthened with higher levels of animal exposure. Parental atopy increased the risk of asthma diagnosis (OR, 3.49; 95%CI, 2.84–4.30), current asthma (OR, 3.94; 95%CI, 2.81–5.54) and asthma-related symptoms. There was an interaction between parental atopy and pet exposure in persistent phlegm, but not in doctor-diagnosed asthma. We conclude that pet keeping and parental atopy increased the risk of respiratory symptoms in children. Parental atopy did modify the effect of pet exposure on persistent phlegm but not on doctor-diagnosed asthma.

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Practical Implications

The relationship between exposure to animals and allergic respiratory diseases in childhood is controversial. Inconsistent with other cross-sectional studies mostly conducted in industrialized countries, our study indicates that exposure to animals may increase the occurrence of respiratory symptoms and diseases in children, and the associations with respiratory symptoms strengthened with higher levels of animal exposure parental atopy did modify the effect of pet exposure on persistent phlegm but not on doctor-diagnosed asthma. These findings support the view that measures should be taken to reduce animals exposure for children in China.

Introduction

The relationship between pet exposure and development of allergic disease is unclear (Apelberg et al., 2001; Bufford and Gern, 2007). Pet exposure in the first year of life has been associated with a lower prevalence of asthma and airway reactivity in later childhood and with less sensitisation not only to pet allergens, but also to other allergens at 6 years of age (Campo et al., 2006; Duramad et al., 2006; Holscher et al., 2002; Ownby

et al., 2002; Roponen et al., 2005), particularly in children with a parental history of atopy (Roost et al., 1999; Svanes et al., 1999). Other studies have not found a protective effect of early pet exposure on either sensitization to cat, or the development of cat allergy or asthma (Ingram et al., 1995; Salo et al., 2004; Sporik et al., 1999), and IPEADAM study found no difference between asthmatic and healthy children in their exposure to pets keeping (Tavernier et al., 2006). A systematic review concluded that exposure to pets

increases the risk of asthma and wheezing in older children (>6 years) but not in children <6 years (Apelberg et al., 2001). Whereas, results from ISAAC and Sweden surveys showed that pets keeping in the first year of life or in early life (<6 years) revealed positive associations with asthma-related symptoms (Behrens et al., 2005; Bornehag et al., 2004), and studies from Finland and Germany showed the risk of asthma and asthma-related symptoms were lower among adults with pets keeping (Chen et al., 2007; Jaakkola et al., 2002).

Pet exposure's contribution to childhood asthma seems to vary in different parts of the world because children with asthma tend to become sensitized to allergens prominent in their living environments (Wood, 1998). Also, the association of race with allergic sensitization among children was different, even exposure to same allergens (Stevenson et al., 2007). However, there is little information about how exposures to pets affect 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 Chinese populations on the mainland compared to populations in industrialized countries in the West as well as in Hong Kong [Kurukulaaratchy et al., 2002; Leung and Ho, 1994; The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee, 1998]. Therefore, it is a distinct opportunity to examine exposures to pets in relation to children's respiratory health in Liaoning province, China.

Family history of allergic diseases is associated with an increased risk of asthma, suggesting that genetic factors play a central role in the development of asthma (Duse et al., 2007; Jaakkola et al., 2001; Morais-Almeida et al., 2007). Some genetic markers could impose susceptibility to the effects of environmental factors. In a recent Norwegian cohort study, the effect of exposure to environmental tobacco smoke (ETS) on asthma was found to be stronger in children of atopic parents compared with children of non-atopic parents (Jaakkola et al., 2001).

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 elementary school students from six 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.

Comparing with the earlier studies, this study was superior in the following aspects:

- The subjects recruited from elementary school, making the scopes of subject's age extended to 7 years old.
- Many earlier studies have included children from

both the urban environment and the rural environment which brought many potential confounders into the picture. But in our study, all the participants were from urban area.

- Many studies did not assess the effect of animal exposure to children's respiratory health in relation to family history of allergic diseases. But in this study, we attempted to adjust the results for potential confounders including family history of allergic diseases.

Methods

Subjects

The procedures followed were in accordance with ethical standards of the responsible committee on human experimentation of China Medical University. A total of 13,778 elementary school children (7–13 years old) should be surveyed from 12 districts in Liaoning province, northeast China. Of those, 12,910 questionnaires from elementary school children were completed, with response rate of 93.7%.

Liaoning province is located in northeast of China, which includes 14 cities. In April of 2007, three cities (Shenyang, Dalian, and Anshan) were randomly selected from Liaoning province. There are five districts in Shenyang city and four districts in Dalian city and three districts in Anshan city. One elementary school was randomly selected from each district of the selected cities. The resulting 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 with envelope and forms to record questionnaire distribution and collection. After obtaining the written parental consent, parents were invited to a parents' night with the attendance of study staff where teachers explained the study and the conditions of consent. Teachers were instructed not to urge parents to fill out the questionnaire, as compliance was strictly voluntary. Parents who wished to participate, completed the questionnaire at home, and returned it (via child) to the teacher in an envelope. Endorsed consent forms were obtained from the parents or guardians of the subjects before their participation in the study.

Questionnaire survey

We assessed children's respiratory health and potential risk factors such as exposures to indoor allergens by questionnaire. We included respiratory health-related questions from American Thoracic Society Epidemiologic Standardization Project questionnaire, which had been proved to be valid in some studies (Dockery et al., 1996; Lee et al., 2006; Qian et al., 2004; Salo et al.,

2004). This questionnaire (ATS) had already been translated into Chinese for previous studies in other Chinese cities (Lee et al., 2006; Qian et al., 2004; Salo et al., 2004). The questionnaire was administered in Chinese and included detailed questions on date of birth, sex, birth weight, breast-feeding, number of years lived in each residence, types and characteristics of dwelling, method of cooking and heating, location of kitchen, types of home ventilation devices (if any), history and current status of children's respiratory illnesses and symptoms, parental education levels, smoking status of parents and other household members, and parental respiratory health histories, and so forth.

Current exposure to *pet keeping* was characterized by questions defining type and number of animals in the child's household during past 12 months. We created a categorical variable indicating whether the child was exposed to dogs, cats, farm animals, or other types of animals. 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. We asked whether children allowed animals to enter the room where they slept and sleeping with the animals in bed during the past 12 months. We also asked whether mother was exposed to animals during pregnancy with this child and whether this child was exposed to animals during the first year of life. *Parental atopy* was defined by reports of the father or mother of the index child's ever having received a diagnosis of asthma, allergic constitution, allergic rhinitis or atopic eczema, and included any history of hay fever, allergies to food or medicine, inhaled dusts, pollen, molds, animal fur or dander, or skin allergies not including poison ivy and oak.

Definitions of respiratory symptoms and illnesses

The following specific respiratory symptoms and illnesses were determined from questionnaire responses:

- *Doctor-diagnosed asthma*: A yes answer to the question 'Has a doctor ever diagnosed asthma in this child?'
- *Current asthma*: under the condition that the child has been diagnosed asthma, a yes answer to the question 'Has this child been in a paroxysm of asthma in last 2 years?' or a yes answer to the question 'Does this child take medicine or treatment for asthma or asthmatic bronchitis?'
- *Current wheeze*: A yes answer to the question 'Does this child's chest ever sound wheezy or whistling, including times when he or she had a cold?' and a yes answer to the question 'Has this child had two or more such episodes in last 12 months?'
- *Persistent cough*: The answers to several cough-

related questions which indicate that the study child has cough on most days (4 or more days per week) for at least 3 months a year either with or without cold during the last 12 months.

- *Persistent phlegm*: The answers to several phlegm-related questions which indicate that the study child has been seem 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 cold during the last 12 months.

Statistical analysis

We calculated adjusted odds ratios (OR) with 95% confidence intervals (95% CI) for each of the five outcome measures (doctor-diagnosed asthma, current asthma, current wheeze, persistent cough, and persistent phlegm) by unconditional logistic regression (Proc Logistic in SAS System for Windows, version 8.02; SAS Institute Inc., Cary, NC, USA). The following covariates were assessed as potential confounders: age, gender, breast feeding, living city, use of domestic cooking and heating fuels, ETS, number of rooms, parental education, and family history of allergic disease. We studied the relation of doctor-diagnosed asthma and asthma-related symptoms to parental atopy and to current exposure to individual pets, or any pet combined.

We also studied the independent and joint effects of parental atopic diseases and pet keeping by comparing the risk of asthma in four exposure categories:

- No parental atopy and no kept pets (reference category);
- no parental atopy but with kept pets;
- parental atopy and no kept pets; and
- both parental atopy and kept pets.

We calculated ORs contrasting each of the three exposure categories with the reference category. Estimates for the independent effects of parental atopy and pet keeping and their joint effect were derived from the same logistic regression model, adjusting for the covariates.

Results

Characteristics of the study population are presented in Table 1. The mean age of the elementary school children was 9.8 years (s.d. 1.8 years). Prevalence of doctor-diagnosed asthma, current asthma, current wheeze, persistent cough, and persistent phlegm (Table 1) were consistent with previous studies among Chinese children (ISAAC, 1998; Qian et al., 2004; Salo et al., 2004). 783 subjects (6.1%) were reported of having doctor-diagnosed asthma. Of the

Table 1 Characteristics of the study population of children ($n = 12910$) at 12 elementary schools in Liaoning province, China

Characteristics	Elementary school children (n , %)
Demographics	
Gender	
Male	6416 (49.7)
Female	6494 (50.3)
Asthma and asthma-related symptoms	
Doctor-diagnosed asthma	783 (6.1)
Current asthma	221 (1.7)
Current wheeze	507 (3.9)
Persistent cough	1072 (8.3)
Persistent phlegm	563 (4.4)
Parental of atopic diseases	
Maternal allergy	359 (2.8)
Paternal allergy	299 (2.3)
Maternal asthma	104 (0.8)
Paternal asthma	132 (1.0)
Any	776 (6.0)
Exposures to pets	
Exposure to pets during pregnancy	469 (3.6)
Exposure to pets in the first years of life	786 (6.1)
Currently exposure to pets	
No	9331 (72.3)
Yes	3579 (27.7)
Sleeping with the pets in the bed during night	
No	3448 (26.7)
Yes	131 (1.0)
Number of pets	
1	2785 (21.6)
≥ 2	794 (6.2)
Dogs	1406 (10.9)
Cats	634 (4.9)
Birds	747 (5.8)
Farm animals	596 (4.6)
Other animals	644 (5.0)
ETS exposure ^a	6078 (47.1)
House decoration in recent 2 years	4790 (37.1)
Breast feeding	9847 (76.3)
Number of room <3	5901 (45.7)
Home coal use	866 (6.7)
Education level of parents <higher school	3749 (29.0)

^aETS, environmental tobacco smoke.

doctor-diagnosed asthmatics, 39.9% reported current wheeze, 29.9% reported allergic rhinitis, 32.7% reported persistent cough and 22.9% reported persistent phlegm in the past 12 months. Prevalence of these symptoms was much lower in children without doctor-diagnosed asthma; 1.6% reported wheeze, 5.9% reported allergic rhinitis, 6.7% reported persistent cough, and 3.2% reported persistent phlegm during the past year. The conditions of exposures to pets and other risk factors in home environment were shown in Table 1.

Table 2 presents the risk of doctor-diagnosed asthma and asthma-related symptoms in relation to parental atopic disease and the presence of current pets in the home. After adjusted for a set of other covariates, parental atopy was a strong determinant of current asthma and asthma-related symptoms. Paternal asthma was the strongest predictor of doctor-diagnosed

asthma and asthma-related symptoms, followed by maternal asthma. In elementary school children, pet exposure during pregnancy was positively associated with doctor-diagnosed asthma, current asthma, current wheeze, and persistent phlegm. Exposure to animals in the first year of life and currently having animals in household were also related to a significantly higher prevalence of doctor-diagnosed asthma and asthma-related symptoms in these children (Table 2). The associations between the respiratory symptoms and animal exposure were stronger among children who allowed animals to enter the bedroom sleeping with animals than among those who did not. In addition, subjects who had two or more animals were more likely to report doctor-diagnosed asthma than those who had only one animal. For persistent cough, persistent phlegm and doctor-diagnosed asthma, there was little difference in the associations by the type of animals (dogs, cats, birds, farm animals, or other animals) when analyzing according to the type of animal(s). However, exposure to farm animals was strongly related to current asthma. Besides that, we also find a strong association between current asthma and exposures to other animals among elementary school children.

Table 3 showed 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 3.68. The effect of pet keeping was significant in subjects with nonatopic parents, with an adjusted OR of 1.58, corresponding to a 58% excess risk. The adjusted OR of wheeze was 4.77, a 377% excess risk, in subjects with both atopic heredity and pets compared with subjects of the reference category. The combined effect of parental atopy and exposure to pets was approximately as expected on the basis of their independent effects in additive scale. Also, according to the current wheeze, in subjects without pets, parental atopy corresponds to a 328% excess risk for current wheeze, and in subjects with nonatopic parents, pet keeping result to a 52% excess risk. The compared with subjects of the reference category, there was a 333% (adjusted OR, 4.33) excess risk for current wheeze in subjects with both atopic heredity and pets.

To our interested, we could find an interacted effect between parental atopy and pet exposure on the risk of persistent phlegm in children. In subjects without pets, parental atopy corresponds to a 67% excess risk for persistent phlegm, and in subjects with nonatopic parents, pet keeping result to a 95% excess risk. However, compared with subjects of the reference category, there was a 341% (adjusted OR, 4.41) excess risk for persistent phlegm in subjects with both atopic heredity and pets, which was approximately two times of their independent effects in additive scale. Among subjects with parents' history of atopy, pets keeping

Effects of pet exposure and parental atopy on respiratory symptoms

Table 2 Adjusted ORs (95%CI) of asthma-related symptoms and doctor-diagnosed asthma in relation to parental atopy and current pets exposure in elementary school children ($n = 12910$)^a

Characteristics	Persistent cough	Persistent phlegm	Doctor-diagnosed asthma	Current asthma	Current wheeze
Parental of atopic diseases (reference: no)	1.00	1.00	1.00	1.00	1.00
Maternal allergy	1.12 (0.78,1.59)	1.00 (0.61,1.63)	1.11 (0.75,1.65)	1.14 (0.58,2.23)	1.50 (0.98,2.31)
Paternal allergy	1.68 (1.19,2.38)	1.99 (1.28,3.07)	2.34 (1.65,3.33)	1.88 (1.01,3.48)	1.93 (1.26,2.97)
Maternal asthma	2.03 (1.20,3.43)	1.15 (0.53,2.52)	5.83 (3.68,9.25)	4.49 (2.13,9.44)	4.38 (2.54,7.56)
Paternal asthma	1.54 (0.92,2.56)	2.11 (1.16,3.83)	4.45 (2.91,6.82)	5.23 (2.80,9.76)	5.32 (3.34,8.45)
Any	1.73 (1.39,2.16)	1.65 (1.23,2.22)	3.49 (2.84,4.30)	3.94 (2.81,5.54)	3.72 (2.92,4.74)
Exposure to pets during pregnancy	1.19 (0.86,1.66)	1.50 (1.01,2.26)	1.86 (1.35,2.57)	3.06 (1.95,4.81)	2.91 (2.10,4.03)
Exposure to pets in the first years of life	1.24 (0.97,1.60)	1.38 (1.00,1.91)	1.42 (1.07,1.88)	2.50 (1.69,3.70)	2.29 (1.73,3.04)
Current exposure to pets (reference: no) ^b	1.00	1.00	1.00	1.00	1.00
Yes	2.01 (1.72,2.33)	2.59 (2.13,3.14)	1.53 (1.28,1.84)	1.07 (0.76,1.50)	1.21 (0.96,1.52)
Sleeping with the pets in the bed during night ^b					
No	2.01 (1.73,2.35)	2.55 (2.10,3.10)	1.47 (1.22,1.78)	0.94 (0.65,1.35)	1.10 (0.86,1.40)
Yes	1.65 (0.83,3.27)	3.47 (1.73,6.96)	3.14 (1.68,5.90)	4.47 (1.92,10.41)	4.31 (2.24,8.29)
Number of pets ^b					
1	2.12 (1.79,2.50)	2.78 (2.25,3.44)	1.29 (0.96,1.73)	1.28 (0.89,1.85)	1.13 (0.87,1.48)
≥2	1.72 (1.32,2.25)	2.09 (1.48,2.94)	1.59 (1.34,1.89)	0.56 (0.26,1.22)	1.39 (0.95,2.02)
Type of pets ^b					
Cats	1.52 (1.04,2.22)	1.79 (1.10,2.92)	1.59 (1.04,2.43)	2.00 (0.99,4.02)	1.94 (1.19,3.16)
Dogs	1.36 (1.09,1.70)	1.67 (1.25,2.23)	1.42 (1.10,1.82)	0.80 (0.46,1.41)	1.42 (1.05,1.93)
Birds	1.66 (1.25,2.21)	1.99 (1.38,2.88)	1.21 (0.84,1.73)	1.00 (0.62,1.62)	0.81 (0.37,1.74)
Farm animals	2.11 (1.53,2.90)	2.81 (1.87,4.20)	1.55 (1.03,2.34)	2.21 (1.43,3.44)	1.01 (0.40,2.53)
Other animals	2.02 (1.56,2.63)	3.14 (2.31,4.28)	1.97 (1.46,2.65)	1.82 (1.07,3.09)	1.50 (1.01,2.24)

^aOdds ratios (ORs) adjusted for age, gender, breast feeding, use of domestic cooking and heating fuels, ETS, Number rooms, home decorations, parents education and other parental atopy and pet variables.

^bAll ORs are computed to subjects with no current exposure to animals.

Table 3 Adjusted ORs (95%CI) of asthma-related symptoms and doctor-diagnosed asthma in relation to the joint effect of parental atopy and exposure to pets in elementary school children ($n = 12910$)^a

Characteristics	<i>n</i>	Persistent cough	Persistent phlegm	Doctor-diagnosed asthma	Current asthma	Current wheeze
Children ^a (reference) ^f	8784	1.00	1.00	1.00	1.00	1.00
Children ^b	3350	1.81 (1.57,2.08)	1.95 (1.87,2.72)	1.58 (1.33,1.88)	1.23 (0.88,1.72)	1.52 (1.23,1.89)
Children ^c	574	1.73 (1.31,2.30)	1.67 (1.21,2.19)	3.68 (2.85,4.75)	4.33 (2.92,6.43)	4.28 (3.20,5.73)
Children ^d	229	2.96 (2.09,4.23)	4.41 (2.77,6.37)	4.77 (3.34,6.83)	3.79 (1.97,7.28)	4.33 (2.79,6.73)
Children ^e (reference) ^g	574	1.00	1.00	1.00	1.00	1.00
Children ^d	229	1.72 (1.08,2.73)	2.83 (1.53,5.22)	1.33 (0.87,2.04)	0.94 (0.45,1.94)	1.08 (0.65,1.78)

^aNo parental atopy and no kept pets (reference category).

^bNo parental atopy but with kept pets.

^cParental atopy and no kept pets.

^dBoth parental atopy and kept pets.

^eOdds ratios (OR) adjusted for age, gender, breast feeding, use of domestic cooking and heating fuels, ETS, Number rooms, home decorations, parents education.

^fAll OR are computed to children with no parental atopy and no kept pets (reference category).

^gOR are computed to children with parental atopy and no exposure to animals.

were also positively associated with persistent cough and persistent phlegm.

Discussion

Our cross-sectional questionnaire survey in 7- to 13-year-old children provides evidence of the effects of pet keeping on the occurrence of childhood asthma and asthma-related symptoms in Liaoning province, China. This study indicated that exposure to pets had adverse effects on respiratory health in these elementary school children. Associations between 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 were also elevated for pets keeping, and the effects on persistent cough and persistent phlegm reached significant level (Table 3).

In general, inhalation of aeroallergens is considered to increase the risk of asthma development, and sensitization to specific allergens is part of the underlying mechanism. For example, there is strong evidence that occupational exposure to high-molecular-weight allergens increases the risk of asthma (Chan-Yeung and Malo, 1995; Krakowiak et al., 2007). Individuals may become sensitized to specific allergens in the

environment and then experience symptoms and signs of asthma when exposed to these allergens. Typically, these reactions can be reproduced in controlled conditions. Our findings of an increased risk of asthma-related symptoms in relation to keeping pets are consistent with this generally accepted theory.

However, this theory has been challenged by a proposition that exposure to allergenic and infectious factors in early life favors the development of tolerance to environmental allergens and reduces the risk of asthma and allergies. Promotion of TH1, as opposed to TH2, cells that mediate allergic reactions has been suggested as the mechanism for the favorable effects of early life exposure (Duramad et al., 2006; Holt and Sly, 1997). Two cohort studies provide evidence of a lower risk of asthma among children exposed to pets in early life compared with unexposed children (Hesselmar et al., 1999; Nafstad et al., 2001). In a Swedish 5-year cohort study of 402 school children 7–8 years of age at baseline, the cumulative incidence of asthma was lower among children who had a pet in the home during the first year of life, with an adjusted OR of 0.34 (95% CI, 0.07–0.77) (Hesselmar et al., 1999). In a Norwegian cohort study of 2531 children followed for 4 years from birth, the risk of asthma was lower in children with any pet at birth, with an adjusted OR of 0.7 (95% CI, 0.5–1.1) (Nafstad et al., 2001). A systematic review concluded that exposure to pets increases the risk of asthma and wheezing in older children (>6 years) but not in children <6 years (Apelberg et al., 2001). In particular, growing up on a farm and exposing to livestock appears to provide protection against development of atopic disease in some Western populations (Ege et al., 2007; Horak et al., 2002). It has been proposed that high exposure to microbial products, such as bacterial endotoxin, in the first years of life may mediate this protective effect (Debarry et al., 2007; Martinez and Holt, 1999; Riedler et al., 2001). 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 microbial exposures (Debarry et al., 2007; Gereda et al., 2001; Kim et al., 2007). Conversely, among non-Western populations, protective effects of animals may not necessarily be seen because microbial burden early in life, irrespective of pets, may be high enough to favor Th1-type immunity (Duramad et al., 2006; Martinez and Holt, 1999). 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 in Liaoning province. However, mechanisms by which exposure to animals can provide

protection against atopic diseases such as asthma are not clear yet. The findings from a large cross-sectional study of 14,077 children (1–6 years old) in Sweden (Bornehag et al., 2003) suggested that the seemingly protective effect of keeping pets may be a result of a ‘healthy pet keeping effect’, as a result of the fact that people avoid exposing their child to something that they believe is a risk factor for allergies. In that study, almost 10% of the population had got rid of pets because of allergy in the family, and 27.3% reported ‘avoidance’ behavior towards pets. It may be that, in Sweden, large information campaigns to the general public on allergy and asthma have been conducted, thus increasing the awareness of the risk with pets. In China, such a protective effect may not be seen where there may be with a lower awareness of risk factors for asthma/allergies. For example, in this study, 29.5% subjects with a family history of allergic diseases had animals, which was higher than that without family history of allergic diseases (27.6%). Another recent hypothesis suggests that the protective effect of animals may also be explained by induced tolerance (Holt and Sly, 1997; Platts-Mills et al., 2001).

Also, the exposure to pet allergens is influenced by both the types of pet and the cultural customs associated with the role of pets in society. In some cultures, children may sleep with or near pets, whereas in other areas they are kept mainly out of the home. A study by Roost et al (Roost et al., 1999) showed that keeping cats outdoors was not significantly associated with an increased risk of sensitization, whereas keeping them indoors was related. In China, animals are more popular in rural than in urban areas, however, animals are usually kept outdoors in rural. In urban areas of China, most of the people live in concrete apartment buildings, in which animals are usually kept with their host. Many earlier studies have compared children in urban environment to those in rural environment which may bring many potential confounders into the picture. A similar study in children from urban and rural 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) (Salo et al., 2004). In our study, exposure to dogs in children was strongly related to doctor-diagnosed asthma (OR, 1.42; 95%CI, 1.10–1.82). This study suggested that when pet keeping was compared among urban children, it becomes a risk factor.

Individual response to animal exposures in childhood is likely to be influenced by genetic susceptibility (Duse et al., 2007; Jaakkola et al., 2001; Morais-Almeida et al., 2007). 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 onset asthma and asthma-related symptoms.

These findings suggest strongly that genetic background is an important determinant of asthma in children. So, we determined whether the effect of animal exposure might differ by hereditary factors. After stratification on the basis of parental atopy, exposures to pets were associated with an increased risk of diagnosed-asthma and asthma-related symptoms in children both with and without family history of allergic diseases. Although, the results showed that the joint effect of hereditary propensity to atopy, representing genetic constitution, and exposure to pets on doctor-diagnosed asthma was not stronger than expected on the basis of their independent effects in additive scale, we could find the interaction between parental atopy and pets keeping on the persistent phlegm in these Chinese children.

A limitation of our study was that our outcome measures were based on questionnaire responses alone. However, large epidemiological studies of asthma often rely on reports on recent symptom history and physician's diagnosis of asthma because these self-reported measures are cost efficient, practical and their repeatability is generally good (Peat et al., 2001; Weissman, 2002). On the other hand, parental atopy is likely to be related to both risk of asthma and keeping pets, we adjusted for parental atopy and elaborated both independent and joint effects of

parental atopy and exposure to pets. And 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, in this study, 29.5% subjects with a family history of allergic diseases had animals, which was higher than that without family history of allergic diseases (27.6%).

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

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